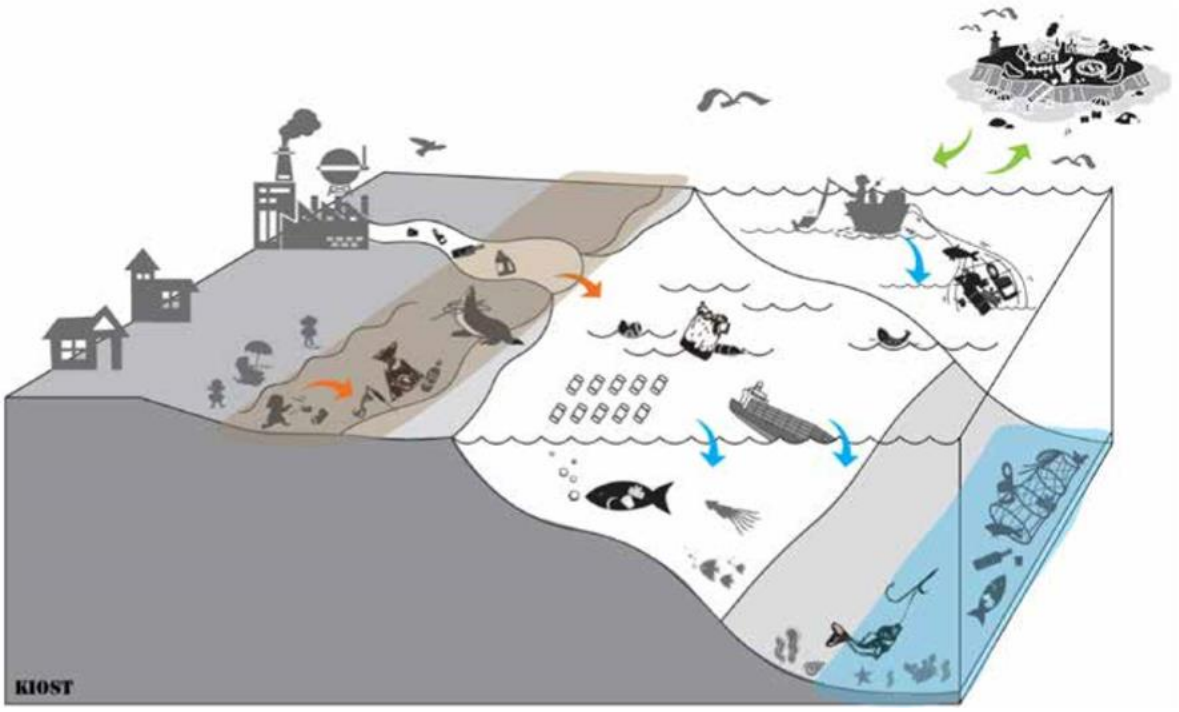
Desk review of methodologies available for identification and quantification of plastic waste leakage into rivers and ocean



(Source: Guidelines or the monitoring and assessment of plastic litter and microplastics in the ocean, GESAMP, 2019)

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Makoto Tsukiji

Introduction

This desk review was initiated by the United Nations Environment Programme (UNEP). The TOR for the desk review was as follows;

- *Desk review of methodologies available for identification and quantification of plastic waste leakage into rivers and ocean.*
- *For the above, which should be a document of 6-7 pages with an accompanying PowerPoint, both in English, should be prepared and finalized by the end of March 2019."*

The UN Environment further provided a list of items to be reviewed. These items included general activities, studies and projects that developed and/ or implemented(ing) various methodologies. Hereafter these items will be referred to as "activity, report or study" in this desk review report.

The review was undertaken through internet search, reviewing homepages of activities implementers and downloading and reviewing activities materials. Additional activities were added for review. Direct contact with an implementer was not made at this stage.

The focus of the review was to identify the relevance of the various methodologies for identification and quantification of plastic waste leakage into rivers and ocean, and initiatives and activities of the projects listed, under consideration for application in India and the Mekong River Basin (hereafter referred to as the Proposed Project), rather than to discuss specifics of these activities. The activities with high relevance to the project should be reviewed more thoroughly once the Proposed Project is commenced.

A summary of the review is provided in **chapter 1** of this report, with more details for each reviewed activity in an **attachment**, at the end of the report. Recommendations are provided in **chapter 2** of this report.

For many of the reviewed activities there were multiple reports and the links to these reports are copied as appropriate. Text directly copied from the homepages or reports are included in Quotations marks (" ").

Table of Contents

1. Desk review summary

A total of 16 activities were reviewed as to their relevance to the Proposed Project. Some associated activities were also identified during the review work, and they were compiled as No. 13 - No. 16 in the Attachment. The main criteria for review in consideration of methodology for identification and quantification of plastic waste leakage were:

(a) Application history of the tool/ initiative in Asia
(b) Coverage of plastic manufacturers and large plastic waste generators
(c) Consideration of local specific plastic waste management (PWM) conditions

A summary of the review results is shown in the following table.

Activity Reviewed	Relevance to the Proposed Project		
	Applicability to Asia	Plastic Manufacturing	Local Specific PWM Condition
1. Global Alert on Floating Trash, by Ocean Recovery Alliance Inc.	Medium	Low	High
2. Plastic Disclosure Project, by Ocean Recovery Alliance	Low	High	Medium
3 Prevent Marine Plastic Litter – Now, by ISWA	Medium	Low	High
4. Plastic Pollution Calculator, by Earth Day Network	Low	Low	Medium
5. Guidelines for the monitoring and assessment of plastic litter in the ocean, by GESAMP G40	Medium	Medium	Medium
6. The New Plastic Economy – Rethinking the Future of Plastic, by Ellen MacArthur Foundation	Low	High	Low
7. Review and Analysis of Existing Floating Marine Litter Prediction Models in the NOWPAP region	Medium	Medium	Medium
8. Marine Litter Management within a River Basin, by NOWPAP	High	High	High
9. The indicator focuses on shoreline debris in the context of SDG 14.1.1, by UNEP-WCMC	Low	Medium	Medium
10. The Marine Debris Tracker, by University of Georgia College of Engineering	Medium	Medium	High
11. Export of Plastic Debris by Rivers into the Sea, by Dr. Christian Schmidt, UFZ	High	Low	Medium
12. Assessment of the sources and inflow processes of microplastics in the river environments of Japan, by Dr. Tomoya Kataoka	High	Medium	Medium
13. Indonesia Marine Debris Hotspot, Rapid Assessment Synthesis Report, by World Bank	High	Medium	High
14. Stemming the Tide: Land-based strategies for a plastic-free ocean, by Ocean Conservancy and the McKinsey Center for Business and Environment	High	Low	High
15. River plastic emissions to the world's oceans, by Dr. Laurent C.M. Lebreton, et. al.	Medium	Low	Medium
16. A Methodology to Characterize Riverine Macroplastic Emission Into the Ocean, by Dr. Tim van Emmerik, et. al.	High	Low	Medium

2. Conclusions and Recommendations

2.1 Conclusions

(1) The activities reviewed are closely interlinked and the reference materials in the study reports are very similar. There is an overlapping of activities.

(2) Estimates, such as 8-10 million tons of plastic debris entering the oceans annually and 70 – 80% of the quantity is generated in land and transported by the rivers, are quoted by many of the activities.

(3) While source sectors can be identified, there is a considerable lack of data quantifying the scale of the issue which is an important challenge for future research.

(4) Many activities encourage community participation and promote citizens science programs. These activities help very much to raise the general awareness on the issue of plastic wastes.

(5) The plastic goods manufacturers and large-scale users are involved in several of the activities which is encouraging.

(6) Papers from Jambeck et al., 2015, Lebreton et al., 2017, Schmidt et al., 2017 and Emmerik et al., 2018 developed the statistical model to identify the plastic leakage from the land to the ocean.

(7) Only the model of Emmerik et al., 2018 is developed by applying for the local data based on the survey conducted by their own.

(8) Main limitations to develop plastic leakage scenario from the existing research are identifies as follows;

- No discussion on plastic leakage sources and pathway
- The Statistical Model is developed from limited data and information from existing studies and reports.
- Mismanaged Plastic Waste (MMPW) data is derived from the Jambeck, 2015 study.
- No detail information on hydrology, weather pattern, landuse including artificial barrier and local context of waste management practice is not considered.
- Not data and contexts of Mekong and Ganges regions are not included.
- The stepwise methodology is shown by Emmerik et al., 2018 according to the local data and context, but it is still difficult to identify the plastic leakage scenario by this methodology.

(9) During the desk review, it became clear that numerous activities related to plastic debris have been posted in the internet during the last 5-10 years

2.2 Recommendations

Some recommendations are put forward for consideration in the design and implementation of the Proposed Project.

(1) The Proposed Project needs to clearly find the methodology to identify the pathway and hotspots for both macro and micro plastics leakage according to the source sectors and entry points including **1) Sampling, 2) Assessing (Measuring and Quantifying), 3) Modeling (Scenario) and Planning of tailor-made activities, 4) Implementation and Monitoring, 5) Evaluation, and 6) Policy development**.

(2) Modeling are very useful, and lessons can be taken from recent modelling of ocean plastics movement and distribution, although at some stage they need to be validated and tested against observations. **Further model development would be required**.

(3) A variety of lessons leant and experiences in Japan especially for the methodology to identify the pathway and hotspots for both macro and micro plastics leakage are accumulated. A methodology harmonized with existing worldwide studies and guidelines **as well as the Japanese experiences and technologies** is expected to develop in line with the regional context of the Proposed Project.

(4) Planning and implementing solutions should be based on scientific evidence, and the results should be monitored and evaluated based on the hypothesis for further improvement. The Proposed Project is expected to deliver the **relevant hypothesis of leakage scenario** for implementation of activities on the ground.

(5) There is a need to improve waste management services as mismanaged services are reported as being the largest source of plastic waste leakage. There should be more emphasis on the separate collection, recycling and treatment of plastic waste stream within the overall solid waste management **including an informal form of waste management** contributing to remove a significant volume of mismanaged plastic from the ground before it enters the ocean.

(6) UNEP has been directly and indirectly involved in scores of activities related to plastic waste and has many information and reports. The TOR for the Proposed Project should benefit from this treasure of information in order to avoid repetition, build on the previous studies and wisely utilize the available resources.

(7) Plastic manufacturers and businesses using large quantities of plastics need to include detailed solid waste management plans in their registration documents.

(8) It is important to reorganize the recycling industries in developing countries from an **informal sector into a formal sector working under recognized standards.**

ATTACHMENT: Activity, Report or Study

1) Global Alert on Floating Trash, by Ocean Recovery Alliance Inc.

(1) Description of the methodology associated

Ocean Recovery Alliance Inc. has developed an online tool in 2014 that allows users to report on "trash hot-spots". (https://www.oceanrecov.org/global-ocean-alert-system/solution.html). The objective of the tool is to address the problem of increasing plastic pollution flowing to waterways and ocean by allowing users to report, rate and map trash hot-spots in their waterways and coastlines via mobile devices and a web-based platform to strengthen awareness, associated activities and sharing information to reduce plastic waste flowing from rivers and streams, and into the ocean.

Users use mobile apps to enter information on the trash hotspots. The homepage advices users on how to enter the data. The entered data may then be observed on global alert maps. Users may then use this information to inform stakeholders of the hotspots, push for improvement of solid waste management, increase community awareness and implement clean-up activities. Two examples of utilizing the global ocean alert were provided in Bali, Indonesia and 6 hotspots in South Africa. Users of the global alert application in these two examples were able to increase awareness of the problems and implemented clean up campaigns as well as introduction of waste collection improvement.

(2) Relevance of the methodology

The mobile application of Global Alert on Floating Trash was developed in 2014 by Ocean Recovery Alliance and the current version is 1.0.5. This is very relevant to promote community awareness and improved services by SWM authorities. Ocean Recovery Alliance provides advise on the data collection in its FAQ section, however it is difficult to use the collected data for modelling means and quantities estimations.

Relevance to this project:

a) Applicability to Asia	b) Plastic Manufacturing and large waste generators	c) Local Specific PWM Condition
Medium	Low	High
They have a case study in Asian region. (Bali, Indonesia) and data can be collected from Asian countries as a pilot, but data collection is not standardized.	There are no data entry applicable for plastic manufacturers and large plastic waste generators.	The tool can make SWM organizations more accountable and increases awareness of community through identification of accumulation hotspots.

(3) Organization responsible and Contact information

Ocean Recovery Alliance Inc. is a Hong Kong and California-based non-profit organization active in the ocean environment field. Ocean Recovery Alliance Inc. is a member of both the United Nations Environment Program (UNEP)'s Global Partnership on Marine Litter, and the World Bank's Global Partnership for Oceans. (www.oceanrecov.org) Mr. Doug Woodring (doug@oceanrecov.org) is a founder of Ocean Recovery Alliance/Global Alert.

2) Plastic Disclosure Project, by Ocean Recovery Alliance

(1) Description of the methodology associated

Ocean Recovery Alliance has, together with other partners developed the Plastic Disclosure Project (PDP) in 2014. The objective of the tool is mainly for plastic manufacturers and large amount plastic users to improve their use of plastic materials and recycling activities to reduce overall plastic wastes in the environment. PDP targets the manufacturing and services industries, inviting them to answer an online survey on their manufacturing processes and waste management systems in place including recycling.
(https://www.oceanrecov.org/pdp/undertake-the-pdp.html)
Based on the survey information analysis, Ocean Recovery Alliance produces an annual report describing the activities of the industries that participated in the survey. The Alliance also advises industries that have participated on improvement measures based on their request. In this regard the Alliance produced the PDP Park Guidelines which advises natural park authorities on waste management. The Alliance has also supported UNEP, contributing to, and providing data from the PDP surveys. One example is the report "Valuing Plastic - The Business Case for Measuring, Managing, and Disclosing Plastic Use in the Consumer Goods Industry". (https://www.oceanrecov.org/assets/files/news/PDP%20Parks%202015.pdf, https://www.oceanrecov.org/pdp/valuing-plastic-report.html)

(2) Relevance of the methodology

PDP is a very important attempt to engage plastic manufacturers and users of large amounts of plastic goods in the problem of the plastic waste trash. The survey data is also an important base of information for research in this field. The data collection is more standardized and those industries cooperating in the survey are in a better position to provide scientific information. However, as the survey participation is voluntary the assumptions made to generalize the data may be risky.

a) Applicability to Asia	b) Plastic Manufacturing and large waste generators	c) Local Specific PWM Condition
Low	High	Medium
Currently no companies and stakeholders in Asian region are listed. Survey participants may be from Asian countries.	Provides a very important format to engage manufacturers and large waste generators. However, with voluntary participation, some significant manufactures and generators may opt not to participate.	Provides a platform for improved collaboration between service providers and manufacturers.

(3) Organization responsible and Contact information

Ocean Recovery Alliance is a Hong Kong and California-based non-profit organization active in the ocean environment field. Ocean Recovery Alliance is a member of both the United Nations Environment Program (UNEP)'s Global Partnership on Marine Litter, and the World Bank's Global Partnership for Oceans. (www.oceanrecov.org)

3) Prevent Marine Plastic Litter – Now!, by ISWA

(1) Description of the methodology associated

A search of the ISWA homepage was made and the reviewer identified the report titled "*PREVENT MARINE PLASTIC LITTER - NOW!*". The report was developed in 2017 by the ISWA Marine Litter Task Force in collaboration with partners mainly aiming for a waste management sector to contribute the prevention of plastic waste reaching to oceans.

(2) Relevance of the methodology

The report consists of four topics which are 1. Introduction, 2. Overview of our current understanding of marine litter issues in terms of its sources, pathways, transformations and fate, 3. Intervention points for tackling marine litter and 4. Proposed next steps especially from the waste management point of view. The report includes systematic review results including that over 74% of most of the release of used plastics from global rivers to the ocean takes place between May to October from Asia during the East Asia Monsoon, and highlights the importance of policy and monitoring indicators including the quantities of plastic leaking, pathways and sinks. The report also highlights four specific tasks including identification of hot spots for intervention and enhancement of information and platform which the Proposed Project could collaborate with.

a) Applicability to Asia	b) Plastic Manufacturing and large waste generators	c) Local Specific PWM Condition
Medium	Low	High
Macro information about the Asian region is included.	There is no detail description for the manufacturing side except for the design of plastic products for recyclability and value retention.	The plastic source, pathway and interventions are clearly explained with its data and priority.

(3) Organization responsible and Contact information

"ISWA – the International Solid Waste Association – is a global, independent and non-profit making association, working in the public interest and is the only worldwide association promoting sustainable, comprehensive and professional waste management." (https://www.iswa.org/iswa/organisation/). ISWA also highlights the marine plastic and established a taskforce namely "The ISWA Marine Litter Task Force" led by Dr. Costas Velis, The University of Leeds (E-mail: c.velis@leeds.ac.uk., Tel: +44 (0)113 34 34196). The aim of the taskforce is to explore and clearly establish the link between sound waste management treatment and the prevention of plastic waste reaching oceans. In September 2017, the taskforce team developed the report titled "Prevent Marine Litter -Now!" in which it identified four priority areas for immediate action such as *1) Prevent uncontrolled dumping by providing waste collection services for all, 2) Stop littering and fly-tipping, 3) Close dumpsites and provide appropriate waste treatment and disposal facilities for all, and 4) Work with the maritime sector to establish effective systems for recovering waste and recyclable materials from the fishing, shipping and tourism sectors*.

4) Plastic Pollution Calculator, by Earth Day Network

During the search for Plastic Pollution Calculator by ISWA, the reviewer came across a calculator developed by Earth Day Network (EDN). This is discussed here.

(1) Description of the methodology associated

EDN launched the Plastic Pollution Calculator in April 2018. (https://www.earthday.org/2018/04/05/earth-day-network-launches-plastic-pollution-calculator-for-earth-day-2018-april-22nd/)

The on-line calculator allows "consumers to calculate the amount of disposable plastic they use in a year and make plans to reduce the waste." Consumers enter numbers of plastic items they use in the Plastic Pollution Calculator charts, together with frequencies of usage.

EDN also provides applications that can help consumers plan for reduction of their plastic wastes as well as follow the progress of the plans they have prepared. (https://www.earthday.org/wp-content/uploads/Earth-Day-Network-Plastic-Pollution-Primer-and-Action-Toolkit-updated-2.20.2018.pdf, https://www.earthday.org/wp-content/uploads/Plastic-Pollution-Calculator-Plan-and-Tracker.pdf)

(2) Relevance of the methodology

This methodology targets the general public and provides a very good opportunity to increase awareness. It does not appear to support data collection and analysis on a global basis.

a) Applicability to Asia	b) Plastic Manufacturing and large waste generators	c) Local Specific PWM Condition
Low	Low	Medium
There is no specific information for Asian region, but consumers of plastic goods may participate from any country	It seems that the extent of direct involvement of these industries in is limited.	The methodology raises community awareness on plastic waste and influences waste reduction.

(3) Organization responsible and Contact information

Earth Day Network (EDN) is an NPO that was formed around 2010 – 2011 by the organizers of Earth Day 2010. The first Earth Day was held in 1970. EDN invites members from all walks of life to join its activities and seeks donations online. (https://www.earthday.org/about/)

5) Guidelines for the monitoring and assessment of plastic litter in the ocean, by GESAMP Group 40

(1) Description of the methodology associated

The objective of the report is to guide the monitoring and assessment of plastic litter (both for macro and micro plastic) in the ocean in general through standardizing the terminology, sampling and surveys and interpretation of data in order to utilize the data collected by separate projects on a global level. GESAMP created a working group in 2012, WG40 led by IOC with additional in-kind or financial support from IMO, UN Environment Programme, the NOAA, Plastics Europe and the American Chemistry Council." The aim of WG40 is to study and report on "Sources, fate and effects of macro and microplastics in the marine environment - a global assessment".

WG40 produced two study reports, in 2016 and 2017, which include details of survey methodologies related to leakage identification and quantities estimation. These reports may be downloaded in PDF format from the GESAMP W40 HP.

The Study is ongoing, and for Phase 3 the "focus in 2017–2018 is to develop guidelines covering terminology and methodologies for the sampling and analysis of marine macro and microplastics, more specifically: the size and shape definitions of particles; sampling protocols for the whole spectrum of particle/object sizes in surface and sub-surface seawater, seabed sediments, shorelines and biota; and, methodologies for physical and chemical identification and analysis of polymers and associated chemicals requirements for monitoring and assessment. It is considered essential to collaborate with a wide range of Regional Seas and other regional organisations, to ensure the guidelines are relevant for those organisations with responsibility for undertaking monitoring and assessment for plastics and microplastics. It is intended to publish the guidelines before the end of 2018." (http://www.gesamp.org/work/groups/40)

(2) Relevance of the methodology

The WG40 study is attempting to standardize the terminology, sampling and surveys and interpretation of data in order to utilize the data collected by separate projects on a global level. An understanding of the contents of this study is very important for future projects in this sector. The table below was developed by the reviewer based on the Phase-2 study report as a framework for the Proposed Project to identify the clear target and approach of activities. In addition, as Output 2-3 in the Proposed Project mentioned that "Mapping of capacities in Southeast Asia to apply the GESAMP Working Group 40 Guidelines on Plastics and microplastics", it is recommended to fully utilize it as well as to input the outcome of the Proposed Project into the WG40.

Table. Plastic Leakage Inventory

Category	Source sector	Description	Entry points							
			River		Coastline		Atmosphere		Marine (directly)	
			Macro	Micro	Macro	Micro	Macro	Micro	Macro	Micro
Producers/ Converters	Plastic Producers, Fabricators & Recyclers	Pellets & fragments	x	x	x	x		x		
Sectoral consumers	Agriculture	Greenhouse-sheets, pots, pipes, nutrient prills	x	x	x	x		x		
	Fisheries	Fishing gear, packaging	x						x	
	Aquaculture	Buoys, lines, nets, PVC pipes	x	x	x	x			x	x
	Construction	EPS, packaging	x	x	x	x		x		
	Terrestrial Transportation	Pellets, tyres, tyre dust	x	x	x			x		

	Shipping/ Offshore industry	Paints, pipes, clothes, miscellaneous, plastic-blasting, cargo	x	x					x	x
	Tourism industry	Consumer goods, packaging, microbeads, textile fibres	x		x				x	
	Textile industry	Fibres			x					
	Sport	Synthetic turf			x					
Individual consumers	Food & drink single-use packaging	Containers, plastic bags, bottles, caps, cups, plates, straws, spoons, etc.	x		x					
	Cosmetics & personal care products	Microbeads, packaging, toothbrushes, etc.	x	x	x	x				x
	Textiles & clothing	Fibres	x	x	x	x		x	x	x
Waste management	Solid waste	Unmanaged or poorly managed waste disposal	x	x	x	x		x		
	Water & wastewater	Microbeads, fragments, fibres	x	x	x	x				
Identification methodology			1. Sampling -> 2. Assessing (Measuring and Quantifying) -> 3. Modeling (Scenario) and Planning of tailor-made activities -> 4. (Implementation and) Monitoring -> 5. Evaluation -> 6. Policy development							

a) Applicability to Asia	b) Plastic Manufacturing and large waste generators	c) Local Specific PWM Condition
Medium	Medium	Medium
Although there are some data as a case of Asian countries, this paper provides comprehensive information including reviews on plastic waste leakage.	Provides standards and technical approaches to collect and analyze data	There is less focus on coverage of PWM condition, but it provides the methodology to identify the condition.

(3) Organization responsible and Contact information

"The Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection (GESAMP) is an advisory body, established in 1969, that advises the United Nations (UN) system on the scientific aspects of

marine environmental protection." At present GESAMP is jointly sponsored by ten UN organizations with responsibilities relating to the marine environment, and they utilize GESAMP as a mechanism for coordination and collaboration among them. GESAMP functions are to conduct and support marine environmental assessments, to undertake in-depth studies, analyses, and reviews of specific topics, and to identify emerging issues regarding the state of the marine environment." (http://www.gesamp.org/about/history)

6) The New Plastic Economy – Rethinking the Future of Plastic, by Ellen MacArthur Foundation

(1) Description of the methodology associated

The original title of this activity in the UNEP list was "Guidance on mapping national recycling system for the plastics by the PiPro SEA project with the Ellen MacArthur Foundation". By using Google search, the reviewer could not find any reference to PriPro SEA Project in the foundation homepage, or in the internet as a whole. There are two reports identified from the reviewer, and the objectives are mainly focusing on the circular economy and not on methodology for identification and quantification of plastic waste leakage;

- In 2014, the foundation published the report titled "The New Plastic Economy – Rethinking the Future of Plastic". Inputs to this work were provided by "polymer manufacturers; packaging producers; global brands; representatives of major cities focused on after-use collection; collection, sorting and reprocessing/recycling companies; and a variety of experts and academics" (Report). The report discusses mitigation methods to reduce leakage as well as introduces recycling technologies and successful experiences. (https://www.newplasticseconomy.org/assets/doc/npec-vision.pdf)
- In 2016, in pursuant of the New Plastic Economy, the foundation issued the report "The New Plastic Economy – Catalysing Action". The report describes specific actions that are recommended to be implemented in an action plan, related to redesign of plastic packaging, promoting its reuse and recycling. The action plan is for a 3-year duration and was scheduled to start in 2017. In this context, the UK Plastic Pact, prepared by the foundation and the UK government was launched. This pact calls for definitive actions to be taken by stakeholders in the UK up to 2025 to reduce plastic waste, in line with the recommendations of the Catalyzing Action. (https://www.ellenmacarthurfoundation.org/publications/new-plastics-economy-catalysing-action, http://www.wrap.org.uk/content/the-uk-plastics-pact)

(2) Relevance of the methodology

These reports are mainly focusing on the circular economy not much on methodology for identification and quantification of plastic waste leakage. The three study reports issued by the Foundation provide a very important contribution to bringing together all sectors of the stakeholders to analyse the situation and commit to develop and implement improvement plans to reduce plastic waste leakage.

a) Applicability to Asia	b) Plastic Manufacturing and large waste generators	c) Local Specific PWM Condition
Low	High	Low
The participants and contributors to the studies where mostly from Europe and US. However, many of the companies involved have global activities. Successful application to Asian countries	The methodologies described in these studies were developed through the manufacturers inputs and had their backing for adoption.	There is less focus on coverage of PWM Condition and waste management services.

would require governments and organizations of those countries to promote similar activities.		

(3) Organization responsible and Contact information

"The Ellen MacArthur Foundation works with business, government and academia to build a framework for an economy that is restorative and regenerative by design." The foundation, launched in 2010 works with businesses, governments and philanthropic organizations to develop what it calls the circular economy. In 2016, the foundation applied the circular economy to plastics and in 2017 it followed with textile fibres.

They have been involved in several studies, research projects, educational programs and actual analysis and support to businesses to promote the "New Plastic Economy". In this regard they have produced reports, books and media information on the plastic waste problem. (https://www.ellenmacarthurfoundation.org/)

7) Review and Analysis of Existing Floating Marine Litter Prediction Models in the NOWPAP region, by NOWPAP MERRAC

(1) Description of the methodology associated

In 2018, NOWPAC MERRAC published the "Review and analysis of floating marine litter prediction models in the NOWPAP region" report. The objective of the report is to identify the modeling for floating marine litter in the NOWPAP region (Current member states are the People's Republic of China, Japan, the Republic of Korea and the Russian Federation). The study focuses on floating marine litter, including but not limited to plastic wastes and has developed a number of models to follow the movement of the litter as well as make estimations of the quantities of floating litter. Surveys covered beach areas, coastal waters, ocean water columns and ocean beds in several sites.
(https://wedocs.unep.org/bitstream/handle/20.500.11822/26237/review_analysis_floatML.pdf?sequence=1&isAllowed=y)

(2) Relevance of the methodology

The results of this study can serve as a monitoring aid for future waste litter and leakage reduction attempts, especially those results for beach areas and coastal waters. The interesting point of the study is the "Modeling" of floating marine litter such as being simulated in an Eulerian-Lagrangian combined framework with the Ocean circulation models include an Ocean General Circulation Model (OGCM), Regional Ocean Circulation Model, Coastal Ocean Circulation Model, Floating marine litter transport model, different kinds of buoyancy ratios, seasonal changes of numbers of beached litter, a numerical particle tracking model study, QuickSCAT/Seawinds data, and a sigma-coordinated Princeton Ocean Model (POM). In addition, the inverse method (Kako et al, 2010b) is introduced for the origins of plastic-bottle caps found at a Japanese island, and the General NOAA Operational Modeling Environment (GNOME model) is used to simulate the movement of the tsunami debris, based on the ocean surface currents (HYCOM) and winds.

a) Applicability to Asia	b) Plastic Manufacturing and large waste generators	c) Local Specific PWM Condition
High	Medium	Medium

While the survey covered countries in Asia, it focused on floating marine litter, as opposed to plastic leakage in land.	The study did not directly address the plastic manufacturing industry, although its results have bearing on the fishing industries.	The results of the study will not contribute much to the improvement of PWM condition, but may provide some indication of beach areas where litter is significant.

(3) Organization responsible and Contact information

"The Marine Environmental Emergency Preparedness and Response Regional Activity Centre (MERRAC) is one of four Regional Activity Centres (RACs) of the Northwest Pacific Action Plan (NOWPAP). It is responsible for regional co-operation in the field of marine pollution prevention and response in the Northwest Pacific region and is supported by the United Nations Environment Programme (UNEP) and the International Maritime Organization (IMO). The Centre was established on 22 March 2000 within Maritime & Ocean Engineering Research Institute (MOERI) / Korea Ocean Research and Development Institute (KORDI) in Daejeon, Republic of Korea, following the decision of the Fourth NOWPAP Intergovernmental Meeting (April 1999)." "The Action Plan for the Protection, Management and Development of the Marine and Coastal Environment of the Northwest Pacific Region (NOWPAP) was adopted in September 1994 as a part of the Regional Seas Programme of the United Nations Environment Programme (UNEP). Implementation of NOWPAP contributes to the Global Programme of Action for the Protection of the Marine Environment from Land-based Activities (GPA) in the Northwest Pacific region." The overall goal of the Northwest Pacific Action Plan is "the wise use, development and management of the marine and coastal environment so as to obtain the utmost long-term benefits for the human populations of the region, while securing the region's sustainability for future generations". NOWPAP covers the countries of Korea, China, Russia and Japan.
(http://merrac.nowpap.org/intro/connector/1/DB/introduction)

8) Marine Litter Management within a River Basin, by NOWPAP

(1) Description of the methodology associated

NOWPAP CEARAC (The Special Monitoring & Coastal Environmental Assessment Regional Activity Centre) developed a case study report in 2015. The objective of the study is to share a series of community and stakeholders' activities both upstream and downstream the river basin to tackle marine debris.

In accordance with the terms of NOWPAP, Toyama Prefecture of Japan developed the 'Toyama Prefectural Regional Plan for the Promotion of Measures against Marine Litter' in 2011. "The Prefecture set up the Oyabe River Basin Subcommittee (Hereafter 'Subcommittee') of the Association Promoting Measures against Marine Litter on the Coast of Toyama Prefecture. The purpose of the subcommittee is to develop cooperative framework for preventing the input of land-based litter and reducing marine litter in the area of the Oyabe River mouth. The subcommittee is currently promoting litter control measures in the upper, middle and lower reaches of the river by the five cities located in the Oyabe River Basin (Imizu City, Oyabe City, Takaoka City, Tonami City, and Nanto City) as well as by the Ministry of Land, Infrastructure, Transport and Tourism (which administers rivers in Japan) and by concerned groups. This report includes various initiatives undertaken in the Oyabe River Basin in terms of preventing the input of land-based litter."

A brochure of the activities conducted by Toyama prefecture, the citizens and other stakeholders is available from NOWPAP homepage. Unfortunately, a full report could not be located.

(https://wedocs.unep.org/bitstream/handle/20.500.11822/26857/ML_brochure.pdf?sequence=1&isAllowed=y)

(2) Relevance of the methodology

The Toyama Prefectural Regional Plan developed a series of community and stakeholders' activities to promote reduction of plastic waste leakage. Targets were also prepared for the stakeholders to measure the success of their work in the future.

a) Applicability to Asia	b) Plastic Manufacturing and large waste generators	c) Local Specific PWM Condition
High	High	High
This paper provides a case study in Japan. Similar approach will be applicable to Asia, especially for Output 1-3 and 1-4 of the Proposed Project.	Actual activities were implemented by all stakeholders including plastic manufacturers and generators with plans also drawn up.	Prefectural and municipal authorities in Toyama took active parts in the preparation of the Regional Plan and implementation of its activities.

(3) Organization responsible and Contact information

"The Marine Environmental Emergency Preparedness and Response Regional Activity Centre (MERRAC) is one of four Regional Activity Centres (RACs) of the Northwest Pacific Action Plan (NOWPAP). It is responsible for regional co-operation in the field of marine pollution prevention and response in the Northwest Pacific region and is supported by the United Nations Environment Programme (UNEP) and the International Maritime Organization (IMO). The Centre was established on 22 March 2000 within Maritime & Ocean Engineering Research Institute (MOERI) / Korea Ocean Research and Development Institute (KORDI) in Daejeon, Republic of Korea, following the decision of the Fourth NOWPAP Intergovernmental Meeting (April 1999)."

"The Action Plan for the Protection, Management and Development of the Marine and Coastal Environment of the Northwest Pacific Region (NOWPAP) was adopted in September 1994 as a part of the Regional Seas Programme of the United Nations Environment Programme (UNEP). Implementation of NOWPAP contributes to the Global Programme of Action for the Protection of the Marine Environment from Land-based Activities (GPA) in the Northwest Pacific region." The overall goal of the Northwest Pacific Action Plan is "the wise use, development and management of the marine and coastal environment so as to obtain the utmost long-term benefits for the human populations of the region, while securing the region's sustainability for future generations".

NOWPAP covers the countries of Korea, China, Russia and Japan.
(http://merrac.nowpap.org/intro/connector/1/DB/introduction)

9) The indicator focuses on shoreline debris in the context of SDG 14.1.1, by UNEP-WCMC

(1) Description of the methodology associated

In February 2018, UNEP-WCMC released the final draft of the report titled "Global Manual on Ocean Statistics – Towards a definition of indicator methodologies." The report provides three main streams such as 1) Coastal Eutrophication, 2) Floating Plastic Debris, and 3) Marine and Coastal Ecosystems. "2) Floating Plastic Debris" is mainly related to the Proposed Project. The objective of the methodology shown in the section is to introduce existing indicators and the available guidelines to monitor plastic debris washed/deposited on beaches or

shorelines (beach litter), plastic debris in the water column, plastic debris on the seafloor/seabed and plastic ingested by biota (e.g. sea birds).

"As methodologies for SDG Indicators 14.1.1 and 14.2.1 are currently being tested and developed ("tier 3" indicator), and so as to begin tracking progress against SDG Targets 14.1 and 14.2, the Global Manual presents step-by-step methodologies for "proxy" indicators, in line with Regional Seas Core Indicators: "Chlorophyll-a concentration" as proxy indicator for eutrophication (14.1.1); "beach litter" as proxy indicator for marine plastic litter (also 14.1.1)".
(https://environmentlive.unep.org/media/docs/statistics/egm/colombia_ocean_statistics_global_manual_ocean_statistics_final_draft.pdf)

In addition, there are four Appendices attached to the report, as follows:

Appendix 1	List of 22 Regional Seas Core Indicator	(https://wedocs.unep.org/bitstream/handle/20.500.11822/11122/wbrs18_pre_%20(5).pdf?sequence=1&isAllowed=y)
Appendix 2	Summary tables of existing indicators (Regional Seas Programmes)	(https://environmentlive.unep.org/media/docs/statistics/egm/colombia_global_manual_ocean_statistics_final_draft_appendix2_indicator_tables.pdf)
Appendix 3	Country case study reports (Colombia, Fiji)	(https://environmentlive.unep.org/media/docs/statistics/egm/colombia_global_manual_ocean_statistics_final_draft_appendix3_country_reports.pdf)
Appendix 4	Operational Guidelines for Comprehensive Beach Litter Assessment (UNEP/IOC)	(https://www.nrc.govt.nz/media/10448/unepioclittermonitoringguidelines.pdf)

Appendix 1 seems to be still under preparation, however the Regional Seas Group has held meetings to discuss potential indicators. One meeting held in 2016 described the following possible indicators related to plastic debris. (Meeting presentation slides can be downloaded following the link shown in the above table against Appendix 1. Only indicators with relevance to the Proposed Project are extracted from the original table in the presentation slides and shown here.

No.	Category of indicator	Possible regional Seas Coordinated Indicator	SDG 14 (plus SDG 1 SDG 2 others)	TWAP* indicators
3	Overall levels of marine litter Quantification of beach litter items	Quantification and classification of beach litter items	14.1	Marine Plastic Litter
10	Pollution hot spots	1) Concentration of Status of selected pollutant contamination in biota and sediments and temporal trends 2) Number of hotspots	14.1	Floating plastic debris
18	Incentive to reduce marine litter at source	1) % port waste reception facilities available 2) Incentives to reduce land based sources 3) Amount of recycled waste on land (%)	14.1	NA

(*Trans-boundary Waters Assessment Programme: TWAP)

It is not clear to the reviewer why indicators are not provided for no. 18. Indicators related to the solid waste management services may be considered here. Appendix 2 provides details of the available indicators and their survey and monitoring methodologies. Appendix 3 provides case studies for Colombia and Fiji. Appendix 4 shows the 2009 guidelines publication. Additional information on other available guidelines may be downloaded and researched as shown in the following table.

Table: Available guidance material for beach litter monitoring produced by Regional Seas Programmes and other intergovernmental, international, regional bodies or national bodies. (CCAMLR: Convention for the Conservation of Antarctic Marine Living Resources (Antarctic Sea); JRC: Joint Research Centre (European Commission); NOAA: National Oceanic and Atmospheric Administration; NOWPAP: Northwest Pacific Action Plan (Northwest Pacific); OSPAR: Oslo-Paris Convention (Northeast Atlantic); IOC-UNESCO: Intergovernmental Oceanographic Commission of the United Nations Educational, Scientific and Cultural Organization).

Regional Seas Programme/ Organisation	Monitoring protocols and guidelines	Available at:
CCAMLR (Antarctic Sea)	The Arctic Marine Strategic Plan 2015-2025 provides standard data forms and instructions for beach survey data collection (Arctic Council 2015)	https://oaarchive.arctic-council.org/handle/11374/413
European Commission Joint Research Centre (JRC)	Guidance on Monitoring of Marine Litter in Europeans Seas (European Commission JRC 2013)	https://ec.europa.eu/jrc/sites/ jrcsh/files/lb-na-26113-enn.pdf
NOAA	NOOA Marine Debris Shoreline Survey Field Guide (Opfer et al. 2012), and a monitoring toolbox with protocol documents and field data sheets	https://marinedebris.noaa.gov /sites/default/files/ShorelineFieldGuide2012.pdf
NOWPAP (Northwest Pacific)	Guidelines for Monitoring Marine Litter on the Beaches and Shorelines of the Northwest Pacific Region (NOWPAP CEARAC 2007)	http://www.cearac-project.org/RAP_MALI/monitoring%20guidelines.pdf
OSPAR (Northeast Atlantic)	Guidelines for monitoring marine litter on the beaches in the OSPAR Maritime Area (OSPAR 2010)	https://www.ospar.org/ospardata/10-02e_beachlitter%20guideline_ english%20only.pdf
UN Environment and IOC-UNESCO	UNEP/IOC Guidelines on Survey and Monitoring of Marine Litter (Cheshire et al. 2009)	http://staging.unep.org/gpa/ Documents/Publications/MarineLitterSurveyandMonitoringGuidelines.pdf
UN Environment	Marine plastic debris and microplastics – Global lessons and research to inspire action and guide policy change (UNEP 2016b)	https://wedocs.unep.org/rest/ bitstreams/11700/retrieve
Source: Global Manual on Ocean Statistics – Towards a definition of indicator methodologies (Main Report)		

(2) Relevance of the methodology

The report and its appendices provide information on available methodologies to survey and monitor plastic debris, towards achieving the related SDG target 14.1.1.

a) Applicability to Asia	b) Plastic Manufacturing and large waste generators	c) Local Specific PWM Condition
Low	Medium	Medium
The section of "Floating Plastic Debris" would be referred. Case studies in Colombia and Fiji, while not in Asia may also serve as good examples.	Provides a better understanding for activities the manufacturers may support to survey and monitor plastic debris.	Provides guidelines on surveys and monitoring while there is less information on the plastic source and pathway.

(3) Organization responsible and Contact information

WCMC is a Cambridge-based biodiversity charity that operates in collaboration with UN Environment as the UN Environment World Conservation Monitoring Centre (UNEP-WCMC). (https://www.unep-wcmc.org/)

"On 1 January 2016, the 17 Sustainable Development Goals (SDGs) of the 2030 Agenda for Sustainable Development — adopted by world leaders in September 2015 at an historic UN Summit — officially came into force. Over the next fifteen years, with these new Goals that universally apply to all, countries will mobilize efforts to end all forms of poverty, fight inequalities and tackle climate change, while ensuring that no one is left behind." (https://www.un.org/sustainabledevelopment/development-agenda/)

The SDG closely related to the Proposed Project is SDG 14 Life below water. The relevant target of this SDG is; **14.1** By 2025, prevent and significantly reduce marine pollution of all kinds, in particular from land-based activities, including marine debris and nutrient pollution. The indicator measuring achievement of this goal is **14.1.1** Index of coastal eutrophication and floating plastic debris density. Other targets of 14.2 and 14.5 have some relationship to the Proposed Project.

10) The Marine Debris Tracker, by University of Georgia College of Engineering

(1) Description of the methodology associated

The objective of the tool is for individuals and communities to report littering points and hotspots by themselves and encourage them to participate in waste management. The Marine Debris Tracker App developed in 2014 (current version is 3.16) can be downloaded by anybody with access to a mobile telephone and the internet. Individuals may report on litter anywhere through uploading the location of the litter, type and photographs (optional). On the internet any individual may access the tracker home page and open a map to show the locations of litter reported during one-month period. The information is recorded in terms of items, and therefore difficult to quantify. However, this tool is very important to encourage community participation on monitoring of waste litter as well as to provide information for SWM service providers.
(http://www.marinedebris.engr.uga.edu/newmap/)

The Jambeck Research Group has made estimates for waste quantities for 192 countries. The often referred to estimate of 31 million tonnes of mismanaged plastic wastes per year is obtained from these estimates. The estimates are prepared based on populations living near coastal area, unit generation rates published in various documents, and economic levels of the countries. While the data may not reflect the amount of waste generated by industries and is based on assumptions rather than direct surveys, still this is a very important attempt to understand the present problem. And the estimates here are used in most of the literature related to marine plastic debris.
(http://jambeck.engr.uga.edu/wp-content/uploads/2015/01/JambeckSData.xlsx,
http://jambeck.engr.uga.edu/landplasticinput)

(2) Relevance of the methodology

While the methodologies used by the Marine Debris Tracker App and estimates of mismanaged plastic waste amount estimates are scientifically imperfect, they provide important tools that encourage community monitoring of plastic wastes and understanding of the problem.

a) Applicability to Asia	b) Plastic Manufacturing and large waste generators	c) Local Specific PWM Condition
Medium	Medium	High
There is little information in the Asian region at the moment, but the app may be used anywhere on earth, and estimations of plastic waste quantities for 192 countries are available.	Empowers community members to monitor and report on waste litter in their areas, thereby indirectly monitoring the manufacturers.	Empowers community members to monitor and report on waste litter in their areas, thereby indirectly monitoring the waste management services.

(3) Organization responsible and Contact information

"The Mobile App namely Marine Debris Tracker originated in 2010 from a joint partnership of the NOAA Marine Debris Program and the Southeast Atlantic Marine Debris Initiative (SEA-MDI), located within the College of Engineering at the University of Georgia. A primary goal of SEA-MDI was to use innovative technologies and unique expertise to add culturally relevant outreach tools and information to the NOAA Marine Debris Program."

Dr. Jenna Jambeck, Associate Professor of Environmental Engineering, College of Engineering, University of Georgia is named as the SEA-MDI Principle Investigator/Developer.
(http://www.marinedebris.engr.uga.edu/about-2/)

In addition to the Marine Debris Tracker, Dr. Jambeck has done some estimations of plastic litter quantities on a global level, through the Jambeck Research Group, at the University of Florida.
(http://jambeck.engr.uga.edu/)

11) Export of Plastic Debris by Rivers into the Sea, by Dr. Christian Schmidt

(1) Description of the methodology associated

The following three objectives of the study is highlighted; 1) consider a plastic leakage pathway from rivers, 2) identify major leakage sources (rivers) and 3) raise a limitation on estimation of plastic leakage including the model from currently available data and information. The study team reportedly used available data from 79 sampling sites along 57 rivers in order to quantify the amount of marine plastic debris originating from land-based sources and transported to the oceans by rivers. The team estimated that 10 rivers transport 88% to 95% of the total amount of plastic debris transported by rivers, ranging from 400 thousand to 4 million tons per year. Those 10 rivers are;

Rank	Name of River	Receiving Sea	Continent	Length
1	Yangtze River	East China Sea	Asia	6,300 km
2	Indus River	Arabian Sea	Asia	3,610 km
3	Yellow River	Yellow Sea	Asia	5,464 km
4	Hau He River	Yellow Sea	Asia	1,078 km
5	Nile River	Mediterranean Sea	Africa	6,853 km
6	Ganges River	Bay of Bengal	Asia	2,620 km
7	Pearl River	South China Sea	Asia	2,200 km
8	Amur River	Sea of Okhotsk	Asia	4,444 km
9	Niger River	Gulf of Guinea	Africa	4,200 km
10	Mekong River	South China Sea	Asia	4,350 km

(2) Relevance of the methodology

This study depends on data collected by other studies to develop the models in order to estimate the plastic debris transported by rivers to the seas and oceans. Considering the total length of the 10 rivers identified by the study as the main transporters of the plastic debris, and the rate of 1.4 sample points per river (79 sampling points for 57 rivers) then each sample point represents 2,900 kilometers of river length. While it is necessary to review the official report, this rough calculation has been made based on the press releases available on the

official homepage. Furthermore, as the sampling and testing is done by others, it is quite possible that the procedures and standards are not uniform.

The models generated by this study probably need to be tested and developed further through obtaining of additional data. At this point they may be used as indicative values.

a) Applicability to Asia	b) Plastic Manufacturing and large waste generators	c) Local Specific PWM Condition
High	Medium	Medium
While the names of the 57 rivers covered in the study are unavailable, 8 of the 10 identified major rivers transporting plastic debris are located in Asia. And the rivers in the Proposed Project, the Ganges and Mekong are covered in this Study.	In principle and based on input of more data the origins of the plastic debris may be elaborated further to identify polluting plastic manufacturers.	In principle and based on input of more data the origins of the plastic debris may be elaborated further to identify areas where waste management services need to be improved.

(3) Organization responsible and Contact information

Dr. Christian Schmidt is a member of the Department of Hydrogeology, Helmholtz Centre for Environmental Research in Leipzig, Germany. Dr. Schmidt and his colleagues have done some studies on the leakage of plastic waste into the rivers and have reported on the results of these studies in an article titled "Export of Plastic Debris by Rivers into the Sea" in Environmental Science & Technology, an online scientific journal in November 2017. The article is not open to the public, however there is an abstract defining the work. (https://pubs.acs.org/doi/full/10.1021/acs.est.7b02368#showFigures)

Furthermore, articles on the study findings appeared in the Daily Mail and Scientific American online journals. These, in addition to the abstract provided some understanding of the study results. (https://www.scientificamerican.com/article/stemming-the-plastic-tide-10-rivers-contribute-most-of-the-plastic-in-the-oceans/, https://www.dailymail.co.uk/sciencetech/article-4970214/95-plastic-oceans-comes-just-TEN-rivers.html)

12) Assessment of the sources and inflow processes of microplastics in the river environments of Japan, by Dr. Tomoya Kataoka et al.

(1) Description of the methodology associated

The objective of the study is to seek the correlation between microplastic and water quality related parameters in the river. The numerical and mass concentrations of microplastics collected at 36 sites on the surfaces of 29 Japanese rivers were mapped and compared with four basin characteristics (basin area, population, density, and urban and agricultural ratios) and six water quality parameters (pH, biochemical oxygen, demand (BOD), suspended solids (SS), dissolved oxygen (DO), total nitrogen (T-N), and total phosphorus (T-P)) in each river basin.

- Field Survey: Collection site selection and sampling methodology including equipment are described, and the supplementary video is also introduced.

- Evaluation of the microplastic concentrations in the laboratory: Details of analysis methodology including the analyzer equipment are described.
- Basin characteristics data: Many information sources to identify the basin characteristic data are introduced.
- Water quality data: Data types and collection and evaluation methodology are described.
- Statistical analysis: The following statistical analysis is done.
  - ✓ T-test between microplastic concentrations and basin characteristics/water quality parameters
  - ✓ Kruskal-Wallis test among averages of the microplastic concentrations/basin characteristics and all water quality classes respectively

(2) Relevance of the methodology

This study reported in the Environmental Pollution 244 (2019) 958e965, October 2018, focuses on the microplastics in the river which is specific among other studies in the list relatively focusing on plastic litters in the ocean. The detail information such as field survey, laboratory analysis and consideration of basin characteristics are included in the study with references accordingly. Although the data collection and correlation with water quality related parameters need to be discussed, the relevancy of the methodology with the Proposed Project seems to be "High", as main target of the Proposed Project also focuses on the plastic waste leakage in the river (Ganges River Basin and Mekong River Basin).

a) Applicability to Asia	b) Plastic Manufacturing and large waste generators	c) Local Specific PWM Condition
High	Middle	Medium
The methodology for identification and quantification of plastic waste leakage from Japanese rivers shown in this study are very practical and detail explained with video clip	There is less information on plastic leakage source from plastic manufacturer and generators, but "Point" and "Non-Point" sources are discussed in the study.	There is less information on plastic leakage source from waste management services, but discussion leaked from wastewater treatment facility is highlighted.

(3) Organization responsible and Contact information

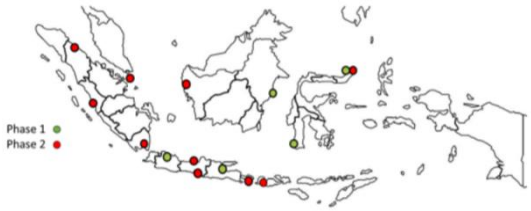
The activity was conducted by Dr. Tomoya Kataoka (tkata@rs.tus.ac.jp), Dr. Yasuo Nihei and Dr. Kouki Kudou from Department of Civil Engineering, Faculty of Science and Technology, Tokyo University of Science, Chiba, and Dr. Hirofumi Hinata from Department of Civil and Environmental Engineering, Faculty of Engineering, Ehime University, Ehime, supported by JSPS KAKENHI Grant Number 17H04937 and the River Fund of the River Foundation (Grant Number: 2017-5211-016), Japan.

13) Indonesia Marine Debris Hotspot, Rapid Assessment Synthesis Report, by the World Bank

(1) Description of the methodology associated

The objective of the study is to provide an informed and focused analysis of land-based leakage of solid waste, particularly plastics, to the marine environment.

The report shows the result of "Marine Debris Hotspot Rapid Assessment" for Indonesia conducted by the World Bank at the request of relevant Indonesia government agencies and research institutions, to provide an informed and focused analysis of land-based leakage of solid waste, particularly plastics, to the marine environment in April 2018. The assessment was a rapid study carried out in two phases, providing up-to-date information from 15 cities (map in the above) in Western and Central Indonesia (*Bali (1): Denpasar, Lombok (1): Mataram, Java (4): Jakarta, Semarang, Surabaya, Yogyakarta, Kalimantan (2): Balikpapan, Pontianak, Sulawesi (3): Bitung, Makassar, Manado, Sumatra (4): Bandar Lampung, Batam, Medan, Padang*). The methodology of the rapid assessment is as follows;



- Desk reviews of legislation and regulations
- Desktop analysis of waste generation information collected from each city to provide detailed estimates of volume and waste composition
- Desktop analysis of recent government data on waste management systems, processes and facilities
- Field analysis of waste disposal and capture scenarios, to identify leakage points and related issues
- Field sampling of waterway waste

The field assessments were carried out both in tidal (coastal area) and non-tidal (Upstream) zones of the target cities mainly to identify waste dumping areas and leakage hotspot with photos including the GPS function by using a motor bike, a canoe and a boat specifically in informal settlements, slum housing areas low-income areas and fishing villages. The survey includes waste composition study at the last physical barrier in the waterways such as flood gates, litter traps and tidal gates. Interviews with residents, traders, waste collectors and local government authorities are also carried out in line with National Statistics Agency's Environmental Behaviors Survey. The hotspots were identified in three land use types such as 1. beach and recreation areas, 2. human settlements and 3. light industrial zones and urban areas.

(2) Relevance of the methodology

The report has a strong linkage with Proposed Project, which covers assessment methodology including waste generation estimation, sampling, waste characterization, waste composition, hotspots mapping, land use at the leakage points in waterways and coastal areas, community profiles, and findings from community attitudes in hotspot locations. When Proposed Project is initiated, it would be recommended to analyze details of the activity especially for assessment method.

a) Applicability to Asia	b) Plastic Manufacturing and large waste generators	c) Local Specific PWM Condition
High	Medium	High
The report shows the marine debris hotspots rapid assessment targeting in 15 cities in Indonesia.	The survey area does not directly cover plastic manufacturer but highlights large waste generator and the potential sites such as beach and recreation areas, human settlements and light industrial zones and urban areas.	The study analyzes the status of waste management in 15 cities both quantitatively and qualitatively in line with local context such as waste management service in place, land use and income levels.

(3) Organization responsible and Contact information

The report of "Marine Debris Hotspot Rapid Assessment for Indonesia" conducted by the World Bank was supported by DANIDA and the Royal Embassy of Denmark in Jakarta financially and technically. The World Bank technical team was managed by Mr. Iain Shuker and led by Ms. Cary Anne Cadman.

(http://documents.worldbank.org/curated/en/983771527663689822/Indonesia-Marine-debris-hotspot-rapid-assessment-synthesis-report)

14) Stemming the Tide: Land-based strategies for a plastic-free ocean, by Ocean Conservancy and the McKinsey Center for Business and Environment

(1) Description of the methodology associated

The objective of the report is to show the scenario, which coordinated actions in five countries (China, Indonesia, the Philippines, Thailand, and Vietnam) could significantly reduce the global leakage of plastic waste into the ocean. The report describes an integrated set of measures (or levers) that together could reduce leakage in these five countries by 65 percent and reduce total global leakage by approximately 45 percent by 2025, and total costs of implementing these levers could be contained at an estimated $5 billion a year. The report was developed by Ocean Conservancy and McKinsey Center for Business and Environment in September 2015. The report highlights the challenges including potential leakage even within the waste-management system, vulnerable recycling system, and less incentives for informal sector with poor working condition. The report suggests recommendations to improve waste management according to the local/regional context in a longer-term perspective.

(2) Relevance of the methodology

The recommendations and solutions mentioned in the report are not specific, but in general. It is worthwhile to analyse in more details the methodology to identify that "75 percent and 25 percent comes from uncollected waste and from within the waste-management system itself respectively" for the Proposed Project. The report mentions the methodology as follows;

- Uncollected waste:
  On average, roughly a tenth of waste deposited in or near waterways is plastic. Making assumptions about waste-leakage rates based on geographic proximity to rivers and the coast at the level of provinces, the report estimates that in the priority countries, for every metric ton of uncollected waste near waterways, almost 18 kilograms of plastic enter the ocean equivalent to the weight of more than 1,500 PET bottles.
- Within a collection system:
  Making assumptions about waste-leakage rates based on the geographic proximity of disposal sites to waterways, as well as comparing the quantities of waste received at those disposal sites with the quantities estimated to have entered the collection system, the report estimated that in the priority countries, for every metric ton of plastic waste that is collected, as much as 7 kilograms of plastic waste are leaked to the ocean between collection and disposal.

a) Applicability to Asia	b) Plastic Manufacturing and large waste generators	c) Local Specific PWM Condition
High	Low	High
This report suggests scenario that coordinated action in five countries (China, Indonesia, the Philippines, Thailand, and Vietnam) could significantly reduce the global leakage of plastic waste into the ocean by 2025.	The report did not directly address the plastic manufacturing industry and waste generators.	The report provides several recommendations on waste management, but they are mostly common and general.

(3) Organization responsible and Contact information

The report is led by Ocean Conservancy and the McKinsey Center for Business and Environment. Advisers to this project include the Global Ocean Commission, The Prince of Wales's International Sustainability Unit, the Ellen MacArthur Foundation, government and multilateral funding agencies, and a range of technical advisers with waste-management expertise and experience in the plastics and recycling industries. In addition, this project is a signature initiative of the Trash Free Seas Alliance and was made possible by support from The Coca-Cola Company, the Dow Chemical Company, the American Chemistry Council, the Recycling and Economic Development Initiative of South Africa, and WWF.

15. River plastic emissions to the world's oceans, by Dr. Laurent C.M. Lebreton, et. al.

(1) Description of the methodology associated

The objective of the study is for understanding and quantification of marine plastic sources with taking spatial and temporal variability into account. The study shows a global model of plastic inputs from rivers into oceans based on waste management, population density and hydrological information. In result, the study estimates that between 1.15 and 2.41 million tonnes of plastic waste currently enters the ocean every year from rivers, with over 74% of emissions occurring between May and October, and the top 20 polluting rivers, mostly located in Asia, account for 67% of the global total which includes both Ganges and Mekong rivers. The following table shows the summary of the study methodology and result.

Methodology	Result
• MMPW (Jambeck et.al) generated in the catchment • Consideration of local topography, artificial barriers, depth of the river and seasonality • Model: Mout (Plastic mass release at the outflow, kg/d), Mmpw (Mass of MPW produced in the catchment downstream of artificial barriers), R (Monthly averaged catchment runoff) • Total mass of MMPW: Estimated from ESRI's ArcGIS • $M_{out} = (k*M_{MMPW}*R)^{a}$	• Global plastic debris inputs from rivers into the sea: 1.15 - 2.41 * 10^{6} t/y • 74% occurred between May and October • Top 20 polluting rivers: 67% • 86% in Total from Asian region • Mekong River: 18,800 - 37,600 t/y

(2) Relevance of the methodology

The statistical model is developed based on existing studies showing the result of river sampling mainly in European region. The only data in Asian region is from the survey conducted at Yangtze in China. In addition, the amount of mismanaged plastic waste (MMPW) is cited from Jambeck, 2015 which is calculated by inadequate waste management (A logistic regression model by limited variables such as waste disposal methods, economic classification and geographic region) and littering impact fixed for 2%. Illegal dumping, recycling or other informal waste collection (especially in low-income countries) as well as local hydrodynamic conditions and international import and export of waste are not considered. Then, detailed profiles of the plastic determined across the river width are not used.

a) Applicability to Asia	b) Plastic Manufacturing and large waste generators	c) Local Specific PWM Condition
Medium	Low	Medium
The study shows that the top 20 polluting rivers, mostly located in Asia, account for 67% of the global total.	There are no information and description to highlight the plastic manufacturing and large waste generators as a source.	Mismanaged plastic waste is considered to develop the statistical model, but data used in the study is not based on the local ones.

(3) Organization responsible and Contact information

This is the research paper published in June 2017 by Nature Communications. The citation of this article is "Lebreton, L. C. M. et al. River plastic emissions to the world's oceans. Nat. Commun. 8, 15611 doi: 10.1038/ncomms15611 (2017)". The all organizations involved in the study are; 1. The Ocean Cleanup Foundation, 2. Delft, 3. HKV Consultants, 4. Department of Chemical and Biomolecular Engineering, North Carolina State University. (email: laurent.lebreton@theoceancleanup.com)

16. A Methodology to Characterize Riverine Macroplastic Emission Into the Ocean, by Dr. Tim van Emmerik, et. al.

(1) Description of the methodology associated

The objective of the study is to show (1) to present a comprehensive methodology to characterize macroplastics in rivers, (2) to better understand spatiotemporal variation in plastic transport in rivers, and (3) to provide refined estimates of plastic emissions from rivers into the ocean.

The study shows a new methodology to characterize riverine macroplastic dynamics. The proposed methodology is applied to estimate the plastic emission from the Saigon River, Vietnam. During a 2-week period, hourly cross-sectional profiles of plastic transport were made across the river width. Simultaneously, sub-hourly samples were taken to determine the weight, size and composition of riverine macroplastics (>5 cm). Then, extrapolation of the observations based on available hydrological data yielded new estimates of daily, monthly and annual macroplastic emission into the ocean. The study suggests that plastic emissions from the Saigon River are up to four times higher than previously estimated. The following table shows the summary of the study methodology and result.

Methodology	Result
• Develop Plastic Flux Profile (Model) ✓ Mp (kg/s): Plastic Load (Plastic emission rate), ✓ Q (m3/s): Discharge, ✓ Cp (kg*plastic/m3): Plastic Concentration ➢ **Mp = Q*Cp = Q ∫ Cpi** (cross-sectional plastic profile) • Couple Plastic Flux to Hydrology (Same with Lebreton), and include information on rainfall events, wind and tidal influence • Extrapolate Observations (Visual counting, time-dependent hydrological data) • Plastic applications (goods type and resin type) with its size are identified by direct sampling by using static bridge-mounted trawls.	• The estimated plastic emissions from the Saigon River: 7.5 -13.7 * 10^3 t/y, up to 4 times higher than Lebreton (3.2 - 6.7 *10^3 t/y) • Due to shorter measurement period, inaccurate calibration/missing physical processes) • Plastic Emission: Strongly governed by tidal dynamics.

(2) Relevance of the methodology

The study proposed "Four Stepwise Methodology" to characterize macroplastic dynamics from rivers into the ocean which includes 1) plastic flux profile, 2) plastic statistic, 3) relation with hydrology, and 4) extrapolation. The following table shows the feature and limitation of the study.

Feature	Limitation
• Cross-sectional Plastic Flux Profile by direct visual plastic debris counting covering river width (12 points from the bridge). • Plastic Statistics by plastic sampling with static trawls (plastic goods type, plastic resin type and plastic size are identified.) • Consideration of Hydrology (1. Confirm correlation of Discharge & Plastic flux, 2. Develop Plastic Concentration Model ($Cp=N_0 * e^{-\beta\|Q\|} + C_0$), 3. Confirmation of Model fittingness) • Consideration of tidal impact affecting to the plastic flux	• Difficulty to identify sources and pathway: The survey site is limited only in the river mouth (based on the study objective). • Limitation of visual survey: There are concerns of accuracy, only visible counting on surface, and weather conditions (heavy rainfall, high wind speed, or sun glare, etc.). • No consideration of meteorological data: impact of wind speed and direction, rainfall, etc. • Limitation of Model fittingness: On average, the error between observed and modeled plastic flux was 58%, which is largely influenced by the days on which flow direction is not modeled correctly.

a) Applicability to Asia	b) Plastic Manufacturing and large waste generators	c) Local Specific PWM Condition
High	Low	Medium
The statistical model is developed by the local data collection and sampling at Saigon River basin in Vietnam.	There are no information and description related to the plastic manufacturing and large waste generators as a source.	The plastic waste statistic such as plastic waste amount and type is one of the main components in the study, but there are no

		consideration about waste management services in place.

(3) Organization responsible and Contact information

This is the research paper published in October 2018 by Frontier Marine Science. The citation of this article is "A Methodology to Characterize Riverine Macroplastic Emission Into the Ocean, Front. Mar. Sci. 5:372. doi: 10.3389/fmars.2018.00372, Van Emmerik T, Kieu-Le T-C, Loozen M, van Oeveren K, Strady E, Bui X-T, Egger M, Gasperi J, Lebreton L, Nguyen P-D, Schwarz A, Slat B and Tassin B". The related organizations are The Ocean Cleanup, CARE, Ho Chi Minh City University of Technology, University of Grenoble Alpes, Ho Chi Minh City University of Technology, Ho Chi Minh City, Vietnam, 6 Laboratoire Eau, Environnement, Systèmes Urbains (LEESU), The Modelling House Limited.

Additional Associated Studies and Reports

These additional reports are recommended for review while implementing the Proposed Project.

1. Plastic Debris in the Ocean - The Characterization of Marine Plastics and their Environmental Impacts, Situation Analysis Report (2014)	https://portals.iucn.org/library/sites/library/files/documents/2014-067.pdf	Information on sampling and analyzing microplastics in the marine environment
2. Marine plastic debris and microplastics: global lessons and research to inspire action and guide policy change	https://wedocs.unep.org/rest/bitstreams/11700/retrieve	A comprehensive general introduction to the problem of plastic debris and its impacts on the marine environment
3. Primary Microplastics in the Oceans: a global evaluation (2017)	https://portals.iucn.org/library/sites/library/files/documents/2017-002.pdf	Discussion on plastic waste pathways; Road runoff, Wastewater, Wind and Ocean Pathways
4. National marine plastic litter policies in EU Member States: an overview (2017)	https://portals.iucn.org/library/sites/library/files/documents/2017-052.pdf	Introduces EU policies on plastic production and use, plastic waste disposal and management of marine plastic waste.
5. The "Public Private Partnership for Sustainable Plastic and Waste Management" is a multi-sector collaboration to reduce plastic waste debris flowing into the ocean from Thailand by half by 2037. IUCN will be the technical partner for this project. (Ongoing)	http://marplasticcs.org/business/	"Developed by the TBCSD, Plastic Industry Club, The Federation of Thai Industries, and Thailand Environment Institute, this partnership encourages the adoption of a Circular Economy principle for waste management. The various stakeholders will provide support for technological innovations, consumer education programmes, the development of a national plastics database and

		the implementation of a clean city model in various Thai provinces."

6. National Guidance for Marine Plastic Hotspotting and Shaping Action, by the Life Cycle Initiative, Economy Division, UN Environment (not issues yet, only powerpoint is available)

(1) Description of the methodology associated

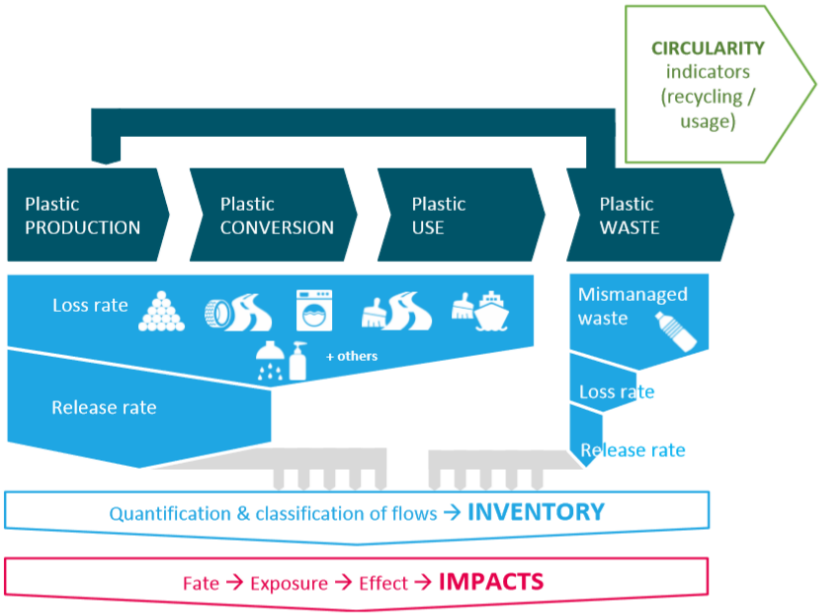
The objective of the report is to provide a guide on how to identify the plastic leakage and hotspots including scenario development (modeling). Under this initiative, in 2013 a report titled "An Analysis of Life Cycle Assessment in Packaging for Food & Beverage Applications", was produced addressing countermeasures to reduce food and beverages packaging.
(https://www.lifecycleinitiative.org/wp-content/uploads/2013/11/food_packaging_11.11.13_web.pdf)
The Life Cycle Initiative has in the last 4 years been working on developing standards to identify priorities, through hotspot analysis. In this respect they have issued two reports in 2014 and 2017 as follows:

- UNEP/SETAC Life Cycle Initiative – Flagship Project 3a (Phase 1) "Hotspots Analysis: mapping of existing methodologies, tools and guidance and initial recommendations for the development of global guidance" (2014)
  (https://www.lifecycleinitiative.org/wp-content/uploads/2014/12/UNEP-Hotspots-Mapping-Project-Final-Report-Phase-1.pdf)
- Hotspots Analysis - An overarching methodological framework and guidance for product and sector level application (2017) report discusses the tools used to identify the hotspots in general.
  (http://www.lifecycleinitiative.org/download/5863/)

These two reports are general in nature and provide some case studies. Now the LCI is finalizing the guidance report namely "National Guidance for Marine Plastic Hotspotting and Shaping Action" which is reportedly expected to be available (guidance, tool, data, case studies) in December 2020. This guidance will show a methodological framework and guidance for countries to "1. Identify key hotspots towards the most relevant plastic polymers, products, and pathways leaking into the marine environment, as well as associated impacts" and "2. Prioritize key areas of intervention relevant for the country, with key stakeholders along the plastics value chain". The reviewer could only identify the Power Point (PPT) document. From the PPT, the following key points and modelling concepts are identified, which must be useful for the Proposed Project. The one of the editorial members of this guidance is Mr. Feng Wang, Programme Officer, Life Cycle Initiative, Economy Division, UN Environment.

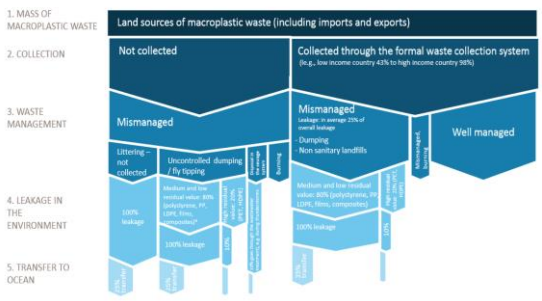
- Key data
  Quantities (Plastic polymer ending up as a waste, Plastic objects (per type) ending-up as a waste), Waste management (% Recycling/incineration/landfill/dumping /other, Estimation of the non-collected fraction (littering, other), Landfill management description/leakage rates, Price of plastic waste (per polymer/objects) on the formal and informal markets, etc.
- Expected benefits
  - Create new knowledge on the transport and distribution pathways as well as on the hotspots of marine litter
  - Identification of knowledge gaps
  - It is expected that the developed methodology could be applied on a broader range of countries in the future
- Key modelling steps for hotspotting

Key modelling steps for hotspotting

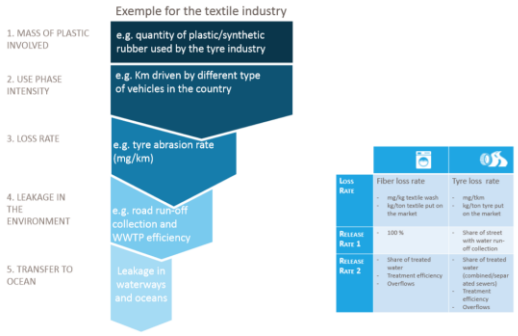


- Model Approach for mismanaged waste and microplastic

Model approach (focus on mismanaged waste)



Model approach (focus on microplastics)



Life Cycle Initiative has joined 250 global organizations to together support the New Plastics Economy that has been discussed in the previous section. This is a welcome move since it unifies the efforts by various organizations to achieve a common goal.