REPORT SNO. 7662-2021

Plastic pollution in Indonesia and the Philippines: current status and upcoming knowledge needs

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Norwegian Institute for Water Research

REPORT

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Title	Serial number	Date
Plastic pollution in Indonesia and the Philippines: current status and upcoming knowledge needs	7662-2021	18.10.2021
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	Geographical area Asia	Pages 40

Client(s)	Client's reference
Ministry of Foreign Affairs/Norwegian Embassy in Jakarta	N/A
	Printed NIVA
	Project number 180356

Summary

Research on plastic leakage and marine debris has developed significantly the last few years, but our knowledge on the scope of the problem, environmental and societal effects, and potential solutions is still limited. Accurate data on plastic waste generation, leakage to rivers and waterways, and total flux to the marine environment is lacking. The *ASEAN-Norwegian cooperation project on local capacity building for reducing plastic pollution in the ASEAN region* (ASEANO) provides research and knowledge to develop regional reduction measures and actions necessary for a global decrease of plastic waste pollution. Here, a summary of waste management, frameworks and environmental awareness in Indonesia and the Philippines is presented, in addition to an overview of relevant industries for plastic waste. Finally, we point to key future knowledge needs for effects on plastic pollution reduction to be seen globally.

Four keywords	Fire emneord
1. Plastic pollution	1. Plastforurensing
2. Waste management	2. Avfallshåndtering
3. Riverine plastic flux	3. Plastavrenning i elver
4. Environmental awareness	4. Bevisstgjøring omkring miljø

This report is quality assured in accordance with NIVA's quality system and approved by:

Hans Fredrik Veiteberg Braaten — Project Manager/Main Author

Sondre Meland — Research Manager

ISBN 978-82-577-7398-4
NIVA-report ISSN 1894-7948

Plastic pollution in Indonesia and the Philippines: current status and upcoming knowledge needs

ASEAN-Norwegian cooperation project on local capacity building for reducing plastic pollution in the ASEAN region

Preface

Countries in Southeast Asia are major contributors of plastic waste to the oceans. It is estimated that globally, five of the eight largest contributors of plastic waste to the oceans are member states of the Association of Southeast Asian Nations (ASEAN). Despite vast media attention, there are substantial knowledge gaps and capacity needs in managing plastic leakage. Targeted science-based knowledge is warranted for sound decision making to solve the problem. Norway has taken a leading role in the international battle against marine litter and microplastic, both in terms of providing funding and in sharing knowledge. Here, we present a summary of the plastic waste management, regulatory frameworks and environmental awareness for the two countries producing the most plastic waste in the ASEAN region, Indonesia and the Philippines.

The work is undertaken as part of the ASEANO project (*ASEAN-Norwegian cooperation project on local capacity building for reducing plastic pollution in the ASEAN region*), led by the Norwegian Institute for Water Research (NIVA). The project is financed by the *Norwegian Development Assistance Program Against Marine Litter and Microplastics*, where the main objective is to prevent and substantially reduce the scope of marine litter in developing countries. The ASEANO project works to strengthen knowledge, capacity, and awareness to tackle plastic pollution from key sources in the ASEAN region by developing a strong network and close interaction with industries and businesses, governmental bodies and other stakeholders, international development organizations as well as non-governmental organizations.

This report has taken a multidisciplinary, cross-sectoral and holistic approach to summarise why and what kind of research and knowledge is needed in order to develop regional reduction measures and actions necessary for a global decrease of plastic waste pollution. This report is a collaboration between NIVA, Center for Southeast Asian Studies (CSEAS, Indonesia) and Partnerships in Environmental Management for the Seas of East Asia (PEMSEA, the Philippines).

We thank all co-authors for their contributions to the report.

Oslo, 18.10.2021

Hans Fredrik Veiteberg Braaten

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Summary

Research on plastic leakage and marine debris has developed significantly the last few years, but our knowledge of the scope of the problem, environmental and societal effects, and potential solutions is still limited. Specifically, accurate data on plastic waste generation, leakage to rivers and waterways, and total flux to the marine environment is lacking. This data is needed to help strengthen policies and to evaluate their effectiveness.

Plastic pollution in Asia is a problem of enormous dimensions: published research has estimated that five East Asian countries account for more than 50 % of the total plastic waste in the oceans. Estimates vary, but Indonesia and the Philippines are generally listed among the top five contributors of marine plastic waste globally. Waste reduction and improved waste management is high on the agenda in the Southeast Asian region – in addition to the national agenda in Indonesia and the Philippines. However, lack of political will and low priority given to waste management, insufficient funding, knowledge and technology, in addition to social and cultural habits, slows down the process. Further, the problem is complex – actors and systems are often intertwined: from production, through consumers, to mismanaged waste. Measures as well as knowledge are required on a variety of stages in the plastic life cycle and in policy and public understanding (**Figure 1**). Billions worth of investments in waste management infrastructure, better alternatives to single-use packaging, stricter producer regulations, and increased consumer awareness are just a few examples.

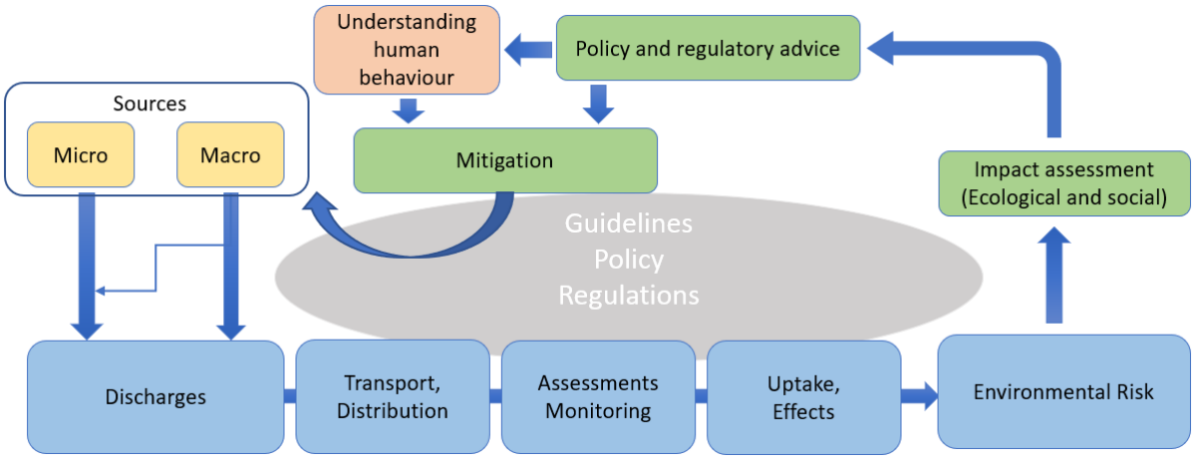


Figure 1 The complexity of the plastic pollution problem: a holistic view is needed for development of effective mitigation measures.

As part of the *ASEAN-Norwegian cooperation project on local capacity building for reducing plastic pollution in the ASEAN (Association of Southeast Asian Nations) region* (ASEANO) this report summarises and presents a concise overview of waste management, frameworks and regulations, environmental awareness and relevant sources for plastic waste in Indonesia and the Philippines. Key pollution sources, regional socio-economic challenges and local infrastructure are discussed for Bandung city in Indonesia, situated along the industrially important and severely polluted Citarum river, and for the urbanized and densely population Cavite province in the Philippines, focusing on the Imus river, an important tributary to Manila Bay. An assessment of present knowledge on a national scale clearly reveals the need for bringing more data together on all spatial scales to provide

a holistic picture of the global plastic problem and associated challenges (**Figure 1**). Suggestions for why and what kind of research and knowledge is needed in order to develop regional reduction measures and actions necessary for a global decrease of plastic waste pollution is discussed. A regional strengthening of collaboration in the East Asian region – through dissemination and knowledge sharing between countries – will contribute to meeting sound reduction targets both nationally and regionally.

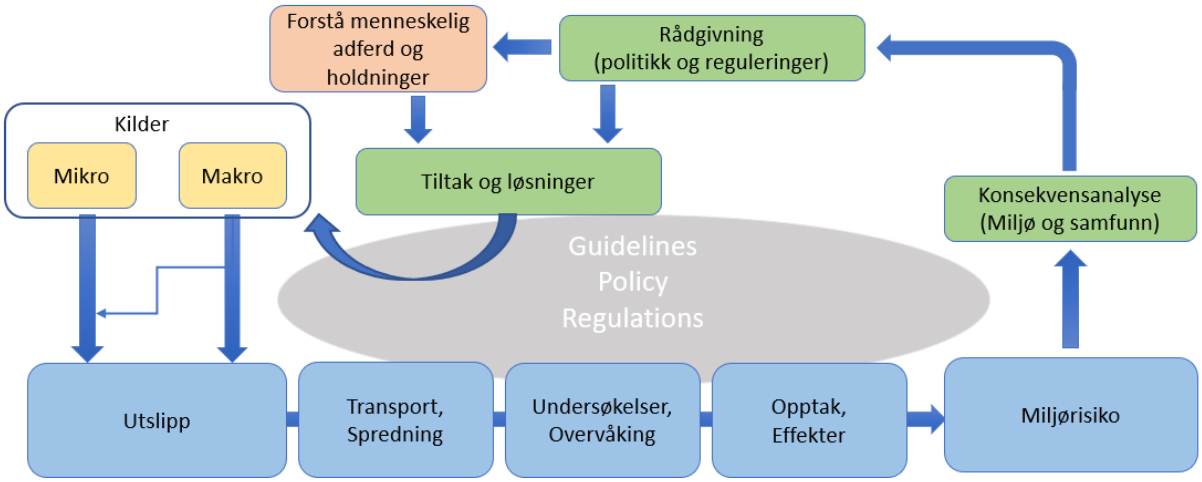
There are three main upcoming knowledge needs for effects of plastic pollution reduction to also be seen globally: 1) Monitoring of riverine plastic transports and harmonization of sampling methodologies in order to make the results from different studies more comparable; 2) Understanding socio-economic drivers for plastic pollution, as implementation of technical, economic, social or regulatory measures locally must be done without putting more pressure on exposed people such as waste pickers and handlers, and small-scale formal/informal recycling enterprises; and 3) A holistic approach and regionally coordinated response to tackle plastic waste is needed by integrating social and economic drivers with environmental impacts, technological solutions and management measures. To conclude, effective measures in Indonesia and the Philippines (and neighbouring countries) have a great potential for reducing plastic pollution both locally, nationally and regionally – and to contribute towards global plastic pollution reduction.

Sammendrag

Tittel: Plastforurensing i Indonesia og Filippinene: status og fremtidig kunnskapsbehov. *Samarbeidsprosjekt mellom ASEAN og Norge for lokal kapasitetsbygging for reduksjon av plastforurensing i ASEAN-regionen.*
År: 2021
Forfatter(e): Hans Fredrik Veiteberg Braaten, Marianne Karlsson, Anne Josephine Nordbø, Rachel Hurley, Caroline O'Neill, Arisman, Ratnawati Kusuma Jaya, Thomas E. M. Bell, Aimee Gonzalez, Kathinka Fürst, Marianne Olsen
Utgiver: Norsk institutt for vannforskning, ISBN 978-82-577-7398-4

Forskning på plastforurensing og marint søppel har hatt en formidabel utvikling de siste årene, men fortsatt er kunnskapen vår omkring problemets omfang, miljø- og samfunnseffekter, og mulige løsninger begrenset. Særlig mangler data på hvor mye og hvilken type plastsøppel som genereres, kunnskap om avrenning til elver og andre vassdrag, og mengden som transporteres til det marine miljøet. Slik data vil styrke implementeringen av politiske beslutninger for redusert plastforurensing og også muliggjøre evaluering av iverksatte tiltak.

Plastforurensing i Asia er en utfordring med enorme dimensjoner: forskning har estimert at fem land i Sørøst-Asia står ansvarlig for mer enn 50 % av plasten som finnes i havene. Selv om estimatene varierer mellom ulike studier blir Indonesia og Filippinene ofte rangert blant de fem største bidragsyterne til marin plastforsøpling globalt. Selv om avfallshåndtering og tiltak for reduksjon av søppel står høyt på agendaen i Sørøst-Asia – inkludert nasjonale agendaer i Indonesia og Filippinene – blir prosessene for å redusere plastforsøpling forsinket av manglende politisk vilje og lav prioritering av avfallshåndtering, i tillegg til mangel på økonomisk støtte, kunnskap og teknologi. Plastproblemet er også komplekst – aktører og systemer er ofte sammenflettede: fra produksjon via forbruker til manglende rutiner for søppelhåndtering. Tiltak og kunnskap er nødvendig på ulike nivåer og stadier i plastens livssyklus og som grunnlag for politiske beslutninger og folkeopplysning (**Figur 1**). Investeringer i milliardklassen er nødvendig for f.eks. avfallshåndtering, bedre alternativer til engangsemballasje, strengere produsentreguleringer og økt forbrukeransvar.



Figur 1 En illustrasjon av hvor kompleks plast er som miljøutfordring: en bred tilnærming er nødvendig for utvikling av effektive tiltak for reduksjon av problemet.

Som en del av *Samarbeidsprosjekt mellom ASEAN og Norge for lokal kapasitetsbygging for reduksjon av plastforurensing i ASEAN (Association of Southeast Asian Nations)-regionen* (ASEANO) presenteres her en sammenfattet oversikt over systemer for avfallshåndtering, politiske rammeverk og reguleringer, miljøbevissthet i befolkningen, og relevante kilder for plastforsøpling i Indonesia og Filippinene. Viktige forurensningskilder, regionale sosialøkonomiske utfordringer og lokal infrastruktur diskuteres for to viktige områder i Indonesia og Filippinene, henholdsvis Bandung med elven Citarum og Cavite med elven Imus. Citarum er en svært forurenset, men viktig industriell elv og Imus renner igjennom et tett befolket område og er en viktig sideelv til Manilabukten. En gjennomgang av nåværende kunnskap på nasjonalt nivå i Indonesia og Filippinene tydeliggjør nødvendigheten av å samle mer data på alle nivåer i plastsyklusen for å muliggjøre en bred tilnærming til plast som global miljøutfordring (**Figur 1**). Vi kommer her med konkrete forslag til hvorfor og hva slags forskning og kunnskap som er nødvendig for å utvikle regionale reduksjonstiltak som igjen kan lede til global reduksjon av plastforurensing. Et styrket samarbeid i Sørøst-Asia – gjennom for eksempel formidling og kunnskapsdeling i ASEAN – vil bidra til å implementere virkningsfulle tiltak både nasjonalt og regionalt.

Det er tre kunnskapsbehov som blir viktig for at en effektiv reduksjon av plastforurensing skal bli synlig også globalt: 1) Overvåking av plasttransport i elver og en harmonisering av prøvetakingsmetoder for å kunne sammenligne resultater fra ulike studier; 2) Forstå sosialøkonomiske faktorer som påvirker plastforurensing slik at tekniske, økonomiske, sosiale eller regulatoriske tiltak lokalt implementeres uten å øke presset på sårbare grupper (eks. søppelplukkere og -forhandlere, og småskala/uformell resirkuleringssektor); og 3) En bred tilnærming og en regionalt koordinert plan for å hanskes med plastforurensing er nødvendig og må integrere sosiale og økonomiske faktorer, miljøkonsekvenser, teknologiske løsninger og reguleringer. Konklusjonen er at effektive tiltak i Indonesia og Filippinene (og naboland) vil ha stort potensial for signifikant reduksjon av plastforurensing lokalt, nasjonalt og regionalt – og vil i tillegg bidra til global reduksjon av plastforurensing.

1 Introduction

1.1 Association of Southeast Asian Nations (ASEAN)

The Association of Southeast Asian Nations (ASEAN) is an intergovernmental organisation comprising the 10 member states Brunei, Cambodia, Indonesia, Laos, Malaysia, Myanmar, Thailand, the Philippines, Singapore, and Vietnam (**Figure 2**). ASEAN was established in 1967 in order to facilitate, among other things, economic, political, educational and sociocultural integration among its members.

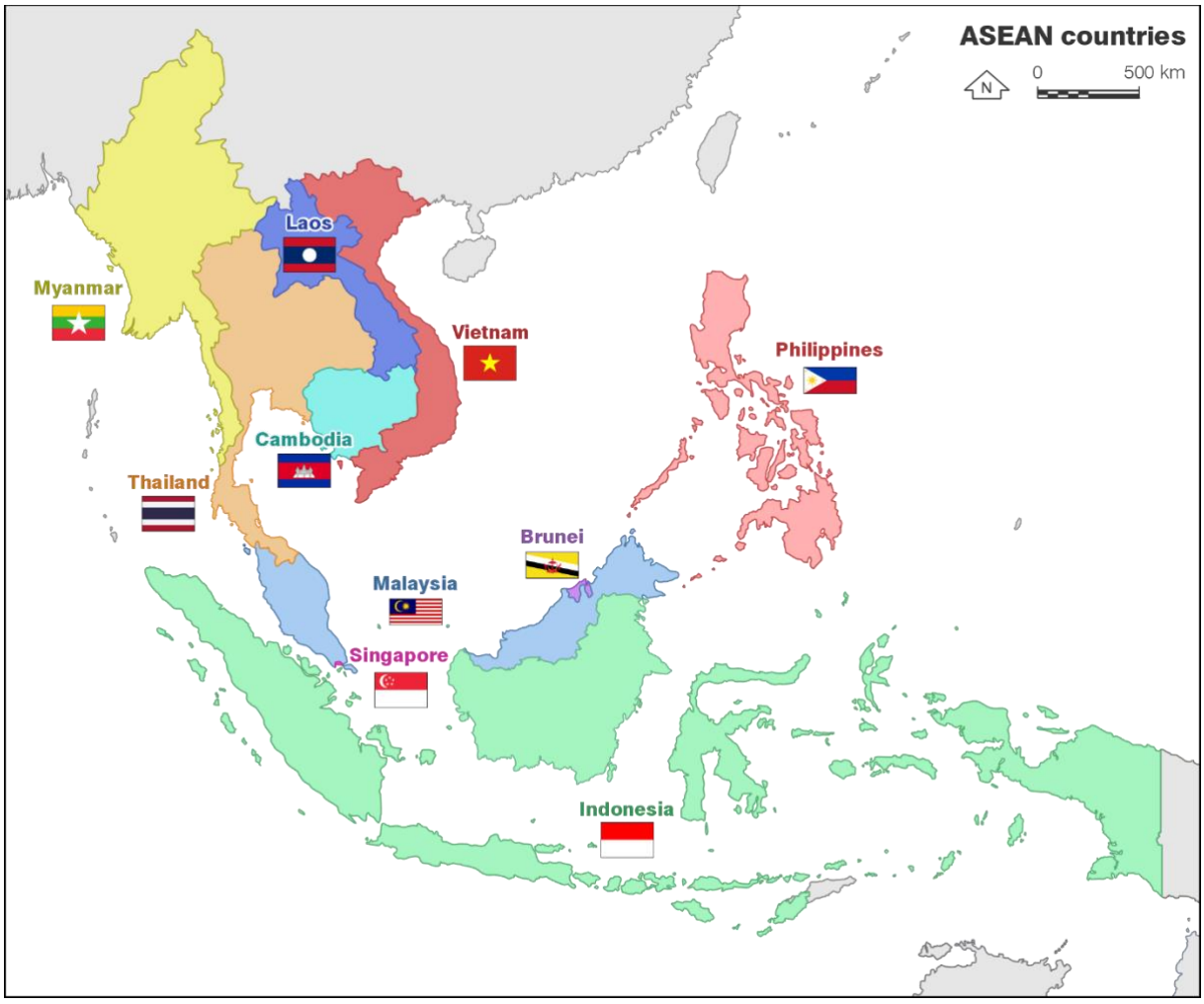


Figure 2 The location of the 10 countries forming The Association of Southeast Asian Nations (ASEAN), including Brunei, Cambodia, Indonesia, Laos, Malaysia, Myanmar, Thailand, the Philippines, Singapore, and Vietnam.

Facing enormous challenges relating to plastic pollution, ASEAN has made several efforts towards better managing the problem. The Bangkok declaration on combating marine plastic debris[1] was

[1] https://asean2019.go.th/en/news/bangkok-declaration-on-combating-marine-debris-in-asean-region/

adopted by ASEAN in 2019, following up on the ASEAN Community Vision 2025[2] ("*promote cooperation for the protection, restoration and sustainable use of coastal and marine environment, respond and deal with the risk of pollution and threats to marine ecosystem and coastal environment, in particular in respect of ecologically sensitive areas*"). Following this commitment, the body launched the ASEAN Regional Action Plan for Combating Marine Debris[3] in 2021. The Regional Action Plan proposes an integrated approach to address marine plastic pollution in ASEAN between 2021 and 2025 through 14 regional actions at three key stages of the value chain: 1) Reduce Inputs into the System, 2) Enhance Collection and Minimize Leakage, and, 3) Create Value for Waste Reuse.

1.2 Plastic pollution in the ASEAN region

The Philippines consists of more than 7 500 islands and has a coastline longer than 35 000 km. Approximately 60 % of the 109 million population lives along the coast. Indonesia, the world's largest island country, has a population of 270 million people of which an estimated 70 % live along the coastline. Both countries are largely dependent on the ocean. Unmanaged plastic waste, plastic leakage and plastic pollution that reaches the ocean is considered one of the most serious environmental problems today. Reports have suggested that roughly eight million tons of plastic waste enter the ocean every year (Jambeck et al., 2015); the numbers are, however, very uncertain due to lack of data (see chapter 2.1 for details). Although figures are uncertain, it is estimated that half of land-based plastic waste leakage originates from four countries alone: China, Indonesia, the Philippines, and Vietnam, of which the last three are members of ASEAN.

Many of the ASEAN countries have experienced rapid industrialisation during the previous decades, followed by economic growth and an improved quality of life. This has allowed people to consume more single-use plastic items than previously, bolstered by the increasing level of marketing and distribution of *Fast Moving Consumer Goods* (FMCG, products that are highly in-demand, sold quickly, and affordable). Companies have also ensured market shares by marketing single use portion sized products to the groups with lower socio-economic status that buy small size products on a daily basis. Poverty makes it difficult for families to shift from this consumption trend. The accessibility and multitude of variation of products available in sachets also means that may citizens prefer consumption of products purchased in sachets rather than in larger quantities. And as such sachets has become an integral part of the lifestyle of many of the citizens in the ASEAN countries, and not only a phenomenon in the lower socio-economic fragments of communities. In sum, material consumption has increased drastically, whilst the development of waste management infrastructure has lagged. As an example, research estimates that a 75 % reduction of land-based waste leakage in China, the Philippines, Vietnam and Indonesia alone would reduce waste flowing into the oceans by 45 % globally (McKinsey, 2015). The need for effective reduction measures is pressing.

Mismanaged waste is an important source of pollution, both as waste itself and through degradation into microplastics. It is therefore important to understand how different sources contribute to the plastic and microplastic problem, how it is generated, transported and transformed. In order to

[2] https://www.asean.org/wp-content/uploads/images/2015/November/aec-page/ASEAN-Community-Vision-2025.pdf
[3] https://asean.org/book/asean-regional-action-plan-for-combating-marine-debris-in-the-asean-member-states-2021-2025-2/

address the problems of mismanaged waste at the source, it is vital to assess people's knowledge, attitudes and practices pertaining to management of plastic waste and to better understand the socio-economic drivers and implications of plastic pollution. Only with this information at hand can policies and initiatives be developed to more effectively reduce the probability of waste being mismanaged at the source. Plastics and microplastics can be transported over long distances by rivers and currents, ending up in the marine environment. Although very much a global problem, efforts to reduce the plastic leakage from the countries that contributes the most, will also make the largest impact on reduction of marine litter and microplastics pollution.

1.3 The ASEANO project

1.3.1 ASEANO project background and tasks

The *ASEAN-Norwegian cooperation project on local capacity building for reducing plastic pollution in the ASEAN region* (ASEANO)[4] strengthens the knowledge, capacity, and awareness to tackle plastic pollution from key sources in the ASEAN region through a strong network and close interactions with industries and businesses, governmental bodies and other stakeholders, other projects as well as NGOs. The project documents the driving forces of plastic pollution and its implications for economy, development, environment and human well-being, with focus on local municipality/city level sustainability. Towards the end of the project, a set of sound and feasible measures to reduce plastic pollution will be developed.

Several ASEAN countries have recently put the fight against plastic pollution high on the political agenda and pilot measures are being developed and tested. However, currently most governments in the ASEAN countries have limited control on plastic contamination and pollution impact, and the region has limited waste-management infrastructure. The ASEANO project aims to strengthen the collaboration in the ASEAN region to reduce plastic pollution, disseminate and share knowledge between countries and contribute to meeting sound reduction targets both nationally and regionally. Effective measures in these countries have a great potential for reducing the plastic pollution input not only on a local and regional scale, but also globally.

Norway has taken a leading role in the international battle against marine litter and microplastic, both in terms of providing funding, and in providing knowledge (Lusher et al., 2021). The potential for Norway to contribute making a difference with respect to protection of human health and the environment in the ASEAN region is large. ASEANO will contribute to the overall impact of the Norwegian *Development Assistance Program Against Marine Litter and Microplastics*: to prevent and substantially reduce the scope of marine litter from sources in developing countries[5]. The project, with selected ASEAN river catchments and industries as focal areas, is targeted towards all the *Development Assistance Program's* outcomes, including improved waste management infrastructure and systems for waste management from land based sources; waste cleaned up from selected rivers and properly managed; the private sector's sustainable production, use, and responsible waste

[4] https://www.niva.no/en/projectweb/aseano

[5] https://www.regjeringen.no/contentassets/9ea1930ef21d4e8d96536ebef2e71147/marin_litter_202008.pdf

management; and a strengthening of national and regional instruments to prevent marine litter and microplastics.

1.3.2 Reduction measures and best practices for key industrial sectors

Plastic waste come from all parts of the society. Thus, in consultation with appropriate ASEAN sectoral bodies, ASEANO focus on selected key sectors that significantly contribute to plastic leakage regionally. The economic forecasts and development outlooks of the ASEAN implies that these sectors will be increasingly important in the future. This work focuses primarily on micro, small and medium size enterprises (MSMEs) given their importance in the ASEAN economy and their potential contribution toward reducing plastic pollution.

In Indonesia, the work is conducted in Bandung and Bekasi, and in the Philippines in Dasmariñas City, Cavite province. In Indonesia, a Focus Group Discussion (FDG) with the aim to understand best practices, current efforts and challenges faced by different actors with regards to sustainable plastic packaging in the food and beverage industry has been arranged. Discussions concerned the gap between the capacity of the recycling industry and the unmanaged plastic waste, the opportunities offered by circular economy, the challenges of waste management infrastructure in rural areas, the need to balance the safety and product quality provided by plastic packaging and the environmental impact of such packaging and to enhance collaboration to achieve the EPR goals set by the Indonesian government. In the Philippines, a province-wide assessment of SMEs in the Cavite was undertaken, including junkshops which buy high value recyclables to establish a baseline on the number, location, nature of business, volume of generated wastes, compliance to regulations, etc. in relation to the establishment of a centralized sanitary landfill and a sophisticated PET recycling facility.

1.3.3 River monitoring and flux calculations

Although several guidelines have been developed describing methods for analysing riverine macroplastic, including Gonzalez et al. (2016), Barnardo et al. (2020), Miliute-Plepiene et al. (2018) and Gonzalez-Fernandez and Hanke (2017), no single method has yet emerged as the standard approach for sampling plastic waste in rivers. This reflects the difficulty in establishing a global ‘one size fits all’ approach for river systems as there is significant variability in river morphology, hydrology, and geomorphology across the world. In the ASEANO project, several monitoring methods are tested out in two different river systems, Citarum river, Indonesia, and Imus river, the Philippines. Data will be used for thorough method validation and quality assurance and control (QA/QC) in order to harmonise methods, in addition to verification of plastic river transport models.

In Citarum river, several methods have been tested for monitoring since March 2021 (**Figure 3**), taking place at several locations along the river, spanning urban, rural and industrialised areas (upstream and downstream of Bandung, in addition to in Bandung, West Java). Visual observations are being combined with net sampling and drone mapping. The riverbanks and sediments are also being sampled. All samples are collected on a monthly basis. In Imus river, visual observations are being carried out alongside trawl netting, with two periods of sampling to capture the difference between the dry and wet seasons (**Figure 4**).

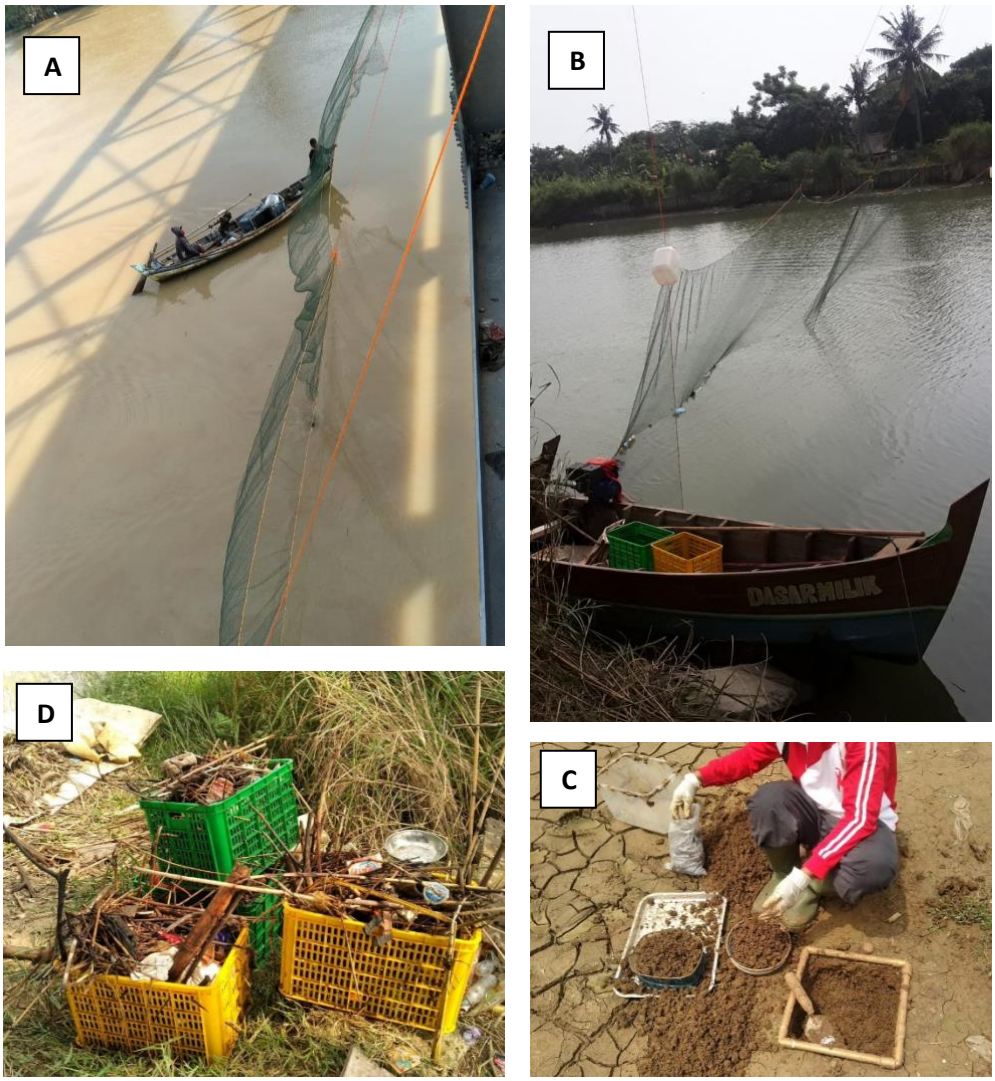


Figure 3 Environmental monitoring in Citarum river. Shown are collection of debris by net sampling (A and B); riverbank sediment collection (C); and data sorting and weighing of collected material (D). Photos: Semeidi Husrin.

Figure 4 Environmental monitoring in Imus river. Shown are preparation of net for river debris sampling (A); visual debris counting from bridge (B and C); and data sorting and weighing of collected material (D). Photos: De La Salle University, Dasmarinas.

1.3.4 ASEANO project outcomes

Mismanagement of plastic waste potentially leads to serious consequences for the marine environment as well as human wellbeing, an issue that can only be solved through cross-sectoral, international collaborations. For the countries in the ASEAN region, it would be highly beneficial to improve and streamline policies, standards and guidance documents both in important source sectors (e.g. plastic and packaging industry, waste recycling), and in the environmental management sector (monitoring, measures and policies). The ASEANO project will provide a knowledge base that will enable local authorities (municipalities/cities), industries and communities to choose better mitigation options to reduce the plastic pollution problem. Holistic and knowledge-based approaches are needed, and much can be learned from international best practises.

2 Rivers as conveyor belts for plastic

2.1 Global and regional plastic river discharge

Plastic is primarily produced and consumed on land. If the resultant waste is not properly collected and managed, it is likely to find its way into nearby rivers through surface runoff and other catchment processes, particularly during heavy rainfalls and flooding events. Rivers act as conveyors belts, where the sea is the ultimate destination. In a river, loads and concentrations of plastic are determined by catchment characteristics, i.e. land use, population density, and river flow (Baldwin et al., 2016). However, sources and transport pathways from land to waterways are not yet linked to the fate of plastic debris in rivers and the marine environment, though it is generally recognised that plastics and microplastics can be transported over long distances by rivers and currents, eventually ending up in the marine environment. Yet, it is important to recognise that rivers do not represent simple pipelines to the ocean, and plastic items and particles may follow a complex journey from initial input to the river to eventual release from the river mouth. Stranding and deposition can lead to storage of plastic which can persist over varying and, as yet, poorly constrained timescales. Riverbanks and shorelines may act as both sinks and sources of settled waste. Several mechanisms could temporarily return plastic debris to land, or could transfer plastic back upstream, for example in the case of tidal influence. Estuarine environments are also complex, and the residence time for plastics in the estuarine zone can be many years. Enhanced understanding of all these processes is required to create suitable measures for plastic pollution reduction.

Published data on global riverine discharge of plastic to the oceans are highly variable and contain large uncertainties (**Figure 5**), especially those based on modelling studies which utilise an array of different data sources to produce estimates. The large discrepancies between studies relate to differences in methods and models, and a lack of field data for testing the model assumptions. In existing studies, there is a dominance of plastic pollution studies in marine over freshwater systems, that of the existing freshwater studies, most come from western countries, and there is a large supremacy of microplastics over macroplastic studies (Blettler et al., 2018).

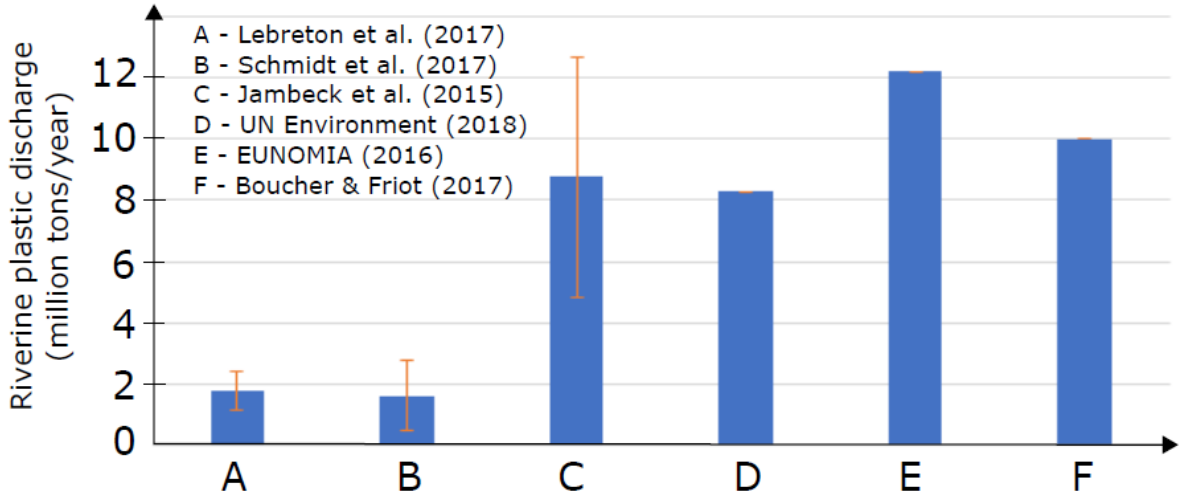


Figure 5 Global plastic river discharge estimates from available literature sources. Loads on the y-axis shown as million tons per year. The letters on the x-axis refer to the different studies indicated on the figure.

In Indonesia, it is estimated that 80 % of marine litter comes from land-based sources (AVP Network, 2019) and that 18.5 million Indonesians (approximately 7 % of the population) use waterways as their primary trash disposal method (UN and Secretariat, 2018). Consequently, there is much to be gained from improving land-based waste collection and management in the ASEAN countries. Mismanaged waste is an important source of plastic pollution, both as waste itself and through the potential degradation into microplastics. It is therefore important to understand how different sources contribute to the plastic and microplastic problem, how it is generated, transported and transformed.

River environments also represent important ecosystems that support several important ecological services. Better understanding the loads of plastic in the active channel, as well as zones where plastic may accumulate over different temporal scales, is an important task to help protect these environments. Mapping of plastic waste can also pinpoint important discharge points that need to be controlled and priority areas for remediation efforts, such as clean-up activities. Temporary stores of plastic in the river environment could act as legacy sources of plastic contamination to the river channel and ultimately the marine environment in the future, so it is important to address this as part of riverine plastic contamination, in addition to other inputs of plastic to the river system.

2.2 Monitoring of plastic waste in rivers

Efforts to reduce plastic leakage from the countries that contribute the most will make the largest impact on the reduction of marine litter and microplastic pollution globally. To be able to suggest and implement adequate reduction measures – including development of infrastructure and prioritisation of policies – and to assess the effects of mitigation measures, accurate estimates of plastic leakage and their sources is fundamental. However, available data on global plastic leakage is highly uncertain, emphasized by the large variation in reported numbers – current estimates ranging from less than 2 to more than 12 million tons per year (**Figure 5**). These model-based estimates are

to a low degree verified by actual monitoring data, and often assessment campaigns are uncoordinated and monitoring methods technically limited and not harmonized across various studies. Hence, improved and harmonized methods for monitoring of rivers are essential in order to move forward in handling plastic pollution.

3 Waste sources and relevant industries

3.1 Indonesia

Indonesia has a large coastal population of 187 million people[6]. The country generates more than 3 million tons of mismanaged plastic waste annually. More than 1 million tons of the plastics end up in the sea (Jambeck et al., 2015). An important – and sometimes less emphasized – aspect to include when discussing these estimated numbers is the actual sources and underlying causes themselves. Here, we introduce source identification in general for Indonesia, and then more detail on the specific sources in Bandung City, located near Citarum river.

3.1.1 Waste in Indonesian waterways

In 2016, the total municipal solid waste for Indonesia was estimated at 65 million tonnes, with a projection of reaching 88 million tonnes in 2030 and 119 million tonnes in 2050 (Kaza et al., 2018). Plastics make up approximately 10-15 % of mismanaged waste in the country (Jambeck et al., 2015; Shuker and Cadman, 2018). A World Bank study from 2018 found that approximately 30 % of the waste in Indonesian city waterways was comprised of plastics (**Figure 6**). Of the plastic waste, approximately 16 % was comprised of plastic bags, making it the most common kind of plastic waste (partially because waste is typically disposed of in plastic bags). Plastic bottles, by contrast, represented only 1 % of plastic waste in the samples, likely because they are of higher recycling value for waste pickers. The study also found that the waterway waste on average was comprised of 21 % disposable diapers. Disposable diapers contain plastic components but are usually not classified as plastics.

[6] Coastal population is here defined as people living within 50 km of the coast. The total population of Indonesia is close to 270 million according to recent UN estimates.

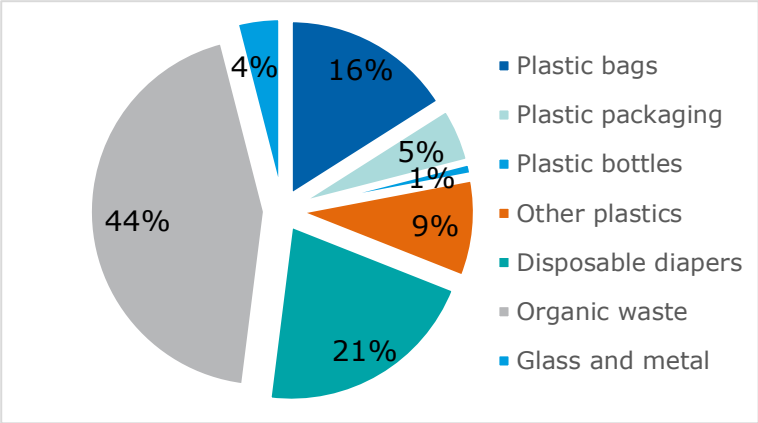


Figure 6 Waste composition in Indonesian city waterways, based on data from the World Bank (Shuker and Cadman, 2018).

80 % of plastic waste leakage comes from land-based sources in Indonesia (Shuker and Cadman, 2018). According to a study of 75,000 households across the country, 10–18 % of households dump their waste directly in waterways and 10–30 % dump their waste in other locations where it can leak into the marine environment. Approximately 18.5 million people use waterway disposal as their primary waste disposal method and many more use waterways as one waste disposal method among several others (Ocean and Conservancy, 2017). Consequently, there is much to be gained by improving land-based waste collection and management in the ASEAN countries.

3.1.2 Waste sources

Agriculture, fisheries, other industries, and markets are all key sources for plastic pollution in Indonesia, but the largest source of waste is households. A report by the World Bank estimates that 40 % of Indonesian waste is generated by households (Shuker and Cadman, 2018). In Jakarta, it is shown that the riverine debris consisted of between 37 % and 54 % plastic, and that the types of plastic indicated that most of it was related to household waste. The plastic debris consisted mostly of soft polyolefins and multilayer plastics which are hard to recover, while valuable plastic such as polyethylene terephthalate (PET) was far less common due to active removal by the informal waste sector (van Emmerik et al., 2019).

The food and beverage industry in Indonesia is comprised of more than 6,000 companies (Asian Development Bank 2016) and consumes almost 70 % of the total packaging in Indonesia. Portion-packaging, so-called sachets, is very common in Indonesia, which contributes greatly to the amount of plastic waste. The sachets, often disposable packages, are launched by large international companies to gain access to the Asian market and are marketed as an affordable alternative to poorer segments of society (Singh et al., 2009). Furthermore, the food and beverage industry often utilize multi-layered plastics, which are notoriously difficult to recycle. Given their important role in plastic management processes, the ASEANO project is working with the plastic packing and recycling industry in Indonesia.

3.2 The Philippines

Sixty percent of the Philippines' population of 109 million live along the coastline. Official reports suggest that the country generated more than 14 million tons of solid waste in 2016 (SEPO, 2017), where around 10 % (~1.4 million tons) was plastics (EMB, 2018) (**Figure 7**). Jambeck et al. (2015) estimate that the Philippines generates 1.88 million tons of mismanaged plastic waste every year, with between 280 000 and 750 000 tons ending up in the sea. An important – and sometimes under-emphasized – aspect to include when discussing these estimated numbers is the actual sources and causes of this mismanaged plastic waste Here, we introduce source identification in general for the Philippines, followed by more detail on the specific sources in the Cavite region, focusing on the Imus river (Chapter 4).

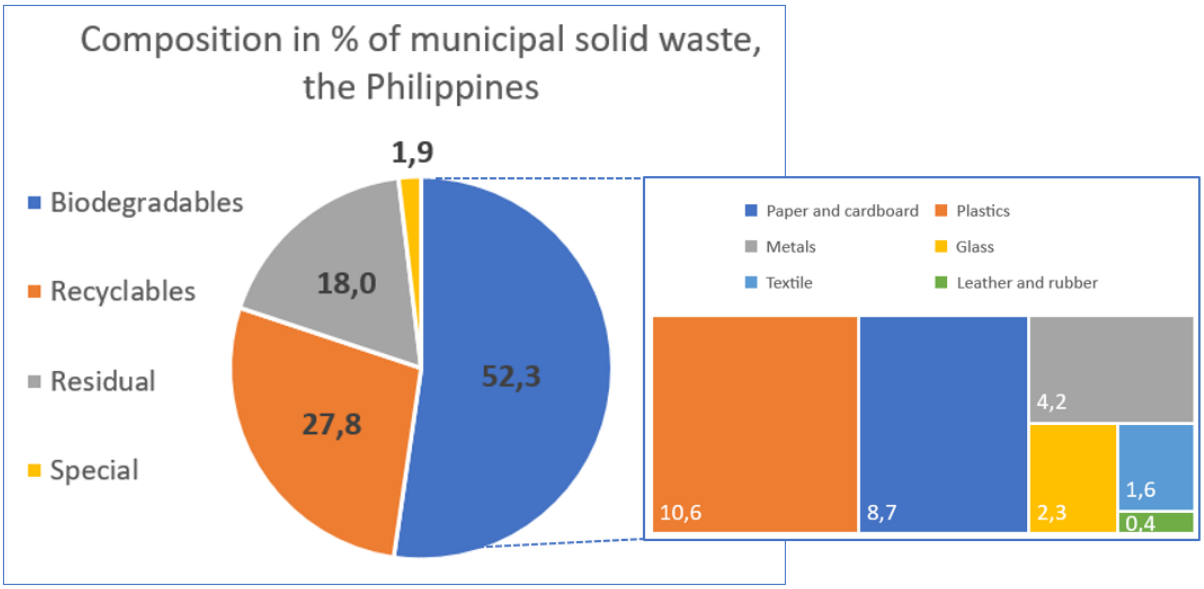


Figure 7 Municipal solid waste composition in the Philippines (edited from EMB Philippines, 2018). All numbers in % of total waste.

3.2.1 Sources and flows of plastic waste in the Philippines

Plastic waste leakage (i.e. the amount of plastic flowing into waterways) predominantly originates from rural areas with different waste densities, illegal dumping by private hauler companies, and poorly located dump sites (e.g. adjacent to waterways) (Ocean Conservancy and McKinsey Center for Business and Environment, 2015). Surprisingly, the majority (74 %) of plastic waste (approximately 386,000 tons) comes from collected waste. Possible explanations include that, based on estimates, over half of dump sites are located within approximately one kilometre of a waterway and 70-90 % of illegally dumped waste ends up in waterways (Ocean Conservancy and McKinsey Center for Business and Environment, 2015). Therefore, interventions to help deal with these issues could have a significant impact.

More recent estimates suggest that the plastic waste issue is increasing in the Philippines. In 2018, it was reported that plastics make up 25 % of municipal solid waste components (China-ASEAN Environmental Cooperation Center 2018). To what extent the percentage of plastic has actually

increased in the last decade is, however, rather unclear, due to the approximate nature of the estimation methods used.

Single-use plastics are an important part of the total plastic waste problem in the Philippines. Important types include sachets, shopping bags and labo bags. Sachets are small packets made of plastic and typically lined with aluminium, adhesives, and different types of plastic (such as polyvinyl chloride (PVC) or polystyrene) (GAIA 2019). They are used to sell small amounts of different products, for example shampoo, coffee or soy sauce. They are sold in large quantities throughout the Philippines, as manufacturers can sell more by targeting consumers who cannot afford to buy larger product volumes (Reuters 2019). According to a 2019 report by the Global Alliance for Incinerator Alternatives (GAIA) (in collaboration with government project partners and based on data from 21 waste assessments undertaken in six cities and seven municipalities), there is no data on sachet production volumes in the Philippines at this time (GAIA 2019). However, they reported that almost 164 million sachets are used daily (equivalent to almost 60 billion sachets yearly) (GAIA 2019). The use of sachets is related to the concept of *tingi* culture (Sy-Changco et al., 2011), which broadly means buying products at the smallest degree of retail. This emerged as a response to ensuing economic crises and later producers capitalised on this norm. Sy-Changco et al. (2011) explain the extensive use of sachets by three factors: accessibility, affordability and dosage controllability of goods. In 2004, CK Prahalad, an economist extolled the value of sachet packaging in his opus, *The Fortune at the Bottom of the Pyramid: Eradicating Poverty through Profits*. The book conveys the thesis that sachet packaging of household products such as coffee, shampoo, toothpaste, powdered juice, conditioner among others, enables the global poor to procure goods that well-off people consume, albeit in small amounts. Instead of the more expensive bottle of shampoo, can of milk, or any other goods in large containers typically found in rich countries, the use of sachet packaging makes sound economic sense as profit can still be made from the bottom of the pyramid (BoP) through quality goods made affordable via sachets (Prahalad, C. K. 2008). Locally*, tingi,* or *tingi-tingi* is pervasive in the Philippines retail industry. It fits the way of life of the common Filipino, especially the minimum wage workers (P303.00 - 400.00 in Cavite for 2021**)** on the premise that based on their earning, sachets of common household products enable them to maximize their limited budget, although they have to purchase goods daily. In addition to this, almost 48 million shopping bags are used daily in the Philippines (equivalent to approximately 17.5 billion yearly) (GAIA 2019). Labo bags are thin bags without handles, and 45.2 million of these are used daily (equivalent to 16.5 billion yearly) (GAIA 2019). In total, 94 billion of these plastic bag types are used annually in the Philippines.

4 Regulatory frameworks

4.1 International level

Indonesia and the Philippines are parties to several international conventions targeting the reduction of marine debris. The *Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter 1972* (London Convention), is one of the first global conventions to protect the marine environment from human activities and has been in force since 1975. Its objective is to promote the effective control of all sources of marine pollution and to take all practical steps to prevent pollution of the sea by dumping of wastes and other matter. The International Convention for the Prevention of Pollution from Ships (MARPOL, 1973) is the main international convention covering the prevention of pollution of the marine environment by ships from operational or accidental causes. The United Nations Convention on the Law of the Sea (UNCLOS, 1982) defines the rights and responsibilities of nations with respect to their use of the world's oceans. The Basel Convention (1989) aims to reduce the transfer of hazardous waste, and particularly the transfer from developed to less developed countries. An amendment of May 10, 2019 led to the inclusion of plastic waste in the framework. The amendment specifies what kind of plastic waste parties to the treaty can trade, making it illegal to export mixed or contaminated plastics without prior consent. The Coordinating Body on the Seas of East Asia (COBSEA) was established in 1977, with Cambodia, Indonesia, Malaysia, the People's Republic of China, the Philippines, the Republic of Korea, Singapore, Thailand and Vietnam as participating countries. COBSEA relies on existing treaties and member country goodwill and lacks a convention to enforce compliance.

Partnerships in Environmental Management for the Seas of East Asia (PEMSEA) is an intergovernmental organization whose mission is to foster healthy and resilient coasts and oceans through integrated management solutions and partnerships. PEMSEA serves as the regional cooperation mechanism to implement the Sustainable Development Strategy for the Seas of East Asia (SDS-SEA). Combatting marine plastic pollution is one of the key areas of work under the Pollution Reduction and Waste Management program of the SDS-SEA. PEMSEA's strategic actions on pollution reduction and waste management include: 1) ENHANCE accession to and/or compliance with relevant international conventions/agreement (UN SDG, Aichi Biodiversity Targets, IMO conventions, ASEAN Cooperation Plan for transboundary pollution Global Plan of Action for the Protection of Marine Environment from Land-Based Activities); 2) REDUCE marine pollution loadings in PEMSEA partner countries (marine debris, plastics/microplastics and nutrient pollution); and 3) DEMONSTRATE good practices and experiences in integrated river basin and coastal area management for improved source to sea governance, management and investments in the East Asian region.

4.2 National level

4.2.1 Indonesia

Indonesia has passed several laws and regulations targeting pollution, waste management and protection of the environment but as of yet no regulation exclusively targeting plastic pollution

(Ministry of Environment and Forestry 2020). Waste management regulations often outline some general principles to apply for all of Indonesia but emphasize local governments and their role in implementing and enforcing the laws locally (Akenji et al., 2020). Some of the regulations also seek to respect local knowledge and traditions regarding management of waste and the environment. The responsibility for managing municipal solid waste is largely decentralized. Local governments are responsible for the planning and implementation of waste management in accordance with national laws, but often lack both the funding and technical skills to do so (Lyons et al., 2020).

The decentralized nature of waste management in Indonesia has led to different cities and districts having widely different waste collection rates. The involvement of communities in waste management practices also varies greatly. Additionally, a decentralization reform has made the environmental programs more vulnerable to corruption, and they have also been criticized for high administrative costs and a lack of transparency (Dethier 2017).

Indonesian governments have also sought to address the plastic waste problem in other ways than through legislation. In 2016, 23 cities were included in a program that imposed a 200 rupiah (around 0.01 Euro, at the time of writing) price on plastic bags. Although the program generated a 55 % reduction in plastic waste during the trial period of three months, the project was discontinued due to stark opposition by retailers. A new government plan for a plastic tax is prepared, although the process is being delayed due to disagreements on the scope of the regulation (Suroyo 2019).

The Indonesian government launched the National Ocean Policy in 2017, which specifically targets marine plastic waste. The plan proposes to address marine plastic pollution through raising awareness, managing terrestrial and coastal waste, managing marine debris, and providing funding and institutional support. President Joko Widodo also promised to “devote $1 billion per year to reduce Indonesia’s plastic and other marine waste by 70 % in 2025” during the G20 Summit in 2017 (Garcia et al., 2019). There are a number of emerging policy initiatives targeting waste and plastic pollution in Indonesia at national and local levels, for example the 2020 local plastic bag ban in Jakarta.

Indonesia’s National Action Plan on Marine Debris for the period 2018-2025 (Ministry of Environment and Forestry, 2020) is structured around the five following components: (i) improving behavioural change; (ii) reducing land-based leakage; (iii) reducing sea-based leakage; (iv) reducing plastics production and use; and (v) enhancing funding mechanisms, policy reform and law enforcement (Government of the Republic of Indonesia, 2017). With the aim to creating the enabling environment for the implementation of these two major Presidential Decrees, the National Plastic Waste Reduction Strategic Actions for Indonesia were announced in January 2020 (Ministry of Environment and Forestry, 2020; Pandjaitan, 2020). Since these regulations and actions plans are rather recent, information about their effects on the ground is scarce at this point.

4.2.2 The Philippines

The Ecological Solid Waste Management Act (RA 9003) was signed into law in 2001 and aims to reduce solid waste at every stage of the process, i.e. from generation to collection, treatment, and final disposal in a comprehensive manner (JICA 2008). The law is based on the following hierarchy:

(1) source reduction, (2) reuse, recycling, and resource recovery at the *barangay* level, (3) efficient collection, transfer, and transport of waste at the city/municipality level, (4) efficient management at the final disposal stage (NSWMC 2015). Before the introduction of the law, most solid waste ended up at dump sites. RA 9003 stipulates that all dump sites should be closed, rehabilitated, and replaced with sanitary landfills (NSWMC 2015).

The National Solid Waste Management Commission (NSWMC), under the Environmental Management Bureau (DENR-EMB), is the main agency responsible for overseeing the implementation of RA 9003 (Philippine Statistics Authority 2014; Asian Development Bank 2009). In practice, however, local government units are responsible for leading the implementation of the law on the ground (Premakumara et al. 2014; Asian Development Bank 2009) and for developing ten-year solid waste management plans (Reyes and Furto 2013). In general, policy planning in the Philippines follows a top-down approach, whereas policy implementation follows a bottom-up direction (Premakumara et al. 2014).

RA 9003 is often considered to be a model legislation for other countries, as it clearly defines solutions to waste management problems (Vila 2018). It has also been suggested that the high collection rates in the Philippines may be a result of the fact that RA 9003 delegates many tasks to the base administrative division, the *barangay* (Ocean Conservancy and McKinsey Center for Business and Environment, 2015). Nevertheless, the implementation of RA 9003 tends to receive more criticism than praise. The most common criticisms are that the rules that are defined within RA 9003 are all too often not put into practice (Saplala-Yaptenco 2015; Vila 2018; JICA 2008; Paul et al. 2015; GAIA 2019) and that citizens are uninformed and/or unconcerned about what is required of them (Sapuay 2016; JICA 2008; Saplala-Yaptenco 2015). As local government levels hold the main responsibility for waste management, attempts to curb the use of single use plastics have mainly been attempted in cities and municipalities (Lyons et al. 2020). Around 300-local regulations aimed at single use plastics have been implemented across the Philippines with various success (Akenji et al. 2019). Local regulations have foremost targeted plastic bags rather than the design and use of sachets.

The coordination between different government levels in designing and implementing policy partly explains the challenges in reducing plastic waste. A perennial problem is that citizens dispose of their plastic bags in neighbouring cities that do not have plastic bag regulations, leading to increases in waste management costs. The situation has also led to confusion for many citizens who are not aware of the different regulations from one city to another. In addition, cities trying to implement waste recovery programs have struggled with finding a place to bring collected plastic bags due to a lack of infrastructure, leading in some instances to bags being brought to cement kilns. Also, an increase in the use of *labo* bags has been observed where they have not been included in bans (GAIA 2019). Thus, the recent nationwide regulations on plastic bags are an opportunity to potentially solve some of these problems. Recently, the Philippines passed a National Plan of Action on Marine Litter which will complement the Solid Waste Management Act (2001) which focused on end-of-pipe solutions, when concepts such as circular economy and sustainable consumption and production were non-existent. These recent policy developments point to the increasing attention the issue is receiving.

In 2020, WWF developed an EPR (Extended Producer Responsibility) scheme for the Philippines, including short- and medium-term actions (WWF, 2020). The scheme proposed to compel obligatory participation for companies that produce household packaging, service packaging and single-use plastic items, and includes both domestic producers and importers.

Whereas the Philippines have developed a regulatory framework aiming to reduce plastic waste, the implementation of such polices are hampered by, amongst others, lack of political willingness to enforce and prioritise waste separation as this is considered by many to bring new inconveniences (as most residents find it more convenient not to separate their waste). Concerns pertaining to re-election prospects might discourage local leaders from prioritising the strict enforcement of waste separation polices.

5 Examples of local waste management

Two case study areas are selected to document, evaluate and compare local waste management in Indonesia and the Philippines, Bandung City and Bekasi Regency, West Java Province, and Cavite province, Luzon, respectively.

5.1 Bandung City

Bandung is the third largest city in Indonesia, with approximately 2.5 million residents. In the Bandung Metropolitan Area, the population is estimated to be over 8.6 million[7] (OECD, 2016). The city is experiencing strong economic growth and is an important industrial area. In 2005, the Indonesian government estimated that 65 % of the country's textile industry was located in Bandung or surrounding areas (OECD, 2016). One of the main reasons for this is the city's location along the Citarum river (**Figure 8**).

Bandung is situated in a valley surrounded by mountains and experiences heavy rainfall in the wet season (December-March). Rapid urban development and land subsidence makes the city and its waterways vulnerable to flooding, a problem that is exacerbated by mismanaged household waste which often clogs drainage systems (OECD, 2016). Close to 50 rivers and creeks run through Bandung (van Ginkel and Özerol, 2015) and transport wastewater, household waste and leakage from landfills into the larger Citarum river south of the city.

The amount of solid waste in Bandung and surrounding areas has risen sharply in later years due to increasing population and economic growth. According to Statistics West Java, waste generation almost doubled in the Bandung Metropolitan Area between 2006 and 2014, from 30 to 57 m^3 of municipal solid waste daily. The coverage of waste management services rose from 36 % to 68 % in the same period (OECD, 2016). A 2018 study estimated the daily waste generation in Bandung to be 0.64 kg per person/day, adding up to a city total of 1,600 tons of municipal solid waste every day (Wang et al., 2018).

[7] These numbers are only a projection. The last population count was in 2010 and counted 2.39 million and 7.62 million for Bandung city and Bandung Metropolitan Area, respectively.

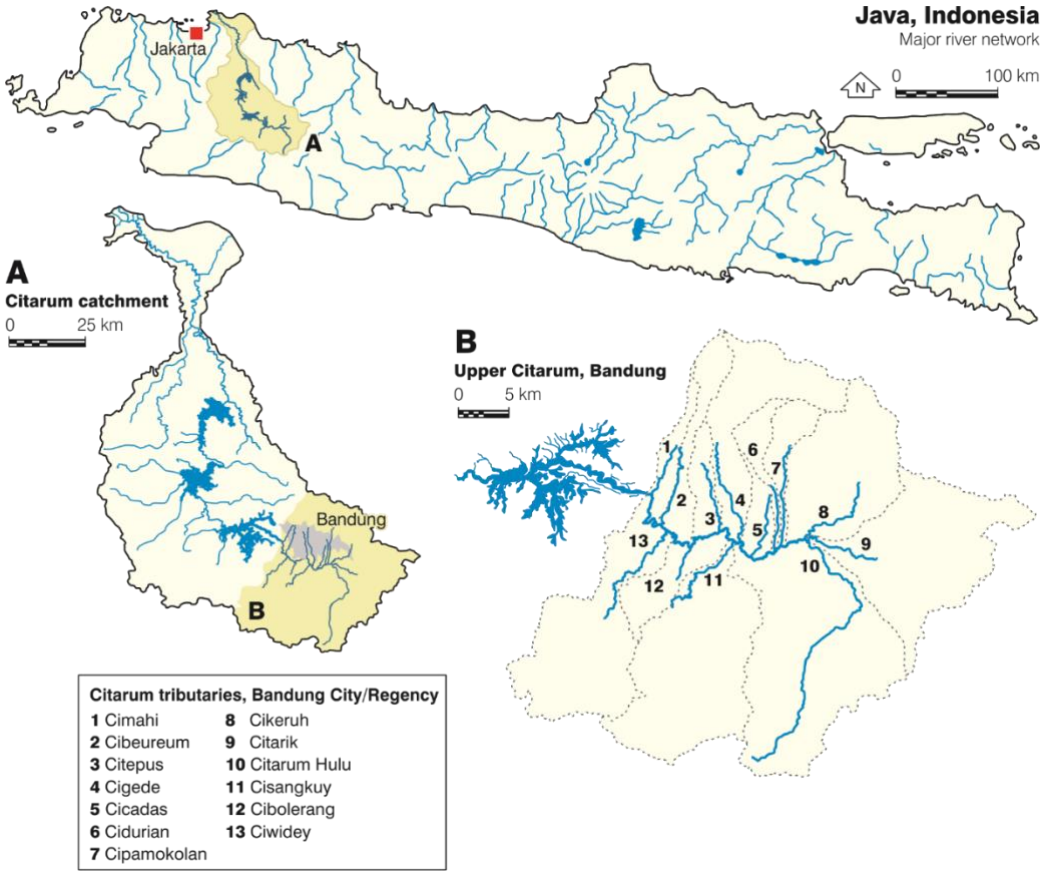


Figure 8 Map of Java, Indonesia (top) with the Citarum catchment (A) and Upper Citarum tributaries (B).

5.1.1 Waste generation in Bandung City, Java

The government-owned sanitation company Perusahaan Daerah Kebersihan (PDK) is responsible for the management of municipal solid waste in Bandung (Wang et al., 2018). According to PDK, 66 % of the waste is generated by households (**Figure 9**), amounting to approximately 1,050 tons every day. Traditional markets produce 300 tons of waste daily, making it the second biggest source of waste generation in Bandung (PDK, 2018). These data from the city reflect the most important national sources, but households seem to contribute even more in Bandung (66 %) compared to the national budget (approximately 40 %).

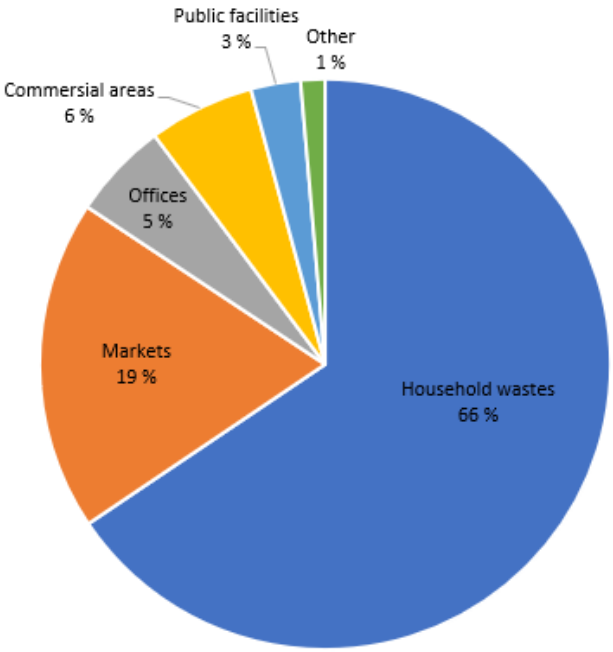


Figure 9 Waste generation by source in Bandung City, based on data from Perusahaan Daerah Kebersihan (PDK, 2018).

5.1.2 Bandung City waste collection infrastructure

The waste collection in Bandung starts with the households storing their (usually un-segregated) waste in the street or outside their house, where it is picked up by waste collectors, typically organized by the respective neighbourhoods. Waste collectors are considered as part of the informal sector. They use handcarts or small trucks to transport the waste to temporary waste disposal sites. Finally, PDK transports the waste from temporary sites to the final disposal site (Wang et al., 2018). Although it is difficult to find reliable data on waste collection, a 2018 study estimated that 84 % of Bandung's waste is collected at a temporary waste disposal site, but only 53 % reaches the landfill (Wang et al., 2018) (**Figure 10**). A 2016 study estimated that 30-40 % of municipal solid waste in the Bandung Metropolitan Area is disposed of in informal ways such as burning or throwing it in the river (Lubis, 2017). This indicate a gap between the waste produced and the City's capacity to collect and dispose of waste. In the rural neighbourhoods, there are no official forms of collection.

Despite multiple local voluntary initiatives to improve waste management, sorting and recycling, there is a general lack of awareness among inhabitants which, combined with absence of infrastructure and capacity, results in the present situation. Waste segregation at the source is uncommon, which makes it harder to recover recyclable material from the waste stream. Low-income households are found to be more willing to segregate their waste due to the extra income gained from selling it to the informal recycling sector (Wang et al., 2018). In Surabaya, Indonesia's largest city after Jakarta, it was found that lack of time and low interest were the most common reasons for not sorting municipal solid waste, while socio-economic factors were of less importance. At the same time, it was proven that availability of waste banks and a high level of knowledge about waste management significantly increased the probability of sorting waste (Dhokhikah and Y

Trihadiningrum, 2015). It is important to understand the motivations and constraints for inhabitants to effectively contribute to waste management and to change current consumption patterns. In combination with improved waste handling infrastructure, reaching out to the city population to increase local awareness appears to be an important action for increasing waste collection efficiency.

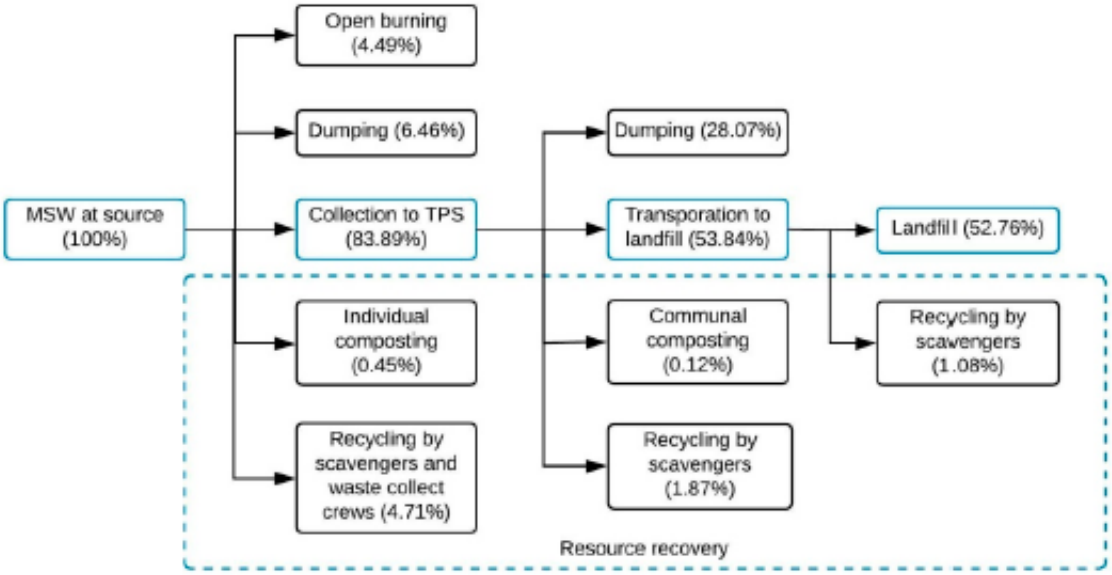


Figure 10 Municipal solid waste from source to final disposal (Wang et al., 2018).

Although only half of the municipal solid waste in Bandung reaches the landfill and the landfill is already close to reaching its maximum capacity. Bandung used to rely on the Leuwigajah landfill, which was originally regulated but evolved into an unregulated open dumpsite where large quantities of unsorted waste were dumped every day. In 2005, 143 people were killed by a waste avalanche from the Leuwigajah landfill. The combination of heavy rains and explosions due to the release of biogas from the dump is believed to have triggered the fatal waste slide (Lavigne et al., 2014). The accident led to the ban of open landfills under the Waste Management Law of 2008, but the ban is still far from being implemented. The Leuwigajah landfill was closed after the accident, and all of Bandung now relies on the Sarimukti landfill (Lubis, 2017).

5.2 Cavite province

The Province of Cavite borders Metro Manila, a large urban area that serves as the National Capital Region (NCR), to the north (**Figure 11**). As the urbanisation of the metropolitan area has expanded beyond the NCR, much of Cavite has become part of this wider urban conurbation, especially in the northern areas closest to the border. Cavite faces challenges posed by being part of this expanding and dense urban hub of the Philippines. According to 2018 data from the Metropolitan Manila Development Authority, the proportion of plastics in municipal solid waste in Manila is around 18 % (MMDA 2018). One of the world's most plastic polluted rivers is located here: the Pasig river, which runs through Manila and connects Manila Bay with Laguna Lake. The Pasig river is estimated to leak between 32 and 64 thousand tons of plastic waste per year into the ocean. It is estimated by models to be one of the top 20 rivers contributing to plastic pollution in the world (Lebreton et al., 2017).

The rivers in the Cavite province flow into the Manila Bay, one of the Philippines' pollution hotspots. Cavite is home to a large portion of the Philippine population and faces challenges regarding urbanization, population growth and economic development. These challenges are similar to those in other cities and provinces bordering the Bay, and good practices and lessons learned can be shared among these areas. The upstream areas of the drainage basin are mostly comprised of agricultural land, with the surrounding landscape becoming increasingly urbanized as the river moves downstream (**Figure 11**).

5.2.1 Waste generation in Cavite province

It is likely that the more upstream agricultural areas leak more yard and field waste into the river system, while the urban areas leak more household waste, including plastics. In the Cavite province, plastics make up 13 % of the waste composition (**Figure 12**). Drains flow directly into the river at various points, but stranded plastic is more visible throughout the region than floating plastic during dry season. This typically changes with seasonal heavy rain, when stored and trapped litter is washed out and remobilized.

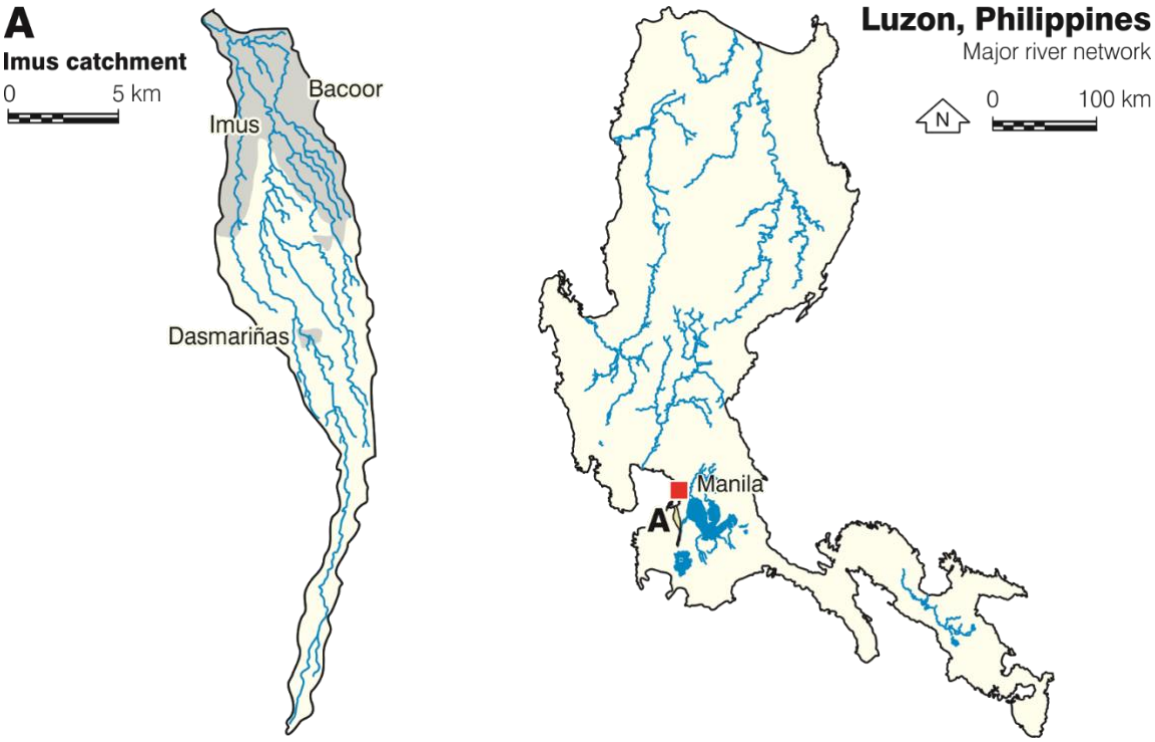


Figure 11 The Luzon island, Philippines (right) and the Imus catchment (A, left).

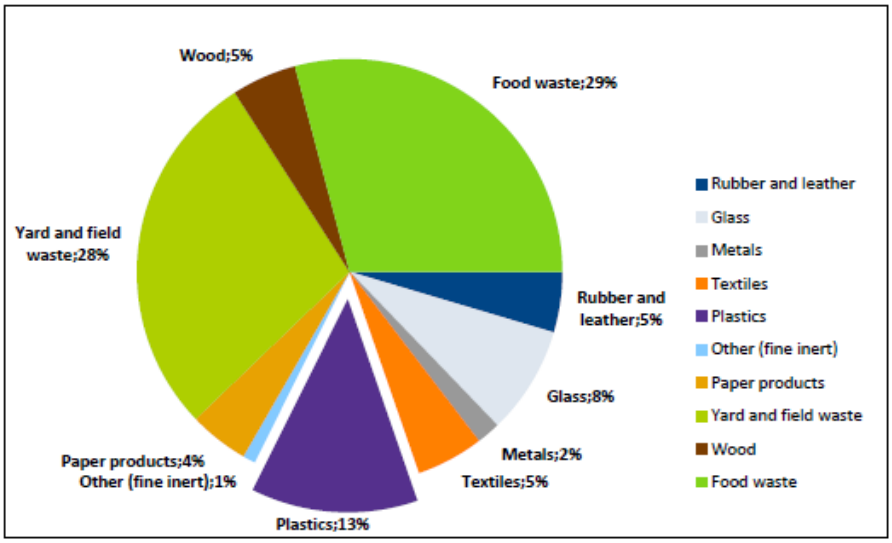


Figure 12 Waste composition in the Cavite region (MMDA 2018).

5.2.2 Cavite Province waste collection infrastructure

Waste collection and management within Cavite is devolved to its local government units (LGUs), the municipality and cities which make up the province, as well as their constituent *barangays*. The specifics of waste collection and management thus vary between the different local government units, rather than being organised on a provincial level. Waste collection can be run by the local government unit or contracted out to private companies on an annual basis. Collection frequency varies by locality, and a large informal sector exists alongside the formal channels, often removing high-value and easily recyclable plastics from the waste stream.

Despite different approaches, the various LGUs share the challenge of a lack of suitable disposal sites. While RA 9003 mandates waste be disposed on in a sanitary landfill, no such landfill exists in Cavite, necessitating the expense of shipping waste to other provinces. The Provincial Government Environment and Natural Resources Office (PG-ENRO) is in the process of developing a sanitary landfill for the province but continues to encourage the development of alternatives to disposal in landfill. A variety approaches have been initiated on the barangay and municipal levels that seek to re-use waste. Examples include producing biogas from organic matter, producing charcoal, turning plastic into bags, and downcycling plastic into paving stones and bricks.

6 Waste management and the role of the informal sector

6.1 Indonesia

While much of the burden of improving the waste pollution situation in Indonesian cities falls to the local government, informal waste collectors and waste banks also play an important role, especially when it comes to reusing and recycling waste. The informal waste sector comprises of waste pickers (scavengers), waste collectors, junkmen (low-level waste sellers), *lapak* (intermediates who often form a kind of employment of the scavengers) and *bandar* (dealers) (Damanhuri, 2012). A study from Bandung city from 2010 found that close to 3,000 people are involved with the informal solid waste management sector, and that they collect 13 % (by weight) of the waste generated in Bandung (Sembiring and Nitivattananon, 2010). The informal waste workers are typically leading poor and insure livelihoods.

It is difficult to quantify the informal waste sector. Due to its informal nature, and lack of overarching organization very little data exist, and most of the available literature is now a few years old. There is little doubt though, that the informal waste sector plays a significant role in recovering recyclable wastes. Yet, there are some drawbacks with their modus operandi. For example, waste pickers are only incentivized to gather wastes with economic value and are known to turn out the contents of bins and plastic bags (often collecting the bags) and leave the rest on the ground, complicating the work of waste collectors (Damanhuri, 2012). Also, waste pickers are often exposed to high risks due to their handling of possibly toxic, contaminated, or otherwise dangerous waste without proper equipment. The informal workers lowest on the waste trade hierarchy are also vulnerable to exploitation (Wilson et al., 2006). A closer integration of the informal sector into waste management along with economic compensation as well as a careful consideration of how different polices may affect this sector are needed to improve livelihood conditions and municipal solid waste (MSW) management.

6.2 Philippines

6.2.1 National level waste recovery

While precise data on plastic waste and environmental action in the Philippines is generally lacking, the country has relatively high collection rates compared to other countries in the region. The national average collection rate is 85 %, reaching 90 % in metro Manila and around 40 % in very rural areas. By comparison, in other parts of Asia, rates are close to 0 % in similarly rural areas (Ocean Conservancy and McKinsey Center for Business and Environment, 2015). However, whilst this is an example demonstrating the potential for success in the area of environmental sustainability, the Philippines does not perform well in terms of overall waste management.

According to the 2011 Asian Green City Index, which ranked more than 20 Asian cities based on sustainability criteria, Manila ranked “below average” overall, along with Bengaluru, Hanoi, Kolkata,

and Mumbai (Economist Intelligence Unit 2011). It also ranked “below average” for waste management (Economist Intelligence Unit 2011). The Metro Manila region (which has an area of 620 square kilometres) generates approximately 560,000 metric tons of plastic waste per year and thus has a plastic waste density of 900 metric tons per square kilometre (Ocean Conservancy and McKinsey Center for Business and Environment, 2015).

There are four main locations in the process of waste management in the Philippines (Ocean Conservancy and McKinsey Center for Business and Environment, 2015):

1. Household/street-level pre-collection.
2. During transportation: waste pickers sort waste while riding on moving trucks.
3. Material-recovery facilities (MRFs): waste is almost entirely sorted manually by waste pickers.
4. Landfills/dump sites.

The main actors in the waste collection process can be divided into two groups (JICA 2008): 1) Primary collectors, including street collectors, collection workers, and disposal site scavengers; and 2) Middlemen and traders, including Eco-aides (organized door-to-door collectors of recyclables), junk shops, and consolidators (larger-scale traders).

Levels of income among primary collectors can differ significantly. Those who sort waste at MRFs are mostly unpaid by the *barangays* (the smallest administrative division) or companies responsible for the MRFs. They instead work in exchange for sellable materials that they retrieve from the waste. In this sense, they are informal workers who are integrated into the formal sector (Gunsilius 2011, 14). Conversely, there are also formal workers who add informal work to supplement their income. For example, “jumpers” who collect extra material from trucks on their way to dump sites, fall into this category. Street collectors and dump site pickers also get their income from selling the materials they collect, though street collectors typically earn more than dump site pickers, as the quality of the materials they collect is usually higher (Gunsilius 2011, 14).

In 2014, there were 8,656 material recovery facilities (MRFs) in the Philippines, serving 10,327 *barangays* (NSWMC 2015). According to data from 2011, 77 % of Manila’s waste is collected and disposed of adequately (Economist Intelligence Unit 2011). Both the informal and formal sectors play an important role in waste collection in the Philippines. The amount of plastic waste collected by waste pickers, middlemen and traders differs rather significantly. Primary collectors collect between 1.63 and 20.32 kg per capita per day, on average, whereas middlemen and traders collect between 5.2 and 266.4 kg per capita per day, according to data from 2008 (JICA 2008).

As may be expected due to their precarious financial situation, waste pickers prioritize monetary gain over environmentalism. They can, however, be highly efficient at collecting plastics that fetch higher prices and take less time to collect. For example, extraction rates for polyethylene (PET) bottles can reach up to 90 %. Financial incentives are therefore not to be ignored in the process of waste collection.

The disadvantage of this situation, however, is that waste pickers are far less efficient at collecting low-value plastics, where the rate is close to 0 %. In addition, there are some instances where high-value materials may not be collected very efficiently as well. For instance, HDPE products, though higher in value than PET bottles, are recovered at a rate of only 40%. The additional reasons for the high rate of collection of PET bottles are that they are easy to recognize, pick up, and sell at local junk shops (Ocean Conservancy and McKinsey Center for Business and Environment, 2015). It is thus clear that for waste pickers, efficiency is strongly tied to a variety of factors that are of a practical nature.

As for concerns of how to improve the collection of low-value plastics, progress is unlikely in the near future, chiefly because the plastic-waste growth rate is higher than the predicted increase in the number of informal waste pickers. Waste pickers will therefore likely not have an incentive to collect low-value plastics in the future (Ocean Conservancy and McKinsey Center for Business and Environment, 2015).

Preliminary findings from the case study in the Cavite province indicates that many residents prefer to give or sell their waste directly to the waste pickers, rather than separating and manage their own waste. First, this is a more convenient option for most residents. Second, residents provide their trash to waste pickers as a form of compassion towards waste pickers.

6.2.2 A local example: Dasmariñas

The Imus River begins in Tagaytay City and then flows through the Municipality of Silang, Dasmariñas City and Imus City (**Figure 7**). Dasmariñas is an area with acute population growth, with a population of 659,019 in 2015, of which 555,932 are considered urban and 155,901 rural (Cavite Ecological Profile 2018). In total, the city is estimated to produce 219,763 kg of solid waste per day, which is expected to rise to 296,437 kg per day over the next decade.

Dasmariñas has its own City Environment Natural Resources Officer (CENRO). *Barangays* within Dasmariñas also have solid waste management responsibilities, working together with the Dasmariñas city administration. The city practices some waste segregation and runs a dedicated composting centre, but it lacks a centralized materials recovery facility (MRF). Throughout the city there are junkshops that recycle high value recyclables (numbers provided differ, but a list of 64 is available in the CLUP 2016), including high-value plastic like PET bottles. These junk shops play important roles in the informal waste collection sector, which removes a high proportion of high value plastics, such as plastic bottles, from the waste management system. This means much of the plastic that ends up in the environment is low value or hard to recycle forms, such as the thin plastic films used for single-use plastic bags, sachets, straws, and cling-film.

Various operations are run by the city and *barangays* to clean rubbish from different areas of the river, with river-pickers clearing up rubbish using hand tools. The waste collected by such efforts is intended to be reported to CENRO, which serves as a central point for data collection. However, doubts were raised by some stakeholders about the accuracy of much of this data given gaps in reporting and a lack of consistent monitoring and verification. Jurisdiction over certain areas of the river is also sometimes unclear. Subdivision boundaries often coincide with the stream, and small

creeks and easements may be paved over. Informal settlers occupying land on or near the river further reduces jurisdictional clarity.

7 Environmental education

The ASEAN Environmental Education Action Plan (AEEAP, 2014–2018) was adopted in 2013. The objective of the AEEAP 2014–2018 was "*to realise a clean and green ASEAN with citizens who are environmentally literate, imbued with environmental ethics, willing and capable to ensure the sustainable development of the region through environmental education and public participation efforts*" (ASEAN Secretariat 2014). The plan has four target areas, each further broken down into four or five strategic actions. The target areas are: (1) the formal sector, (2) the non-formal sector, (3) institutional and human resources capacity building, and (4) networking, collaboration and communication (ASEAN Secretariat 2014). It is currently unclear to what extent the AEEAP 2014–2018 has made a difference on the ground (Yee and Rahman 2019).

Some elements from the AEEAP have been integrated into the ASEAN Strategic Plan on Environment (ASPEN), specifically to Strategic Priority 6: the AWGEE Action Plan. Some of the key activities put in place under the AWGEE Action Plan are: (1) the ASEAN Eco-schools Program, (2) the ASEAN Eco-schools Award, (3) the ASEAN Green Higher Education Programme, (4) the ASEAN Plus Three Youth Environment Forum, (5) the ASEAN Youth Eco-champions Award, (6) ASEAN Environment Year, and (7) the ASEAN Plus Three Leadership Program on Sustainable Consumption and Production (SCP) (ASEAN 2019).

The National Environmental Education Action Plan (NEEAP) 2018–2040 serves as the official national framework for environmental education in the Philippines (**Figure 13**). It was developed with support from the European Union SWITCH-Asia Program (NEEAP 2017). It serves as a guiding framework; such that educational institutions have individually formulated their responses to it (Galang 2010). One key program is the National Service Training Program (NSTP), which all first-year students at higher education institutions must take (Galang 2010). Seven key strategies have been defined in order to achieve the key results in the NEEAP: (1) institutional arrangements, (2) national and international partnerships, (3) initiatives and awards, (4) curriculum, (5) teaching and learning materials, (6) capacity building, and (7) monitoring and evaluation (NEEAP 2017).

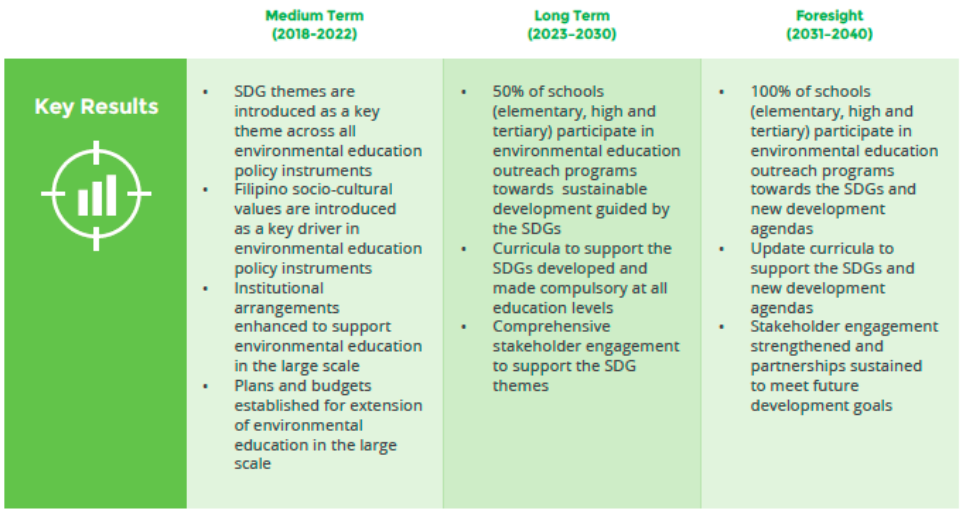


Figure 13 Envisioned key results of the NEEAP 2018–2040.

8 Conclusion and upcoming knowledge needs

The knowledge on the effects of plastic pollution and so the efforts to reduce plastic pollution are rapidly increasing in Indonesia and the Philippines. However, there are three main upcoming needs for an additional levelling and for effects to also be seen globally:

1. **Monitoring of riverine plastic transports**
   According to a recent summary report on the status of plastic research in the ASEAN region, Indonesia has the most extensive track-record in undertaking research, with the most studies focused on the marine environment. Research efforts prioritise surveying and monitoring microplastics floating on the sea surface or in the water column, sampling macroplastics found among macro-debris on the shoreline, and sampling microplastics in various marine biota. Most of the field research has been conducted on the sea surface or water column, from estuaries, to coastal waters and out to the open ocean. More than half of the articles published seek to quantify the presence and abundance of marine plastic debris (Lyons et al., 2020). There is a clear need for including rivers and calculations of riverine plastic transport. Since the issue of plastic and microplastic contamination is a relatively new topic, there is currently no standardized sampling or analytical method available. As an example, countries and research/monitoring groups are using different samplers with different mesh sizes and often inadequate quality assurance and control, leading to incomparable results. Globally, there is a strong need for harmonization of sampling methodologies and protocols in order to make the results from different studies more comparable.

2. **Understanding socio-economic drivers for plastic pollution**
   Leakage of plastic waste into the environment and the ocean have negative impacts on both local, regional and global scales. Impacts on environmental quality have been estimated to a yearly cost to the global economy of approximately $ 13 billion. Pollution significantly affects fragile rural/coastal communities in impacted environments, and people living in and around landfills. Plastic pollution has multiple socioeconomic drivers that differ from region to region. It is important to assess the effectiveness of existing legislations and to identify cultural and socioeconomic factors that motivate and constrain people in reducing plastic pollution. In Indonesia, it remains important to assess what policy instruments and economic incentives that can reduce plastic waste and steer the country toward a circular economy. In developing countries in Asia, millions of informal waste pickers and handlers and thousands of small-scale formal/informal recycling and remanufacturing enterprises exists. This workforce can represent a significant node for reducing plastic pollution from both local sources and from plastic-containing waste imported from developed countries. Any implementation of measures at the local level – technical, economic, social or regulatory – may have a critical impact on a large and vulnerable group of people. Thus, the socioeconomic impacts of any measure and action must be critically assessed to avoid putting more pressure on an already exposed group of people.

3. A holistic approach

As for many pollution issues, plastic waste and microplastics are global challenges because of their potential for transboundary movement in the environment and for their impact on global sustainable development, as addressed by the UN Sustainable Development Goals (SDGs). International efforts and effective regulations are pivotal to reduce plastic pollution and its environmental effects. A holistic approach and regionally coordinated response to tackle this complex environmental problem is needed, especially in Southeast Asia. There is a strong need to integrate the social and economic drivers of plastic pollution (preference for single-portion packaging, production and marketing modes) with environmental impacts, technological solutions and management measures. To ensure that policies targeting industries and households are effective, it is important to consult with relevant actors and that their concerns are considered. Moreover, policies and management measures need to be evaluated continuously with quantitative as well as qualitative approaches to ensure that the targets of reducing plastic release and pollution are reached.

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