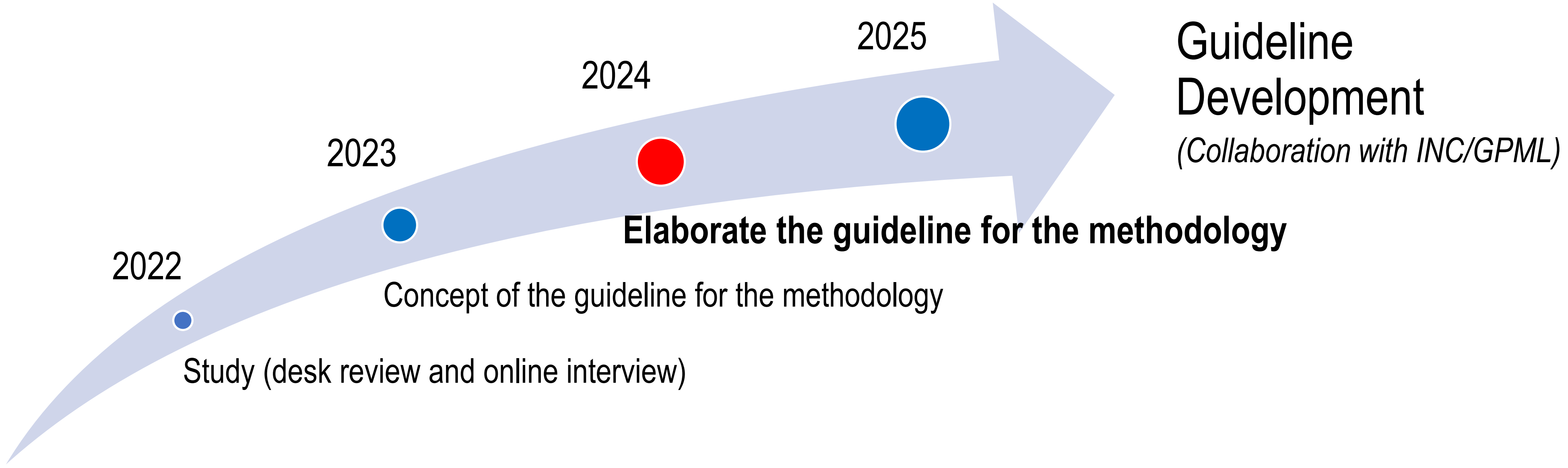
# Project on Inventory Development Methodology for a Plastic Leakage into the Environment, Including the Marine Environment (FY 2024)

# 1-1. Progress of the project on plastic inventory development methodology conducted by the Ministry of the Environment, Government of Japan

- Global/National plastic pollution issue: Project on understanding of the amount of plastic discharged into the ocean in Japan conducted by the Ministry of the Environment, Japan (MOEJ) since 2020
- Overall project objective: Develop and Elaborate the Plastic Discharge Inventory (macro/microplastic) with the estimation and evaluation methodologies in Japan
- One of the component added in 2022: Study on harmonized methodology for development of Plastic Discharge Inventory
- Progress in 2023: Develop the Classification of existing estimation methodologies for Plastic Discharge Inventory Development
- Plan in 2024: Elaborate the Classification of estimation methodology for Plastic Discharge Inventory Development



# 1-2. Draft Table of Contents: Plastic Inventory Development Guideline

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# 2-1. Elaboration of the Classification Table for Plastic Leakage Estimation Method (M1: Production and consumption)

| Name | | UNITAR, 2024, Statistical Guideline for Measuring Flows of Plastic Throughout the Life Cycle | OECD, 2020, ENV-Linkages Modelling Framework | Nakatani et al., 2020, Revealing the Intersectoral Material Flow of Plastic Containers and Packaging in Japan |
|---|---|---|---|---|
| Category | | M1. Production and Consumption | M1. Production and Consumption | M1. Production and Consumption |
| Scale of Estimation | Spatial | Global, National, Regional | Global, Regional, National | National |
| | Temporal | Long-term, Continuous | Long-term (2019–2060), Continuous | Long-term (2000-2015) |
| Input Data (Variables) | Data Types | Plastic production and consumption data, waste management statistics, trade data | Economic flows, plastics use by sector, product lifespans, recycling rates, mismanaged waste rates | Resin type, processed forms, sector-specific usage |
| | Sources | SEEA CF, CPC, ISIC classification, national trade & waste datasets | OECD databases (e.g., GTAP 10), Ryberg et al., 2019、Geyer et al., 2017, regional economic data | Japan's input-output tables, industrial production and shipment statistics |
| | Plastic Granularity | Plastic Granularity: Polymer- and sector-based | Plastic Granularity: Polymer- and sector-based | Plastic Granularity: Resin-based, sector-based |
| | Sector Details | Packaging, transport, construction, electrical, textiles | Packaging, textiles, construction, consumer goods, transportation | Food packaging, industrial packaging, retail |
| Estimation Approach | Type of Model | Physical Supply and Use Tables (PSUT) | Computable General Equilibrium (CGE) Model | Input-Output Material Flow Analysis (IO-MFA) |
| | Description | Tracks plastic flows across production, use, and waste phases using the SEEA framework | Links sectoral economic projections to plastics use, waste, and environmental impacts; incorporates feedback from external models | Tracks intersectoral flows of plastic containers and packaging using IO tables |
| | Leakage Pathways | Managed and unmanaged waste, informal and illegal waste handling | MPW to terrestrial and aquatic environments, emissions from lifecycle stages | N/A (focus on waste streams and recycling) |
| | Assumptions | Homogeneity of classification systems; consistent unit measures across datasets | Homogeneity in polymer use, static material composition, fixed GDP-plastic waste relationships | Consistent resin usage across sectors; alignment with IO table precision |
| Output (Estimation Result) | Results: | Quantified plastic flows by sector and lifecycle stage | Plastics use (Mt), waste management (recycled, landfilled, incinerated, mismanaged), environmental impacts | Material flows of 4.8 Mt of containers/packaging; sectoral inflow and recycling rates |
| | Temporal Scale | Annual | Annual | Annual |
| | Accuracy, Validation | Alignment with SEEA standards, validated through expert reviews and pilot testing | Calibrated using observed data, verified via expert reviews and literature benchmarks | Validated against survey data and historical trends |
| Details of applied model | Name of the model | PSUT Framework | ENV-Linkages Model | IO-MFA Model |
| | Description of the model, equation, | Integrates environmental and economic data to map plastic lifecycle | Dynamic CGE model integrating sectoral and regional economic activities with plastic flows | Estimates plastic flows into demand sectors via product lifecycles |
| | Calibration | National statistical datasets | Based on GTAP 10 database, historical and regional waste data | Uses historical IO data for accuracy |
| | Verification | Expert reviews, alignment with international classifications | Benchmarked against observed recycling and waste Mgt. trends | Compared with waste generation and recycling data |
| Analysis of Practicality and Versatility | Granularity | Supports detailed sector-specific insights | Enables detailed polymer- and sector-specific analysis | Effective for detailed sector analysis, limited to micro-intervention |
| | Data Collection | Dependent on accessibility to consistent classification (Plastic Key)& trade data | High dependency on regional economic and waste statistics; sensitive to data availability | Dependent on IO table precision and sectoral statistics |
| | Impact Verification | Allows tracking of plastic lifecycle, waste flows, and recycling rates | Supports identification of plastic leakage sources, waste management efficiencies, and policy development | Identifies key sources and recycling potentials |
| Additional Notes | Strengths | Standardized methodology for global comparability; modular structure for phased implementation | Comprehensive integration of economic and environmental dimensions; long-term projections | Comprehensive sectoral flow insights; supports policy formulation |
| | Weaknesses | Reliance on data availability; complex for countries with limited statistical infrastructure | Complexity of calibration, reliance on static assumptions for polymer distribution | Relies on data aggregation; limited granularity for resin-specific flows |
| | Tool kit | Yes (webpage) | No | No |

# 2-2. Elaboration of the Classification Table for Plastic Leakage Estimation Method (M2: Waste Flow)

| Name | | Lau et al., 2020, P2O Model | Cottom et al., 2024, SPOT Model | University of Leeds, 2019, ISWA Plastic Pollution Calculator | GIZ, 2020, Waste Flow Diagram |
|---|---|---|---|---|---|
| Category | | M1. Production & Consumption, M2. WM | M2. Waste Management | M2. Waste Management | M2. Waste Management |
| Scale of Estimation | Spatial | Global | Global, sub-national (50,702 municipalities) | Global, regional, city, and district levels | Municipal/City Level |
| | Temporal | Long-term (2016-2040) | Temporal: Continuous, focusing on the year 2020 | Long-term, with capacity for scenario analysis | Short-term to Long-term (annual estimates) |
| Input Data (Variables) | Data Types | Population size, per capita macroplastic MSW, microplastic product use, loss rates, collection rates | Municipal waste generation rates, waste composition, collection coverage, socioeconomic indicators | Waste generation rates, waste composition, collection coverage, socio-economic conditions, littering prevalence | Population, MSW generation rates, waste composition, collection efficiency, leakage influencers |
| | Sources | World Bank, UNEP, industry reports, scientific literature | Global and national databases, including WaCT, WABI, WaW2.0, and UNSD city data | Local waste management data, literature defaults, expert-reviewed leakage factors | Primary data collection, SDG 11.6.1 assessment, existing waste management studies, local waste authorities |
| | Granularity | Macro (MSW) and Micro (textiles, tires, pellets, PCPs) | Macroplastic (>5mm) by rigid and flexible types | Item-specific analysis: type, shape, size, and material | Macroplastic by material types: plastic film, dense plastic |
| | Sector Details | Packaging, consumer goods, municipal waste systems | Municipal solid waste management | MSWM, informal and formal waste collection | MSWM, informal and formal waste collection sectors |
| Estimation Approach | Type of Model | Coupled ODE Model, Monte Carlo Simulation | MFA combined with Machine Learning | Material Flow Analysis (MFA), GIS tool | Material Flow Analysis (MFA), Decision Trees |
| | Description | Calculates plastic flows through stocks and pathways using differential equations, accounting for feedbacks and uncertainties | Utilizes a bottom-up approach with municipal-level data, employing Monte Carlo simulations to handle uncertainties | Models plastic movement from waste generation through collection, treatment, and potential leakage pathways | Maps waste flows through the MSWM system, identifies stages where plastic leaks, and estimates quantities using predefined leakage factors |
| | Leakage Pathways | Land-based mismanagement, aquatic and terrestrial leakage pathways | Open burning, debris emissions from uncollected waste, collection systems, uncontrolled disposal, and mismanaged sorting reject | Open burning, on-land dispersion, entry into water bodies | Open burning, on-land dispersion, drains, entry into water systems |
| | Assumptions | Constant growth rates, stable informal sector impact, region-based differentiation | Assumes constant waste generation rates, regional socioeconomic influences, and informal sector impact | Local waste infrastructure influences leakage; uniformity in socio-economic conditions in each district | Simplified linear flows, no tracking between leakage fates, dependent on local conditions and data reliability |
| Output (Estimation Result) | Results: | Quantities of plastic entering ecosystems (e.g., 710 million metric tons cumulative by 2040) | Estimated 52.1 Mt/year of macroplastic emissions, with 57% from open burning and 43% from debris | Quantifies plastic leakage per item type and ranks pathways for targeted interventions | Quantified plastic leakage amounts, fates of unmanaged plastic (e.g., tons/year) |
| | Temporal Scale | Global, split into eight geographic archetypes | Global, with sub-national granularity | District to global | Municipal/City Level |
| | Accuracy, Validation | Uncertainty analysis via Monte Carlo simulations; sensitivity analysis included | Validation through comparison with existing estimates and extensive sensitivity analysis | Higher accuracy with additional data collection; scenarios modeled to reflect interventions | reliability assessed using a traffic light system; higher accuracy with primary data |
| Analysis of Practicality and Versatility | Granularity | Differentiates macroplastic types and microplastic sources, adapted for regional income levels | Differentiates rigid and flexible plastics, adaptable to various socioeconomic contexts | Allows item-based detail, adaptable to district or city scales for local specificity | Simplified yet effective for rapid assessment; adaptable to data availability and local contexts |
| | Data Collection | Relies on global datasets, subject to data availability and regional variability | Incorporates multiple global and national datasets, but faces challenges in rural and informal data accuracy | Can use default values or require on-ground data collection for higher reliability | Supports using existing data but emphasizes primary data collection for higher accuracy |
| | Impact Verification | Models source, pathway, and hotspot impacts; scenarios tested for intervention effectiveness | Effective in identifying emission hotspots and assessing intervention impacts at municipal levels | Identifies sources, pathways, and hotspots for evidence-based solutions | Identifies hotspots and potential interventions; useful for scenario analysis and SDG alignment |
| Additional Notes | Strengths | Comprehensive global model, accounts for economic and social variability | High-resolution data at municipal scale, robust handling of uncertainties | Comprehensive toolkit, scenario modeling for effective planning | User-friendly, aligns with SDG indicators, rapid assessment with low data requirements |
| | Weaknesses | High data uncertainty, limited granularity in informal sector dynamics | Limited applicability for regions with insufficient data, exclusion of microplastics and plastic exports | Requires investment in data collection for higher accuracy | Limited to macroplastic, data-dependent, does not track microplastic or inter-stage plastic movement |
| | Tool kit | No | No | No | Yes |

# 2-3. Elaboration of the Classification Table for Plastic Leakage Estimation Method (F: Coastal and other Land Field Measurements)

| Name | | CSIRO and COBSEA, 2024, Regional Assessment on Marine Litter in the East Asian Seas |
|---|---|---|
| Category | | F1. Field Survey (Land), F2. Field Survey (Waterways) |
| Scale of Estimation | Spatial | Local (Cambodia coast, inland, and river sites) |
| | Temporal | Short-term (based on data from two collection periods in 2022 and 2023) |
| Input Data (Variables) | Data Types | Site accessibility, cleanliness, population density, infrastructure, distance to roads, rivers, and coastlines |
| | Sources | On-site observations, GIS data, socioeconomic datasets |
| | Plastic Granularity | Macro-based (whole and fragmented items) |
| | Sector Details | Consumer products, specifically single-use items (water bottles, polystyrene foam) |
| Estimation Approach | Type of Model | General Additive Model (GAM) |
| | Description | GAMs assess debris density relationships with socioeconomic and geographic factors across site types |
| | Leakage Pathways | Land to coast, inland to river, river to ocean |
| | Assumptions | Consistent distribution patterns and influence of local socioeconomic variables |
| Output (Estimation Result) | Results: | Estimated density of 70,000 items per km of coastline, equating to over 80 million items on Cambodian coastlines |
| | Temporal Scale | Spatial Scale: Local (Cambodia) |
| | Accuracy, Validation | Site data compared across socioeconomic and geographic parameters, noting influence by nearby infrastructure and river distance |
| Details of applied model | Name of the model | General Additive Model (GAM) |
| | Description of the model, equation, | Utilizes socioeconomic predictors (population, lighting, distance to coast/river) to determine debris density |
| | Calibration | Based on socioeconomic variables |
| | Verification | AIC criterion used to verify model accuracy |
| Analysis of Practicality and Versatility | Granularity | Model tracks macroplastics and differentiates whole vs. fragmented items |
| | Data Collection | Requires in-person site surveys with GIS support, socioeconomic databases |
| | Impact Verification | Model provides data on debris distribution and source pathways, aiding hotspot identification |
| Additional Notes | Strengths | Robust method providing high-resolution insights into plastic pollution hotspots |
| | Weaknesses | Limited applicability beyond local scale; may not account for seasonal variations due to short-term data collection periods |
| | Tool kit | Monitoring guides and apps, etc. (Estimation method tools are not explicitly specified.) |

# 2-4. Elaboration of the Classification Table for Plastic Leakage Estimation Method (F: Aquatic (mainly Riverine) Field Measurements (1/2))

| Name | | Schmidt et al., 2017<br>Export of plastic debris by rivers into the sea | Lebreton et al., 2017<br>River plastic emissions to the world's oceans | Mellink et al., 2022, The plastic pathfinder |
|---|---|---|---|---|
| Category | | M2. Waste Management, F2. Field Survey (Waterways): | M2. Waste Management, F2. Field Survey (Waterways): | M2. Waste Management, F1. Field Survey (Land) |
| Scale of Estimation | Spatial | Global, Regional | Global, with focus on large river basins | Regional to Local (terrestrial environments and river basins) |
| | Temporal | Continuous | Continuous, with emphasis on seasonal variability | Daily with potential for annual projections |
| Input Data (Variables) | Data Types | Population density, waste generation rates, mismanaged plastic waste, river discharge | Population density, waste generation rates, mismanaged plastic waste, river discharge, catchment characteristics | Wind speed, surface runoff, land use, terrain slope, MPW generation |
| | Sources | Statistics, remote sensing data, river network, HydroSHEDS, GPWv3 | National statistics, remote sensing data, river network databases | Global databases (e.g., HydroSHEDS, ESA CCI) |
| | Plastic Granularity | Microplastic (<5mm) and Macroplastic (>5mm) | Macro- and microplastic | Macroplastic (>0.5 cm) |
| | Sector Details | N.A. | N.A. | N.A. |
| Estimation Approach | Type of Model | Power-law regression model, Linear regression | Empirical model with MPW data, hydrology, and population density | Numerical, spatiotemporal model |
| | Description | Used MPW data as a predictor for estimating plastic loads transported by rivers to the sea | Estimates plastic emissions by correlating MPW and runoff data to observed riverine plastic concentrations | Calculates plastic transport based on wind and runoff overcoming terrain friction thresholds |
| | Leakage Pathways | MPW transported from land to rivers, then to oceans | Plastic moves from inland areas to rivers and then to oceans | Plastic moves overland toward river basins based on topography |
| | Assumptions | High uncertainties due to limited and heterogeneous observational data | Artificial barriers (e.g., dams) act as sinks for plastic, influencing transport | Uniform thresholds for macroplastic mobilization; assumptions about runoff based on rainfall coefficients |
| Output (Estimation Result) | Results: | Estimated global plastic debris inputs to the sea range between 0.41 to 4 million tons per year | Global riverine plastic input to oceans estimated at 1.15 to 2.41 million tonnes per year, with over 80% from Asia | Generates potential plastic routing maps and accumulation hotspots; shows MPW distribution over time |
| | Temporal Scale | Global | Global, with local and regional inputs | Local river basins, adaptable to regional |
| | Accuracy, Validation | High uncertainties acknowledged, with validation through comparison to other studies such as Lebreton et al. ,2017 | Model calibrated with field data from selected global rivers, but high uncertainties remain | Requires empirical validation; calibration based on topography and expert inputs |
| Details of applied model | Name of the model | Power-law model | Empirical regression model | Plastic Pathfinder |
| | Description of the model, equation, | Log-log linear regression between mismanaged plastic waste (MPW) and plastic load | Regression model based on MPW and runoff data for prediction | Simulates plastic movement based on wind, runoff, and terrain friction thresholds |
| | Calibration | Performed using 5000 bootstrap samples to account for uncertainties | Calibrated with 30 records from 13 rivers globally | Designed to calibrate based on land cover and terrain slope data |
| | Verification | Through comparisons with independent estimates from other research (e.g., Lebreton et al.) | Validated against observed data from selected river systems | Requires empirical studies; threshold values based on expert assumptions |
| Analysis of Practicality and Versatility | Granularity | Micro/macro-plastic; affect by transport efficiency, with microplastics showing higher transport efficiency in rivers with high MPW | Addresses both micro- and macroplastic transport in rivers | Macroplastic, accounting for physical transport influenced by terrain |
| | Data Collection | Limited availability and accessibility of required data for plastic concentrations in rivers | Limited data for plastic concentrations in specific rivers; uses available field data for calibration | Requires accessible land use and topographic data; some limitations in high-resolution terrain mapping |
| | Impact Verification | Ability to verify high-load rivers' contribution to ocean plastic pollution enables targeted mitigation efforts | Model effectively identifies high-leakage rivers, aiding targeted intervention | Aims to identify hotspots for plastic accumulation and entry points to rivers |
| Additional Notes | Strengths | Major rivers contributing significantly to ocean, targeted interventions; combines multiple data sources for comprehensive analysis | Major rivers contributing significantly to marine plastic pollution; seasonal variability provides insights for intervention timing | First terrestrial plastic transport model to include detailed threshold-based mobilization approach |
| | Weaknesses | High uncertainties due to limited temporal and spatial data, limited applicability in regions with sparse data coverage, reliance on MPW data without considering other potential sources | High uncertainties in estimations due to limited data, especially in under-monitored regions | Lacks empirical calibration for all terrain types and specific plastic types; currently generalized thresholds for various terrains |

# 2-4. Elaboration of the Classification Table for Plastic Leakage Estimation Method (F: Aquatic (mainly Riverine) Field Measurements (2/2))

| Name | | Van Emmerik et al., 2018, A Methodology to Characterize Riverine Macroplastic Emission Into the Ocean | Van Emmerik et al., 2019, Seasonality of Riverine Macroplastic Transport | Strokal et al., 2023, River Export of Macro- and Microplastics to Seas by Sources Worldwide | Schreyers et al., 2024, River Plastic Transport and Storage Budget |
|---|---|---|---|---|---|
| Category | | M2. WM, F2. Field Survey (Waterways) | M2. WM, F2. Field Survey (Waterways) | M2. WM, F2. Field Survey (Waterways) | M2. WM, F1/2. Field Survey (Land/Waterways) |
| Scale of Estimation | Spatial | Local (Saigon River, Vietnam) | Spatial: Local (Saigon River, Vietnam) | Global | Regional (focused on the Rhine River sections) |
| | Temporal | Short-term with extrapolation to daily, monthly, annually | Continuous monthly, seasonally, and annually | Annual | Long-term |
| Input Data (Variables) | Data Types | Plastic piece count, mass, size, type; hydrological data | Plastic item count, plastic mass, hydrological data | Population density, MPW, sewage system data | Plastic transport, storage/river compartment, flow velocity |
| | Sources | Field observations, visual counting, static bridge-mounted trawls | Visual counts, trawling for samples, rainfall and discharge records | National statistics, geospatial data, modeled parameters for retention rates in rivers | Field measurements, literature (e.g., van Emmerik et al., 2022a) |
| | Plastic Granularity | Macroplastic (>5 cm) | Primarily macroplastic (>5 cm) with polymer-specific observations (e.g., PS-E, POsoft) | Macro/Micro | Macroplastics (>2.5 cm) |
| | Sector Details | N.A. | N.A. | Waste management, sewage treatment | N.A. |
| Estimation Approach | Type of Model | Empirical field-based model combined with hydrology | Empirical field observation model | Statistical Model, Process-based Modeling | Conceptual model based on transport and storage budget |
| | Description | Count plastic debris, determines cross-sectional flux profile, and calculates plastic mass flux | Combines visual and trawl data to estimate seasonal flux and spatial distribution of plastic | Socio-economic data & river retention rate for plastic export, Integrate macro/micro pathways/pollution source | Quantifies plastic storage and transport in river compartments including surface, suspended, floodplain |
| | Leakage Pathways | Plastic emissions estimated from rivers to ocean | Plastic emissions from river transport to coastal waters | Diffuse (mismanaged waste), point (sewage systems) | From land to river, floodplain to river |
| | Assumptions | Rely on tidal patterns and discharge data for extrapolation | Consistent tidal impacts on plastic distribution, seasonal variance and organic content effects | Assumptions: Differing regional treatment rates and river retention parameters | Steady-state, simplified storage across compartments |
| Output (Estimation Result) | Results: | 0.18-0.33 tons/day and 7.5-13.7 kilotons annually for the Saigon River | Estimated plastic outflow of $1.1 \times 10^3$ to $1.6 \times 10^3$ tons annually from the Saigon River | Approx. 0.5 million tons of plastic exported to seas annually | Quantifies plastic mass storage in floodplains (98%) and transport across river sections |
| | Temporal | Local (Saigon River) | Local (Saigon River) | Global with regional details | Regional, annual average |
| | Accuracy, Validation | High variability due to tidal influences and limited temporal coverage | Limitation by specific sampling location and conditions; Variability of tidal patterns & organic accumulation | Compared with other models (Lebreton, Jambeck) and validated against individual river measurements | Comparison with observed plastic transport in field studies |
| Details of applied model | Name of the model | Empirical macroplastic emission model | Empirical macroplastic transport model | MARINA-Plastics Model (Over 10,000 sub-basins worldwide including SE Asia) | Conceptual River Plastic Budget Model |
| | Description of the model | Estimates plastic flux by observed cross-sectional plastic profiles, mass per piece, and river discharge | Derives plastic flux using item counts and mass, accounting for cross-sectional and vertical distribution | Accounts for both diffuse and point sources of plastic pollution. | Assesses plastic flux and retention using input parameters from field measurements |
| | Calibration | Calibrated with daily plastic counts and discharge estimates | Calibrated based on visual counts and trawl samples | Based on field data from specific rivers | Based on observational data for the Rhine |
| | Verification | Comparison with previous estimates and observations in similar settings | Comparisons with existing estimates for similar river systems | Comparison with existing models for macro- and microplastic pollution | Compared with literature values for riverine plastic dynamics |
| Analysis of Practicality and Versatility | Granularity | Focus on macro emissions, with an emphasis on spatial variability across river width | Includes size and polymer-specific granularity; variability in plastic transport by MSW patterns | Differentiates between macro- and microplastics | Focused on macroplastics, adaptable for other size classes |
| | Data Collection | Field measurements adaptable to available resources (e.g., visual counts, trawling) | Visual counts and trawling are practical but sensitive to river dynamics | Extensive use of available global data, assumptions for regions lacking direct data | Based on field observations, challenges include lack of consistent floodplain measurements |
| | Impact Verification | Effective in estimating emissions in rivers influenced by urban waste | Seasonal insights aid in identifying peak transport periods for targeted interventions | Enables source-specific policy recommendations for diffuse and point sources | Limited by assumptions on retention and exchange rates |
| Additional Notes | Strengths | Adaptable for various river systems; includes short-term, high-frequency sampling | Seasonal variability; provides detailed composition and distribution of riverine plastic | Sub-basin-level analysis, differentiates between point and diffuse sources | Retention estimates for floodplain plastics, importance of floodplains in plastic storage |
| | Weaknesses | Limited local hydrodynamic influences and seasonal variations; required for year-round estimation | Limited temporal and spatial coverage; dependent on specific sampling points & influenced by high river traffic | Model uncertainties due to variability in data sources and assumptions across regions | Limited short-term temporal data, assumption on floodplain exchange & transport to downstream boundary |
| | Tool kit | No | No | No | No |

# 3. Elaborated Classification of Existing Estimation Methods

| Main Input Data | | | | Existing method | Life cycle* | | | | | Data Source, Model, National Statistic, Leakage rate | Stakeholder / Measure | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | P | C | W | E | O | | Stakeholder | Indicator |
| 1 | M1 | Production & Consumption (total plastic, sector, polymer) | | ・Nakatani et al., 2020<br>・UNITAR, 2023（Toolkit for the Product-Lifespan Method）<br>・OECD, 2020（ENV-Linkages Modelling Framework） | | | | | | ENVI/CGE, Input-Output Table, Physical Supply and Use Tables | Ministry of Industry, etc. | Reduction, Substitution, SUP reduction/phase-out, green procurement, etc. |
| | | Production & Consumption (item) | MacP | ・MOEJ, 2024（Lost fishing gear estimation） | | | | | | National Statistic, Discharge rate, etc. | | |
| | | | | ・MOEJ, 2024（PET bottle estimation） | | | | | | National Statistic, Discharge rate, etc. | | |
| | | | MicP | ・ECHA, 2020<br>・ICF&Eunomia, 2018<br>・UNEP, 2018<br>・MOEJ, 2024（Buildup estimation by sources and items） | | | | | | National Statistic, Discharge rate, etc. | | |
| 2 | M2 | Waste Management | Waste Flow | ・GIZ, 2020（Waste Flow Diagram (WFD)） | | | | | | National Statistic, etc. | Ministry of Environment (MOE), Ministry of Interior (MOI), Local Government (LGs), etc. | 3Rs, improved waste collection, EPR, various recycling schemes, introduction of WtE, improved landfill sites, etc. |
| | | | | ・Basel Convention, 2022（Toolkit for Material Flow Analysis Method）<br>・University of Leeds, 2019（ISWA Plastic Pollution Calculator (PPP)） | | | | | | National Statistic, Discharge rate, etc. | | |
| | | | | ・GPAP, 2022（National Analysis and Modelling (NAM) Tool）<br>・Cottom et al., 2024（SPOT Model） | | | | | | Global, National Statistic, Statistic model, etc. | | |
| 3 | F | Field survey and Monitoring | Coastal and other Land Field Measurements | ・CSIRO and COBSEA, 2024（Regional Assessment on Marine Litter in the East Asian Seas） | | | | | | Survey, Statistic model | MOE, LGs | Mitigation measures (Collection, Awareness-raising, etc.), Impact assessment of the mitigation measures |
| | | | | ・MOEJ, 2024（Beach litter survey）<br>・S-19 (Environment Research and Technology Development Fund) | | | | | | Survey, extrapolation | | |
| | | | Aquatic (mainly Riverine) Field Measurements | ・Nihei et al., 2020 ・Schmidt et al., 2017 ・S-19<br>・van Emmerik et al., 2019 ・Lebreton et al., 2017<br>・Meijer et al., 2021 ・World Bank et al., 2021<br>・Mellink et al., 2022<br>・MOEJ,2024（Pumping station survey） | | | | | | Survey, Statistic model | MOE, Water & Marine related departments, LGs | |
| | | | | | | | | | | Survey, Discharge rate, Statistic model | | |

(**Reference:** The estimation methods used by OECD (ENV-Linkages model + UOL + DTU) and UNEP (National Guidance on Plastic Pollution Hotspotting and Shaping Action) integrate data from both M1 and M2.)

* Blue: Data Input, Yellow: Output, P: Production、C: Consumption、W: Waste Generation/Management、E: Leakage to the environment、O: Leakage to the ocean

# 4. Consideration of the Algorithm for Selecting Practical Estimation Method

**Three steps** for selecting practical estimation method based on the elaborated classification table (previous page)

- Identify the applicable estimation method and corresponding existing methods (yellow & red boxes in the figure) based on the intended purpose
- Classify the selected estimation method according to the number of steps involved in the leakage pathway to calculate the target output.
- The concept of this document (illustrated on the next page) is to classify the level (① – ③ ) based on the number of steps required to calculate the output data. (e.g. IPCC GHG inventory guidelines adapt the "Tier" approach to classify methods based on the level of accuracy, reflecting the extent to which country-specific data and national circumstances are incorporated.

**Step 1:** Purpose of Estimation (Policy & Interventions)
- Production and Consumption Measure
- Improvement of Waste Management
- Environmental Impact on Terrestrial, Riverine, and Marine Areas

**Step 2:** Output (Targeted Indicator)
- Waste Management
- Leakage to Environment
- Leakage to Ocean

**Step 3:** Data Availability
- Production & Consumption Data
- Waste Statistic
- Terrestrial Data
- Watershed & Aquatic Data

### Examples of Policy & Interventions

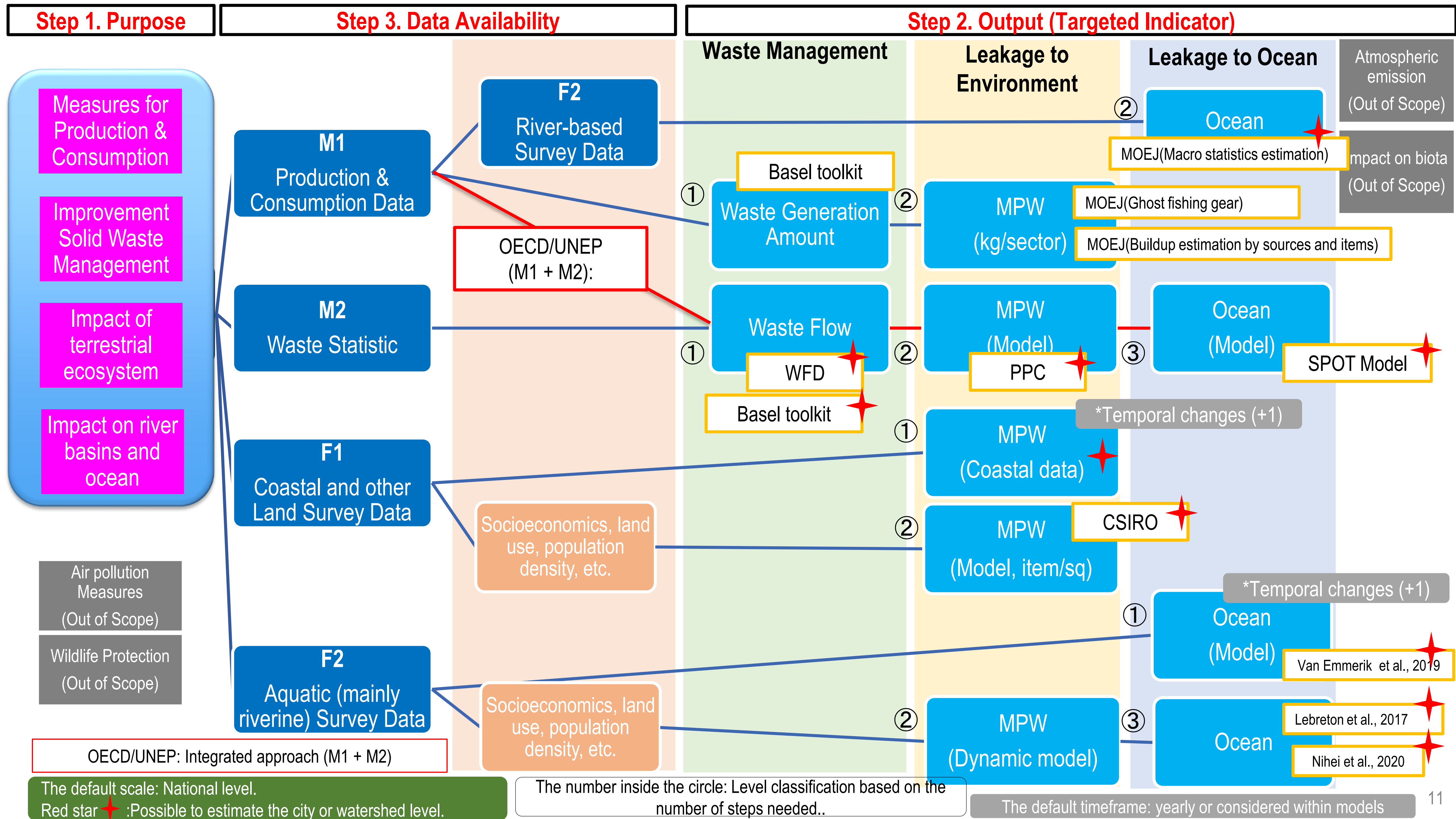
- **Production and Consumption Measure**
  Reduction in plastic use, Alternatives, Reduction or phase-out of SUPs, Green procurement policies , Measures for lost and abandoned fishing gear, etc.
- **Improvement of Waste Management**
  3Rs (Reduce, Reuse, Recycle) Enhance waste collection system, EPR, Various recycling schemes, Waste-to-Energy, Landfill O&M, etc.
- **Impact on Terrestrial, Riverine, and Marine Areas**
  Cleanup, Awareness-raising, Countermeasure development for plastic leakage, Impact assessment after the implementation of policies/interventions, etc.

### Examples of Targeted Indicator

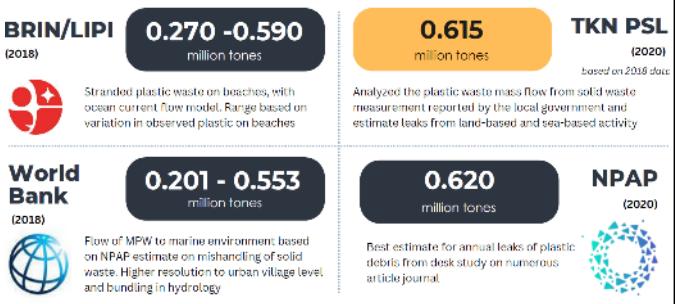
- **Waste Management**
  - ✓ Waste Generation Amount
  - ✓ Waste Flow
- **Leakage to Environment**
  - ✓ Mismanaged Plastic Waste Amount/Density
- **Leakage to Ocean**
  - ✓ Plastic leakage into the ocean via rivers and coastal areas

### Examples of Data Types

- **M1: Production & Consumption Data**
  Production, import, and conusmption amounts, Trade statistics, etc.
- **M2: Waste Statistic**
  Waste amount, Self-managed waste amount, Waste collection rate, Recycling rate Landfill conditions Government statistics, Global data, etc.
- **F: Coastal and other Land Data**
  Illegal dump, Waste found in riverbanks and coastal areas, Population density, Land use, etc.
- **F: Aquatic (mainly riverine) Data**
  Measured data from river basins, Model analysis, etc.


Step 1. Purpose
Step 3. Data Availability
Step 2. Output (Targeted Indicator)
Waste Management
Leakage to Environment
Leakage to Ocean
Atmospheric emission (Out of Scope)
mpact on biota (Out of Scope)
Measures for Production & Consumption
Improvement Solid Waste Management
Impact of terrestrial ecosystem
Impact on river basins and ocean
Air pollution Measures (Out of Scope)
Wildlife Protection (Out of Scope)
M1 Production & Consumption Data
M2 Waste Statistic
F1 Coastal and other Land Survey Data
F2 Aquatic (mainly riverine) Survey Data
F2 River-based Survey Data
OECD/UNEP (M1 + M2):
Socioeconomics, land use, population density, etc.
Socioeconomics, land use, population density, etc.
Basel toolkit
① Waste Generation Amount
① Waste Flow
WFD
Basel toolkit
② MPW (kg/sector)
② MPW (Model)
PPC
① MPW (Coastal data)
*Temporal changes (+1)
② MPW (Model, item/sq)
CSIRO
② MPW (Dynamic model)
② Ocean
MOEJ(Macro statistics estimation)
MOEJ(Ghost fishing gear)
MOEJ(Buildup estimation by sources and items)
③ Ocean (Model)
SPOT Model
*Temporal changes (+1)
① Ocean (Model)
Van Emmerik et al., 2019
③ Ocean
Lebreton et al., 2017
Nihei et al., 2020
OECD/UNEP: Integrated approach (M1 + M2)
The default scale: National level.
Red star :Possible to estimate the city or watershed level.
The number inside the circle: Level classification based on the number of steps needed..
The default timeframe: yearly or considered within models

# 5-1. In-Depth Hearings in the in the Southeast Asian Region (Indonesia)

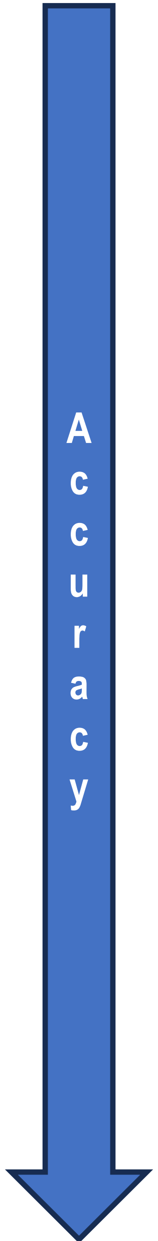
| Criteria | Summary |
|---|---|
| Estimation of Leakage Amount and Monitoring-Related Activities<br><br>Methodologies and Tools Used | • **The National Coordinating Team for Marine Debris Management (TKN PSL)** estimates “Land-based” and “Sea-based” sources by reviewing the National Action Plan (NAP), defining the total of these estimates as “Marine Debris Leakage”.<br>• **Estimation method for land-based leakage:** MPW: Derived from SIPSN and Ministry of Health survey data, Impact of plastic regulations (such as EPR and bans on single-use plastics)<br>• **Estimation method for sea-based leakage:** Fisheries waste (vessel numbers, operating day), Passenger vessel waste (passenger capacity, operational hours, etc.), Illegal marine dump (Self-reported, monitoring data)<br>• **Upstream data (production and consumption)** is not included in the estimation.<br> |
| Challenges in Data Collection, Analysis, and Management | • **TKN PSL:** collecting data from relevant ministries and conducts estimations.<br>• **Progress toward the 70% reduction target (by 2025):** 42% achieved as of 2023.<br>• **Data Gaps:** Lack of digital integration (No real-time plastic leakage monitoring system), Difficulty in short-term variation analysis (Seasonal fluctuations and short-term trend), Insufficient data (Offshore industries, ports, and aquaculture sectors), Limited onsite measurements (Heavy reliance on statistical data, Less measurement).<br>• **Policy Sustainability Challenges:** Uncertainty (Under the new administration), Post-2025 revision of the NAP<br>• **TKN PSL‘s Role:** Stipulated by Presidential Regulation No. 83/2018, Funds from UNDP<br> |
| Required Support and Resources | • **Data Management & Integration:** Enhance real-time monitoring systems, Improve the national data platform (Integrating data from LGs and the private sector).<br>• **Technology Development:** Establish AI-based data analysis infrastructure, Introduce new measurement technologies (Drones, sensors, etc.).<br>• **Policy & Funding:** Maintain a long-term policy framework, Promote private sector participation, Expand international funding and technical cooperation. |
| Existing Policies, Programs, and Guidelines | • **National Action Plan (NAP):** Presidential Regulation No. 83/2018, Target: 70% reduction by 2025, 5 strategies and 59 activities by 22 ministries and agencies.<br>• **Key Measure:** Extended Producer Responsibility, Ban on Single-Use Plastics, (Regulatory strengthening contributes to leakage reduction).<br>• **Infrastructure Development:** 850 waste management facilities in 200 cities by Ministry of Public Works |
| Key Outcomes | • **Reduction in Plastic Leakage:** Reduced from 615,000 tons in 2018 to 359,000 tons in 2023 (a 41% decrease)<br>• **Improvement in Data Collection & Reporting Systems:** Establish a national reporting platform enables real-time progress tracking across ministries<br>• **Advancements in Policy & Legal Framework:** Introduce plastic reduction policies, including EPR and bans on SUPs |
| Stakeholders | • **Ministry of Environment (MOE):** SIPSN (266 verified < 441 registered < among 514 cities), SIMBA<br>• **Ministry of Industry (MOI):** National database on plastic production (Based on voluntary reporting by businesses and surveys)<br>• **Ministry of Public Works (MPW):** SI-INSAN (Infrastructure database)<br>• **Ministry of Health (MOH):** Household sanitation survey (Conducted every 5 years nationwide in Indonesia)<br>• **Ministry of Home Affairs (MOHA):** SIPD (Statistical data from local governments) |

# 5-2. In-Depth Hearings in the Southeast Asian Region (Vietnam)

- **Challenges in Addressing Plastic Pollution and Marine Debris**
  - ✓ Lack of dedicated policies on plastic pollution and marine debris
  - ✓ Poor coordination among relevant agencies (e.g. PCD: land, rivers, and waterways, VASI/VEMSI: estuaries, coastal areas, and the ocean, and no harmonized approach)
  - ✓ Disproportionate funding allocation (Majority to VASI, rather than PCD)
- **Key Reports & Data Collection Efforts**
  - ✓ UNDP/GEF's initial plastic pollution data collection (including production and consumption)
  - ✓ 2022 Status Report on Plastic Waste
- **Monitoring & Budgetary Constraints**
  - ✓ No official monitoring activities in place
  - ✓ Rely heavily on donor funding (No budget)
  - ✓ No national standards or methodologies
- **Planned Actions & Data Limitations:**
  - ✓ VEA Plan: Plan to formulate a plastic leakage inventory and estimation method
  - ✓ Data limitations: Primarily SWM data, limited production and consumption data collection (VPA is the main source of information)

| Criteria | Summary |
| --- | --- |
| Estimation of Leakage Amount and Monitoring-Related Activities | • VASI's Marine Pollution Report (WWF State Report, 2023, MCD's Waste Composition Survey by communities and interceptors (The Ocean Cleanup classification).VNU's State Report (Macroplastic, waste flow analysis) and microplastic research, UNDP/GEF's baseline survey (initiated from 2025) |
| Methodologies and Tools Used | • Macroplastic Monitoring (Field surveys, interceptor systems, GIS-based hotspot mapping, Waste management data), Microplastic Analysis (using FTIR microscopy, USEPA sampling protocols), Data Sources (Local government reports, Customs data, Private sector contributions) |
| Challenges in Data Collection, Analysis, and Management | • Data Gaps (Lack of baseline data and polymer-specific data), Coordination Challenges (Insufficient collaboration among relevant agencies), Infrastructure Barriers (Limited availability of advanced tools, Inconsistent monitoring protocols) |
| Required Support and Resources | • Capacity Development (Training programs for government officials and local communities), Policy & Guidelines (National standards for plastic and microplastic monitoring), Financial & Technical Support (Funding for large-scale surveys and advanced monitoring tools), International Cooperation (Sharing best practices and collaborative initiatives) |
| Existing Policies, Programs, and Guidelines | • NAP for Marine Plastic Waste Management 2019–2025 (Focuses on integration across sectors), Environmental Protection Law 2022 (Includes waste management regulations but does not specifically address plastic leakage/pollution) |
| Key Outcomes | • Research on Baseline Data for Plastic Waste Sources (Deficiencies in waste collection systems, Identification of data gaps and the need for standardization), Scalable Model (MCD's initiative in Ha Long Bay as a potential expansion model) |
| Stakeholders | • Government/NGO Collaboration (Joint initiative by VASI, PCD, and WWF like State Report), Academic Institutions (research collaboration with int. organizations), Community Engagement (Waste monitoring activities by local communities) |

# Classification of methods based on the level of accuracy in the input data (harmonization between macro and field data )




| Input | Output | | |
|---|---|---|---|
| **Tier 1 (Basic Form)** | **Waste Generation Amount** | **Leakage (Terrestrial)** | **Leakage (Aquatic)** |
| M1 Production & Consumption | ・Nakatani et al., 2020<br>・UNITAR Toolkit | (M1 x Leakage rate) | M1 x Leakage rate<br>(MOEJ Macro Statistics estimation) |
| M2 Waste Management | ・Basel Toolkit<br>・WFD<br>・SPOT Model | | ・Lebreton et al., 2017<br>・Meijer et al., 2021<br>・World Bank et al., 2021<br>・Mellink et al., 2022 (based MPW) |
| F1 Field Data (land) | | Accumulation of Field Data, Extrapolation | Leakage rate, Model, Simulation |
| F2 Field survey (waterways) | – | – | Accumulation of Field Data, Extrapolation<br>(MOEJ Pumping station survey) |

| Input | Output | | |
|---|---|---|---|
| **Tier 2 (Applied Form)** | **Waste Generation Amount** | **Leakage (Terrestrial)** | **Leakage (Aquatic)** |
| M1 -> M2 (Harmonized) | ・UNEP National Guidance ・OECD（ENV-Linkages Modelling Framework + UOL + DTU） | | |
| F1 -> F2 (Harmonized) | – | x | x |
| M2 <-> F1 (Verification) | x | x | x |
| M2 <-> F2 (Verification) | x | x | x |

| Input | Output | | |
|---|---|---|---|
| **Tier 3 (Advanced Form)** | **Production, Consumption & WM** | **Leakage (Terrestrial)** | **Leakage (Aquatic)** |
| M1 -> M2 -> F1 -> F2 | x | x | x |

# Results of a Survey on the Feasibility of Implementing Estimation Methods Using Macro Statistical Data Overseas （FY 2024）

# Estimation by using macro-statistical data

In theory, there are two methods using macro statistical data:
1.Estimating the outflow volume by subtracting macro statistical data such as disposal amounts from macro statistical data such as usage amounts.
2.Estimating the outflow volume by multiplying macro statistical data such as usage amounts by parameter/coefficients (e.g., outflow rates).
Method (1) is calculating by using macro statistical data obtained for different purposes (which may contain errors), raising concerns about high uncertainty. Therefore, Method (2) was chosen for consideration.

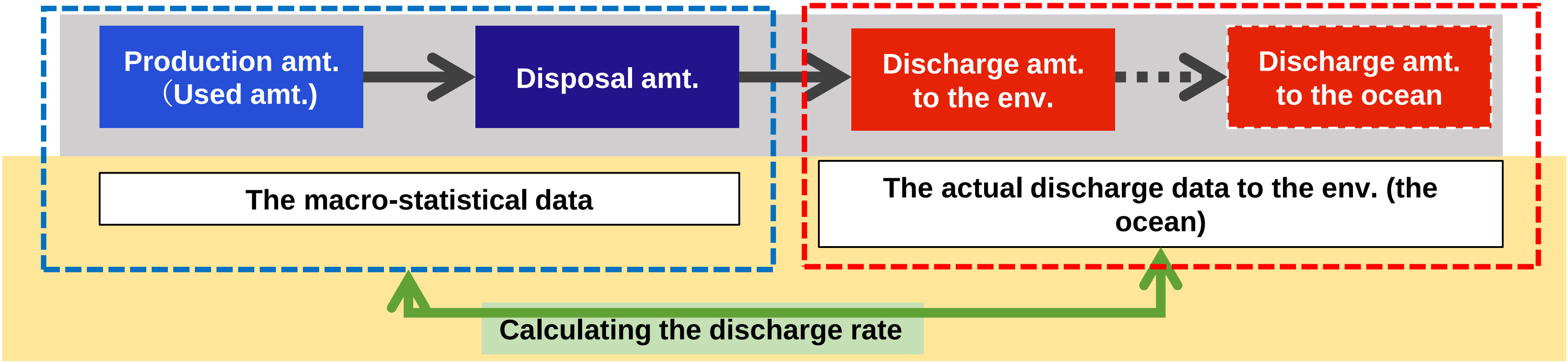
・**The calculation of the discharge amount using the macro-statistical data is done by multiplication, not subtraction.**

**A（Macro-statistical data）×B（Discharge rate）＝C（Discharge amount to the env./ocean**

・For **"Calculation of discharge rate"** and **"Consideration of estimation methods by (the macro-statistical data ×discharge rate)", item (product) whose "macro-statistical data" and "data of the actual discharge amount to the environment" are considered relatively easy to obtain should be selected**

・**Trial using Japanese data in FY2023, and other developing countries data in F'2024**

(Example of Japan's case in FY2023)
【Item (product) example】 PET bottles
【Candidates for obtaining the macro-statistical data】 Data from the Council for PET Bottle Recycling, results of input-output analysis
【Actual data on the amount discharged to the environment】 Results of a survey of the amount of waste collected at a pump station (using results from a separate operation).



# List of results of estimation methods using macro statistical data in foreign countries.

(3) is calculated by dividing (2), which was calculated using research papers from various countries, by statistical data (1).
(5) is calculated by multiplying (3) by statistical data (4), which was obtained separately.
The following are the results of applying the estimation method using macro-statistical data to other countries, and are "Marine leakage rate of PET bottles [%]", "Marine leakage volume of PET bottles [t/y]", and "Estimated marine leakage volume of plastic products [t/y]".

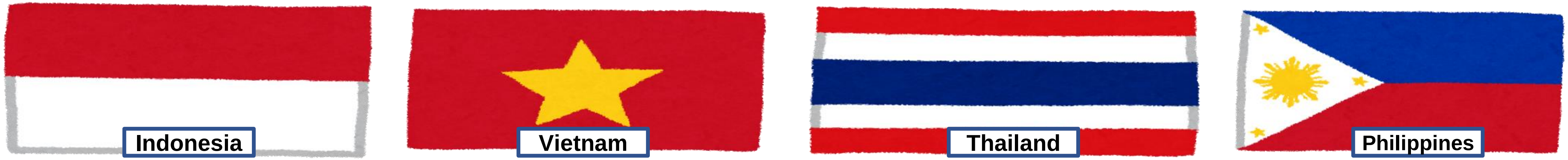
| country | (1) PET Bottles Sales volume [t/y] | (2)Marine leakage volume of PET bottles [t/y] | (3)=(2)/(1) Marine leakage rate of PET bottles [%] | (4) Plastic Products Amount used [t/y] | (5)=(3)×(4) Estimated marine leakage volume of plastic products[t/y] | Amount of plastic leaked into the ocean as reported by countries[t/y] | (Reference) Jambeck (2015). Marine Leakage [t/y] | (Reference) Meijer (2021). Marine Leakage [t/y] |
|---|---|---|---|---|---|---|---|---|
| Indonesia | 298,113 | 2,004～4,008 | **0.67～1.34** | 4,206,000 | **28,000～56,000** (28,180～56,360) | **359,061** | 480,000～1,290,000 | 56,000 |
| Vietnam | 203,774 | 3,755～6,259 | **1.84～3.07** | 2,930,000 | **54,000～90,000** (53,912～89,951) | - | 280,000～730,000 | 28,000 |
| Thailand | 184,906 | 5,560 | **3.01** | 6,070,000 | **183,000** (182,707) | - | 150,000～410,000 | 23,000 |
| Philippines | 147,170 | 2,414 | **1.64** | 2,150,000 | **35,000** (35,260) | - | 280,000～750,000 | 360,000 |
| Japan | 583,000 | 629 | **0.108** | 4,558,433～8,950,000 | **4,900～9,700** (4,923～9,666) | **11,000～27,000** | 21,000～57,000 | 1,835 |

| | Bibliography related to (1) | Bibliography related to (2) | Bibliography related to (4) | Reference material on the amount of plastic waste leaking into the sea reported by each country. | Differences from estimates in Japan | Points to note |
|---|---|---|---|---|---|---|
| **Indonesia** | GA Circular, 2019, Full Circle: Accelerating the Circular Economy for Post-Consumer PET Bottles in Southeast Asia | Hariyadi et al. 2022 Plastic debris in citarum river | Direktorat Industri Kimia Hilir dan Farmasi (2025) | TKN PSL(2025).The Indonesia National Action Plan for Marine Debris Management "Secretariat of The National Coordinating Team for Marine Debris Management | • Normal data.<br>• Targeting of PET bottles flowing on the surface.<br>• Measured by wet weight (converted to dry weight by a factor). | • Using 2021 data.<br>• When a river branches, it is necessary to pay attention to the population of the catchment area.<br>• The boundaries of the river basins may not correspond to the actual situation. |
| **Vietnam** | | Nguyen et al., 2024 Assessment and sustainable management strategies for plastic waste in Can Tho City, Vietnam: A circular economy approach | WWF, 2023 Report on plastic waste generation in 2022 | – | • PET bottles stagnating under the bridge are targeted. | • Using data from 2021 data.<br>• The collection period is not specified, so we assume it is one day.<br>• Difficult to identify detailed catchment area due to Mekong Delta region. |
| **Thailand** | | UNEP, IUCN and Life Cycle Initiative, 2020 National guidance for plastic pollution hotspotting and shaping action | Ministry of Natural Resources and Environment, 2021 Action plan on plastic waste management phase I (2020 – 2022) | – | –<br>(No observation information) | • Calculated based on 2019 data.<br>• Amount of leakage into the environment, not the ocean. |
| **Philippines** | | Requiron and Bacosa, 2022 Macroplastic transport and deposition in the environs of pulauan river, Dapitan City, Philippines | WWF-Philippines, 2020 EPR scheme assessment for plastic packaging waste in the Philippines | – | • Normal data.<br>• Targeting of PET bottles flowing on the surface.<br>• Measured by wet weight (converted to dry weight by a factor). | • Using 2021 data.<br>• When a river branches, it is necessary to pay attention to the population of the catchment area.<br>• The boundaries of the river basins may not correspond to the actual situation. |
| **Japan** | Ministry of the Environment "FY2023 Study Results: Estimation of the Amount of Marine Plastic Litter in Japan" | | | | | |

# Evaluate availability of data in other countries and the direction of future surveys.

- As an evaluation of the data utilized in this study, in terms of statistical data, in the **case of PET bottles, there is no established system or mechanism to collect individual information as in Japan, and the availability is generally low.** In the case of plastic products, information is often published by government agencies (especially for Indonesia, there is detailed information by product and polymer in cooperation with industry associations). Surveyed data is literature-based information only, and leakage rates may be underestimated/ overestimated depending on the setting of watershed boundaries, consideration of high water, and the scope of data acquisition.

→ In the future, with **Indonesia and Vietnam** in mind, **where detailed statistical data may be available,** we will consider conducting field surveys at **locations where watershed boundaries can be established** and **where surveys can be conducted under normal conditions and during high water**, and obtaining our own measured data (leakage rates) (we aim to calculate leakage rates for plastic products rather than PET bottles in combination with statistical data).



| | | Indonesia | Vietnam | Thailand | Philippines |
|---|---|---|---|---|---|
| statistics data | PET bottle | **Availability [Low]**<br>• The only information we were able to confirm was the information on sales volumes indicated in the literature.<br>• There is information that it is unlikely that industry groups in Vietnam and Indonesia are compiling and updating data on the production, sales and consumption of PET bottles through local surveys (there is no established system or mechanism for collecting information on PET bottles). | | | |
| | Plastic Products | **Availability [High]**<br>• Government agencies work with industry groups to release information.<br>• Detailed information available by product and polymer. | **Availability [Medium]**<br>• Information is available in a report from a government-affiliated research institute.<br>• There is a possibility that the industry group may have information, and we are currently investigating. | **Availability [High]**<br>• Government agencies release information. | **Availability [Medium]**<br>• International organizations publish information. |
| actual measure ments data | PET bottle Leakage rate | • Problems related to watersheds are small.<br>• Adopted survey results for normal conditions only.<br>• Sampling at river surface (leakage rates may be underestimated).<br>• The number of samplers used is unknown (one or two). | • It is difficult to set the boundaries of the watershed around the Mekong Delta (there is a possibility of underestimation).<br>• Data on the garbage collected under the bridge (there is a possibility that it is overestimated because it may include garbage from outside the survey period). | • The source of information on which it is based is not the amount of leakage into the river, but the amount of leakage into the environment (the leakage rate may be overestimated).<br>• No observation information. | • It may be difficult to set up a watershed.<br>• Adopted survey results from normal and high water conditions.<br>• Visual observation at river surface (leakage rate may be underestimated). |

# Conditions and methods for obtaining the data used in the calculation.

The amount of plastic bottles littered in each country is an estimate based primarily on the results of academic studies.

- ✓ The sampling methods and conditions for each country's data are as follows. **Terms vary by country.**
- ✓ It is important to note that, unlike in Japan, data is obtained from the surface.
- ✓ For Indonesia and the Philippines, where wet weight is used, we selected appropriate wet/dry conversion factors to convert to dry weight, considering whether it would be possible to estimate the weight of PET bottles. The wet and dry conversion factors are taken from the "FY2023 Survey on the Current State of Plastic Waste in Rivers, Lakes and Marshes Ending up in the Ocean“ by MOEJ in Japan.

| country | Normal/ High water | Sampling method | Data acquisition range (Transverse direction) | Data acquisition range (Vertical direction) | Wet/ Dry weight※2 | Estimation Method |
|---|---|---|---|---|---|---|
| **Indonesia** | Normal | Catching in a net | 2m or 4m | Surface | Wet※3 | Days converted into |
| **Vietnam** | Normal | Collection of retained garbage under the bridge | 3m or 5m | Surface | Dry | Days converted into |
| **Thailand※1** | - | | | | | |
| **Philippines** | Normal and High water | Visual observation | Whole area | Surface | Wet※4 | Days converted into |
| **Japan** | Normal and High water | Collected at the river mouth weir and drainage pump station | Whole area | Whole layer | Dry | Days, rainfall conversion |

※1 : Organized as the quantity for the entire country of Thailand, with no observational information to serve as a basis.
※2 : The wet weight is converted to the dry weight by multiplying by a coefficient. The coefficient is based on the results of the “FY2023 Survey on the Current State of Plastic Waste in Rivers, Lakes, and Marshes Endangering the Ocean”(The weight of the samples before drying was measured when they were brought back, and then the weight after drying was measured after drying in a dryer (50°C to 100°C).)
※3 : It was not possible to estimate the weight of PET bottles in relation to the total weight of plastic. Therefore, the total wet weight of the plastic was multiplied by the plastic conversion factor of 0.67, and the resulting figure was multiplied by the proportion of PET bottles to estimate the PET bottle leakage rate.
※4 : The amount of PET bottles leaked was estimated by estimating the wet weight of PET bottles from the total weight of the plastic surveyed, and then multiplying by the wet/dry conversion factor of 0.86.

| country | elevation | Reference Watershed Boundaries | Rivers used as reference | catchment population |
|---|---|---|---|---|
| Indonesia<br>Philippines<br>Vietnam | Approx. 30m DEM<br>NASA Earthdata | HydroBASINS<br>HydroSHEDS | HydroRIVERS HydroSHEDS<br>Google map Google | Approx. 5 km × 5km grid<br>SEDAC |
| Japan | 5~10m DEM<br>basic mapping information | Watershed Mesh<br>National land data, river development plans, etc. | river line<br>National Land Numerical Data | 3rd to 5th order (250m to 1km) grid<br>e-Stat |

# Issues and proposed responses for next year's survey.

item | issue | proposed responses

## (1) Consideration of monitoring methods that can be compared.

In the survey, the amount of plastic product leakage was estimated by calculating the amount of PET bottle leakage in each country from existing literature. As mentioned above, data can vary between countries due to data collection methods, such as whether it's collected during normal or high water, and whether it's visually observed or sampled with a net.

**Visual sampling is considered to be the most suitable** method for conducting simple cross-country comparisons during next year's field survey. On the other hand, in the case of visual sampling, there is a possibility of errors being made by the observer, so if possible, it is preferable to conduct monitoring surveys using equipment such as cameras.
In addition, since the visual sampling only targets the surface layer, there is a possibility that the results of the estimated leakage volume will be underestimated. In order to accurately determine the leakage volume of each country, **it is desirable to conduct parallel surveys using "trash removal devices" and "interceptors" that have functions similar to those of Japanese drainage pumping stations.**

## (2) Investigation of estimation methods.

In this trial calculation, the amount of PET bottle leakage per person in the target catchment area was calculated and multiplied by the total population to estimate the amount of leakage nationwide. This method may lead to a large error when estimating the entire country from the point of view of representativeness of the target sites and other land uses such as agricultural land.

In addition to this calculation method, it is **desirable to compare and consider other estimation methods**, such as estimating from the area using water balance analysis and estimating by taking into account land use, with reference to Japanese calculation methods. It is also important to check the data that has been organized in each country.

## (3) Survey of typical plastic waste that is desirable as a target for tracking in Southeast Asia.

In calculating the leakage rate by product in this year's survey, PET bottles were selected as the tracking target for the following reasons.

- As in Japan, statistical data is considered to be well developed.
- Even if it leaks into the environment, there is little chance that it will be mistaken for another substance, and it is a typical classification item.

On the other hand, this year's field survey confirmed that it is not appropriate to calculate the leakage coefficient using PET bottles in Southeast Asian countries due to the following problems.

- Statistical data on production and sales volumes, etc., are not available.
- PET bottles have a market value after use and are considered to be collected by the informal sector, so they are not representative as an item for estimating leakage rates due to their high recycling rate compared to other plastic products.

In preparation for next year's survey, it is necessary to **select polymers and products that are suitable for verification**, such as polyethylene. Factors to be considered include the **availability of statistical data** (production volume, sales volume, etc.), the ease of **identifying the target substance in the event of a leak**, and the representativeness of the product (for example, the fact that the recovery rate is not as high as for other plastic products such as PET bottles).