Regional Report on the Status and Trends of Plastic Pollution in the Lower Mekong Basin

Final Draft

Prepared by

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Acronyms and Abbreviations

Abbreviation	Explanation
3Rs	Reduce, Reuse, Recycle
AIT	Asian Institute of Technology of Thailand
ASEAN	Association of Southeast Asian Nations
CARE	Centre Asiatique De Recherche Sur L'eau (Asian Water Research Center)
CEM	Center for Environmental Monitoring of Viet Nam
CEMA	Center for Environmental Monitoring and Analysis of Viet Nam
CENM	Centrer for Environmental and Natural Resources Monitoring of Viet Nam
CITENCO	City Environment Company of Viet Nam
COBSEA	Coordinating Body on the Seas of East Asia
DARD	Department of Agriculture and Rural Development of Viet Nam
DMCR	Department of Marine and Coastal Resources of Thailand
DONRE	Department of Natural Resources and Environment of Viet Nam
DRS	Deposit Refund Scheme
DWR	The Department of Water Resources of Lao PDR
ED	Environmental Management Division
EGAT	Electricity Generating Authority of Thailand
EPR	Extended Producer Responsibility
FADM	Fishery Abundance and Diversity Monitoring
FTIR	Fourier transform infrared spectroscopy
GDP	Gross Domestic Produce
GIC	Geoinformatics Center of Thailand
GISTDA	Geo-Informatics and Space Technology Development Agency of Thailand
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit
HDPE	High-density polyethylene
HPP	Hydro Power Plant
ICC	International Coastal Cleanup
IER	Institute for Environment and Resources of Viet Nam
IUCN	International Union for Conservation of Nature
JICA	Japan International Cooperation Agency
Lao PDR	Lao People's Democratic Republic
LAOs	Local Administrative Organizations of Thailand
LDPE	Low-density polyethylene
LMB	Lower Mekong Basin
LNMC	Lao National Mekong Committee
MAF	Ministry of Agriculture and Forestry of Lao PDR
MARD	Ministry of Agriculture and Rural Development of Viet Nam
MBT	Mechanical and biological treatment
MCD	Center for Marine Life Conservation and Community Development of Viet Nam
MOH	Ministry of Public Health of Lao PDR Ministry of Health of Viet Nam
MOIC	Ministry of Industry and Commerce of Lao PDR
MONRE	Ministry of Natural Resources and Environment of Lao PDR Ministry of Natural Resources and Environment of Thailand Ministry of Natural Resources and Environment of Viet Nam
MoU	Memorandum of Understanding
MPWT	The Ministry of Public Works and Transport of Lao PDR
MRC	Mekong River Commission

MRC MCs	Mekong River Commission Member Countries
MRCS	Mekong River Commission Secretariat
MSW	Municipal Solid Waste
MWA	Metropolitan Water Authority of Thailand
NGGS	National Green Growth Strategy
NGO	Non-governmental Organization
NOAA	National Oceanic and Atmospheric Administration
NPO	Non-Profit Organization
NUOL	The National University of Laos
P4G	Partnering for Green Growth and Global Goals 2030
PCD	Pollution Control Department of Thailand
PDIES	Procedures for Data and Information Exchange and Sharing
PET	Polyethylene terephthalate
PP	Polypropylene
PPC	Of Viet Nam
PS	Polystyrene
PTIH	Plastics Institute of Thailand
PTIT	Petroleum Institute of Thailand
PVC	Polyvinyl Chloride
PWQ	Procedures for Water Quality
RDF	Refuse Derived Fuel
RID	Royal Irrigation Department of Thailand
RPM	Riverine Plastic Monitoring Programme
SCG	Siam Cement Group of Thailand
SCP	Sustainable consumption and Production
SDGs	Sustainable Development Goals
SEM	Scanning Electron Microscope
SUP	Single Use Plastic
SW	Solid Waste
SWM	Solid Waste Management
TEI	Thailand Environment Institute
TGWQ	Technical Guidelines on the Implementation of the Procedures for Water Quality
UNDP	United Nations Development Program
UNEP	United Nations Environment Programme
URENCO	Urban Environment Company of Viet Nam
USAID	United States Agency for International Development
VASI	Viet Nam Administration of Seas and islands
VCOMS	Vientiane City office for Management and Service
VEA	Viet Nam Environmental Administration
VIWA	Viet Nam Inland Waterways Administration
VNMC	Viet Nam National Mekong Committee
VPA	Viet Nam Plastics Association
WQI	The water quality indices
WQMN	The Water Quality Monitoring Network
WWF	World Wide Fund for Nature
XRF	X-Ray Fluorescence

Executive Summary

Introduction

This report explains the status and trends of plastic pollution in the Lower Mekong Basin (LMB) from the perspectives of plastic pollution itself, and also the frameworks and capacity of each member country to address the issues of plastic pollution. Each chapter consists of the explanation of the situation, being followed by challenges to be overcome by the cooperative efforts of the region.

Key findings

1. Background
The problems of riverine debris are highly extensive, exceeding the region of solid waste management, circular economy and 3R policies. Therefore, combatting riverine plastic debris requires comprehensive approaches including multi-sectoral cooperation and oceanographical knowledge.

2. Plastic today, and how Mekong River Commission member countries (MRC MCs) are handling
Due to a variety of functions and cheap production price of plastic, its production is increasing worldwide and also in some MRC MCs such as Thailand and Viet Nam. However, when plastic leaks into the environment, it poses serious dangers to the environment to a very wide area almost forever as it cannot be naturally degraded. Although countries in LMB produce relatively less amount of waste in the ASEAN, development can cause steep increase in the amount. Furthermore, open dumpsite which is one of the major ways of treating waste in LMB can also cause the leakage of debris into the environment.

3. Policy and Institutional Frameworks
At regional and international levels, Regional Action Plan on Marine Litter 2019 of Coordinating Body on the Seas of East Asia (COBSEA RAP MALI 2019) seems the most specific framework including the concrete plan for establishing monitoring mechanism. There are several international conventions that covers prevention of marine pollution from ships, discharge of harmful substances, open dumping, or completely prohibiting the disposal of plastic in all forms. However, ratification status of these conventions in LMB is yet to be improved. Also, they both leave behind the landlocked countries such as Lao PDR.

As per national political framework, it seems that none of 4 MRC MCs have specific policy framework for monitoring of plastic debris, nor monitoring of riverine debris. In national institutional frameworks, there was a lack of clear allocation of work and responsibility between the institutions on the riverine debris.

4. Capacity of Riverine Plastic Debris Monitoring
The lack of research equipment was striking within countries. Some facilities in Thailand and Viet Nam own FTIR and Raman spectroscope that is required in identifying the plastic material. On the other hand, available equipment is limited to a stereo dissecting microscope in Cambodia, and water sampler in Lao PDR.

5. Current Trends and Status of Plastic Pollution in LMB
5.1 Riverine Monitoring Activities and Results in LMB

There were several monitoring activities addressing riverine plastic debris outside the LMB. However, in the LMB, the monitoring of riverine plastic debris was only covered by UNEP's project "Promotion of action against marine plastic litter in Asia and the Pacific" (CounterMEASURE II).

In CounterMEASURE II, status of pollution in the LMB was surveyed from 4 perspectives, namely, riverine macroplastic, riverine microplastic, plastic leakage hotspots, and plastic accumulation hotspots. Although survey results conducted in 5 areas can be used as the first step of understanding the situation in each area, the method of surveys largely varied making the detailed comparison impossible. For collecting the scientific knowledge on plastic pollution to reflect into policy making, standardization of survey methods and regular monitoring is indispensable.

5.2 Riverine Monitoring Results outside LMB

Outside the LMB in MRC MCs, monitoring of marine debris both addressing macroplastic and microplastic are being implemented. Sharing the resources such as human resource and equipment, as well as knowledge and experience will surely accelerate the efficient monitoring of riverine plastic pollution in LMB.

5.3 Clean up and collection activities in LMB

It was found that there are no regular cleaning activities specifically focuses on LMB region.

5.4 Solid waste management at 12 ports in 4 MCs

In 12 surveyed ports, 11 ports experience accumulation of waste including plastic debris. The ratio of plastic waste in accumulated debris was above 70 % in 7 ports out of 11, while the ratio of plastic in debris flowing from upstream reached 50 % in only 1 port, with rest of them being 10 % to 30 %. As for the items, bags and bottles were reported to be most found in spatial accumulation. And similarly in the accumulated debris, bottle accounted for the largest part in 8 ports, and bags account for the largest in 4 ports among the reported items. And together they compose more than 50 % in 8 locations.

6. Fishery Activities and the Impacts of Plastic Pollution to living organisms

Among 19 species that was observed by the fishermen to be entangled or ingesting plastic, 6 species contribute to more than 1 % of the fish catch in LMB. Also, one of the affected specie is classified as "VULNERABLE" in the International Union for Conservation of Nature (IUCN) red list.

Other effect on the species in MRC MCs and other Asian countries were found through desktop survey. The effect can be both physical and chemical, such as entanglement in macroplastic and ingestion of microplastic, or accumulation of harmful chemical substances transferred through ingestion of plastic.

Recommendation

To assess the basin-wide status and trends of riverine plastic pollution and gather information and knowledge to inform decision making in effective and efficient management of riverine plastic pollution in the LMB, Recommendations on addressing the identified gaps and challenges and developing, monitoring system for riverine plastic pollution on each MRC MCs are followings.

- Conducting riverine debris monitoring rigidly following the protocol by MRC, and sharing the experience as well as data. This will enable the data compilation for scientific research and active involvement of stakeholders.
- Collaboration between government and academic or institute is required to conduct riverine debris monitoring, to maximize the outcome with the limited resources.

- Providing capacity building for development of, definition and classification of riverine debris, sampling methodology, sample analysis and monitoring protocol. Monitoring program should include both macroplastic and microplastics in a cost-effective way.
- Identifying government authorities or research institutions suitable for conducting and maintaining monitoring activities in cooperation with related organization.
- Establishing a collaborative mechanism among MRC MCs for riverine debris monitoring activities to fill the gaps in availability of necessary equipment such as FT-IR (e.g., sending the samples after pre-treatment for analysis from a country where FT-IR is not available).
- Establishing and enforcing policies and regulations on waste littering, 3R, riverine plastic waste management including clear responsibility of national government, local government, private sector and community.
- Regular collection of riverine debris and appropriate treatment of collected debris.
- Raising public awareness regarding to impacts of plastic waste on environment and water resources.
- An integrated monitoring system that consolidates the monitoring activities and results of each organization.

Through the recommended items above, results of riverine debris can be evaluated, and Material Flow Analysis and Inventory Analysis of plastic can be facilitated. These will also contribute to evaluating the effectiveness of the measure.

Regional Report on the Status and Trends of Plastic Pollution in the Lower Mekong Basin

1. Background

The Mekong River Commission (MRC) was established by the 1995 Agreement on Co-operation for the Sustainable Development of the Mekong River Basin, between the governments of Cambodia, Lao PDR (Lao People's Democratic Republic), Thailand and Viet Nam. The role of the MRC is to coordinate and promote cooperation in all fields of sustainable development, utilization, management and conservation of the water and related resources of the Mekong River Basin.

The MRC Secretariat (MRCS) is the operational arm of the MRC. It provides technical and administrative services to the Joint Committee and the Council to achieve the MRC's mission.

The Environmental Management Division (ED) is responsible for environment monitoring, assessment, planning and management to support basin planning management and development for sustainable development of the Mekong River.

The Mekong River Basin is one of the largest and most biodiverse river basins in the world, spreading over more than 795,000 km^2 and extending over 5,000 km through six different countries and providing a home to more than 70 million people alone in its lower reaches (Lower Mekong Basin). However, the Mekong River is also one of the 10 major contributors to marine plastic pollution. Collectively these major contributors discharge about 95% of the plastic strangling the world's oceans.

In 2019 the United Nations Environmental Assembly agreed on measures aiming at curtailing global plastic pollution and leakage into the world's oceans with the commitment of 180 countries including the MRC Member Countries. The main aim is to reduce the use of single-use plastic products. However, it is known that this will not be enough to effectively address the magnitude of plastic waste that pollutes our freshwater ways and our oceans.

The MRC has six core functions including assessments and analysis, monitoring of environmental status and trends and the implementation of MRC procedures. Among the five MRC procedures are the Procedures for Water Quality (PWQ) and the Procedures for Data and Information Exchange and Sharing (PDIES). One of the key objectives of the MRC core function for monitoring is the continuous assessment and identification of basin changes of 5 different disciplines: i) Hydrology and Hydraulics, ii) Sediment and Discharge, iii) Water Quality, iv) Aquatic Ecology, and v) Fisheries. The MRC has long experience with environment and fisheries monitoring according to the key disciplines. The MRC water quality monitoring activity dates back to 1985 with the establishment of the Water Quality Monitoring Network (WQMN) in Lao PDR, Thailand and Viet Nam, with Cambodia joining the network in 1993. Presently, its activities spread to 48 sites throughout the Lower Mekong Basin (LMB) with 18 sites located on the Mekong mainstream and 5 sites located on Bassac River. The MRC Fisheries monitoring began in 1995, consisting of three categories to date, namely, Fish Abundance and Diversity Monitoring (FADM), Fish larvae drift monitoring, Bagnet (dai) fishery monitoring. Among them, FADM which was set up in 2007 takes place throughout the basin in 38 sites today, and will soon be more based on recommendations from the Joint Environmental Monitoring (JEM) Programme for the Mekong mainstream hydropower projects. These procedures and monitoring activities lay the groundwork for this assignment.

The MRC and UNEP (United Nations Environment Programme) have signed a Memorandum of Understanding (MoU), among others, to work on water quality monitoring including plastic waste leakage into the Mekong River system. Under this partnership arrangement in 2019, the MRC supported the first phase of the project of UNEP, "Project on Promotion of Countermeasures Against Marine Plastic Litter in Southeast Asia" (CounterMEASURE) including regional workshops, capacity mapping for plastic pollution in the Mekong basin and support to the pilot projects in the 4 MRC Member Countries; Cambodia, Lao PDR, Thailand, and Viet Nam.

To build on the initial efforts under the first phase of the CounterMEASURE, the MRC and UNEP have agreed on further cooperation in the year 2020 including the identification of sources of plastic waste leakage, and the development of a standardized/harmonized methodology for plastic debris assessment and monitoring in the Mekong River. The final objective is to collect up-to-date data and information on transboundary plastic waste pollution status and trends, and to make that information available for policy decision making processes.

To achieve this, the MRC implemented two key activities for 2020 including the review of the status and trends of plastic waste pollution and management in Lower Mekong Countries and the development of a concept note for a long-term and cost-effective assessment and monitoring methodology of plastic waste in the Mekong River.

With the continuous partnership with the UNEP and based on the outcomes of the activities carried out so far, the MRC looks into the status of plastic pollution and the way of analysing, specifically :

- Including the scope and impact of plastic and microplastic pollution in the Mekong River fauna with a focus on migratory freshwater fish species in the report of the review of the status and trends of plastic waste management in the LMB; and
- Including biological monitoring protocol in the concept note on methodological and tool for a long-term and cost-effective assessment and monitoring of plastic debris pollution in the Lower Mekong River.

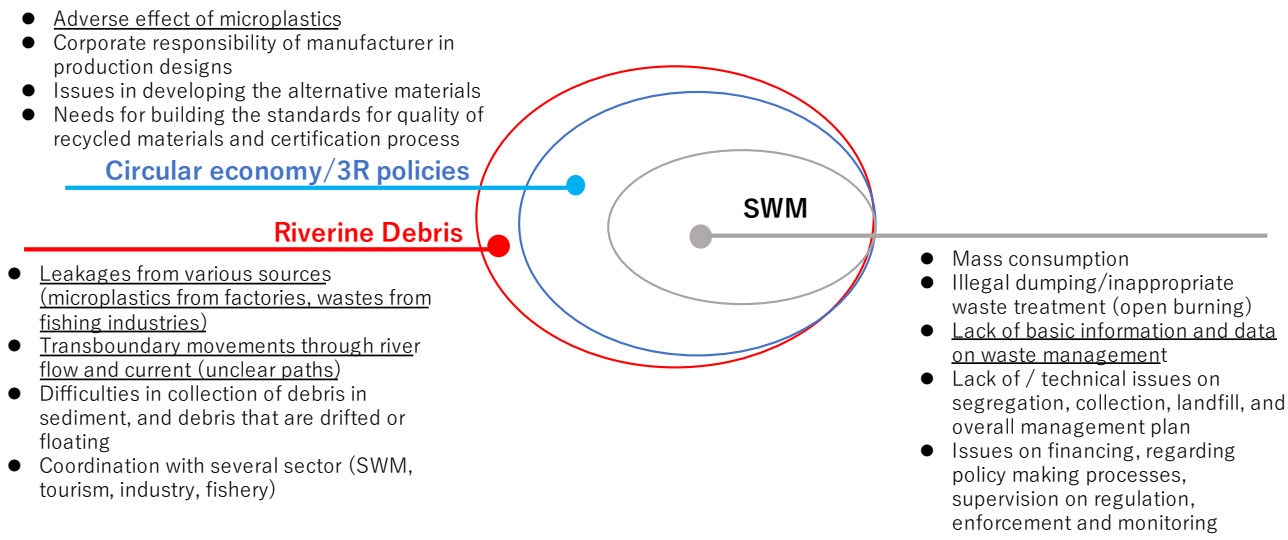
1.1. Problems of riverine debris

The problems of riverine debris are highly extensive, as ***Figure 1-1*** shows the outline of its influencing area and the details of regarding regions. When we talk about riverine debris, we tend to only focus on issues in solid waste management, circular economy or 3R. However, the actual problem of riverine debris is much broader, lying in the very existence of riverine debris itself. The 3 main specific problems of riverine debris are stated below.

1) Leakages from various sources need to be tackled from diverse fields such as manufacture, Solid Waste Management (SWM), fishery, tourism and so on. This cannot be improved without multi-sectoral approach from cooperation among Governmental bodies, private sector and research institutions.

2) Difficulties in collecting debris once it flows into the water. Also, its transboundary movements through river flow and current makes the responsibility of management unclear.

3) Understanding and monitoring of their occurrence and flowing paths requires oceanographical approach.



Source: S. Sasakura (2021)

Figure 1-1 The Outline of riverine debris problems and its relevant areas

Still, several research have been carried out for the deeper understanding of its behaviour. The amount of plastic waste, one of the key components of riverine debris, is estimated to be 275 million tonnes per year globally. Among that, 8 million tonnes (2.9%) are estimated to enter the ocean (Our World in Data, 2018).

Mekong River is estimated to be the 10th largest river contributing to the marine plastic occurrence in the world (Schmidt et al., 2017). They calculated the amount of plastic debris discharged from each river using data from various studies, with the aim of integrating as much data as possible. The research team divided the riverine plastic debris into two categories: microplastics smaller than 5 mm in diameter and macroplastics larger than that. The calculation was done using two models: model 1 using all the acquired data, model 2 using only the data with dataset that contains information on both microplastics and macroplastics. The results are shown in ***Table 1-1***, in which calculated microplastics loads showed a significant difference between Model 1 (third column from the right) and Model 2 (second column from the right) nearly 10 times higher in some areas. In contrast, the results for macroplastics were the same for both models (rightmost column).

Since this study integrates secondary data from various survey methods altogether, it is difficult to say which model to fully trust. However, this fluctuation increasingly underscores the importance of collecting primary data to confirm the actual pollution situation. As river networks can facilitate transport of plastic debris over long distances into the sea (Schmidt et al., 2017), it goes without saying that we need to take urgent actions to stop the further pollution. The top 10 rivers shown in the ***Table 1-1*** are said to be transporting 88-95 % of the global load into the sea (Schmidt et al., 2017).

Table 1-1 Top 10 rivers transporting marine plastic debris

Rank	Name of the river	Microplastic load Model 1 [tons y-1]	Microplastic load Model 2 [tons y-1]	Macroplastic load [tons y-1]
1	Chang Jiang (Yangtze River)	85,440	1,469,481	69,282
2	Indus	12,378	164,332	11,977

3	Huang Hec (Yellow River)	9,678	124,249	9,561
4	Hai He	7,434	91,858	7,515
5	Nile	6,919	84,792	7,043
6	Meghna, Bramaputra, Ganges	6,039	72,845	6,230
7	Zhujiang (Pearl River)	4,577	52,958	4,823
8	Amur	3,429	38,267	3,708
9	Niger	3,185	35,196	3,469
10	Mekong	3,044	33,431	3,330
SUM		**142,123**	**2,167,409**	**126,938**

Source: Schmidt et al., 2017

Another study by Charlotte J Haberstroh et al (2021) estimated that around 74,095 ton/year of plastic were released from Phnom Penh into the Mekong River during the wet season. This accounts for 3.4 % to 52 % of microplastic load estimation by Schmidt et al. (2017).

Yet, Meijer et al. (2021) estimate that more than 1000 rivers account for 80% of global annual emissions, which range between 0.8 million and 2.7 million tons per year, with small urban rivers among the most polluting. These varying results emphasizes the importance of monitoring riverine debris for specifically identifying the emission source of debris.

Main results and key challenges

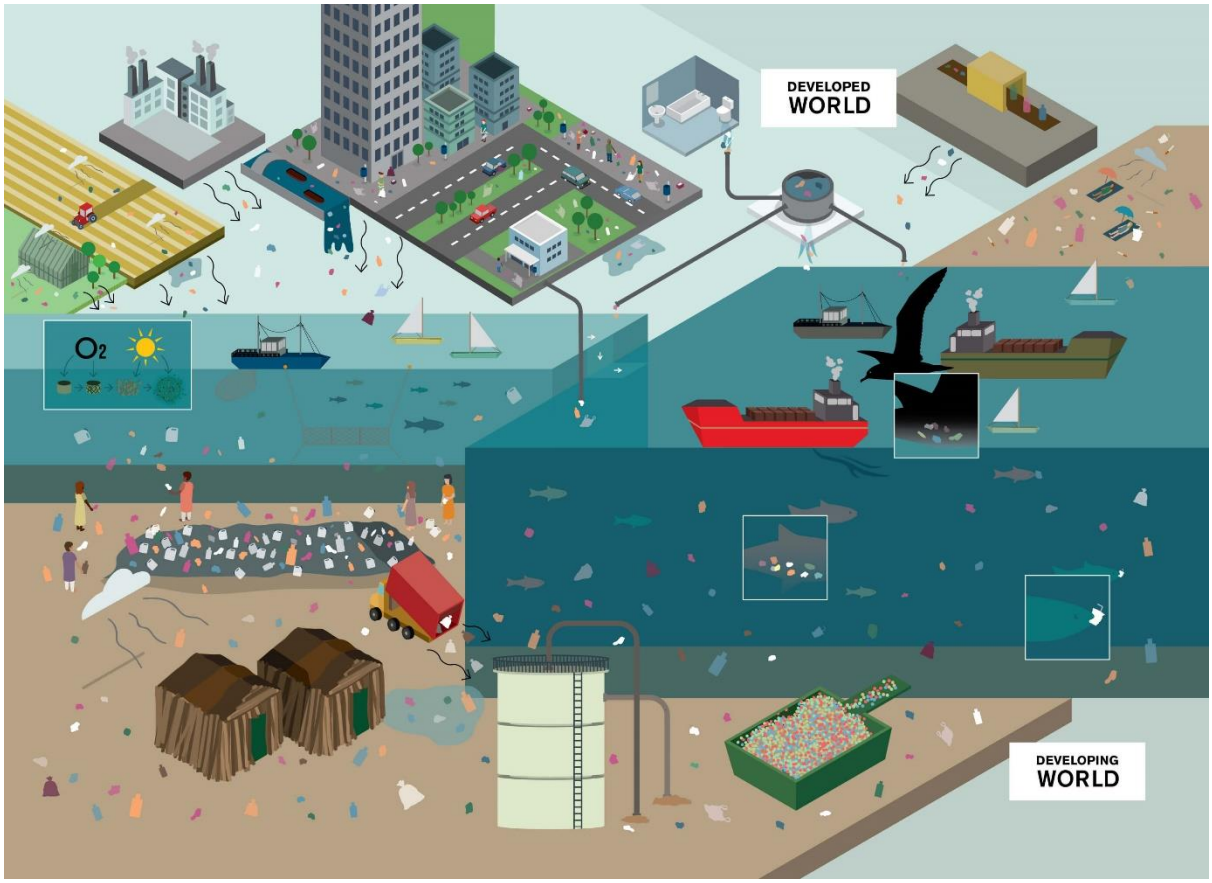
- 8 million tons of plastic wastes are estimated to enter the ocean annually (Jambeck et al., 2015).
- Top 10 rivers contributing to the marine plastic occurrence are said to be transporting 88-95 % of the global load into the sea (Schmidt et al., 2017). In the Mekong River which ranks 10th, the annual flux of riverine plastic is estimated to be 142,123 tons/year to 2,167, 409 tons/year for microplastic, and 126,938 tons/year for macroplastic (Schmidt et al., 2017). Summing up the amount of microplastic and macroplastic makes 269,061 tons/year to 2,294,347 tons/year, which is 3.4 % to 29 % of 8 million tons, which is the annual flux into the ocean (Jambeck et al., 2015).
- The problems of riverine debris are highly extensive, exceeding the region of circular economy and 3R policies. Therefore, combatting riverine plastic debris requires comprehensive approaches including multi-sectoral cooperation and oceanographical knowledge.

2. Plastic today, and how MRC MCs are handling

Plastic in our lives, and in environment

Plastic is one of the key components of debris in the water. In fact, it is said that plastic makes up 80% of all marine debris from surface waters to deep-sea sediments (IUCN, 2021). The features of plastic, which is why they are so widely used in our daily lives today, are very much why they pose a crucial impact on the environment.

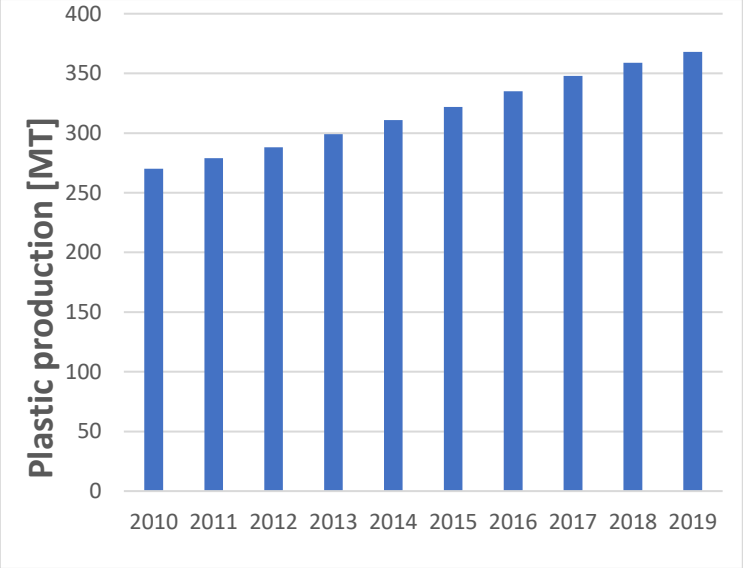
To begin with, its low cost of production has made the widespread consumption available regardless of income. However, due to its convenience and inexpensive product price, it is frequently disposed of in mass consumption. Also, due to its light weight, it can travel a very long distance once disposed of. In addition, due to its durable structure, it remains in the environment almost indefinitely without being decomposed, becoming fine particles (microplastics)..



Source: ISWA Marine Task Force (n.d.)

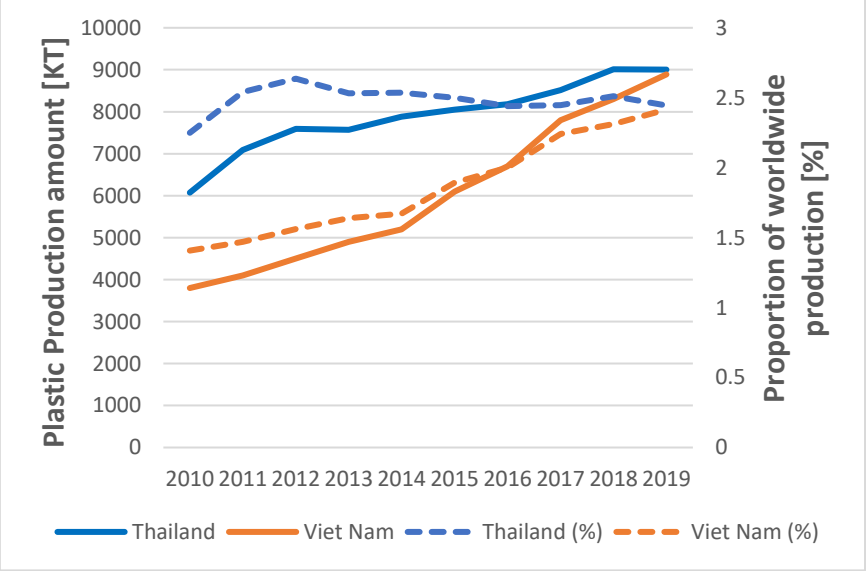
Figure 2-1. Production, use, and fate of plastic in the environment

Despite these known environmental effects, plastic today have gained the remarkable popularity all over the world. Looking at the trend of global plastic production, the total amount has been steadily increasing (***Figure 2-2)***. This trend is also noticeable in MRC MCs. ***Figure 2-3*** shows the growing amount of plastic production in Thailand and Viet Nam, as well as their proportion of worldwide production. Thailand has been producing increasing amount of plastic with the constant share around 2.5%, where Viet Nam came ascendant in just a decade. In Cambodia and Lao PDR, there is no official data on plastic production.



Source: Statista, 2022

Figure 2-2. Amount of Plastic Production in the world

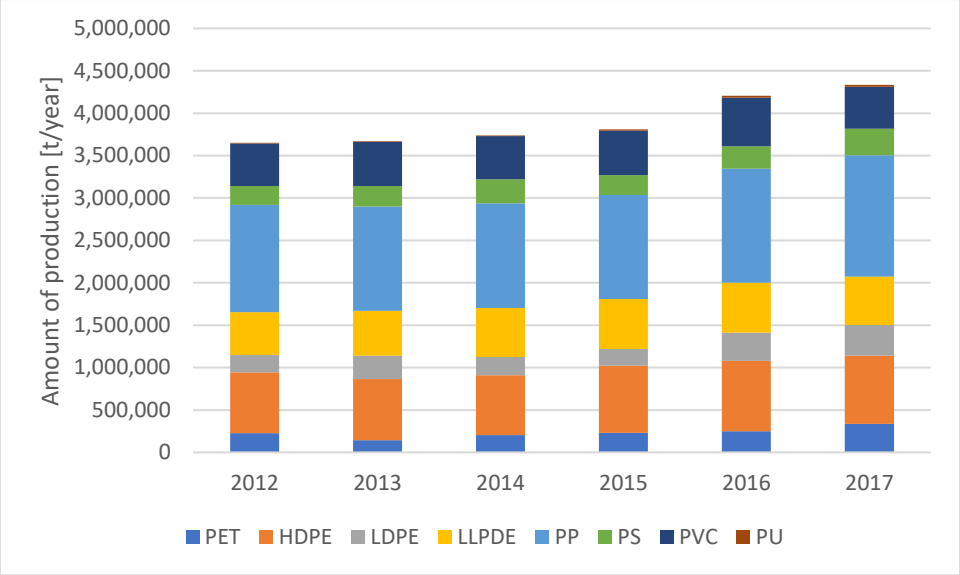


Source: Petroleum Institute of Thailand (PTIT), unpublished; FPT Securities, 2019

Figure 2-3. The amount of Plastic Production in MRC MCs (Thailand and Viet Nam) and their proportion of worldwide amount

Figure 2-4 shows the detail of plastic resin pellets production in Thailand, showing that production in each kind is increasing almost constantly.

Polypropylene (PP) accounts for more than 30% of Thailand's annual production and has been in the top spot for six consecutive years from 2012 to 2017 (***Figure 2-4***), being widely used for production of wrappers, bottles, bottle caps, or utensils such as cups and straws (Malakul, P. et al, 2019). Second comes the HDPE around 19% in the period of 2012 to 2017, which is mainly used for the production of bags, wrappers, bottle caps, or fishing gear (Malakul, P. et al, 2019). Third is the PVC in 2012, being passed by the LLDPE which has been growing these years.

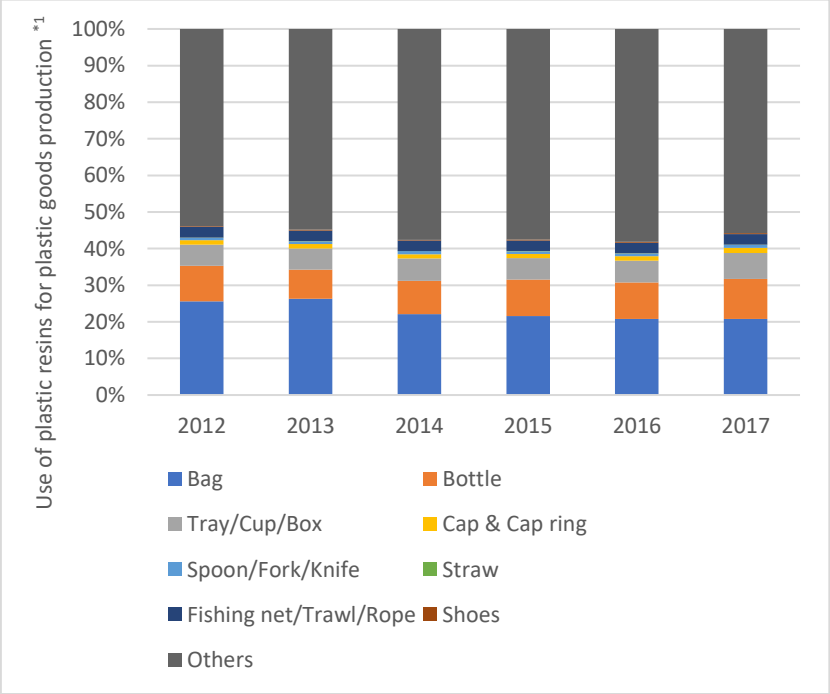


Source: Malakul, P. et al (2019)

Figure 2-4. Production of resin pellets in Thailand from 2012 to 2017

Use of these resin pellets, PET, HDPE, LDPE, LLPDE, PP, PS, PVC, and PU for production of plastic goods has been studied, showing more than 20% of the domestic production being used for "Bag", which is the study's classification including wrappers, and glocery bags (unlike other chapter in this report) (***Source: Malakul, P. et al (2019)***

Figure 2-5).

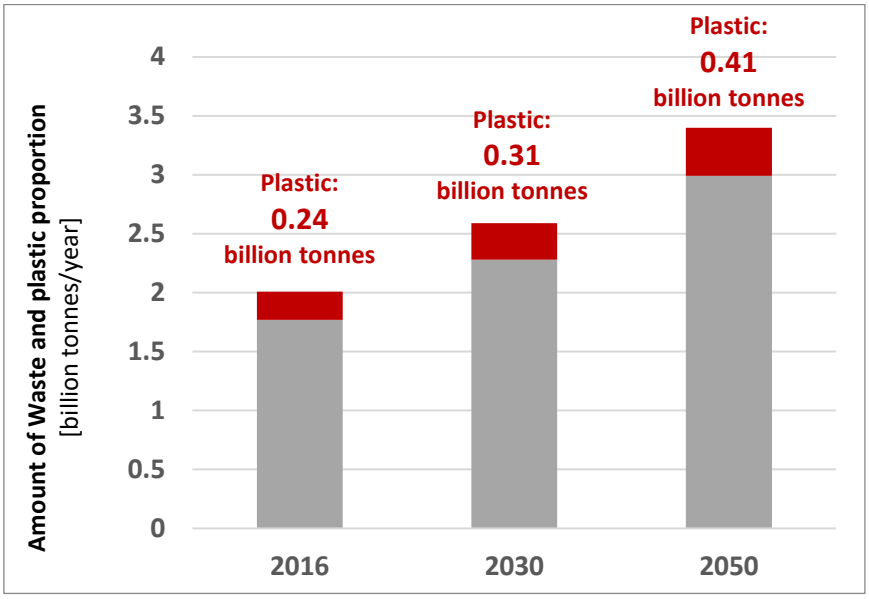


*1 Considering only the production of plastic resins for use in 8 targeted plastic products listed in the legacy.
Source: Malakul, P. et al (2019)

Figure 2-5. Proportion of plastic goods production

Overwhelming plastic waste - all over the world

What comes after the growing plastic production? Surely, the growing amount of plastic waste generation. The global amount of waste is estimated to grow 1.7 times larger from 2016 by 2050 (World Bank, 2018). By multiplying 0.12, the ratio of plastic waste to the overall amount of waste (World Bank, 2018), the amount of plastic waste is estimated to grow from 240 MT/year to 410 MT/year, assuming that the ratio of plastic waste to the overall amount stays the same (***Figure 2-6***). The previous report of World bank in 2012 even indicated that the ratio of plastic waste would increase, which further threatens a number of countries to drown in the overwhelming plastic waste. From 2012 to 2015, "Low Income Countries" in which Lao PDR and Viet Nam are categorized, is said to experience the growth from 8% to 9%, and "Lower-Middle Income Countries" in which Thailand is categorized, is said to experience the growth from 12 % to 13 %.



Source: Arranged based on World Bank (2018)

Figure 2-6. Estimated amount of worldwide waste generation and plastic waste generation

Plastic waste in MRC MCs

Table 2-1 shows the current situation of MRC MCs regarding waste generation and management**.** Several items are not available, and several countries have no data for overall country. In particular, data of source segregation rate is not available for 4 MRC MCs. It has found that plastic in waste stream of Thailand (17.62%) is the highest, followed by Cambodia (15%), Lao PDR (12%) and Viet Nam (10%). The collection rate in urban areas of Cambodia and Vietnam is higher than the others, while Lao PDR has a relatively low rate of 40% even in Vientiane Capital. It is hoped that the waste management capacity will be improved mainly in major cities, followed by expansion to rural areas. Collected waste would be intermediate treatment, resource recycling, or final disposal. The recycling rate and source segregation rate is high in Thailand compared to other MRC MCs, and these may be the contributing factors to the low disposal rate compared to other countries. The reduction in the amount of waste disposed will reduce the amount of leakage from the disposal site.

Mismanaged rate is stated by Jambeck et al. (2015) which are 89.0% for Cambodia, 75.4% for Thailand (75.4%) and 87.9% for Viet Nam. Its report defined mismanaged waste is either littered or inadequately disposed. Inadequately disposed waste is not formally managed and includes disposal in dumps or open, uncontrolled landfills, where it is not fully contained. Mismanaged waste could eventually enter the ocean via inland waterways, wastewater outflows, and transport by wind or tides (Jambeck et al., 2015). Mismanaged general waste rate on Lao PDR was not estimated by Jambeck but Schmidt estimated mismanaged general waste rate (84.2%). Estimation of littering rate is difficult to synthesize because they are typically designed to evaluate counts of particular items which limits comparison between studies (Jambeck et al., 2015). Jambeck et al. (2015) estimated percentage of waste littered using the only available national estimate of litter mass, which reported 4.17 million MT of litter generated in the United States in 2008, equivalent to approximately 2% of national waste generation. They estimated 2% of the mass of total waste generated is littered for each country.

For acquiring the data of source segregation rate and littering rate, it is required not only to monitor regarding to segregation and littering but also to formulate the reporting system of its monitoring. There are many types of landfills including open dumping, which will cause waste leakage.

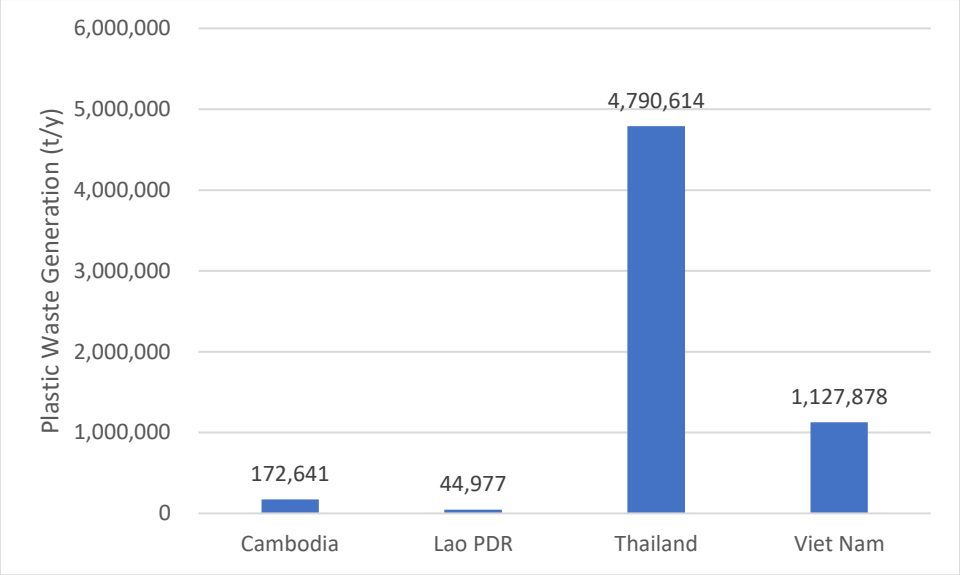
Figure 2-7 is the comparison of plastic waste generation in MRC MCs in 2010. We can see the distinctly large amount of plastic waste in Thailand and Viet Nam, nonetheless, followed by Viet Nam.

Table 2-1. Summary of waste management situation on each MRC MC.

Country	Waste generation volume (ton/year)	Waste generation rate (kg/person/day)	Plastic in waste stream (%)	Source segregation rate (%)	General Waste collection rate (%)	Landfill rate (%)	Recycling rate (%)	Mismanaged rate (%)
Cambodia	1,150,939 (2016)	0.2 (2016) [1]	15[2]	4.3[3]	80 (urban)[4]	41[5]	11[5]	89.0[6]
Lao PDR	374,810 (2016)	0.15 (2016) [1]	12[2]	No data	40 (Vientiane)[7]	No data	7.8 (Vientiane) [7]	84.2[8]
Thailand	27,188,499 (2016)	1.08 (2016) [1]	17.62[2]	34[9]	58[4]	33[9]	36[9]	75.4[6]
Viet Nam	11,278,784 (2016)	0.33 (2016)[1]	10[2]	No data	85-90 (urban)[10] 40-55 (rural)[10]	56[10]	8-12 (urban)[11]	87.9[6]

Source: ***1. The World Bank (2018a), 2. UNEP (2017a), 3. Sethy (2017), 4. UNEP (2017b), 5. UNEP (2020e), 6. Jambek et al. (2015), 7. JICA (Japan International Cooperation Agency) (2021), 8. Schmidt (2017), 9. PCD (2021), 10. UNEP (2020g), 11. Nguyen Trung Thang (2017)***

** Waste generation volume is calculated by Waste generation rate and population from The World Bank DataBank (2020).*

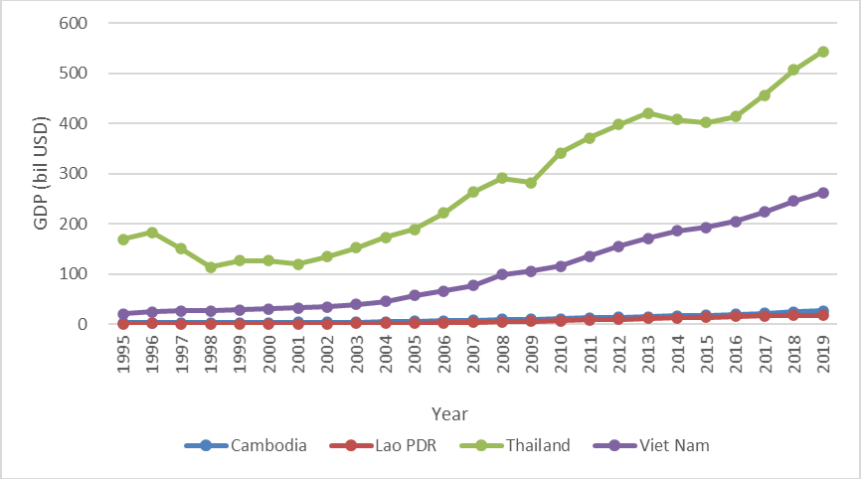


Note: Data calculated by waste generation and plastic in waste stream in Table 2-1.

Figure 2-7. Plastic waste generation in 2016 in 4 MRC MCs

In the Association of Southeast Asian Nations (ASEAN) region, waste generation rate of countries with low or middle income is lower than more developed countries (e.g., waste generation rate of Singapore is 3.72.) (The World Bank, 2018a). Still, it is questionable that it will remain the same for coming decades. The amount of waste per capita has a close correlation with GDP, which is solidly increasing in MRC MCs. Also, the rapid urbanization, industrialization and strong economic growth are likely to cause a steep increase in the amount of waste in these developing countries (UNEP, 2017).

To roughly see the development of MRC MCs, we have put The Gross Domestic Product (GDP) and their growth rate from 1995 to 2019 in ***Figure 2-8*** and ***Figure 2-9***. The GDP continues to grow in all MCs, especially Thailand and Viet Nam. From 1995 to 2019, Thailand's GDP increased from 169.3 to 543.5 billion USD, a change of 221%. For Viet Nam, GDP increased from 20.7 to 261.9 billion USD a change of 1163%. Other MCs also show steady growth. Even though the GDP growth in Cambodia and Lao PDR seems smaller than that of Thailand and Viet Nam in ***Figure 2-8***, the percent change of GDP in Cambodia is above 4.00 % from 1995 to 2019 except in 2009 which was 0.087 % (World Bank, 2020b). Similarly, the percent change of GDP in Lao PDR is above 4.65 % except in 1998 which was 3.97 % (World Bank, 2020b) (***Figure 2-9***). While this growth can considerably improve the lives of people in those countries, it can also cause a much larger amount of waste as stated above.



Source: World Bank (2020b)

Figure 2-8. GDP on each 4 MRC MCs in LMB during 1995-2019.

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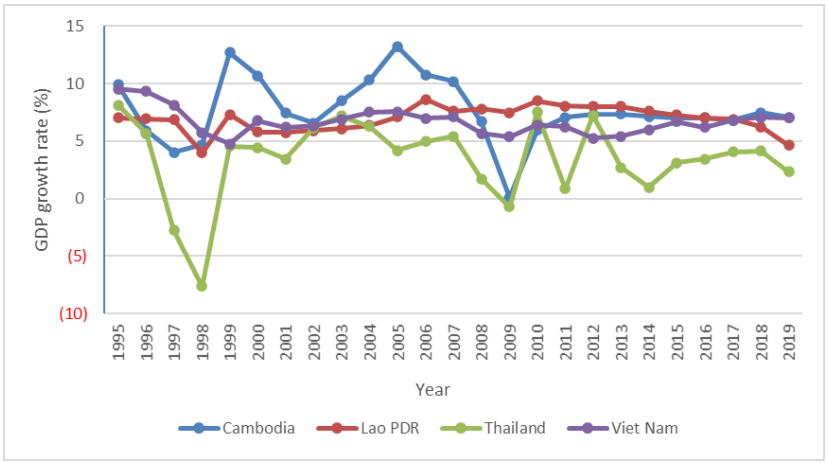


Source: World Bank (2020b)

Figure 2-9. Percentile change of GDP in each MRC MCs during 1995-2019.

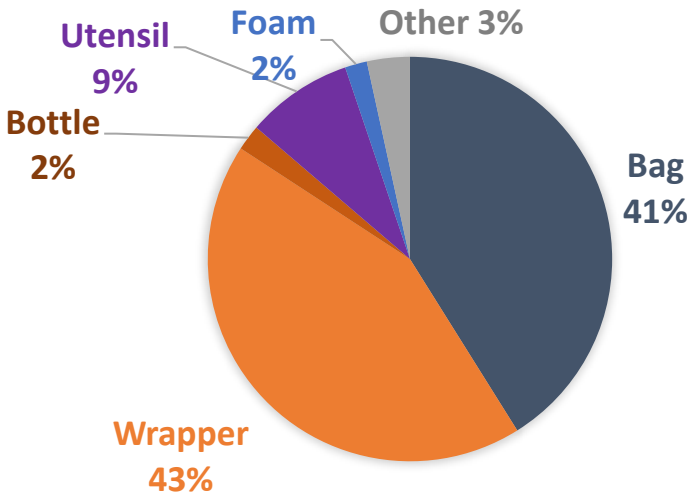
The details of the plastic wastes, such as composition in the landfill and incineration system, has been studied in the Chulalongkorn university, through surveying the waste generated in nine coastal areas of Thailand by interviewing the relevant agencies such as municipalities and the Pollution Control Department (Malakul, P. et al., 2019).

Since wastes in the area are sent to either landfill or incineration after collection by municipalities, the results show the composition in those system likewise.

The results are shown in ***Figure 2-10***. Wrapper topped accounting for 43%, followed by bags for 41%, utensil for 9%, together making up the 93% of the overall composition. These three has the same issue, which is the low selling price for recycling. Also, its food stains often increase the cost of washing, which demotivates the recyclers from buying them (Malakul, P. et al., 2019).

On the other hand, bottles having high demand in the recycle market accounts for only 2%, despite its high popularity in our daily lives. Especially PET bottle is of the large demand for recycling

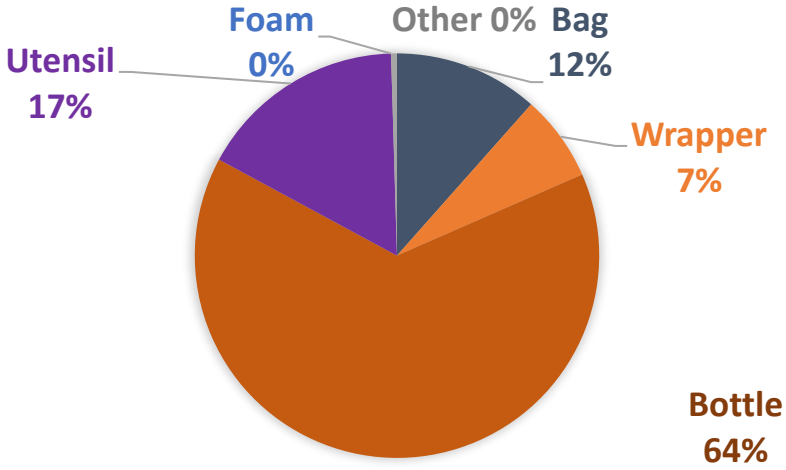
(***Figure 2-11***) especially in the fiber industry and the food packaging industry, in some countries where recyclable materials are allowed in production (Malakul, P. et al., 2019).



Source: Malakul, P. et al (2019)

Figure 2-10. Composition of plastic waste in waste management system in Thailand

Figure 2-11 shows the types of plastic waste handled by the recycle shops of the same area, surveyed in the same study, showing the remarkably large proportion of bottle accounting for 64%.



Source: Malakul, P. et al (2019)

Figure 2-11. Composition of plastic waste handled in recycle shops in Thailand

Plastic waste in LMB

The Lower Mekong River Basin is made up of the Northern Highlands, the Khorat Plateau, the Tonle Sap Basin and the Mekong Delta. It covers Cambodia, Lao PDR, Thailand, and Viet Nam. The economies of the LMB countries have experienced a period of rapid growth and transformation over recent decades, which also benefits these riverine communities. However, millions of people in the LMB still live without basic amenities such as clean drinking water and electricity (MRC, 2021).

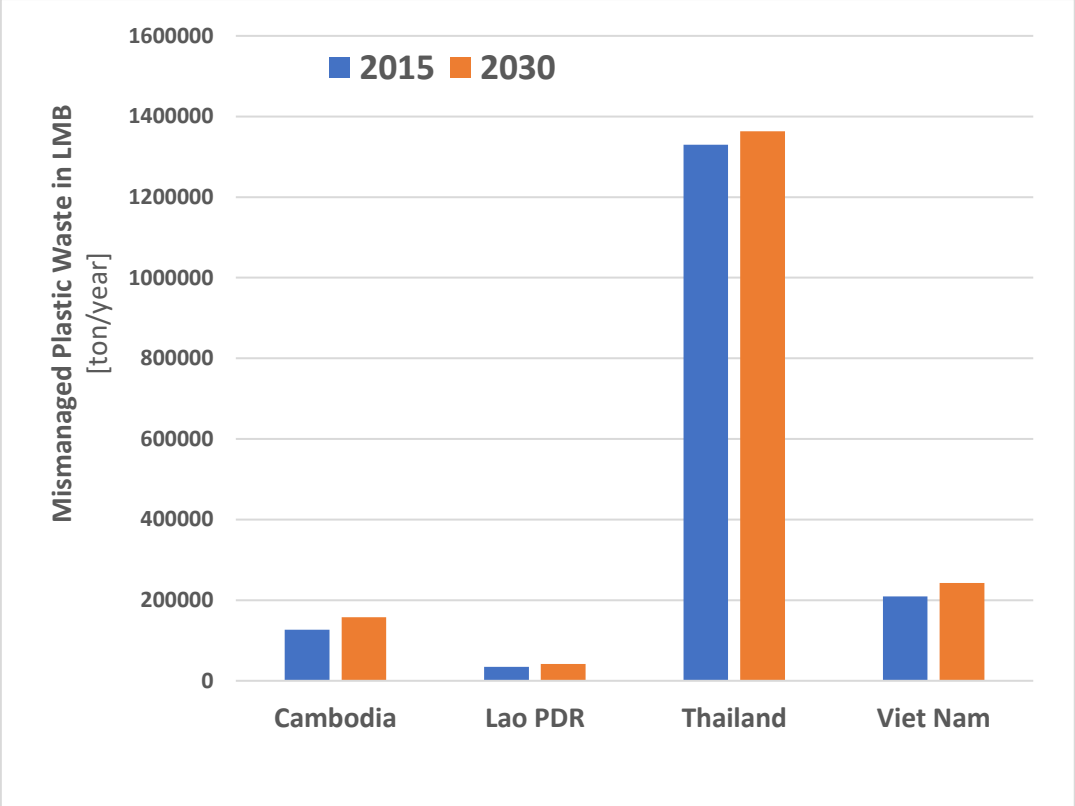
A bit of demographical and geographical information of LMB is available in ***Table 2-2***. There are approximately 65 million people living within the LMB (Global Population Data (2015). Population of Thailand and Viet Nam together account for 70%, over two thirds of the population in the LMB, and Cambodia a fifth and Lao PDR the remainder. There is a large variation in population distribution throughout the LMB. The large, sparsely populated mountainous areas of the LMB in Lao PDR have the lowest population densities at 30 person per square kilometer. Cambodia's population density is nearly triple that of Lao PDR, and Thailand's a little higher than that of Cambodia, and the Vietnamese portion of the basin has the highest population density (MRC, 2019).

Table 2-2. Population and population density in the LMB

Country	Population in LMB (million) (2015)	Share of LMB population (%)	Share of national population (%)	Land area within basin (km^2)	Share of total country land area (%)	Population density (pax/km^2)
Cambodia	13.4[1]	22[1]	86[1]	156,435[1]	89[2]	86
Lao PDR	6.2[1]	10[1]	91[1]	206,620[1]	90[2]	30
Thailand	25.4[1]	39[1]	37[1]	203,060[1]	40[2]	125
Viet Nam	19.8[1]	31[1]	22[1]	66,773[1]	22[2]	297
Total	65.0[1]	100[1]	-	632,888[1]	-	103

Source: 1. MRC (2019), 2. Calculated by land area within basin and land area data from the World Bank databank.

From this information combined with the per capita waste generation (***Table 2-1***), we calculated the amount of mismanaged plastic waste particularly generated in LMB region (***Figure 2-12***). It did not show as significant a difference as the amount of plastic waste in Cambodia and Lao PDR because share of national population is high and mismanaged general waste rate is also high (***Figure 2-7***), still, it is too big an amount considering the lack of basic infrastructure in LMB which will be further discussed in ***Capacity of Riverine Plastic Debris Monitoring***.

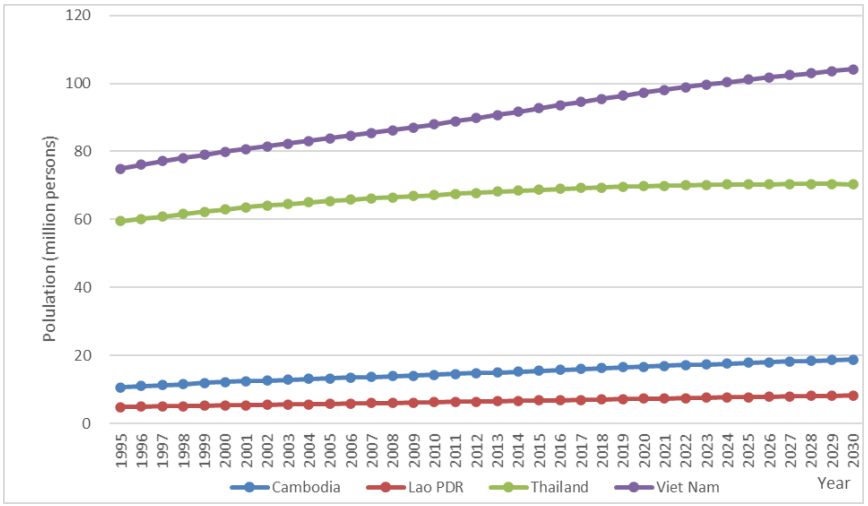


Source: Arranged based on The World Bank (2020, 2019), MRC (2019), UNEP (2017a), Jambeck et al. (2015), Schmidt et al. (2017)

Figure 2-12. Estimated amount of Mismanaged Plastic Waste in LMB from each MRC MCs

The populations in 4 MRC MCs have all been growing steadily, and are projected to continue growing in the future (***Figure 2-13***). The total population of MRC MCs is estimated to be approximately 202 million in 2030, which is 1.34 times larger than that of 1995 (World Bank, 2020b).

Assuming the waste generation rate the same, current and future amount of waste produced in LMB can be calculated by multiplying the population into the per capita generation. This makes the total amount 172 kilo tonnes/day in 2015, and 187 kilo tonnes/day in 2030. We will discuss the amount of plastic wastes in particular, later in ***Section 5***.

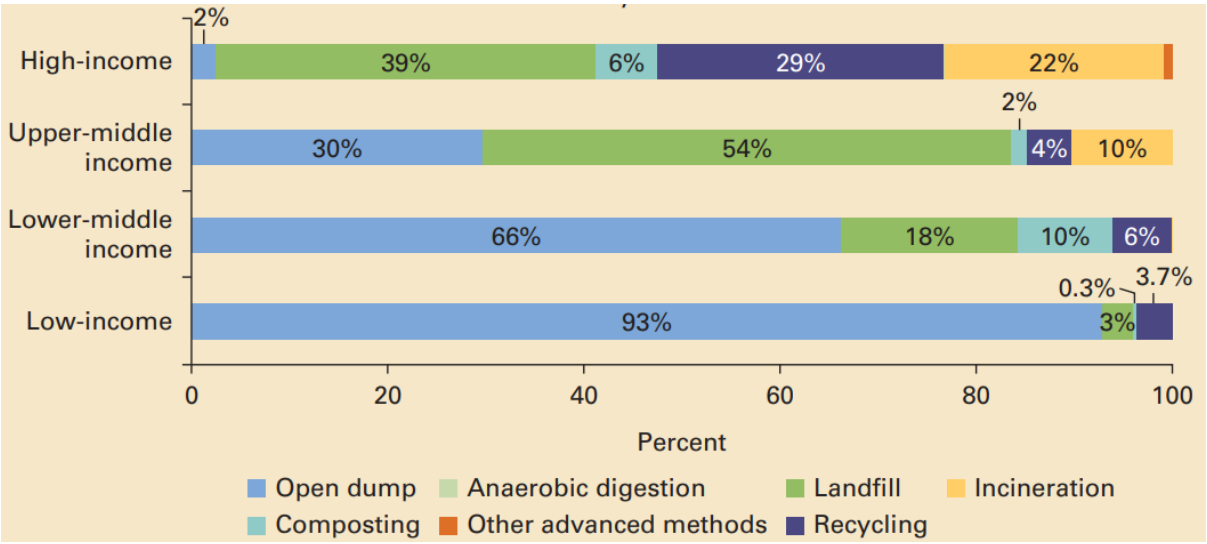


Source: World Bank (2020b)

Figure 2-13. Estimated and projected Population in MRC MCs from 1995-2030 by World Bank

The plastic waste flow provides an overall picture of the movement of waste in different sectors and how countries are addressing the plastic waste issue (***Figure 2-15***, ***Figure 2-16***, ***Figure 2-17***, and ***Figure 2-18***). The diagrams respectively show the waste flow in Phnom Penh (Cambodia), Vientiane (Lao PDR), Thailand and Viet Nam. Among them, ***Figure 2-15*** and ***Figure 2-16*** show the estimated amount of "unmanaged waste" or "uncollected waste" which can eventually leak into the environment. However, the actual understanding of leakage behavior requires filling the gap in the definition of terms.

In lower-middle income countries in which Cambodia, Lao PDR, and Viet Nam is classified (World Bank, 2018), Open dumping accounts for 66 % of the disposal method. And in Upper-middle income countries where Thailand is classified (World Bank, 2018), open dumping still accounts for 30% (***Figure 2-14***).



Source: World Bank (2018a)

Figure 2-14. Waste disposal method compared by income levels

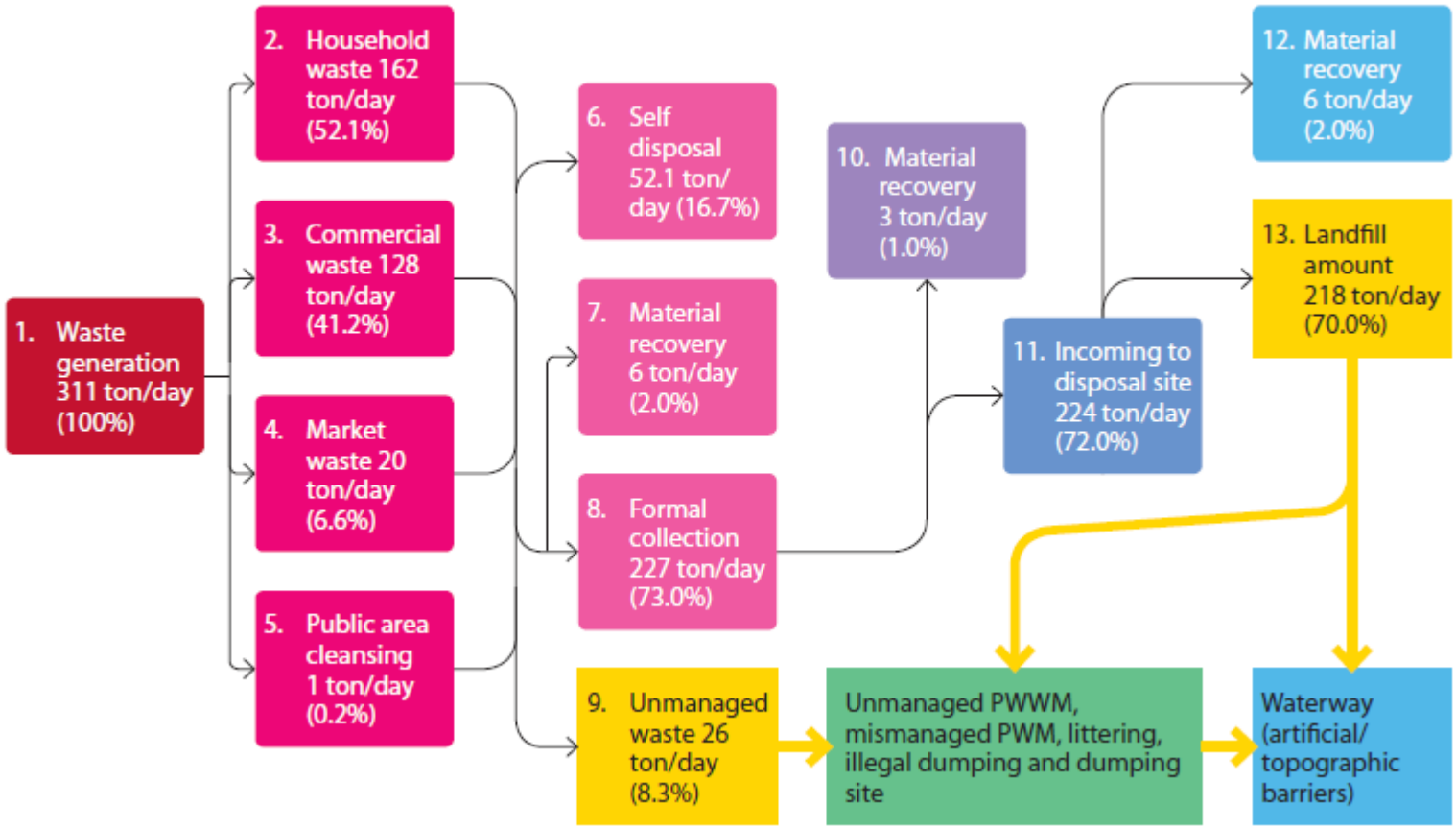
On the other hand, the study by Jambeck et al. (2015) defines "mismanaged waste" as material that is either littered or inadequately disposed i.e., not formally managed, including disposal in dumps or open, uncontrolled landfills or final disposal site such as open dumping. This means that what is understood as "collected" or "landfilled" in the existing waste flow diagrams maybe "mismanaged waste" in Jambeck et al. (2015)'s interpretation. So, the precise comparison of diagrams and existing research data on plastic debris emission still requires the consideration of plastic debris emission from various areas including open dumping sites.

Although composing plastic waste flow helps us understand the amount of waste flowing in different stage of treatment, the CounterMEASURE project's conceptual framework mentioned that plastic leakage can occur in any phase of waste flow, such as production and consumption, retailing and waste management services (UNEP, 2020a) , underlining the importance of close look into the actual behavior of waste.

Plastic leakages from each value chain are triggered by specific causes including accidental loss (degradation of buoys, loss of nets), unintentional loss (unintentional littering), and unmanaged and mismanaged waste. Some plastic loss and leakage directly fly into the waterways (or indirectly via drainage systems), and some is formed at the inland accumulation sites such as illegal dumpsites or littering spots, where wastes get scattered by human behavior or the topographic features. The accumulation sites are the most possible potential plastic leakage source (plastic leakage source hotspot), where wastes can leak into the waterway and can get scattered by environmental factors (i.e., strong wind, heavy rain and flooding) and by human factors (e.g., intentional dumping to the waterway) (UNEP, 2020).

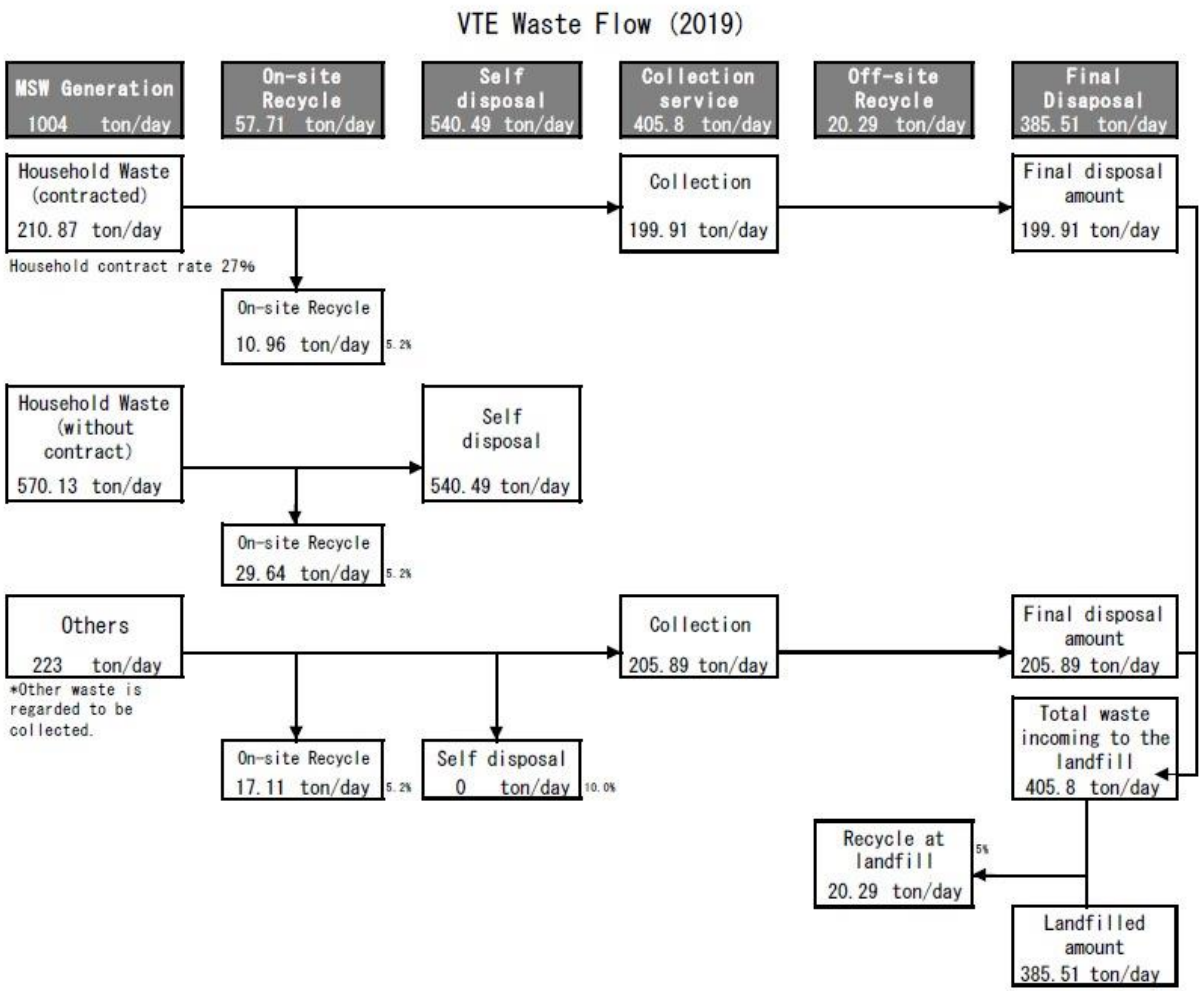
For the complete treatment of plastic waste leaving no mismanaged behind, a systematic monitoring through explicit policy frameworks is vital. Meaning, prevention, collection and treatment of waste leakage both in the water and on land through appropriate waste management should be strictly supervised on the national level.

In this report, we will discuss about frameworks that work as guideposts, capacity required in monitoring implementation, and results of monitoring activities for further development of harmonized monitoring system.



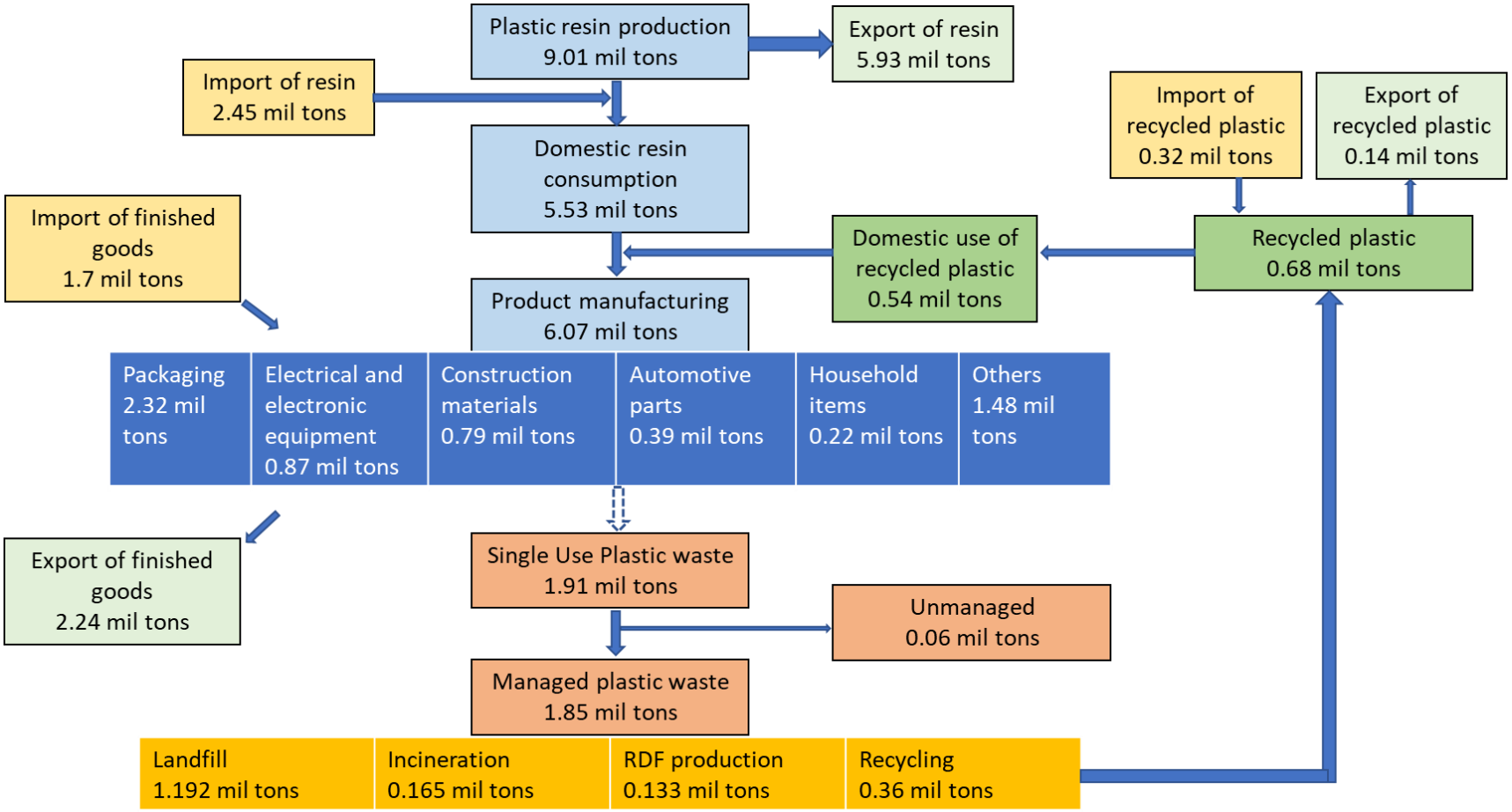
Source: UNEP (2020a)

Figure 2-15. Plastic waste flow in Phnom Penh (Cambodia)



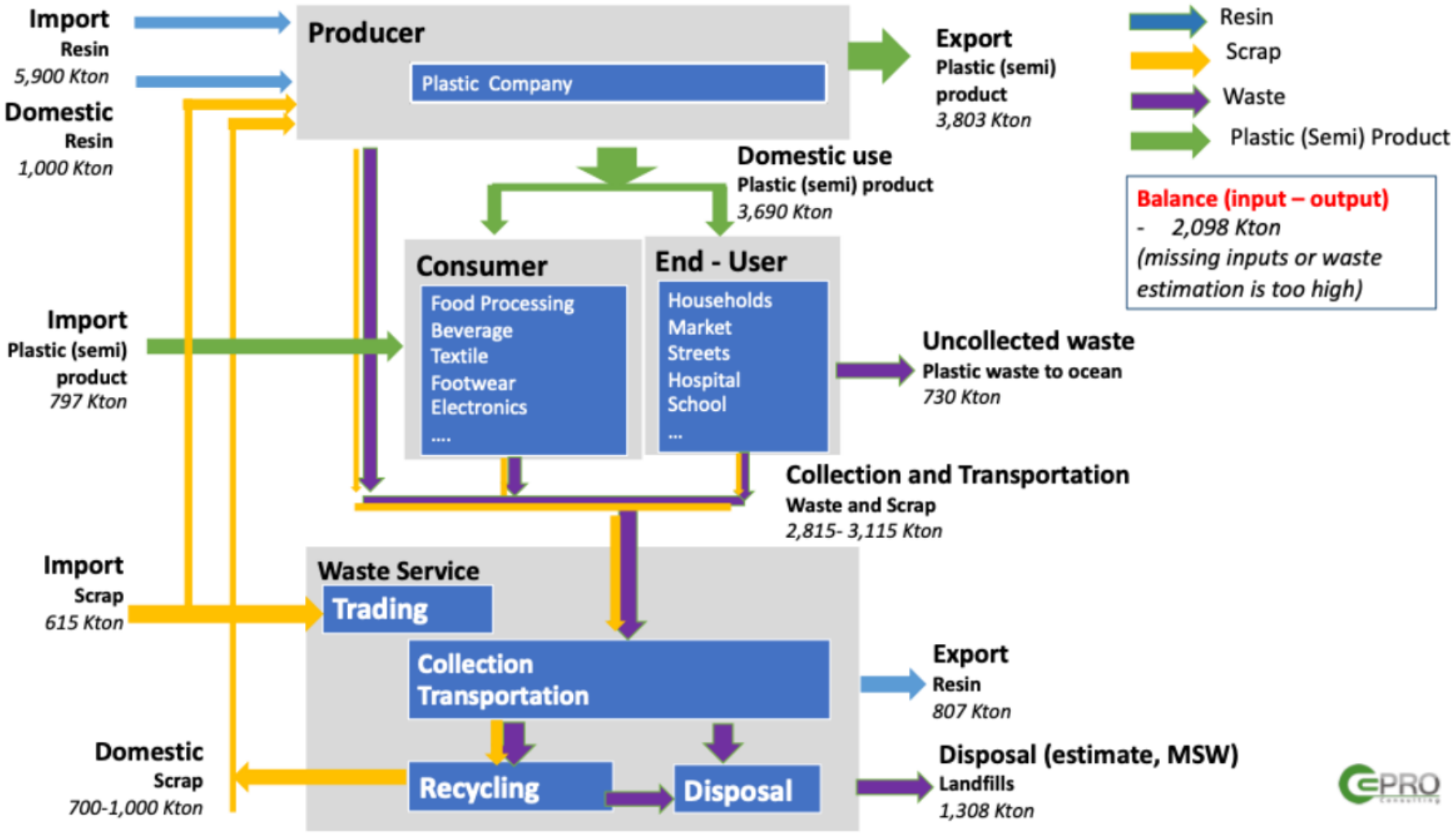
Source: JICA (2021)

Figure 2-16. Plastic waste flow in Vientiane



Source: PCD 2020, unpublished

Figure 2-17. Plastic waste flow in Thailand



Source: Viet Nam Chamber of Commerce and Industry (VCCI) and Partnering for Green Growth and Global Goals 2030 (P4G), 2019

Figure 2-18. Plastic waste flow in Viet Nam

Main results and key challenges

- Despite its convenience, plastic pose serious dangers to the environment in a very wide area, almost forever.
- Production of plastic is increasing worldwide and also in some MRC MCs such as Thailand and Viet Nam (***Figure 2-3***).
- Countries in LMB produce considerably less amount of waste than developed areas in the ASEAN, but development can cause steep increase in the amount of waste (UNEP, 2017).
- The amount of plastic waste is estimated to significantly increase in every step of development (World Bank, 2012).
- The actual amount of plastic waste was distinctly large in Thailand and Viet Nam. Furthermore, mismanaged rate of general waste in MCs are all above 75 %, emphasizing the increased need for the appropriate waste management. Also, vulnerable waste collection service and uncontrolled disposal site are the challenges in MRC MCs.

3. Policy and Institutional Frameworks for Plastic Waste Management in LMB

3.1. Regional Framework

Marine debris has been recognized as one of the key environmental issues at the global level. A recent study estimates that between 4.8 and 12.7 million tons of plastic were discharged into the ocean in 2010, and five ASEAN countries are included in the 10 top-ranked countries and account for 28% of the land originated debris with the potentiality to be discharged into the sea in the world (Jambeck *et al.*, 2015). For LMB, this rank included Thailand and Vietnam. Several research reported that the mismanaged wastes are transported to the sea and marine debris gives negative impacts on the ecosystem and several industries, such as tourism and fishery as below. Votier et al. (2011) raise an alert that the items used by birds for nest construction typically are ropes, straps and fishing line, which pose an entanglement threat to adults and chicks. Young et al. (2009) found a dead Laysan albatross chick with plastic in its stomach. Nets, pots and traps can continue to attract and entangle or capture biota, both target and non-target species, a phenomenon referred to as 'ghost fishing'. Thus, marine debris issues should be tackled in land to sea integrated manner. The impact of plastic pollution to the living organisms is later discussed in ***Chapter 6***.

On this background, nations in the ASEAN region have worked together in various events, publishing regional frameworks that clarify the activities to be done in the region (***Table 3-1***). For example, ASEAN Conference on Reducing Marine Debris in ASEAN Region held in Thailand in November 2017 recommended to consider integrated land-to-sea policy approach by developing and implementing a regional action plan on marine debris in the ASEAN region. In order to enhance the concreate action in ASEAN Region, Bangkok Declaration on Combating Marine Debris in ASEAN Region and ASEAN Framework of Action on Marine Debris were adopted on ASEAN Summit in June 2019. Particularly, ASEAN Framework of Action on Marine Debris stipulates the formulation of Regional Action Plan (RAP) which has been launched in May 2021 aiming to enhance coordination at the regional and international levels for achieving sustainable management of coastal and marine environments through responding to marine plastic pollution. Similarly, The Action Plan for the Protection and Development of the Marine Environment and Coastal Areas of the East Asian Seas Region (the East Asian Seas Action Plan) was approved by the Coordinating Body on the Seas of East Asia (COBSEA), in 1981 with concerns over the impacts and sources of the marine pollution. COBSEA is one of the regional seas conventions and action plans initiated by UNEP. Its nine participating countries are Cambodia, Thailand, Viet Nam, People's Republic of China, Indonesia, Republic of Korea, Malaysia, the Philippines, and Singapore. Its regional action plan COBSEA Regional Action Plan on Marine Litter 2019 (COBSEA RAP MALI 2019) agrees well with the ASEAN Framework of Action, it focuses much more on the monitoring, national action plans against marine litter and their removals, and it establishes a science-to-policy body specifically on marine litter (ASEAN, 2020b).

Among all the regional frameworks listed up, COBSEA RAP MALI 2019 and ASEAN RAP seems the most specific framework with the concrete action plan for monitoring. Emphasizing the importance of data compilation and analysis, it plans to establish a Marine Litter Monitoring Expert Group for building a motoring programmes, as well as regional guidance and trainings. Even though Lao PDR is not the member of this community, hopefully, the MRC MCs can cooperate in working out the monitoring system for marine debris.

Summary of published regional frameworks covering the LMB region has been provided in ***Table 3-1*** below.

Table 3-1. Regional frameworks which cover LMB

Name of reginal framework	Purpose and Overview
Agreement on the Cooperation for the Sustainable Development of the Mekong River Basin 5 April 1995	- The Governments of The Kingdom of Cambodia, The Lao People's Democratic Republic, The Kingdom of Thailand, and The Socialist Republic of Viet Nam, being equally desirous of continuing to cooperate in a constructive and mutually beneficial manner for sustainable development, utilization, conservation and management of the Mekong River Basin water and related resources. - Even though the Mekong Agreement does not specifically mention plastic debris pollution, it contains articles relating to the protection and conservation of water quality and ecosystems of the Mekong River.
Bangkok Declaration on Combating Marine Debris in ASEAN Region (June, 2019)	- Declared on the occasion of the 34th ASEAN Summit in Bangkok, Thailand on 22 June 2019. - Emphasizes the ASEAN Community Vision 2025, particularly the ASEAN Socio-Cultural Community (ASCC) Blueprint 2025 on Conservation and Sustainable Management of Biodiversity and Natural Resources which reaffirmed the commitment of strategic measures to "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"; - Declares to strengthen the actions at national level and inter-sectoral levels between ASEAN sectoral bodies, but the included statements do not go any further than general courses of actions, such as encouraging integrated land-to-sea approach.
ASEAN Framework of Action on Marine Debris (June, 2019)	- ASEAN Member States including Cambodia, Lao PDR, Thailand and Viet Nam welcomed this framework at the Special ASEAN Ministerial Meeting on Marine Debris on 5 March 2019 in Bangkok, Thailand. - Comprises four (04) priority areas namely: (i) Policy Support and Planning; (ii) Research, Innovation, and Capacity Building; (iii) Public Awareness, Education, and Outreach; (iv) Private Sector Engagement. - Each priority area consists of actions and suggested activities for further collaboration in ASEAN region and among ASEAN and its partners in combating marine debris. - Stipulates the formulation of regional action plans on combating marine debris in the ASEAN Region. - Suggested activities include standardization of methods for the measurement and monitoring of marine debris, as well as providing trainings on monitoring and management of marine debris. - Suggested activities also include the corporation and partnership across research institutions to collect and exchange data and information to corporate on combating marine debris. -
ASEAN Regional Action Plan on Combating Marine Debris	- Launched in May 2021 by ASEAN Secretariat, aiming to enhance coordination at the regional and international levels for achieving sustainable management of coastal and marine environments through responding to marine plastic pollution. - Plans include developing a guidebook for common methodologies for assessment and monitoring of marine Litter.

Name of reginal framework	Purpose and Overview
	- Plans also include conducting a regional study on microplastics. - ASEAN Working Group on Coastal and Marine Environment (AWGCME) will be in charge of overall management coordinating with relevant sectoral bodies.
COBSEA Regional Action Plan on Marine Litter (COBSEA RAP MALI 2019)	- COBSEA aims at the sustainable development and protection of the marine environment and coastal areas of East Asian Seas. The Strategic Directions 2018-2022 and COBSEA Regional Action Plan on Marine Litter (RAP MALI) provide regional frameworks for cooperation and identify regional priorities to guide action. - Overseeing the implementation of the East Asian Seas Action Plan, adopted in April 1981, and revised in 1994. The Action Plan for the Protection and Development of the Marine Environment and Coastal Areas of the East Asian Seas Region (the East Asian Seas Action Plan) aims at protecting the marine and coastal environment in the region for the health and well-being of present and future generations - In LMB, Cambodia, Thailand and Viet Nam participate in COBSEA. - Published at the 24th Intergovernmental Meeting of the Coordinating Body on the Seas of East Asia (COBSEA) at Bali, Indonesia, on 19-20 June 2019. - Supports COBSEA participating countries (Cambodia, People's Republic of China, Indonesia, Republic of Korea, Malaysia, the Philippines, Thailand, Singapore and Viet Nam) to deliver target 14.1 of Sustainable Development Goal 14, to prevent and significantly reduce marine pollution of all kinds. - Its goals and objectives include improving the monitoring and assessment of marine litter and its impacts for a science-based approach. Mentioning the absence of adequate science-based monitoring and assessment programs, it plans to: 1) establish a Marine Litter Monitoring Expert Group under the COBSEA 2) prepare regional guidance on the development of monitoring programmes 3) conduct regional training for monitoring 4) develop national monitoring programmes based on respective national policies and circumstances 5) prepare regional report on marine litter and microplastic 6) explore development of a regional marine litter and microplastic monitoring meta database/portal

Source: ASEAN (2019a), UNEP (2021), ASEAN (2019b), MRC (1995)

3.2. International Convention

There are certain International Conventions related to the prevention of marine pollution, and MRC MCs have ratified some of those with a view to save the environment.

International Convention for the Prevention of Pollution from Ships (MARPOL) is one of the international conventions for the prevention of marine pollutions. It is the main international convention covering prevention of pollution of the marine environment by ships from operational or accidental causes. The MARPOL Convention was adopted on 2 November 1973 at IMO. The Protocol of 1978 was adopted in response to a spate of tanker accidents in 1976-1977. As the 1973 MARPOL Convention had not yet entered into force, the 1978 MARPOL Protocol absorbed the parent Convention. The combined instrument entered into force on 2 October 1983. In 1997, a Protocol was adopted to amend the Convention. Annex 3 'Prevention of Pollution by Harmful Substances Carried by Sea in Packaged Form' identifies substances that are harmful to marine environment. This includes marine pollutants stated in the International Maritime Dangerous Goods Code (IMDG Code) or those

who met the criteria stated in the Convention. Annex V 'Prevention of Pollution by Garbage from Ships' deals with different types of garbage and specifies the distances from land and the manner in which they may be disposed of. The most important feature of the Annex is the complete ban imposed on the disposal into the sea of all forms of plastic.

The Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter 1972, (London Convention) for short, 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 practicable steps to prevent pollution of the sea by prohibiting the dumping of wastes and other matter. In 1996, the "London Protocol" was agreed to further modernize the Convention, and eventually, replace it. Under the Protocol all dumping is prohibited, except for possibly acceptable wastes.

The Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal 1989 (The Basel Convention) regulates the transboundary movement of hazardous waste and other wastes to make such trade operate in accordance with environmentally sound management principles. The 2019 amendments clarify the scope of plastic wastes presumed to be hazardous and therefore subject to the Prior Informed Consent (PIC) procedure.

It seems quite satisfactory for the prevention of pollution in the water, nevertheless, all of them place emphasis on marine pollution alone, leaving behind the landlocked countries such as Lao PDR. Also, ratification status of these multi-lateral treaties in LMB is yet to be improved as shown in **Table 3-2**.

Table 3-2. Ratification status of multi-lateral treaties to the prevention of marine pollutions

State	Ratification status of multi-lateral treaty (as of 12 July 2020)						
	IMO Convention 48[*1]	MARPOL 73/78[*2]	MARPOL 73/78 (Annex III)[*3]	MARPOL 73/78 (Annex V)[*4]	London Convention 72[*5]	London Convention Protocol 96[*6]	Basel Convention[*7]
Cambodia	x	x	x	x			x
Lao PDR							x
Thailand	x	x					x
Viet Nam	x	x	x	x			x

Source: ASEAN (2020a)

Legends

x: Convention/Protocol/Annex ratified, Leg: Legislation enacted

Note

****1 International Maritime Organization (IMO) Convention***

****2 International Convention for the Prevention of Pollution from Ships, 1973, as modified by the Protocol of 1978 relating thereto (MORPOL 73/78)***

****3 Annex III Prevention of Pollution by Harmful Substances Carried by Sea in Packaged Form***

4 Annex V Prevention of Pollution by Garbage from Ships
5 Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter (London Convention: LC).
6 1996 Protocol to the Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter, 1972 (London Protocol: LP)
7 The Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal 1989 (The Basel Convention)

3.3. National Policy Frameworks (Laws/ Regulations)

Policy frameworks on plastic waste management and monitoring of each 4 MRC MCs in LMB are shown in this section.

Each country has respectively published the plans or the laws regulating the use of plastic, to realize the appropriate management of plastic waste/debris in the near future. Still, checking their contents makes us realize that we need more strict and specific laws empowered in order to control the plastic waste/debris at the national level. Even some existing action plans themselves may need some revision, since it put too much emphasis on awareness raising or lacks some essential parts to cover riverine plastic pollution.

And it seems that none of 4 MRC MCs have had policy framework for monitoring of plastic waste, nor monitoring of riverine debris. To grasp the up-to-date situation of waste such as volume, composition and littering accumulation, building the concrete system for monitoring of waste built and supervised with policy frameworks is necessary.

Table 3-3 summarizes the national policy frameworks in MRC MCs, and the following sections discuss the detailed information in each country.

Table 3-3. Summary of National Policy Framework regarding waste/debris monitoring in MRC MCs

Country	Basic env	SWM	3R, EPR	Marine debris Action Plan	MD related (e.g., collection, monitoring)
Cambodia	Law	Law, Strategy	Strategy		
Lao PDR	Law, Strategy	Law	Action Plan		
Thailand	Law	Law	Action Plan, Roadmap	Plastic Action Plan	
Viet Nam	Law	Law	Action Plan	Action Plan	

Source: Sith (2021), Chansomphou (2021), Phong (2020), Tularak (2020)

3.3.1. Cambodia

Sub-decree No. 36 ANK.BK, dated on 27 April 1999 on Solid Waste Management was ratified with the goal of protecting the health of the Nation's citizens and its environment by governing "collection, storage, transportation, recycling and disposal of municipal wastes".

Sub-Decree No. 113 on ANK.BK. Dated on 27 September 2015 on the litters and solid waste management in urban-town, delegate solid waste management's mandates to local government, requiring them to handle waste collection, final disposal, clean-up recreation areas, public awareness dissemination, and enforcement.

Sub-decree No.168 ANK.BK. dated 10 October 2017 on the Management of Plastic Bags, promotes the reduction of import, production, distribution and use of plastic bags in order to enhance public health, environment, and landscaping. Its decree also includes provisions to manage and reduce SUP, reduce and management plastic imports and address micro-plastic pollution.

Cambodia's Law on Fisheries, which is currently under review, will include provisions on inland aquaculture and mariculture management, water quality and discharge of waste matter.

As an action plan, **Policy on litters and solid waste management in urban-town, 2020-2030** includes the medium- and long-term strategies outline the further formulation of legal frameworks for sound waste management including plastic, mandating the local government to take measure for sound waste management, and engagement of private sector in investing waste management including landfill operation.

3.3.2. Lao PDR

There are 1 national strategy and 1 capital strategy for waste management and environmental pollution in Lao PDR. Even though they cover the aspect of plastic waste and plastic pollution, there is no specific policy framework for plastic waste. Whereas, Ministry of Natural Resources and Environment (MONRE), Lao PDR recognises land-to-sea leakages of marine debris, and it is interested in NAP against freshwater debris rather than marine debris, as an inland country (ASEAN, 2020 a).

National Pollution Control Strategy to 2025 with Vision to 2030 (NPCSAP): Pursuant to the Revised Law on Environmental Protection 2012 and subsequent decrees, regulations and instructions, the Pollution Control Department (PCD) of MONRE is tasked to prepare a National Pollution Control Strategy to 2025 with Vision to 2030 (NPCSAP). This strategy and long-term vision to 2030 will guide the country's environmental pollution prevention and control work in the period of promoting industrialization and modernization of the country.

Sustainable Solid Waste Management Strategy and Action Plan for Vientiane 2020-2030: The long-term targets for sustainable solid waste management for Vientiane are developed to contribute to achieving the National Green Growth Strategy (NGGS) of the Lao PDR till 2030 and the Sustainable Development Goals (SDGs). This action plan presents the indicative long-term targets which are aligned to associated goals specified in NGGS and SDGs.

3.3.3. Thailand

Thailand's Roadmap on Plastic Waste Management 2018-2030 and the Action Plan on Plastic Waste Management 2018-2022 (PCD 2019) are the most direct policies concerning plastic waste. They were introduced by PCD, MONRE. Under the Roadmap, there are 2 main targets to be achieved by 2030. The details of targets are explained as follow:

- **Target 1**. ***Phase I***: Elimination of cap seal, oxo-plastic and microbead from use within 2019.

  Phase II: Elimination of plastic bags with thickness < 36 microns, food-containing foam, single-use plastic cup and plastic straw from use by 2022.

- **Target 2**. Recover and utilization 100% of target plastic waste by 2027.

It should be noted that implementation of this policy is mostly based on awareness raising and cooperation. There is not penalty of fine enforced if the targets are not met. In addition, most of the targets in the Action Plan are not quantifiable.

Action Plan on Plastic Waste Management 2018-2022: Targets of this action plan are 1) to stop using Styrofoam food containers, plastic straws, Single Use Plastic (SUP) bags thickness <36 micron, and SUP cup thickness <100 micron, 2) 50% recycling of targeted plastic wastes to meet circular economy concept. However, regulation of banning SUP does not exist.

There are also 2 policy frameworks for import of plastic waste as follows:

Export and Import of Goods Act, B.E. 2522 (1979): There is a Ministerial Notification concerning the control of import of plastic waste. The regulation authorizes the Department of Industrial Works to give or reject import licenses for plastic waste for the purpose of recycling.

The Notification of Ministry of Commerce regarding an import of goods into the Kingdom of Thailand (No.112) B.E. 2539 (1996): prescribes that plastic waste, plastic chip, and unusable plastic product, shall get an approval prior to import into the country. Import permit will be granted after an approval of Ministry of Industry is received.

The Enhancement and Conservation of National Environmental Quality Act B.E.2535 (1992) states that sample collection and analysis methods shall be studied before new parameters for water quality standards is proposed. Seeing the water quality parameters not including concentration of garbage or plastic waste in the water as of October 2020, further research may be required to introduce these standards for riverine debris monitoring.

Extended Producer Responsibility (EPR) which has been proven successful in many countries in Europe and South Korea, has not gained political attention in Thailand. The Pay as You Throw (volume-based waste management fee), packaging taxes and Deposit Refund Scheme (DRS) principles are also effective in reduction of waste and increase recycling rate. For EPR, packaging taxes and the volume-based waste management fee may require a new regulation while DRS can be implemented by private companies, without a new law, if they are willing to do so. If EPR law is in place, DRS can be one of mechanisms to support compliance.

3.3.4. Viet Nam

There are laws and regulations in Vietnam coping with the plastic pollution. In particular, Viet Nam has policy framework regarding to SUP bag such as establishing tax, eco-friendly plastic bag. In addition, the amendments to the Environment Law, which is expected to come into effect in 2020, propose new contents on SWM (Solid Waste Management) and plastic pollution including: plastic pollution management, segregation of solid waste at sources, collection fee for different types of wastes. Although Viet Nam has approved the National Action Plan on Marine Plastic Debris Management by 2030, but the country is yet to publish the action plan for plastic waste from Municipal Solid Waste (MSW).

Decision 1746/ QD-TTg dated 04/12/2019, on national action plan for management of marine plastic litter by 2030: plans the following;

1) Education and change to behavior pertaining to plastic and marine plastic.
2) Collection, classification, storage, transfer and processing of plastic waste from coastal and ocean based activities.
3) Control of plastic litter at source
4) International cooperation, scientific research, application, development and transfer of marine plastic litter processing technologies
5) Consistent and effective investigation, survey, review, research and formulation of mechanisms for marine plastic litter management

Decision No. 491/QD-TTg dated 07/5/2018, the national strategy on integrated solid waste management to 2025 vision to 2050 : 85% of MSW will be recycled, reused, recovered for use as an energy source or to produce organic fertilizer (by 2020), and 90% of MSW will be recycled, reused, recovered for use as an energy source or to produce organic fertilizer (by 2025).**Law No. 57/2010/QH12, Environmental Protection Tax**: established taxable commodity groups of which plastic bags are included and taxed. Moreover, **Decree No. 67/2011/ND-CP** detailing and guiding a number of articles of the Law on Environmental Protection Tax (i.e., taxable plastic bags specified in Clause 4, Article 3 of the aforementioned).

The Prime Minister's Decision No. 06/2018/QDTTg of 2018: regulate the functions, tasks, powers and organizational structure of the Vietnam Administration of Sea and Islands (VASI) under the Ministry of Natural Resources and Environment. With China putting a restriction on the import of scrap plastic, waste import in Viet Nam has increased significantly (0.25 million tonnes of plastic was imported in 2016 and 0.27 million tonnes in just the first half of 2018).

Decree No. 38/2015/ND-CP on waste management and scraps: requires sorting of plastic waste in domestic solid waste and industrial solid waste for recycling; such waste must be managed from generation to collection, transportation and handling.

Decision 582/QD-TTg dated 11/4/2013 of Prime Minister on approving the project on improving the environmental pollution control for the use of non-biodegradable plastic bags by 2020.: This policy aimed (i) to reduce plastic bag consumption by 40 per cent in supermarkets and shopping malls and by 20 per cent consumption in the markets and (ii) to collect and recycle domestic plastic bags by 25 per cent in 2015 as compared to 2010. By 2020, the corresponding rates were set at 65 per cent, 50 per cent and 50 per cent, respectively, as compared to 2010.

Circular No. 07/2012/BTNMT details the regulation on eco-friendly plastic bags: Up to March 2017, 34 different kinds of plastic bags from 30 companies were approved as eco-friendly bags; Decision No. 582/QD-TTg was notified in 2013 to approve the project on enhancing the control of environmental pollution due to the use of non-biodegradable plastic bags by 2020.

3.4. National Institutional Frameworks

This section shows the roles and actions of various institutions involved in reducing plastic pollution in MRC MCs. Other than governmental authorities, this includes the public and private sectors, multinational development agencies, international Non-Governmental Organization (NGO)s and community-based/civil society organizations. Institutional arrangements involve inter- and intra-agency coordination. And cooperation between multiple governmental authorities at the central/national and local government levels seems common in these countries.

Nonetheless, the detailed information of institutional frameworks in each country suggests the lack of clear allocation of work and responsibility between the institutions. For the smooth operation of waste management, establishment which explicitly states the responsibility would be of great value.

Table 3-4 summarizes the national institutional frameworks in MRC MCs, and the following sections discuss the detailed information in each country.

Table 3-4. Summary of National Institutional Frameworks regarding waste/debris monitoring in MRC MCs

Country	Environment	SWM	Marine debris	Riverine debris

Cambodia	MOE	Dpt. of SWM (MOE), Provincial administrations / Phnom Penh administration, MOI	Dpt. of Pollution Control (MOE)	N/A
Lao PDR	MONRE	PCD (MONRE), MOPWH		DWR
Thailand	MONRE	PCD (MONRE), DEQP (MONRE), MOPH, DLA (MOI), LAOs	DMCR (MONRE), Marine Dpt. (MOT), PAT (MOT), Fishery Dpt. (MOAC)	PCD (MONRE), DMCR (MONRE), Fishery Dpt. (MOAC)
Viet Nam	MONRE	VEA (MONRE), MOC, MOH, MPI, District People's Committees	VASI (MONRE), Directorate of Fisheries (MARD)	PPC, DARD, VIWA (MOT)

Source: Sith (2021), Chansomphou (2021), Phong (2020), Tularak (2020)

3.4.1. Cambodia

Table 3-5. Summary of roles of organizations related to waste management in Cambodia

Sector	Organization	Roles
Government	Ministry of Environment (MOE)	- Establishment of guidelines on solid waste management (SWM) including disposal, collection, transport, storage, recycling, minimising and dumping; monitoring of SWM plans.
	Ministry of Environment (Provincial Departments)	- Provides technical advice to the municipality - Collaborates in planning and implementing laws, legal instruments, and promoting citizen education - Approves landfill selection and use
	Provincial administrations / Phnom Penh administration	- Implementation of waste management policies, delivery of waste management services; municipalities have been encouraged to take over more of the role from provinces. - Preparation of action plans and budgets, and establishment of waste collection fees
	Ministry of Commerce	- Permits for the export of household waste
	Ministry of the Interior	- Support to the Ministry of the Environment in co-ordinating with other ministries (
	Ministry of the Interior (Provincial Administration)	- Approves landfill selection and use
	Ministry of the Interior (Municipality)	- Overall management of urban garbage and solid waste in their territory - Can collect service fees for waste management purposes - Must provide enough bins and services in public places - Approves recycling activities or other uses of waste
	Ministry of Economics and Finance (MoFE)	- Establishment of waste collection fees
	Ministry of Public Works and Transport	- Implementation of various international donor projects relating to solid waste management

Sector	Organization	Roles
	Ministry of Agriculture, Forestry and Fisheries	- MAFF includes a number of fisheries focused research bodies that ay support marine litter monitoring, including the Inland Fisheries Research Division and the Marine Fisheries Research Division.
	MOWRAM (Ministry of Water Resources and Meteorology)	to support data collection and monitoring efforts in the Mekong River delta – both national and transboundary - Cambodian National Mekong Commission is a key body to monitoring the status of plastic pollution in Mekong River Delta in Cambodia (with support from the Mekong River Commission);
	MOI, Capital and Provincial Department of Environment, Municipal and District Administrations	- Also responsible of SWM in addition to MOE
	Ministry of Tourism (MoT)	- Responsible for public education and identifying indicators for "aesthetics" in controlling use of plastic bags
Academia/ Research institute	RUPP	- Conducted research for JICA and SEA CIRCULA project (UNDP) related to plastic leakage into sewage system and marine.
	MOE Lab, MOWRAM	- Public water quality control (Open sources, end of pipes)
NGO	COMPED	- Co-operation with local authorities in dealing with the waste crisis, saving the environment and the reduction of greenhouse gas emissions by reducing the amount of organic waste diposed into dump site by promoting the compost approach - Has composting facility in Battambang Plastic Products, which recycles plastic bags.
International	UNEP	- Leading intergovernmental agency that encompasses the work on COBSEA (SEA circular) and the complementary CounterMEASURE project
	UNDP	- Support MOE to develop regulation related to sound waste management of plastic
	FFI ()	- In-country technical partner for COBSEA's SEA circular project and a leading NGO focusing on monitoring and data collection for biodiversity conservation including plastic in Cambodia

Source: Roath Sith

3.4.2. Lao PDR

Several stakeholders are currently involved in addressing waste issues; these include, MONRE, Ministry of Public Works and Transport (MPWT), Ministry of Industry and Commerce (MOIC), Ministry of Public Health (MOH) and Ministry of Agriculture and Forestry (MAF). Several international organizations work on raising awareness about plastic waste; assessing plastic waste littering in the rivers; and supporting Lao government on establishing policies to reduce plastic waste.

Summary of roles of organizations which are related to waste management in Lao PDR are provided in ***Table 3-6*** below.

Table 3-6. Summary of roles of organizations related to waste management in Lao PDR

Sector	Organization	Roles
Government	MONRE	- Develop and implements regulation, strategies, policies and guidelines; and - Develop a National Plastic Management Action Plan.
	PCD (MONRE)	- Responsible for formulating policies, guidelines, programmes, regulations and standards.
	Ministry of Public Works and Transport (MPWT)	- Responsible for issues related to solid waste management.
	Lao National Mekong Committee (LNMC) and Department water resources (DWR)	- Responsible for coordinating with Mekong River Commission and supervising the plan and management of river basins in Lao PDR.
	MOIC	- Issue the permits for plastic producing or waste-recycling businesses such manufacturers who produce, use, and import and export plastic; plastic recycling factories; and waste recovery centres.
Academia/ Research institute	National University of Laos (NUOL)	- The biggest national university in the country; - Faculty of Environmental Sciences of NUOL has been recently involved in the monitoring of marine plastic litter; and - NUOL has laboratory handling testing quality of recycled plastic and conducting research on microplastics.
Private Sector	Several hydropower projects	- Clean up sediment and wastes on dams.
NGO	- Green Vientiane - Various CSOs	- Raise awareness on waste and waste management.
International	- MRC - World Bank - UNDP (United Nations Development Program)	- Currently working on raising awareness about plastic waste; assessing plastic waste littering into the rivers; and supporting Lao government on establishing policies to reduce plastic waste.

Source: Vatthanamixay Chansomphou

3.4.3. Thailand

There are several ministries involved directly and indirectly in waste management. The three main ministries directly responsible for MSW are MONRE, the Ministry of Public Health and the Ministry of Interiors. Both Ministry of Public Health and Ministry of Interiors directly delegate duties to local administration to manage solid waste while MONRE formulates policies and technical guidelines, monitor, and report environmental data and serve as a coordinating body for inter-ministerial committees.

There have been increasing efforts in cooperation among public and private organizations and communities, domestically and internationally to tackle marine and riverine plastic debris. Roles of relevant organizations are explained in ***Table 3-7*** below.

Table 3-7. Summary of roles of organizations related to waste management in Thailand

Sector	Organization	Roles
Government	Pollution Control Department, MONRE	- Formulate national solid waste and plastic waste plan; - Produce national report on the state of pollution; - Monitor and report environmental data; and - Serve as a coordinating body for inter-ministerial committees.
	Regional Environment Office, MONRE	- Monitor MSW disposal facilities; - Collect MSW data; and - Monitor water quality.
	Department of Marine and Coastal Resources (DMCR), MONRE	- Conduct research study; - Formulate policies and measures; and - Provide floating garbage traps and other supports to local administrations in river mouth areas.
	Department of Health, Ministry of Public Health (MOPH)	- Oversee and facilitate implementation of the Public Health Act.
	Department of Local Administration (DLA), Ministry of Interiors	- Collect MSW data; and - Formulate policy on MSW management for Local Administration Organizations (LAOs) to implement.
	Department of Industrial Works (DIW), Ministry of Industry	- Issue permits and ensure leak-free operation of plastic recycling factories; and - Control import/export of hazardous waste and plastic waste import.
	Fishery Department, Ministry of Agriculture and Cooperatives	- Enforce the Royal Ordinance on Fisheries to prohibit illegal waste discharge into water.
	Marine Department, Ministry of Transport	- Enforce the Navigation in the Thai Waters Act to prohibit illegal waste discharge into water.
	LAOs	- Manage MSW generated in jurisdiction area; - Enforce rules on violators who dump garbage in the water bodies; and - Clean up garbage at riverbanks and in canals or rivers in jurisdiction area.
	Electricity Generating Authority of Thailand (EGAT)	- Report of hydrology, telemetry of 11 own dams; - Install nets prior to penstocks to capture riverine debris which does not cause any problems. Most of debris are biomass such as tree branches and water hyacinth; and - Invent and operate air spiral barriers (patented by EGAT) to prevent riverine debris from entering water cooling system of the gas-fired power plant in Bangkok.
Academia/ Research institute	Chulalongkorn, Kasetsart, Mahidol, Thammasart University, Prince of Songkla University, etc.	- Conduct research studies on waste and plastic waste.
Private Sector	IRPC, PTT GC, SCG (Siam Cement Group) Chemicals, DOW	- Raise awareness on plastic littering; - Provide plastic collection bins; and - Develop and produce biodegradable plastic.
	Coca Cola, Unilever, P&G, Thai Bev, etc.	- Raise awareness on plastic littering; - Provide plastic collection bins; - Redesign packaging to reduce plastic use; and - Organize cleanup activities.
	Siam Piwat, CPN, CP All, etc.	- Stop giving free plastic bags; - Allow polymer and product manufacturers to place plastic waste collection bins near supermarket zones; and

Sector	Organization	Roles
		- Allow customers to decline SUPs.
	TPI, Insee EcoCycle, SCI Eco, Eastern Energy Plus, etc.	- Use Refuse Derived Fuel (RDF)s made from plastic waste as alternative fuels.
	Suez, Starboard, etc.	- Reutilize plastic waste as raw materials.
NGOs	Thailand Environment Institute (TEI), Sustainable consumption and Production (SCP) Network	- TEI has been conducting research project on Support Development of Thailand's National Action Plan on Marine Plastic Debris, commissioned by World Bank Group. It aims to identify gaps between existing plans and marine plastic pollution.
	Trash Hero	- Organize regular cleanups on beaches, rivers, and canals around Thailand.
International	UNEP	- Initiate SEA Circular together with the COBSEA to inspire market-based solutions and encourage enabling policies to prevent marine plastic pollution.
	International Union for Conservation of Nature (IUCN)	- Produce National guidance for plastic pollution hotspotting and shaping action; - Conduct studies on marine litter; and - Cooperate with other organizations to implement projects to reduce marine litter.
	Government of Japan	- Support UNEP in CounterMEASURE project.
	Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ)	- Provide technical support to Thai government agencies on circular economy and Rethinking Plastic project.
	World Wide Fund for Nature (WWF)	- Conduct plastic waste management projects in coastal cities; - Develop EPR proposal for Thailand; and - Raise funds to support project implementation related to marine plastic.

Source: Patarapol Tularak

3.4.4. Viet Nam

Many institutions are involved in reducing plastic pollution in Viet Nam, involving the public and private sectors, multinational development agencies, international NGOs, and community-based/civil society organizations. Solid waste management falls under the jurisdiction of several governmental bodies at the national, provincial, and municipal levels, although there is no unified or standardized system of waste collection. Institutional arrangements involve inter- and intra- agency coordination and the support of multiple government institutions at the central/national and local government levels (Rab *et al*., 2015). The National Action Plan stipulates that MONRE will lead in the collaboration to periodically develop and operate environmental monitoring networks and programmes. So far, no existing monitoring and assessment programmes for plastic pollution have been approved.Among all the related organizations, Center for Marine Life Conservation and Community Development (MCD) plays a crucial role in reducing the marine debris.

Summary of roles of organizations which are related to waste management in Viet Nam has been provided in ***Table 3-8*** below.

Table 3-8. Summary of roles of organizations related to waste management in Viet Nam.

Sector	Organization	Roles

Government	MONRE	- (i) development and provision of regulations, technical guidelines, standards, policies, and systems for solid waste management; (ii) support for research and technical development related to waste management; (iii) development of projects related to waste management; and (iv) approval of environmental impact assessment reports
	Vietnam Environment Administration (VEA) under MONRE	- Responsible for planning, formulating strategies, legislation, and policy nationally and provincially. It covers guidelines and environmental standards for MSW, industrial, hazardous waste and emerging waste stream including plastic
	Administration of Sea and Islands (VASI) under MONRE	- Responsible for preparation of the national action plan for management of marine plastic litter; and - Survey, monitoring, analysis, inspection, research supervision of marine plastic waste and control of environmental pollution; Organization of investigation, evaluation, and management of marine plastic litter.
	Ministry of Construction Ministry of Construction	- Responsible for municipal solid wastes: (i) formulating policy and legislation; (ii) developing, and instructing on implementation of the SW treatment investment program; (iii) developing, appraising, instructing, and monitoring implementation of SWM interprovincial planning; (iv) instructing, and monitoring the development and management of construction planning of SWM facilities; (v) appraising the SWM planning of state-run cities; and (vi) organizing investment promotion activities and

		instructing on the implementation of investments in interprovincial SWM facilities.
	Ministry of Health (MOH)	- Develop guiding documents, regulations, and standards on plastic waste management for the health sectors; and - Assess the impacts of solid waste on human health and inspect and supervise hospital waste treatment.
	Directorate of Fisheries under Ministry of Agriculture and Rural Development (MARD)	- Develop guiding documents, regulations, and standards on plastic waste management for fishery and aquaculture sectors; and - Assess the impacts of solid waste on fishery and aquaculture.
	Provincial People's Committee (PPC)/Department of Agriculture and Rural Development (DARD) Management	- Responsible for management of rivers; and - Responsible for management of Irrigation, Agriculture, and Water resources.
	Vietnam Inland Waterways Administration (VIWA) under Ministry of Transport	- Responsible for management of and environmental protection in inland waterway navigation activities, including management of plastic pollution; - Preside and coordinate with the MONRE in, guiding and organizing the implementation of management of and environmental protection in inland waterway; - Examine and promote the implementation of law on environmental protection in inland waterway navigation activities; - Elaborate plans on environmental protection in inland waterway navigation activities;

		- Organize training and dissemination of the law on environmental protection among cadres, civil servants, public employees, and staff members of management units in charge of inland waterway navigation; and - Study the pilot application of and expand the model of environmental protection and treatment of environmental pollution at establishments engaged in inland waterway navigation activities.
	Ministry of Planning and Investment (MPI)	- Responsible for municipal solid waste, industrial solid waste, and hazardous waste.
	District People's Committees	- Local governments responsible for environmental issues in their provinces including urging and directing the implementation of regulations and decentralized programs in SW management.
Academia/ Research institute	Ho Chi Minh City University of Technology	- Conduct macroplastic and microplastic survey
Private Sectors	HPP (Hydro Power Plant) etc. such as - Yali hydropower company, Se San Hydropower Development Company, Dong Nai hydropwer company (under Vietnam Electricity – EVN) - Buon Don Hydropower Company	- N/A
	URENCO (Urban Environment Company)/CITENCO (City Environment Company)	- Responsible for collecting solid wastes in the cities and on rivers/canals.
	the Viet Nam Plastics Association (VPA)	- Support funding for research; and - Conduct awareness campaign in collaboration with other parties.
NGO	Center for Marine Life Conservation and Community Development (MCD)	- a non-governmental organization in Vietnam, established in 2003, operating in the field of marine environmental protection and sustainable development of coastal areas 19, Vietnam. - One of the priority contents in the period of 2018 - 2023 is to promote efficiency in marine debris management, especially

		to reduce plastic debris in the ocean. - Has had a long and effective cooperation with Vietnam Administration of Sea and Islands. MCD has made active contributions to the drafting of the National Action Plan for Ocean Plastic Waste Management up to 2030.
	WWF, IUCN, Greenhub, (MCD)	- Conduct awareness campaign on solid waste in collaboration with other parties (NGOs, NPOs, international organizations); - Conduct survey on solid waste treatment and management; - Propose incentive on solid waste management; and - Create forum/network of the related parties.
International	Japan International Cooperation Agency (JICA), United States Agency for International Development (USAID), UNDP	- Support funding on survey, treatment, and management of solid waste.

Source: Diep Dinh Phong

Main results and key challenges

- Among all the regional frameworks listed up, COBSEA RAP MALI 2019 seems the most specific framework with the concrete action plan for building marine debris monitoring system. Even though Lao PDR is not the member of COBSEA, hopefully, the MRC MCs can cooperate in working out the riverine debris monitoring system in LMB.
- There are several international conventions aiming to prevent and control the marine pollution from ships, discharge of harmful substances, open dumping, or completely prohibiting the disposal of plastic in all forms. It seems quite satisfactory for the prevention of pollution in the water, nevertheless, it leaves behind the landlocked countries such as Lao PDR. Also, ratification status of these multi-lateral treaties in LMB is yet to be improved.
- It seems that none of 4 MRC MCs have specific policy framework for monitoring of plastic debris, nor monitoring of riverine debris. To grasp the up-to-date situation of waste such as volume, composition and littering accumulation, building the concrete system for monitoring of waste/plastic debris is necessary.
- The information of National Institutional Frameworks suggests the lack of clear allocation of work and responsibility between the institutions on the riverine debris. As responsibility of riverine debris often gets ambiguous through its transboundary movements, establishment which explicitly states the work and responsibility would be of great value.

4. Capacity of Riverine Plastic Debris Monitoring

To solve the plastic pollution issue, it is crucial to accurately monitor the current situation of waste as well as comparing the data over time. As it requires human resources and equipment for this monitoring, governmental agencies, universities or institutes at the early stage of research often suffer from lack of these resources. However, there are certain universities such as Chulalongkorn University and Kasetsart University in Thailand possessing proper equipment for monitoring. To maximize the outcome with the limited resources, collaboration between government and academic or institute is required in conducting the riverine debris monitoring.

Information on capacity of riverine debris monitoring, that is organizations, laboratories, human resources, equipment of each 4 MRC MCs in LMB are shown in ***Table 4-1***, ***Table 4-2***, ***Table 4-3***, and ***Table 4-4***).

In surveying plastic debris in rivers or in the ocean, various equipment is required from sampling to analyzing. Plankton nets such as zooplankton nets are used in sampling microplastics. Fourier transform infrared spectroscopy (FTIR) and Raman spectroscope is used in identifying the material of plastic. A stereo dissecting microscope can be used in sorting microplastic debris that will enable more accurate analysis.

4.1. Cambodia

Since there is no riverine debris monitoring activities being taken place so far, thus Cambodia needs to build capacity of relevant institutions such as MOE, MOWRAM, MAFF, MPWT, local authority, etc. to be able perform riverine debris monitoring in the future.

Currently, Fishery Administration under Ministry of Agriculture, Forestry and Fishery, is working on Ecological Health Monitoring and Larvae Drift Monitoring in Cambodia; The laboratory capacity in Fishery Administration is relevant to capacity for conducting plastic monitoring.

Table 4-1. Capacity of riverine debris monitoring activities in Cambodia

Organization	Items	Description
Fishery Administration, Ministry of Agriculture	Source and amount of budget	- N/A
	Human resources	- N/A
	Sampler	- Zoo plankton net with 20 μ m mesh size - D - frame net with 30 cm x 20 cm with mesh size of 475µm - Bongo net with 1-metre diameter and a 1-mm mesh size, a flow meter
	Analytical equipment	- A stereo dissecting microscope with a 2x – 4x objective lens and a 10x eyepiece

4.2. Lao PDR

Laboratory in National University of Laos have human resources who can conduct microplastic and microplastic sampling though there is no analytical equipment. Government lacks the capacity of riverine plastic debris monitoring to sample, monitoring and analysing.

Table 4-2. Capacity of riverine debris monitoring activities in Lao PDR

Organization	Items	Description
Faculty of Environmental Sciences' laboratory in National University of Laos	Source and amount of budget	- N/A
	Human resources	- 6 staffs are trained for riverine macroplastic sampling. - 2 staffs are trained for riverine microplastic sampling.
	Sampler	- Five water samplers
	Analytical equipment	- N/A

Source: Vatthanamixay Chansomphou

4.3. Thailand

DMCR has sampler for microplastic and analytical equipment such as FTIR. However, FTIR is only at Phuket Marine Biological Center. DMCR also has 2 boats and booms installed in the rivers in the coastal areas for capturing riverine and marine debris. Government agencies lack equipment for analysing and implementing plastic pollution monitoring. Chulalongkorn University and Kasetsart University have analytical equipment. Collaboration between government and university is required to conduct plastic debris monitoring.

Table 4-3. Capacity of riverine debris monitoring activities in Thailand

Organization		Description
Marine and Coastal Resources Research and Development Centers (7 locations) in DMCR	Source and amount of budget	Fiscal budgets from central government
	Human resources	- About 20 employees each at the Eastern Gulf of Thailand Center, the Eastern Upper Gulf of Thailand Center, the Upper Gulf of Thailand Center, The Lower Andaman Center. - About 30-40 employees each at the Central Gulf of Thailand Center and the Lower Gulf of Thailand Center. - More than 60 employees at the Phuket Marine Biological Center.
	Sampler	- Plankton nets
	Analytical equipment	- Microscope - FTIR (only at Phuket Marine Biological Center) - Other details are not available
Laboratory in Marine Science Department, Faculty of Science, Chulalongkorn University	Source and amount of budget	- University budget and project-based grants
	Human resources	- 18 faculty members and 4 research assistants
	Sampler	- 0.33mm and 4.75mm meshes - Other details are not available
	Analytical equipment	- Microscope at ×40 magnification - FTIR is available - Raman spectroscope is available - Other details are not available
Laboratory in Material	Source and amount of budget	- University budget and project-based grants
	Human resources	- N/A

Organization		Description
Engineering Department, Faculty of Engineering, Kasetsart University	Sampler	- Details are not available
	Analytical equipment	- FTIR is available - Raman spectroscope is available - Other details are not available
Mahidol University - Frontier Research Facility (MU-FRF)	Source and amount of budget	- N/A
	Human resources	- 11 scientists to support researchers.
	Sampler	- N/A
	Analytical equipment	- FTIR, micro FTIR, Raman and Stereomicroscope are available

Source: Patarapol Tularak

4.4. Viet Nam

MONRE and DONRE does not have sampler and analytical equipment for plastic monitoring. For academic, Environmental laboratory in Ho Chi Minh City University of Technology have around 2 trained staff for marine debris monitoring and, sampler and analytical equipment for microplastic monitoring. Aquatic ecology laboratory in Southern Institute of Ecology and Ecological toxicology laboratory in Institute for Environment and Resources have trained staff for marine debris monitoring and microplastic analyser.

Table 4-4. Capacity of riverine debris monitoring activities in Viet Nam

Organization		Description
- Center for environmental monitoring (CEM) of MONRE: - Centrer for environmental and natural resources monitoring (CENM) or center for environmental monitoring and analysis (CEMA) of DONRE (Department of Natural Resources and Environment)	Source and amount of budget	- N/A
	Human resources	- N/A
	Sampler	- Beta water sampler - Van veen grab sampler
	Analytical equipment	- N/A
Environmental lab in Ho Chi Minh City University of Technology/CARE (Asian Water Research Center)	Source and amount of budget	- N/A
	Human resources	- Around 15 (CARE center) - Around 2 (trained staffs for marine debris monitoring)
	Sampler	- Beta water sampler - Plankton/fish-egg net (e.g. manta net, neuston net): mesh size 300 um
	Analytical equipment	- FTIR, Scanning Electron Microscope (SEM)
Aquatic Ecology Lab in Southern Institute of	Source and amount of budget	- N/A
	Human resources	- Around 35

Organization		Description
Ecology (SIE)/ Department of aquatic ecology		- 2 (trained staffs for marine debris monitoring)
	Sampler	- Beta water sampler - Van veen grab sampler - Fishing sampling net: Various mesh sizes - Manta net, size 100 um
	Analytical equipment	- FTIR, SEM
Ecological Toxicology lab in Institute for Environment and Resources (IER)	Source and amount of budget	- N/A
	Human resources	- Around 200 - Around 2 (trained staffs for marine debris monitoring)
	Sampler	- Beta water sampler - Van veen grab sampler
	Analytical equipment	- FTIR, SEM
Environmental lab in Department of land resources, Can Tho University	Source and amount of budget	- N/A
	Human resources	- N/A
	Sampler	- Beta water sampler - Van veen grab sampler
	Analytical equipment	- N/A

Source: Diep Dinh Phong

Main results and key challenges

- Not only governmental agencies but also universities or institutes work on research on plastic pollution. However, as most of them are at an early stage of research on plastic pollution, they suffer from lack of human resources with riverine debris monitoring skill and monitoring equipment.
- Concrete system for cooperation to supplement the lack of resources is required. For example, some facilities in Thailand and Viet Nam own FTIR and Raman spectroscope that is required in identifying the plastic material. On the other hand, available equipment is limited to a stereo dissecting microscope in Cambodia, and water sampler in Lao PDR. As also emphasized in ASEAN Framework of Action on Marine Debris (***Table 3-1***), the regional collaboration between government and academic or institute is required to conduct riverine debris monitoring, to maximize the outcome with the limited resources

5. Current Trends and Status of Plastic Pollution in LMB

There were several monitoring activities addressing riverine plastic debris outside the LMB. However, in the LMB the monitoring of riverine plastic debris was only covered by UNEP's project "Promotion of action against marine plastic litter in Asia and the Pacific" (CounterMEASURE II) which aims to determine the origins and pathways of plastic waste in major rivers in Asia and provide governments with bespoke policy recommendations to help beat plastic pollution.

Even though the collected information allows us to make general comparison of plastic debris pollution status in the LMB area, it also suggests lack of a standardized method for data collection which makes precise analysis impossible, and the number of NGO's activities outweighing that of MRC MC's governmental bodies.

Other than reflecting the results of CounterMEASURE project in policy formulation, the shared experiences can also be utilized for standardizing the method of riverine debris data collection and expanding the monitoring activities throughout the LMB region for the future step to combat riverine plastic debris in the Mekong River.

This chapter, divided into 3 sections, will show the general trend of plastic debris pollution in the LMB, ("***5.1 Riverine monitoring Activities and results in the LMB***"), the Introduction of Riverine debris monitoring activities that do not directly address LMB but can be utilized for enhancing the monitoring activities in LMB ("***5.2 Riverine monitoring Results outside LMB"***), and Riverine debris Cleaning activities in LMB that can be accelerated along with the monitoring of collected debris ("***5.3 Clean up and Collection Activities in LMB***").

5.1. Riverine Monitoring Activities and Results in LMB

In LMB, 5 survey areas were chosen along the Mekong River in CounterMEASURE II as shown in the ***Figure 5-1***.

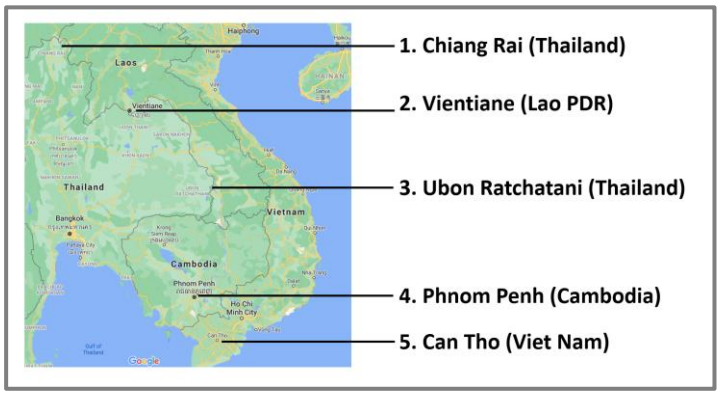


Figure 5-1. Five survey areas of CounterMEASURE II

Then, 4 target categories of plastic pollution were investigated in each survey area, namely, riverine macroplastic, riverine microplastic, plastic leakage hotspot, and plastic accumulation hotspot (***Figure 5-2***). Plastic pollution challenges have traditionally focused on macroplastics and their management. However, recent research focus is being directed towards understanding of the sources, fate, sink and transport, and generation mechanisms of microplastics (UNEP, 2020b). 2 types of riverine plastic debris were collected and analysed: "Microplastic" whose diameter is smaller than 5 mm, and

"Macroplastic" bigger than that. Also, 2 types of Plastic waste hotspots located near the Mekong River were investigated mainly by visual inspection. Namely, "Plastic Leakage Hotspots" are the piles of waste formed by activities such as illegal dumping or unsanitary landfill, and these locations can be the main source of plastic waste leakage from land into the water. "Plastic Accumulation Hotspots" are mostly artificial barriers where riverine plastic debris is especially likely to get stuck and accumulate. Figure shows the summary and pictures of each target category. These 4 target categories in each survey area are not necessarily investigated by a unique organization, or can be not conducted. Riverine macroplastic, plastic leakage hotspots, and plastic accumulation hotspots are surveyed mainly by national universities, and riverine microplastic is sampled and analyzed by Pirika, Inc.

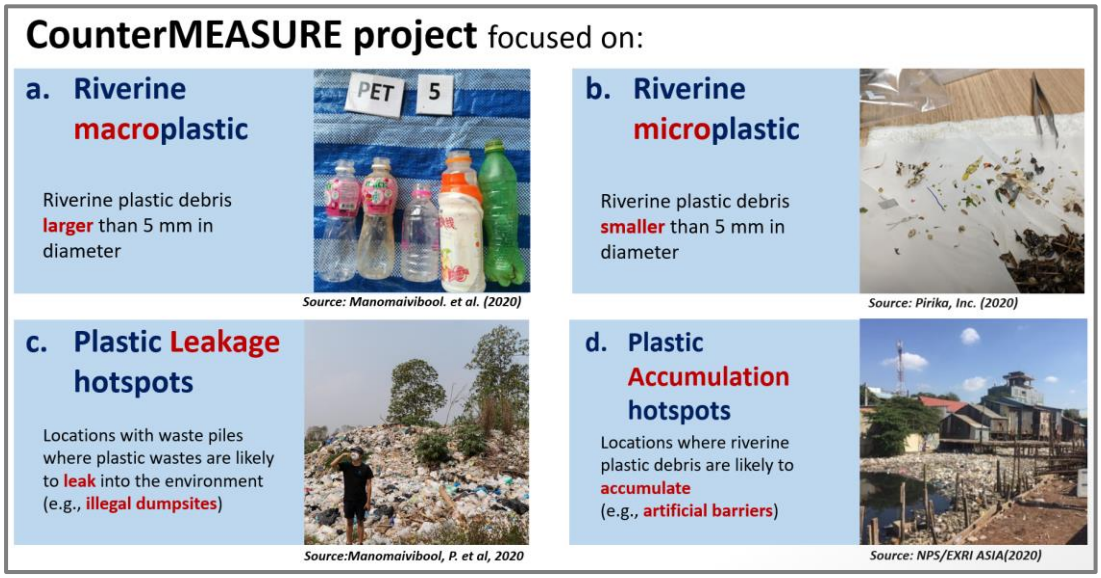


Figure 5-2. Four target categories of CounterMEASURE

Table 5-1 briefly explains the polymers addressed in the CounterMEASURE project. Each material has different structure, density and use leading to diverse behavior both on land and in the water.

Table 5-1. Plastic Polymers addressed in the CounterMEASURE II

Polymer	Abbreviation	Density (g/cm3)		Main application
		Min	Max	
Polypropylene	PP	0.9	0.91	Food containers, utensils, packaging
Low Density Polyethylene	LDPE	0.91	0.94	Packaging
High Density Polyethylene	HDPE	0.94	0.97	Bags, bottles, buckets, pipes
Polyethylene terephthalate	PET	1.37	1.45	Bottles
Polystyrene	PS	1.01	1.04	Food foam containers
Polyvinyl chloride	PVC	1.16	1.58	Pipes, hoses, building and construction

Source: Malakul, P. et al (2019), UNEP (2020f)

This lack of surveyed data and significant difference in the units and methodology of collected data made the precise data comparison impossible. Still, combining the existing data and modifying some units made general comparison possible.

Figure 5-3 shows the material and quantity of macroplastics and microplastics in the riverine plastic debris collected by in CounterMEASURE II from upstream to downstream of the Mekong River. The left side of the figure shows the results of macroplastics, and the right side shows the results of microplastics. The pie charts show the percentage of what material the collected plastic debris was made of, and the numbers on the grey arrows show how much debris was flowing in the river.

Regarding macroplastics, the concentration varied from place to place as shown on the grey arrow in the left of **Figure 5-3**. Also, looking at the pie charts presented in the left side of **Figure 5-3**, PE was the most popular material in 3 surveyed points. And from the pie charts presented in the left side of **Figure 5-4**, plastic wrapper was the most popular product showing the importance of the alternative packaging materials. Regarding microplastics, the concentration increased as it went down the stream shown on the grey arrow in the right of **Figure 5-3**. At all the points surveyed, PP was the most popular material as shown in the 5 pie charts listed in the right of **Figure 5-3**. This may have resulted from its lowest density among all the plastics which enables it to be carried for a long distance. PET with the high density was not seen at any points as it may sink in the water and does not appear in the surface water.

The lower part of the **Figure 5-3** compares the flux of macroplastics at Can Tho, located in the most downstream of the five sites surveyed, with the flux of riverine debris in the Mekong River predicted (Schmidt et al., 2017). In CounterMEASURE II, the flux was found to be 2.14 - 12.4 % of the predicted value (Schmidt et al., 2017).

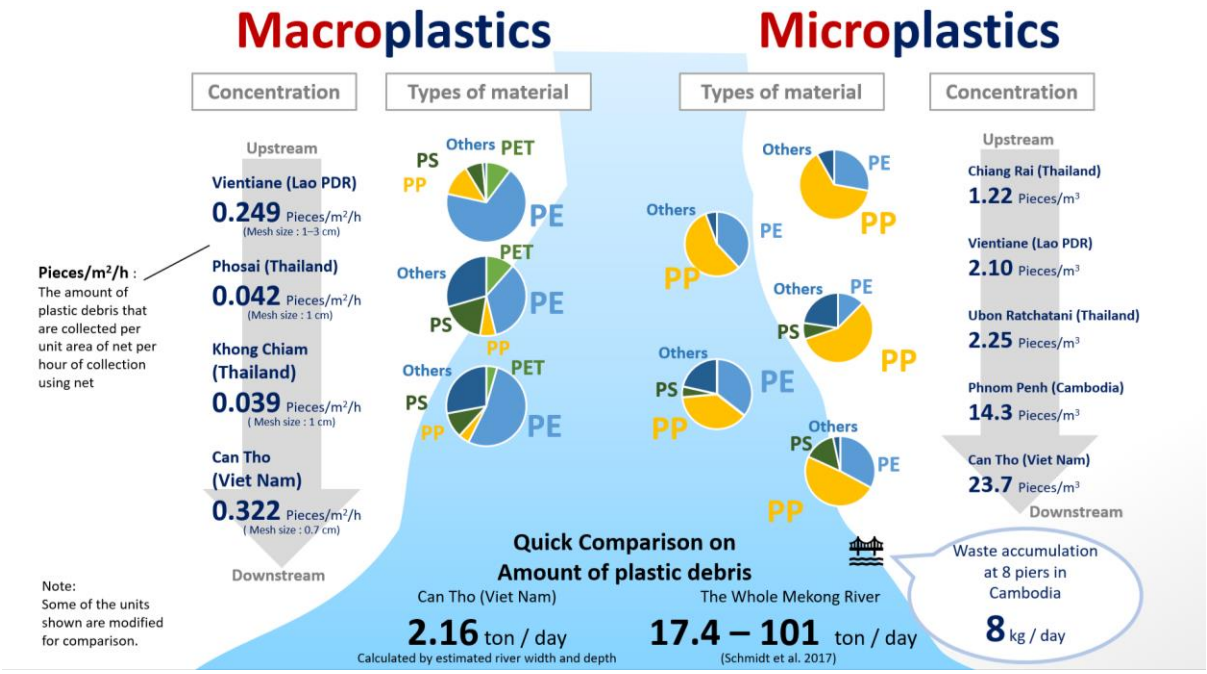


Figure 5-3. Summary of CounterMEASURE II in LMB (1/2)

Figure 5-4 compares the riverine macroplastic debris that are flowing in the river, and accumulated plastic waste that are stuck at artificial barriers. Wrapper was dominant in riverine

macroplastic debris in all surveyed points, while the composition of debris accumulated at artificial barriers varied greatly in all locations with no common point found, emphasizing the need for the individual treatment at each location. Right side shows the total amount of waste pile and the total number of sites identified as illegal dumpsites and artificial barriers. Several locations contained vast amount of waste calling for the urgent treatment. More detailed information will be provided in the subsequent chapters for each site.

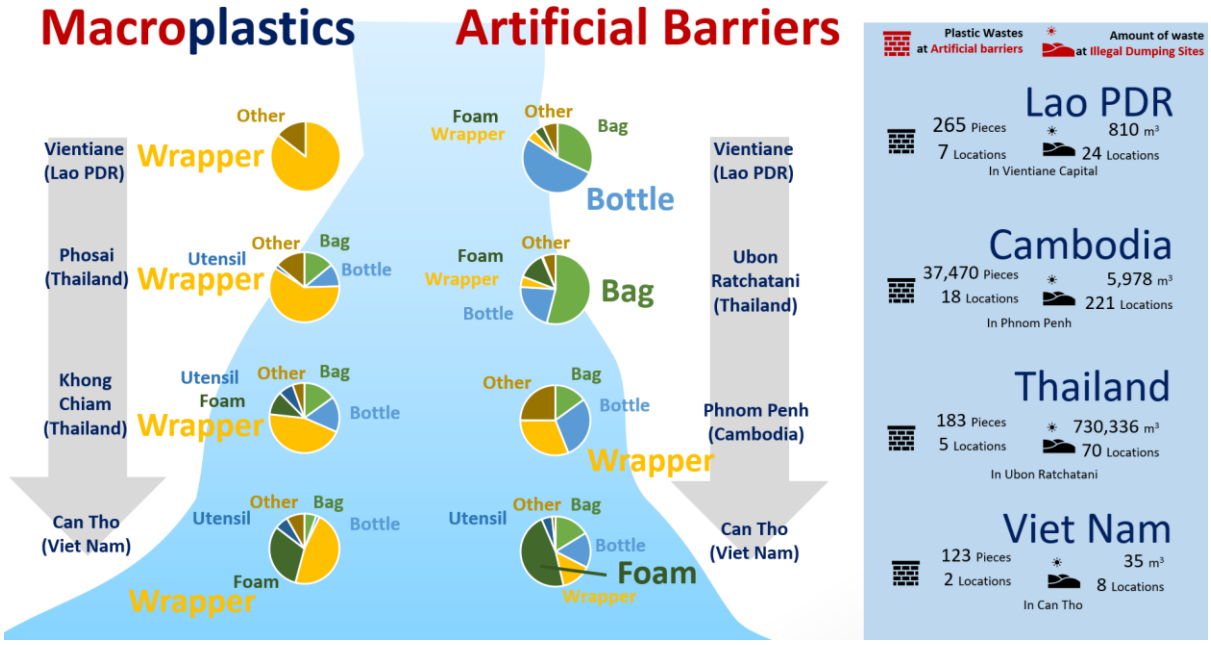


Figure 5-4. Summary of CounterMEASURE II in LMB (2/2)

The following chapters describe the detailed results along with the comments from survey teams in each survey conducted at the five sites presented above. Quick profile table (***Table 5-2***) attached in each paragraph will provide the general methodology how each survey was conducted, such as debris collection methods and debris classification methods. Please see the referenced documents for the detailed information.

Table 5-2. Quick profile table of projects

Location	Locations where sampling was conducted
Duration	Time duration of sampling conducted
Samples dried?	Whether samples were dried after collection before weighing
Classification by	By which factor samples were classified (weight, material, use, quantity, etc.)
Collection by	Method taken for sampling

5.1.1 Area 1/5: Chiang Rai (Thailand)

a. Riverine Macroplastic

Location	Chiang Saen Port
Duration	2 times/day, 7 days in Mar 2020
Samples dried?	No
Classification by	Material, Quantity, Weight
Collection by	Net installation

Figure 5-5. Sampled locations

Area	Amount of collected debris in 7 days
Chiang Saen Port	1587 pieces / 51810 g

Figure 5-6. Summary of collection activity

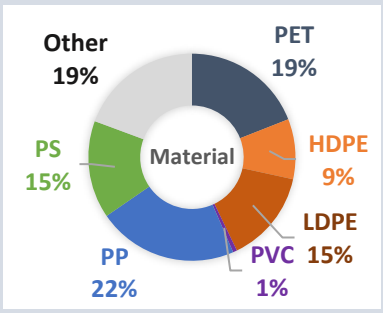


Figure 5-7. Debris classification by Quantity

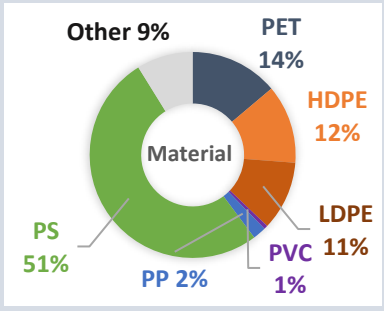


Figure 5-8. Debris classification by Weight

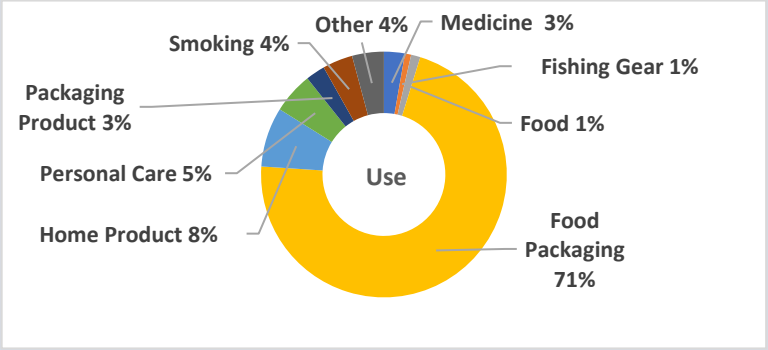


Figure 5-9. Debris classification by Quantity

Manomaivibool, P. et al. (2020) conducted macroplastic sampling at the Chiang Saen port, collecting more than 1500 pieces or 51 kg of riverine plastic debris by installing a net at the Chiang Saen Port in the Mekong river. The detailed classification of collected debris is shown in the figures on the right. However, the survey team explained that the results might not represent the normalcy of the area and most likely underestimated the amount of plastic waste found in Mekong, therefore, recommending the repeated survey for more accuracy. Also, the flows of waste might not be well illustrated due to the extended drought experienced in the region since the majority of macroplastics is likely collected from nearby activities. The survey team recommended that methods of site selection, equipment setting, and documentation be standardized for great benefit in the region.

b. Riverine Microplastic

Location	Chiang Rai
Duration	Jan – March 2020
Samples dried?	Not described
Classification by	Material, quantity
Collection by	Albatross Mark V lite

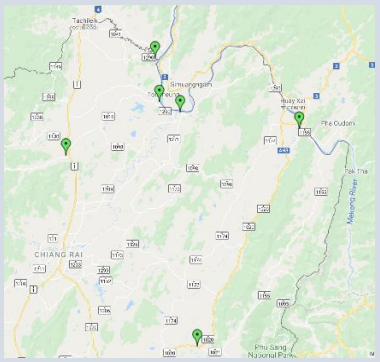


Figure 5-10. Sampling Location

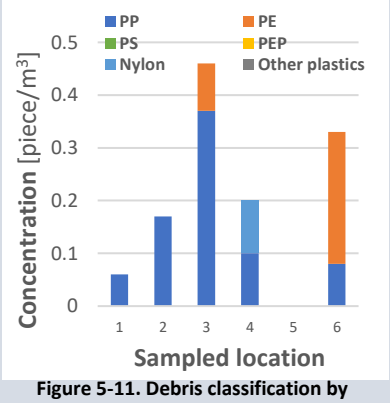


Figure 5-11. Debris classification by Quantity

Chiang Rai, located in the most upstream of 5 surveyed areas, had the smallest average microplastic concentration (PIRIKA Inc., 2020). Microplastic concentration mostly composed of PP, with the Nylon and PE

appearing in several locations. The highest concentration recorded was 0.46 m3, and the lowest was under the detectable limit.

c. Plastic leakage hotspots (illegal dumpsites)

Location	Chiang Rai
Duration	Feb-Mar 2020
Samples dried?	No
Classification by	-
Collection by	GIC mobile app

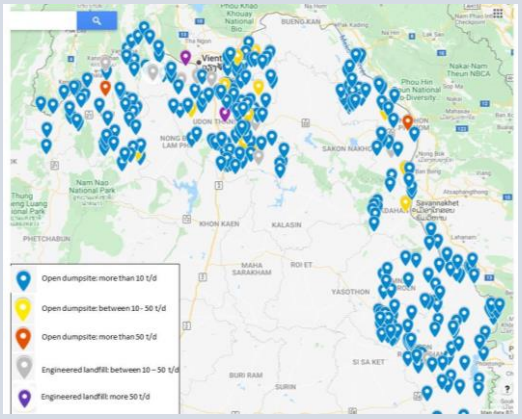


Figure 5-12. Leakage hotspot's location

Manomaivibool, P. et al. (2020) has visited 4 dumpsites in Chiang Rai for investigation, from a list of 213 dumpsites provided by Department of Local Administration and Pollution Control Department. The interview and photos taken in the study re 369 dumpsites and landfills in the provinces sharing border with Mekong River. Moreover, the study reported that illegal dumpsites and littering spots have never been officially recorded in Thailand.

d. Plastic accumulation hotspots (Artificial Barriers)

Location	Chiang Rai
Duration	Feb-Mar 2020
Samples dried?	No
Classification by	-
Collection by	Visual inspection

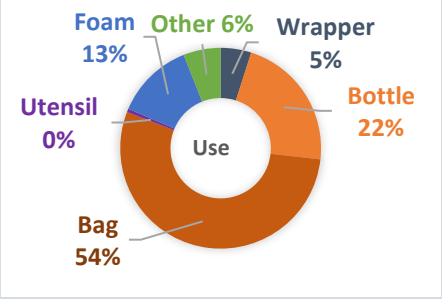


Figure 5-13. Debris classification by Quantity

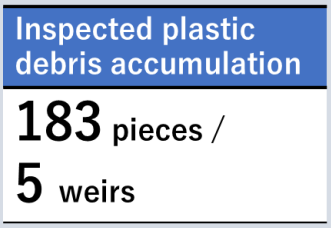


Figure 5-14. Summary of Collection Activity

Manomaivibool, P. et al. (2020) listed up 25 weirs managed by the Royal Irrigation Department and local governments in 3 districts in Chiang Rai. The field inspection selected 5 locations from these and collected data on their location and plastic waste that could be found stuck to the barriers.

5.1.2 Area 2/5: Vientiane (Lao PDR)

a. Riverine macroplastic

Location	Vientiane Capital
Duration	● 24 h/day, 7 days in Feb 2020 (net) ● 3 h/day, 7 days in Feb 2020 (boat)
Samples dried?	No
Classification by	Material, Quantity, Weight
Collection by	● Large net installation (W:40m, D:2m) ● Small net installation (W:10m, D:1.5m, L:3m) ● From boat

Chansomphou, V. et al (2020) used 3 collection methods trying to cover entire cross-section of the river, namely, installing 2 kinds of nets and collection from a boat. Total 150 kg of debris was collected; within which plastic waste accounted for 29%. The report pointed out the following difficulties faced during this study:

- Tools and methods of primary data collection are not standardized among implementing institutes
- It was difficulties in installing the net trap in the Mekong due to strong water current.
- Although the simple net traps are applicable, there might be some wastes escaping the trap due to strong water current.

Table 5-3. Summary of colledted debris in each method

Method	Summary of Debris by Item (pieces)	Summary of Debris by Weight (g)
Small trap	918	7,971
Large trap	1,789	15,494
Boat collection	1,351	19,720
Total	4,058	43,185

Figure 5-15. Sampled locations

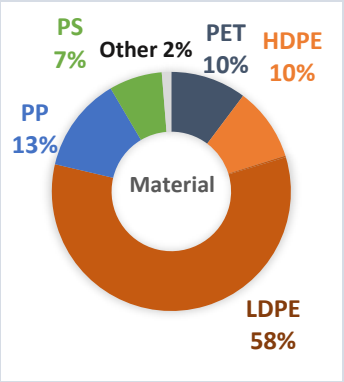


Figure 5-16. Debris classification by Quantity

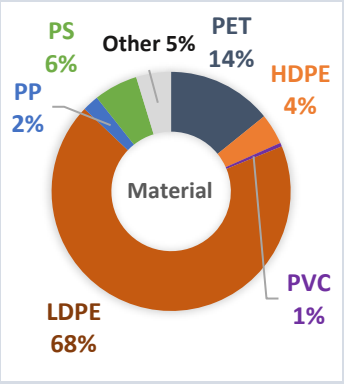


Figure 5-17. Debris classification by Weight

b. Riverine Microplastic

PIRIKA Inc. (2020) [*6]

Location	Vientiane Capital
Duration	Jan – March 2020
Samples dried?	Not described
Classification by	Material, quantity
Collection by	Albatross Mark V lite

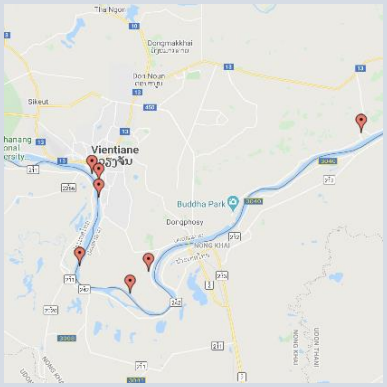


Figure 5-18. Sampled Locations

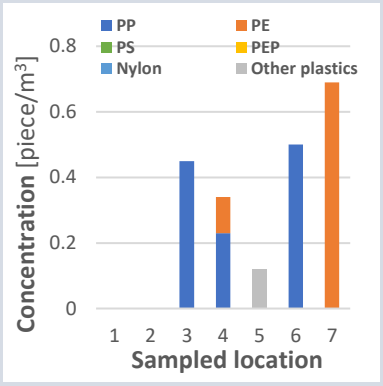


Figure 5-19. Debris classification by Quantity

Vientiane, located in the second most upstream of 5 surveyed areas, had the second smallest average microplastic concentration (Pirika, Inc., 2020). A high ratio of PP was seen in 3 sampled locations, while 1 location had a surprisingly large amount of PE. The highest concentration recorded was 0.69 m3, and the lowest was under the detectable limit in 2 sampled locations.

c. Plastic leakage hotspots (illegal dumpsites)

Location	Vientiane Capital
Duration	15th-17th Mar 2020
Samples dried?	No
Classification by	Volume
Collection by	Measuring dimensions of waste piles

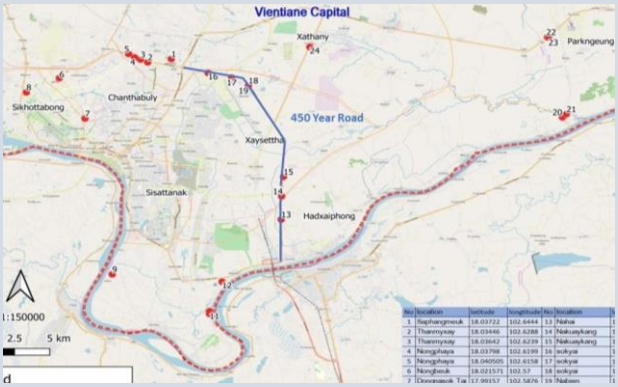


Figure 5-20. Locations of leakage hotspots

Chansomphou, V. et al (2020) observed no illegal dumpsites nearby the city center, but many beyond 15 Km. These illegal dumpsites are not big; they have small piles of wastes scattered around.

From the observation and interviewing people living nearby, it seems that wastes dumped in the sites are from households and most people wanted to throw away their wastes would sneak and dump wastes at night. Some wastes are burned, while many are not.

d. Plastic accumulation hotspots (artificial barriers)

National University of Lao (2020) [*2]

Location	Vientiane Capital
Duration	26th Feb- 16th Mar 2020
Samples dried?	No
Classification by	Quantity
Collection by	Not described

Figure 5-21. Locations of accumulation hotspots

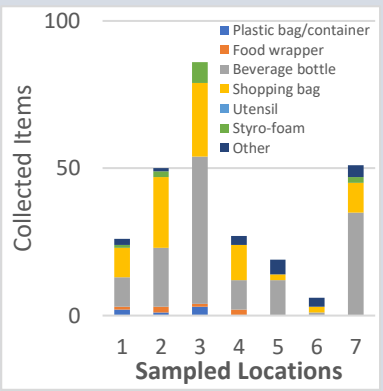


Figure 5-22. Debris classification by Quantity

Total 265 plastic debris was collected nearby the artificial barriers by Chansomphou, V. et al (2020) for classification by quantity and types.

The survey team noted that most wastes are plastic beverage bottles and

plastic shopping bags, which are common products and containers used by local people in their daily life consumption.

5.1.3 Area 3/5: Ubon Ratchatani (Thailand)

a. Riverine Macroplastic

Location	Ubon Ratchatani
Duration	7 days for each location in Jan-Feb 2020
Samples dried?	Yes
Classification by	Material, quantity
Collection by	Net (W:7m, D:1.5m, L:6m) from boat

Figure 5-23. Sampled locations

District	Amount of collected debris in 7 days
Khong Chiam	81 pieces / 1214.2g
Phosai	61 pieces / 443.92g

Figure 5-24. Summary of collection activity

Limpiteeprakan, P. et al (2020) targeted on 2 sites in Ubon Rachatani, that are Khong Chiam District and Phosai District.

Other than the composition of riverine plastic debris, the study team found that some of plastic is old and some very new. Based on the types of plastic, the Survey team assumed that their sources are both activities both on land and in water itself.

The study pointed out the following difficulties faced in the study:

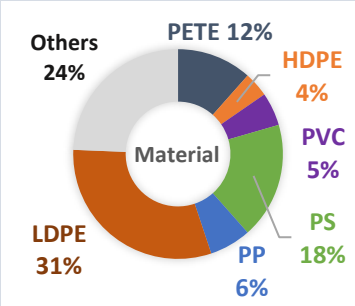


Figure 5-25. Debris classification by Quantity (Khong Chiam)

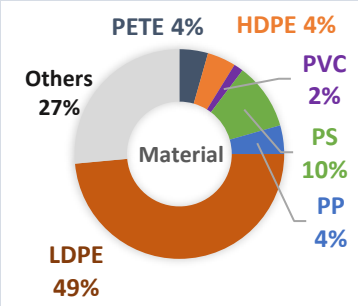


Figure 5-26. Debris classification by Quantity (Phosai)

- Nets can be installed only in certain parts of the river such as the shallow part and the place near to the shore.
- In January and February, there is a lot of freshwater seaweed in the river which get stuck in the net.
- Not so many wastes leakages were collected by the net.

b. Riverine Microplastic

PIRIKA Inc. (2020) [*6]

Location	Ubon Ratchatani
Duration	Jan – March 2020
Samples dried?	Not described
Classification by	Material, quantity
Collection by	Albatross Mark V lite

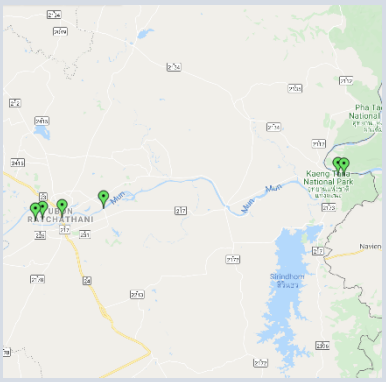


Figure 5-27. Sampled locations

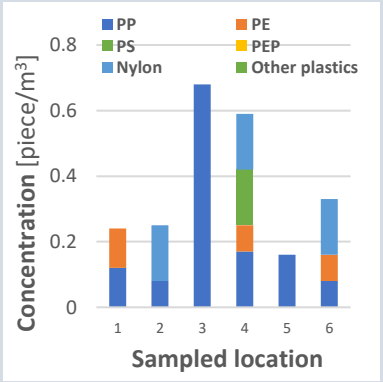


Figure 5-28. Debris classification by Quantity

Ubon Ratchatani, located in the third most upstream of 5 surveyed areas, had the third smallest average microplastic concentration (Pirika, Inc., 2020). PP was seen in all the 6 sampled locations, with PE, Nylon, PS appearing in some locations. The highest concentration recorded was 0.68 m^3, and the lowest was 0.16 m^3.

c. Plastic leakage hotspots (illegal dumpsites)

Location	Ubon Ratchatani
Duration	Feb-Mar 2020
Samples dried?	No
Classification by	-
Collection by	GIC mobile app

By Limpiteeprakan, P et al (2020), the number of illegal dumpsites pointed out in Ubon Ratchatani was 65, and among that, 62 were unsanitary disposal sites that belong to local municipality, and 3 were not included in the list provided by the Ministry of Interior, meaning they are not under any supervision. Frequency and person of cleaning activities in these sites are shown in the figures above, further emphasizing lack of supervision or appropriate management.

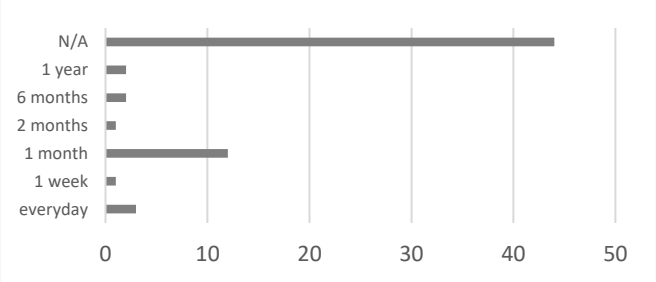


Figure 5-29. Cleaning freuqency of illegal dumpsites

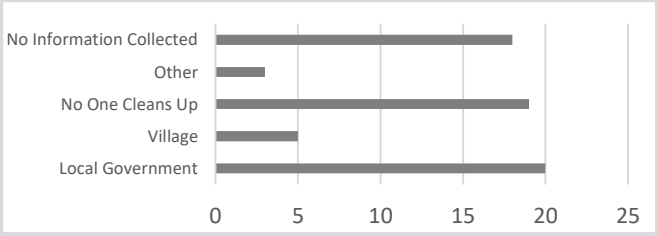


Figure 5-30. Responsible agency of cleaning dumpsites

d. Plastic accumulation hotspots (artificial barriers)

Not conducted

5.1.4 Area 4/5: Phnom Penh (Cambodia)

a. Riverine macroplastic

Not conducted.

b. Riverine microplastic

PIRICA Inc. (2020) [*6]

Location	Phnom Penh
Duration	Jan – March 2020
Samples dried?	Not described
Classification by	Material, quantity
Collection by	Albatross Mark V lite

Figure 5-31. Sampled locations

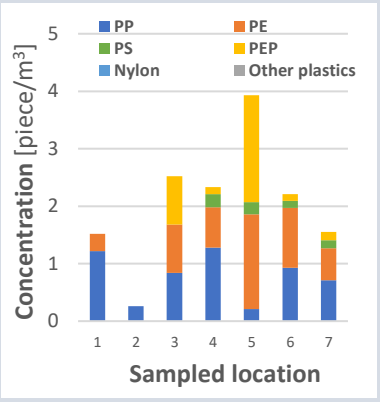


Figure 5-32. Debris classification by Quantity

Ubon Ratchatani, located in the second least upstream of 5 surveyed areas, had the third smallest average microplastic concentration (Pirika, Inc., 2020). PP was seen in all the 6 sampled location, with PE, Nylon, PS appearing in some locations. The highest concentration recorded was 0.68 m^3, and the lowest was 0.16 m^3.

c. Plastic leakage hotspots (illegal dumpsites)

Royal University of Phnom Penh (2020) [*4]

Location	Phnom Penh
Duration	Feb 20th-23rd 2020
Samples dried?	No
Classification by	Volume
Collection by	GIC mobile app

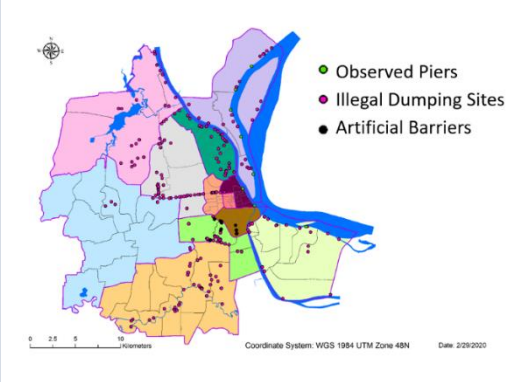


Figure 5-33. Locations of leakage/accumulation hotpots

The study by NPS / EXRI ASIA (2020) reported that Phnom Penh has no recycling, transfer station, or sanitary landfill and its only municipal solid waste disposal site (Dangkor Landfill) is also not managed properly.

The Survey team has found 221 illegal dumping sites through series of visual inspection in Phnom Penh as shown in the ***Figure 5-33*** along with the piers and artificial barriers with waste accumulation.

The study team pointed out that low accessibility to the service could have caused the frequent illegal dumping in the sub-urban areas where the waste collection trucks go door to door to collect the discharged garbage.

The waste volume in each illegal dumping site differed from 0.08 to 3500 m^3, as shown in Figure 5 28. Even though there were some locations with vast amount of waste, almost 90 % of the sites were below 20 m3.

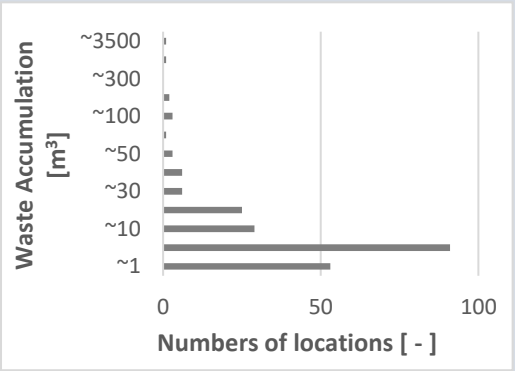


Figure 5-34. Volume of accumulated waste in illegal dumpsites

d. Plastic accumulation hotspots (artificial barriers)

Royal University of Phnom Penh (2020) [*4]

Location	Phnom Penh
Duration	Feb 20th-23rd 2020
Samples dried?	No
Classification by	Quantity, use
Collection by	GIC "20 litter plastic bag method"

In the survey by NPS / EXRI ASIA (2020) Accumulations of mismanaged waste were seen at 18 artificial barriers in total, and the majority of their compositions was plastic bags, PET, Styrofoam, plastic bottle.

Quantity of accumulated waste along the artificial barriers was estimated as 96,600 Liters in total. Daily waste accumulation at piers was investigated through interviews to pier staff, which sums up to 97.5 kg/day in just 8 piers.

The survey team found 4 locations filled up by especially large amount of garbage, where each estimated amount of garbage is 4,000, 10,000, 32,000 and 40,000 Liters. Detailed locations are shown in the figure above.

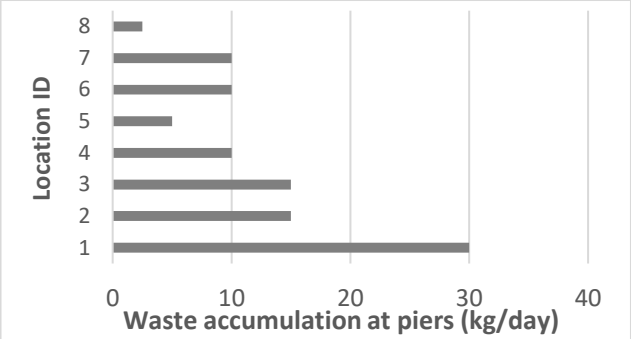


Figure 5-35. Daily waste accumulation at piers

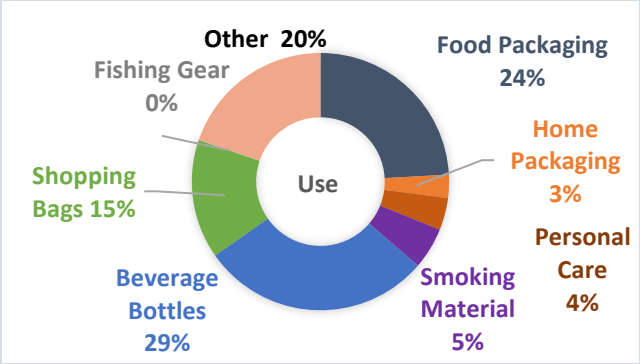


Figure 5-36. Debris classification by Quantity

5.1.5 Area 5/5: Can Tho (Viet Nam)

a. Riverine macroplastic

Can Tho University (2020) [*5]

Location	Can Tho
Duration	8 h/day, 7 days in Mar-Apr 2020
Samples dried?	Yes
Classification by	Quantity, Weight (sum)
Collection by	Net installation (W:8m, L:7m), ESRI survey 123

Figure 5-37. Sampled locations

Area	Amount of collected debris in 7 days
Can Tho	519 pieces / 2178.42 g (Dried)

Figure 5-38. Summary of collection activities

Since the data collected was only for the dry season, it does not represent data for the entire year Minh, V. et al (2020). Therefore, data from the rainy season would be necessary for a more accurate estimation of the amount of littering in Can Tho City in the Mekong Delta, Vietnam.

Furthermore, more durable and sturdy equipment may be needed to collect data in Can Tho City along the Mekong River. However, it may be costly to build such equipment.

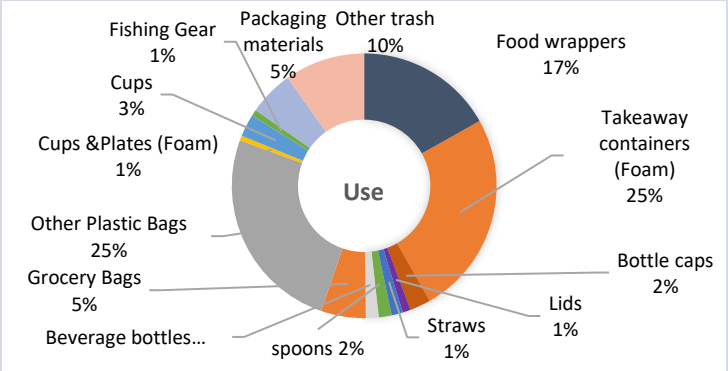


Figure 5-39. Debris classification by Quantity

b. Riverine Microplastic

PIRIKA Inc. (2020) [*6]

Location	Can Tho
Duration	Jan – March 2020
Samples dried?	Not described
Classification by	Material, quantity
Collection by	Albatross Mark V lite

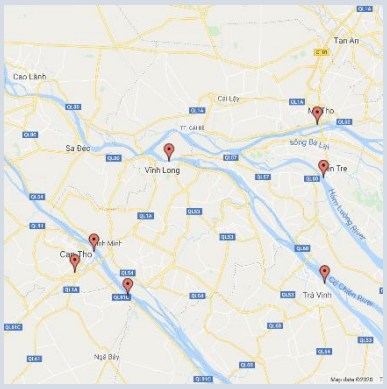


Figure 5-40. Sampled locations

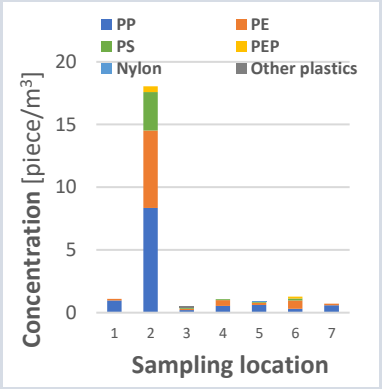


Figure 5-41. Debris classification by Quantity

The amount of plastic particles in Can Tho is larger than any other survey location, Phnom Penh, Vientiane, Chiang Rai and Ubon Ratchathani (Pirika, Inc., 2020). Also, components of samples have a wider variety compared with other survey location. In Table 5-11, we can see that location No. 2 has a significantly high number of samples than at other locations, and therefore, only 60 pieces were analyzed to calculate the overall figures.

c. Plastic leakage hotspots (illegal dumpsites)

Can Tho University (2020) [*5]

Location	Can Tho
Duration	Not described
Samples dried?	No
Classification by	Volume
Collection by	Measuring dimensions

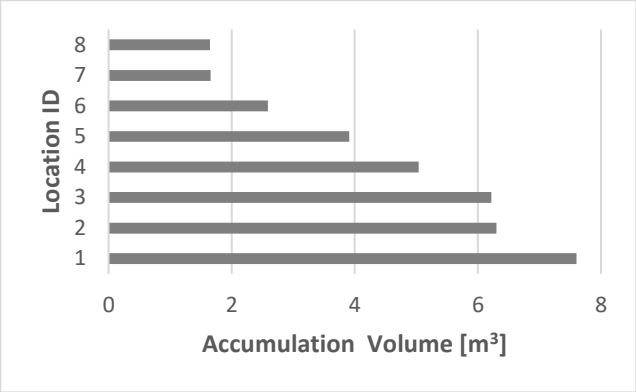


Figure 5-42. Volume of accumulated waste in illegal dumpsites

Results of surveying at illegal dumps in Can Tho city by Minh, V. et al (2020) are presented in Fig. 33. There were 8 illegal dumpsites detected during surveying time. The volume of wastes at illegal dumps ranged from 1.65 to 7.70 m^3, on average of 4.37 m^3. It could be seen that the big dumps were located in the central areas of the city, especially near resident zones such as Hung Phu, Tam Vu.

d. Plastic accumulation hotspots (artificial barriers)

Can Tho University (2020) [*5]

Location	Can Tho
Duration	Not described
Samples dried?	No
Classification by	Quantity, use
Collection by	Collecting in 20 litter plastic bag

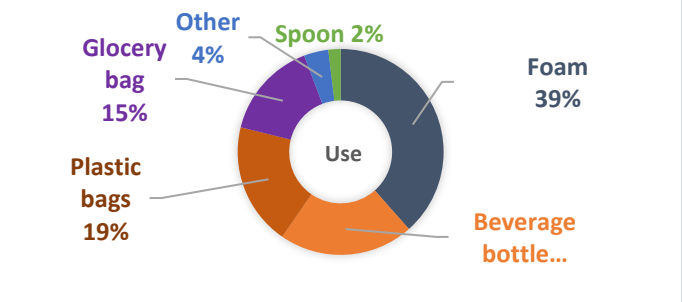


Figure 5-43. Debris classification by Quantity

Survey results of plastic wastes at two barriers, Xang Thoi barrier and Xuan Khanh barrier, showed that foam presented the highest proportion in both barriers (Minh, V. et al., 2020). Total of pieces collected on the Xuan Khanh barrier was about 1.5 times higher than that on the Xang Thoi barrier.

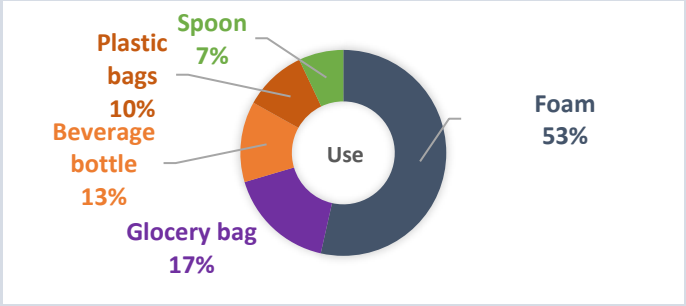


Figure 5-44. Debris classification by Quantity

On the Xang Thoi barrier , plastic beverage bottle was ordered in the second followed with other plastic bags and grocery plastic bags, respectively. The Xang Thoi barrier is located at the gate of an artificial lake which is a relaxing place in the city. Plastic waste could be originated from improper withdraw of waste by people living around. Meanwhile, the Xuan Khanh barrier is located near an open market. Therefore, most plastic wastes could be withdrawn from commercial activities in the market.

5.2. Riverine Monitoring Results Outside LMB

Outside of LMB, there are several reports on marine plastic debris that focus on items collected from the beach, river mouth, estuary, and open sea as shown in ***Table 5-4***. Just like in LMB, the number of monitoring activities of riverine plastic debris conducted and reported is very limited, and almost all the activities are not done regularly. However, sharing the resources such as knowledge, equipment and expertise among the area will surely accelerate the riverine monitoring system in LMB.

Table 5-4. Riverine Monitoring Results Outside of LMB

Project name	Organization	Location	Method	Volume		Description
				Tons	Pieces	
Cambodia						
Lao PDR: N/A						
Thailand						
Monitoring of macroplastics in 1-year period from March 2017-March 2018	DMCR	In 5 rivers including Bang Pakong, Chao Phraya, Tha Chin, Mae Klong and Bang Taboon rivers	Floating oil booms with underwater net	2,172	98,822,270 (plastic bag)	- Highest amount was captured from Chao Phraya River with the weight of 1,425 tons; and - For the type of most contributing pieces of garbage, 98,822,270 plastic bags were collected from the traps over this period.
Collected marine debris in 2019	DMCR	Beaches, coral areas, mangrove areas and river mouths	Collected 185 times	101.88	1,398,329	The highest number of garbage found includes plastic bottles (16%), bags (13%) and plastic packaging (9%).
Survey on type and amount of floating garbage going into the Gulf of Thailand and out of Songkla Lake	DMCR	At 5 river mouths and 4 stations at Songkla Lake	Based on International Coastal Cleanup (ICC)	2.879 (kg/ day) to the Gulf of Thailand 11.87 (kg/ day) out of Songkla Lake	245,755 (pieces/day) to the Gulf of Thailand 43,970 (pieces/day) out of Songkla Lake	Garbage is from recreational activities (90.8%), Fishing and marine transport (6.5%), medical activities (1.7%) and others.
Microplastic samples collected 2 times in 2019 during dry and rainy seasons	DMCR	21 beaches	FT-IR was used at the wavenumber 600-4,000 cm^{-1}	N/A	N/A	- Microplastic density in sand sediment ranged from 19 - 2,102 pieces/m^2 for dry season and 0 - 1,052 pieces/m^2 for rainy season; and

Project name	Organization	Location	Method	Volume		Description
				Tons	Pieces	
						- Major types of plastic found are PE, PET, PS and PP.
Total 1,235 cleanups in 2019	Trash Hero Thailand	From canals, rivers, beaches and open seas		280	N/A	
Clean-up collection	The Ocean Conservancy	N/A	- ICC - Collection by volunteers	10.4	191,916	The types and amount of garbage found are 31,408 plastic bottles, 10,391 food wrappers, 7,750 plastic bags, 6,316 plastic caps, 5,886 food takeout containers, 5,543 straws, 2,211 plastic cups and plates, 1,433 cigarette butts, 627 cup lids and 32,030 other items.
Viet Nam						
Marine debris survey and clean-up events in June 2016 and January 2017	N/A	Ha Long Bay	N/A	1.57 (2.2 km coastal-line)	N/A	- 220 volunteers and stakeholders participating, including local governments, distinguished guests (US Embassy in Vietnam, USAID), Ha Long Bay Management Board, the Youth Union, and the mass media; and - The most common marine litter items collected during coastal clean-up events were: Polystyrene (45.30%), plastic grocery bags (17.78%), plastic beverage bottles (9.40%), rubber sandals and shoes (2.96%), plastic bottle caps (2.03%), and others (22.53%).
International coastal clean-up	Coco Cola, Dow Vietnam, Amcham Vietnam and Keep Vietnam Clean and Green in collaboration	Vung Tau City	N/A	2.398 along 10.3 km of the coast	17,002 along 10.3 km of the coast	- 869 participants

Project name	Organization	Location	Method	Volume		Description
				Tons	Pieces	
	with Vung Tau's local committee and Ba Ria – Vung Tau university					
Beach monitoring activities	IUCN in partnership with GreenHub	In 132 transects (11 locations) including Bai Tu Long, Cat Ba, Bach Long Vi, Con Co, Cu Lao Cham, Ly Son, Hon Cau, Nui Chua, Nha Trang, Phu Quoc and Con Dao	N/A	N/A	N/A	- Forty-four debris categories were collected from beaches. Plastic items were the most numerous debris item (92% of the total number – 61% in weight): Styrofoam (31.37%), fishing net – rope (15.49%), container/foam (8.28%), plastic bags (6.93%) and beverage bottle (3.51%)
Study on macro and micro-plastic	Lahens *et al.* (2019)	In the Saigon River	sampling bulk water for anthropogenic fiber analysis and 300 mm mesh size plankton net exposition for fragment analysis	N/A	N/A	- The analysis of floating debris collected daily on the Nhieu Loc Thi Nghe canal by the municipal waste management service shows that the plastic mass percentage represents 11 - 43%, and the land-based plastic debris entering the river was estimated from 0.96 to 19.91 g/inhabitant/d, namely 350 to 7270 g inhabitant/ yr.; and - The macroplastics and fragments were mainly made of polyethylene and polypropylene while the anthropogenic fibers were mainly made of polyester.

Source: ***UNEP (2020c), GISTDA (2019), DMCR (unpublished), DMCR (2020), DMCR (unpublished) and Trash Hero (2020), Sunwook (2017), Ocean Conservancy (2020), IUCN (2020***

5.3. Clean up and collection activities in LMB

Table 5-5 shows the clean up and collection activities conducted in LMB. Some of the cleaning activities are included in **Section 5.1** and **5.2** (Monitoring activities and results in and outside LMB) since these include the information of collected debris.

In spite of large number of the plastic waste leakage/accumulation hotspots and the vast amount of unmanaged debris identified by CounterMEASURE II, there are no regular cleaning activities specifically focuses on LMB region. Other than the contents in the table, plastic debris monitoring activities all resulting from CounterMEASURE II in LMB (Section 5.3.1), and the absence of regular riverine debris monitoring activities outside LMB (Section 5.3.2) back up this argument.

Since cleaning up the debris requires allocation of human resources and financial resources, efficient collection system that can minimize the required effort of collection and the scientific evidence that back up the policy making is the urgent need.

Table 5-5. Summary of Riverine Plastic Debris Collection Activities in LMB

Type of Activity	Method	Organization	Location	Duration	Volume	Composition	Analysis	Disposal	Reporting
Cambodia									
World and National Environment Day	Awareness campaign	MOE, its line departments, relevant ministries, local authority	Random throughout Cambodia	one day event	No recorded	N/A	No	At dumpsites	No
National cleanup day (5 June)	Awareness campaign	MOE, its line departments, relevant ministries, local authority	Random throughout Cambodia	one day event	No recorded	N/A	No	At dumpsites	No
Recyclable plastic collection at referral hospital	Setup collection bins for plastic bottles	Referral hospitals	Mostly surrounding Tonle Sap's provinces	Daily	No recorded	N/A	No	Sale to scavengers/informal waste collector	No
Lao PDR									
Regularly clean-up	Manual collection	District Agriculture and Forestry Office (DAFO)	Water gates and irrigation canal	Every 3 months	N/A	reported	N/A	Disposed at landfill	Not exist
Thailand									
Regularly clean-up	Automatic screen	Department of Drainage and Sewerage, Bangkok Metropolitan Administrative	170 out of 300 pump stations		Daily	Recorded	No recorded	No	At dumpsite	Yes
Viet Nam									
Campaign "Clean up the Mekong River"	2 solar-powered garbage collectors (ship)	Hanwha Group (Korea) in collaboration with the Vietnam Environment Administration and	In Vinh Long	In 2019	N/A	N/A	N/A	N/A	N/A

Type of Activity	Method	Organization	Location	Duration	Volume	Composition	Analysis	Disposal	Reporting
		the Global Green Growth Institute (GGGI) of Vietnam.							
Regularly Collection	The Interceptor with autonomous in 24 hours a day, 7 days a week	The Ocean Cleanup (NGO)	Can Tho City	In 2019	50,000 kg of trash per day	N/A	N/A	N/A	N/A

Source: Vatthanamixay Chansomphou, Patarapol Tularak, Diep Dinh Phong

5.4. Solid waste management at 12 ports in 4 MCs

In surveying the solid waste management at ports and piers in MRC MCs, three ports were selected from each country for interviews. In the interviews, the amount of waste generated at the port, the amount of waste that are drifted to the shore, and the amount of the waste currently accumulated at the port were surveyed. Moreover, the method and system of managing both solid waste and accumulated/drifted debris was surveyed.

The map below shows the 12 locations selected for the survey, and IDs are given from the most upstream toward the downstream.

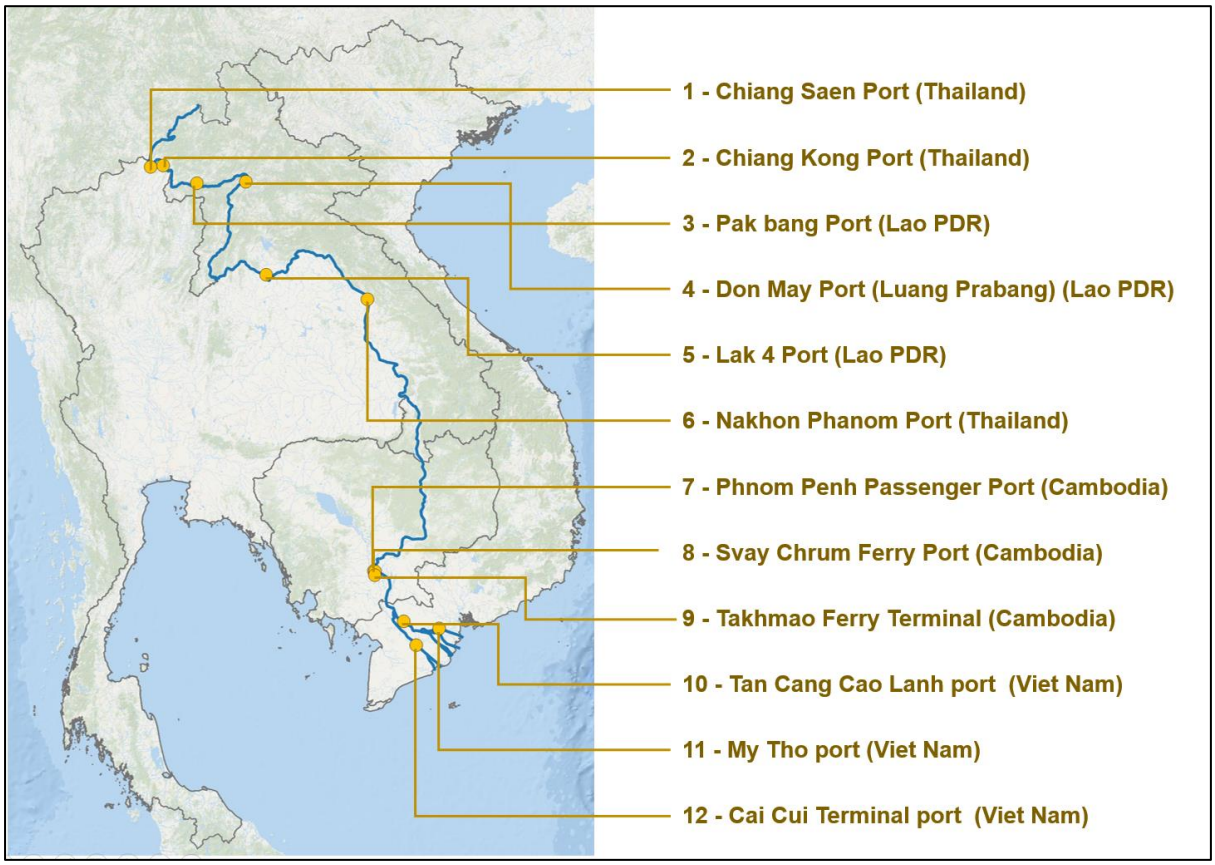


Figure 5-45. The map of 12 surveyed ports/piers

Interviewed results were then integrated using the conversion factor to calculate the weight of plastic waste from volume (or other way round) which is 0.35 t/m^3. This value is used in managing industrial waste in Japan (Japan Industrial Waste Information Center, 2013). In Japan, category of "plastic waste" in industrial waste includes waste plastic containers and packaging, Styrofoam, Urethane foam, Polystyrene foam, PVC construction materials, Waste tires, Plastic bumpers for automobiles, and Waste agricultural plastic. Although specific numbers are stated for each item, the weight of plastic waste per unit volume, on the whole, is stated to be 0.35 t/m^3. Similarly, in this report, 0.35 t/m^3 is used to convert the volume of overall plastic waste into weight as the recorded volume of plastic waste is the mixture of various kinds of goods. Some of the units are also modified from daily/weekly amount into monthly amount assuming that 1month equals to 4 weeks or 30 days. 3 figures below suggest the amount of waste generation, the amount of riverine debris flowing from the upstream, and the amount of current waste accumulation at each port, each of them defined in this report as follows.

- **Waste generation at port [kg/month]**:
  The total amount of general/plastic waste that is generated from activities at each port.
  Total amount of waste is cited from “6.2 Daily amount of wastes generated (t/d)” in the questionnaire (ANNEX-3).
  Amount of Plastic waste is cited from “6.2 Waste composition or type of waste” (ANNEX-3).
- **Spatial accumulation from upstream [kg/month]:**
  The amount of debris that is transported by the river from upstream.
  Total amount is cited from “7.1 Amount of (total) waste accumulation (per day, week, or year)” (ANNEX-3),
  Amount of plastic debris is cited from “7.2 Proportion of plastic waste accumulated” (ANNEX-3).
- **Accumulated plastic waste at port [kg]:**
  The amount of waste and debris that currently remain accumulated and uncleaned.
  It is cited from “8.2 Estimate total amount of accumulated wastes” and “8.3 Estimate total amount of accumulated plastic wastes” (ANNEX-3).

(1) **Waste generation at port [kg/month]**:
The amount of waste generation did not depend solely on the purpose of the port. The largest amount occurs at Port 8: Svay Chrum Ferry Port (Cambodia), with 7920 kg/month of median overall waste generation, however, the ratio of plastic could not be estimated because several people are engaged in waste collection and information is not shared among them. The main source of waste is the passengers from 11 ferries. The second largest is at the most upstream of surveyed ports, Chiang Saen Port in Thailand. It generates 3210 kg/month of waste overall, with 1350 kg of it being plastic. Its main purpose of use is trade, and the main source of wastes is the office.

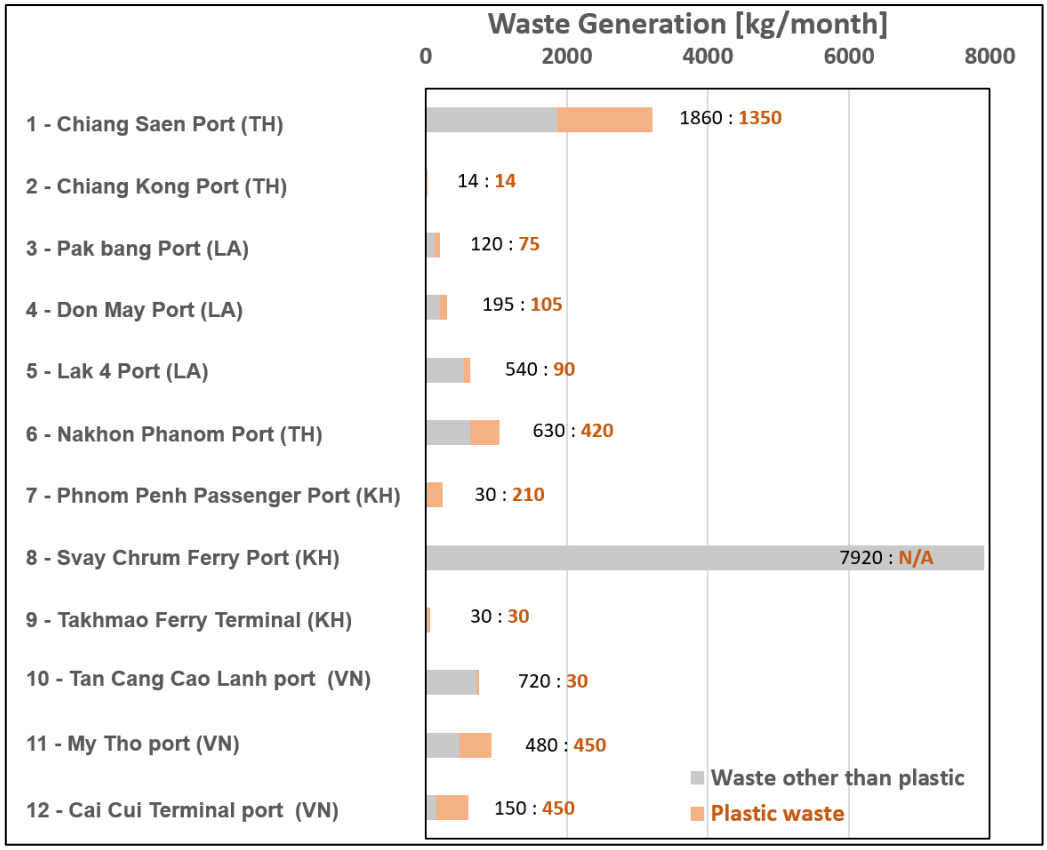


Figure 5-46. Generation of general/ plastic waste in 12 surveyed ports

(2) Spatial accumulation of riverine debris [kg/month]:

The monthly amount of debris flowing from upstream did not show the tendency to increase toward downstream showing large difference even within a country, both in the total debris including plastic and non-plastic. For example, at Port 1: Chiang Saen Port (Thailand), the monthly amount of overall drifted debris is 0 kg since its structure does not allow any debris accumulation, as observed in the interview survey. However, at Port 2: Chiang Kong Port (Thailand) located just down the Port 1, experiences the largest amount of debris accumulation among all the surveyed port, which is 150 kg/month in total, with 75 kg of it being plastic. Similarly, Port 9: Takhmao Ferry Terminal (Cambodia) also receives 150 kg/month of riverine debris with 45 kg of it being plastic. Debris is then cleaned by regular cleanup activities in Takhmao Ferry Terminal, while 3 ports located downstream does not observe accumulation. From these observations, there is an obvious difference in the locations where debris gets accumulated easily or merely, just like concentration of riverine plastic debris as stated in the previous chapter. The amount of the riverine plastic debris that a port receives in a unit time can be affected from a number of factors such as the structure of port and the frequency of cleaning activity in the upstream.

The ratio of plastic debris to the overall amount was the highest in Port 1: Chiang Saen Port. In the other ports where spatial accumulation was observed, the ratio of plastic debris varied from 10 % to 30 %. The most observed plastic item was plastic bag ranking top in 5 observed ports, then the bottle ranking top in 4 ports.

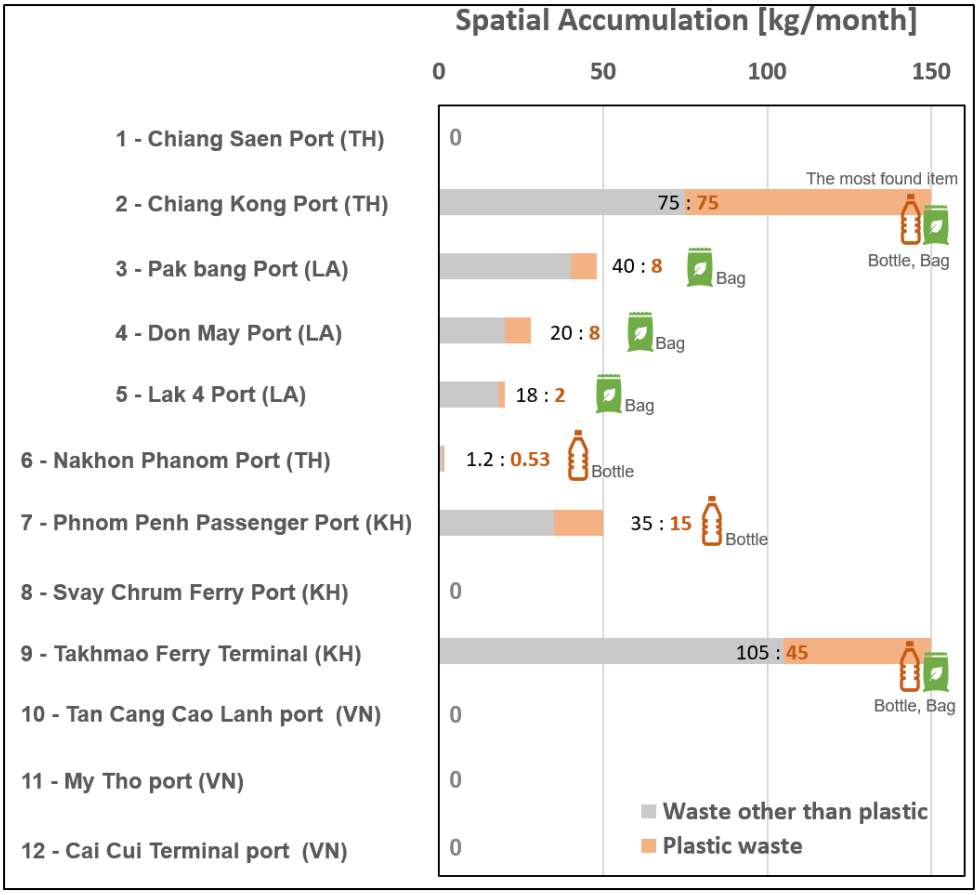


Figure 5-47. Spatial accumulation of riverine debris in 12 surveyed ports

	1st	2nd	3rd
1	(Not observed)		
2	Bag, Bottle		
3	Bag	Bottle	Foam container
4	Bag	Bottle	Container
5	Bag		
6	Bottle (90%)	Bag (10%)	
7	Bottle (40%)	Bag, Container (30%)	
8	(Not observed)		
9	Bag, Bottle (40%)	Container (20%)	
10	(Not observed)		
11	(Not observed)		
12	(Not observed)		

Figure 5-48. Popular plastic items that drift to the 12 surveyed ports

(3) Accumulated plastic waste at port [kg]:

The overall amount of debris accumulation at each port/piers showed increase from upstream to the downstream, unlike the debris flow. With concentration and destination of riverine debris varying complicatedly from place to place, it can be suggested that this difference results from the frequency and scale of cleanup activities. For example, 3 ports in Viet Nam, Tan Cang Cao Lanh Port, My Tho Port, and Cai Cui Port where no cleanup activities are conducted experiences the largest debris accumulation among 12 ports, which is 840 kg, 910 kg, and 4900 kg respectively, including both plastic and non-plastic. On the contrary, Port 4: Don May Port (Lao PDR) and Port 9: Takhmao Ferry Terminal (Cambodia) with regular cleanup activities of 12 times/month and 30 times/month accumulates relatively small amount of debris which is 5 kg and 40 kg respectively, including both plastic and non-plastic, despite the large amount flowing from the upstream.

In the accumulated debris, the ratio of plastic waste to the overall accumulation was above 70 % in 7 surveyed ports, namely, Port 1: Chiang Saen Port 100 %, Port 2: Chiang Kong Port 100 %, Port 6: Nakhon Phanom Port 100%, Port 7: Phnom Penh Passenger Port 100 %, Port 10: Tan Cang Cao Lanh port 70 %, Port 11: My Tho Port 70%, and Port 12: Cai Cui Port 90 %. Unlike the ratio in the spatial accumulation that mostly

For further analysis, the composition of accumulated plastic debris is shown in figure .In 8 locations, the sum of the percentages of bottles and bags was above 50 %.

Figure 5-49. The amount of accumulated debris (plastic and non-plastic) in 12 surveyed ports

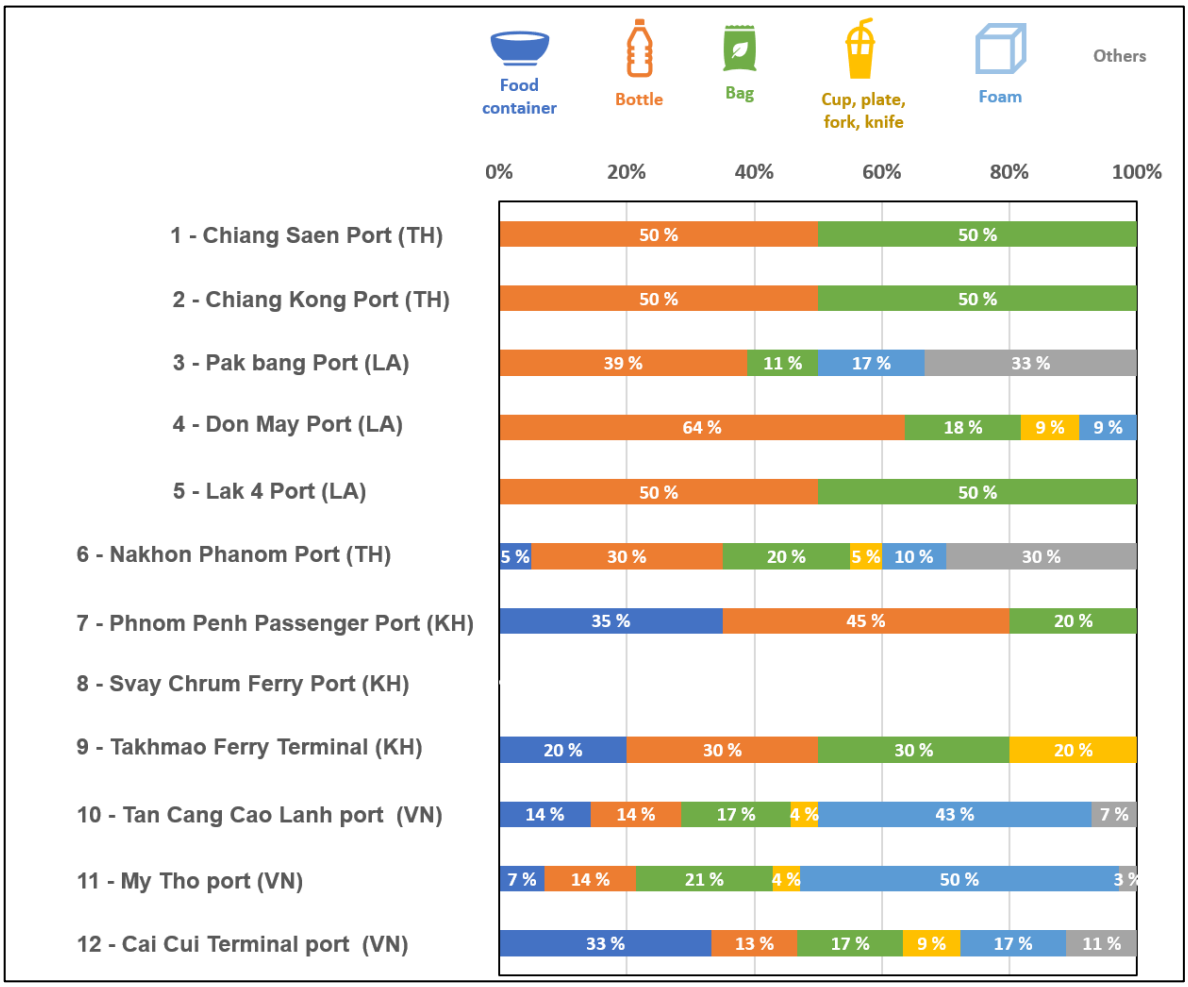


Figure 5-50. The composition of accumulated plastic debris

(4) Relation between waste generation, spatial accumulation, and accumulated debris

There was a significant difference in amount of waste generation, spatial distribution, and debris accumulation among the surveyed locations, however, comparing them gives us an interesting perspective. For example, Port 2: Chiang Kong Port (Thailand) generates the smallest amount of waste while receiving the largest amount of riverine debris from upstream, therefore its monthly accumulation exceeding its solid waste generation. This unbalanced source of waste is also seen at Port 9: Takhmao Ferry Terminal (Cambodia), that is located directly downstream of Phnom Penh city. Because of the transboundary movements of riverine debris, it is highly possible that some locations bear the burden in managing the wastes from other area, in terms of both financial and human resources. This is nothing but one of the biggest problems of riverine plastic debris "unclear responsibility due to the transboundary movements", which underlines the increased importance of clarifying the path of riverine debris movements. While the ratio of plastic waste in accumulated debris was above 70 % in 7 ports out of 11, the ratio of plastic in spatial accumulation reached 50 % in only 1 port, with rest of them being 10 % to 30 %. This suggests that the plastic debris that drift to the port can remain in the environment longer than other items due to its persistent structure, compared to other items such as organic matter that gets decomposed by the microorganisms in the riverbank. As for the items, bags and bottles were reported to be most found in spatial accumulation. And similarly in the accumulated debris, bottle accounted for the largest part in 8 ports, and bags account for the largest in 4 ports among the reported items. And together they compose more than 50 % in 8 locations.

To appropriately address the riverine plastic debris problems in close cooperation within 4 MCs, the agreed concept and framework on managing the drifted debris is necessary. To do so, analyzing the path of riverine debris, systematic solid waste management, and role sharing considering the capacity of each country will play a crucial role.

Note (Data modification):

- Specific gravity of plastic waste = 0.35 ton/m^3
- 1 month = 4 weeks = 30 days
- The values answered in range is modified into the median (e.g., 10 – 20 kg => 15kg).
- For the unification of data sources, all the numbers are cited from the original questionnaires, not from the national report.
- "Accumulated plastic waste" was significant in Lao PDR, being around 1000 times bigger than others. Please confirm the units as also commented in the national report.

5.4.1. Cambodia

- **Waste generation**

Wastes are mainly generated from the passengers in tourism and trade. Especially Svay Chrum Ferry Port, where 9 medium and 2 big ferries operate every day, manages 99 kg/day to 165 kg/day of waste, which ranks first in all the 12 surveyed ports.

- **Waste management**

The waste management in each port is tasked by the manager to keep each boat clean. However, the management follows their own rules with the lack of official management plans. Segregation of waste is only done in the Svay Chrum Ferry Port, only when primarily collecting them right after use.

- **Accumulation and cleanup activity**

Unlike the waste generation, the largest amount of waste flow from upstream was observed at Takhmao Ferry terminal. Despite the large amount drifting to the shore, the accumulation at Takhmao Ferry Terminal was as small as any other ports in MCs due to regular cleanup activities. Cleanup activities are conducted about 3 times a week based on the project "one earth one ocean", where COMPED (Cambodia Educational Waste Management Organization) collects and record the drifted waste. As reported by the manager, total waste collected within 6 months in 2021 around 50t in which plastic accounts for 15%, and 82.2% of collected waste goes to land fill.

Figure 5-51. Map of surveyed ports in Cambodia

Table 5-6. Profile of 3 surveyed ports in Cambodia

Port ID		7	8	9
Name		Phnom Penh Passenger Port	Svay Chrum Ferry Port	Takhmao Ferry Terminal
Management		Government	Private	Government
Main purpose		Tourism	Tourism	Trade
Waste management				
Main source of waste		Passenger	Passenger	Passenger
System	Designated agency	-	-	-
	Management plan	-	-	-
	Awareness in personnel	-	-	-
Generation	Plastic [kg/month]	210	N/A	30
	Overall [kg/month]	240	3960	60
Routine Collection	Overall [kg/month]	300	N/A	30
	Collection Bin	X	X	X
	Central Collection	X	X	-
	By	Government	Government	Government
	Segragation	-	Primarily	-
Accumulation and cleanup activity				
From upstream	Plastic [kg/month]	15	-	45
	Overall [kg/month]	50	-	150
At artificial barrier	Plastic [kg]	2	0	10
Collection [time/month]		0	0	12

5.4.2. Lao PDR

- **Waste generation**

Wastes are mainly generated from the port office, and ship operation. Passenger cruises are the main source of waste as they carry and dispatch about 200 people/day/port. The waste mainly consists of organic materials such as food waste, green waste (garden and park waste), and paper and cardboard.

- **Waste management**

At all ports, waste baskets/bins are set for waste collection. Central waste collection point exists for the port at Vientiane; however, none exists at Done Mai port of Luang Prabang. Waste recycling facility being not available at any ports, most recyclable materials are usually collected informally by the port workers/keepers.
There is scheduled clean-up at each port; at least once a week in Vientiane and twice a week in Don May and Pak Bang. Event-based clean-up activities also exist at each port; they occurred depending on national events. Besides, there are also unscheduled clean-up due to unexpected accumulation of waste along the riverside in the port area. These are done twice a month in Vientiane, and twice a week in Luang Prabang and Pak Beng.

- **Accumulation and cleanup activity**

Waste found at these ports are mostly removed by the port authority with conventional manual removal. In Vientiane, all waste is removed and disposed at central waste collection point, while in Luang Prabang and Pak Beng, most riverine waste is collected and put in the temporary designated collection point the day before the waste truck arrives.

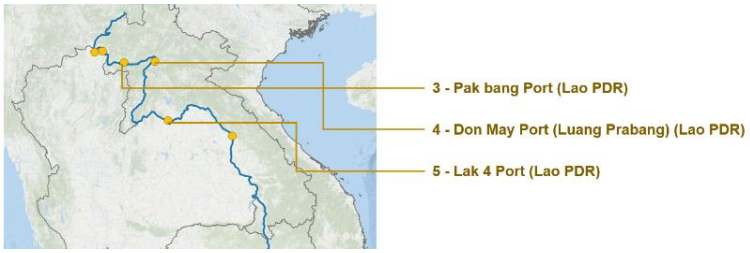


Figure 5-52. Map of surveyed ports in Lao PDR

Table 5-7. Profile of 3 surveyed ports in Lao PDR

Port ID		3	4	5
Name		Pak bang Port	Don May Port (Luang Prabang)	Lak 4 Port
Management		Government	Government	Government
Main purpose		Trade, Tourism	Tourism	Trade, Tourism
Waste management				
Main source of waste		Tourism	Ship operation	Office
System	Designated agency	X	X	X
	Management plan	X	X	-
	Awareness in personnel	X	X	-
Generation	Plastic [kg/month]	75	105	90
	Overall [kg/month]	195	300	630
Routine Collection	Overall [kg/month]	300	N/A	4500
	Collection Bin	X	X	X
	Central Collection	X	X	X
	By	Government	Government	Government
	Segragation	-	Collection	Primarily
Accumulation and cleanup activity				
From upstream	Plastic [kg/month]	10.5	18	2
	Overall [kg/month]	30	75	20
At artificial barrier	Plastic [kg]	1	27.5	4
Collection [time/month]		0	Depends	30

5.4.3. Thailand

- **Waste generation**

The waste types, quantity, and the distributions among the survey ports varied possibly due to their operation objectives. Food and plastic waste seem to be in high proportion in Nakhon Phanom City Port that hosted a dining boat cruise while plastic and paper/cardboard wastes are at major fraction in Chiang Saen Commercial Port.

- **Waste Management**

Waste management among three surveyed ports in Thailand are moderately to readily available. All three ports are equipped with collection system in terms of collection bins. Segregations are in practice, and waste management personnel or units have been designated and in operation in all three surveyed ports. Chiang Saen Commercial Port has central waste collection site along with waste management plan, according to their EIA requirement. Its employees are also aware of this waste management plan.

- **Accumulation and cleanup activity**

Waste accumulation from upstream seems to be very light at 2 ports including Chiang Saen Commercial Port not experiencing accumulation because of the location. On the contrary, Chiang Kong Port has approximately 100-200 kg of upstream waste per month, 50% being plastic. The crew of Mekong Paradise Cruise II of Nakhon Phanom City Pier schedule a monthly clean-up for good aesthetics monthly by using dip net to take accumulated waste out of the river. Wastes are then carried to the municipal bins for further transported to landfill. Nevertheless, Chiang Saen Commercial and Chiang Kong Ports do not hold such clean-up programs for accumulated waste from upstream.

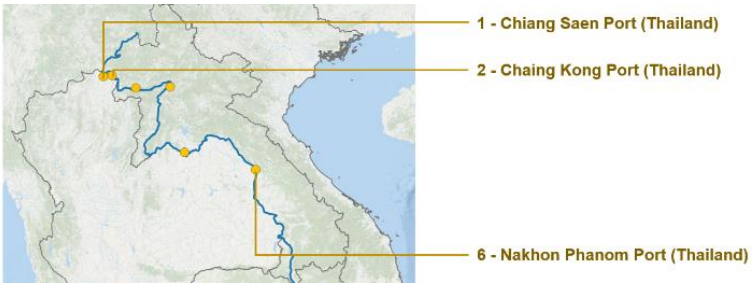


Figure 5-53. Map of surveyed ports in Thailand

Table 5-8. Profile of 3 surveyed ports in Thailand

Port ID		1	2	6
Name		Chiang Saen Port	Chiang Kong Port	Nakhon Phanom Port
Management		Government	Government	Government
Main purpose		Trade	Trade, Tourism	Tourism
Waste management				
Main source of waste		Office	Tourism	Ship operation
System	Designated agency	X	X	X
	Management plan	X	-	-
	Awareness in personnel	X	-	-
Generation	Plastic [kg/month]	1350	14	420
	Overall [kg/month]	3210	28	1050
Routine Collection	Overall [kg/month]	6000	28	630
	Collection Bin	X	X	X
	Central Collection	X	-	X
	By	Private	Government	Government
	Segragation	X	-	Primarily
Accumulation and cleanup activity				
From upstream	Plastic [kg/month]	-	75	0.525
	Overall [kg/month]	-	150	1.75
At artificial barrier	Plastic [kg]	1	0.2	1
Collection [time/month]		0	0	0

5.4.4. Viet Nam

- **Waste generation**

In the three ports, the waste sources are from port office and ship operation. Other sources come from passing by tourist in My Thuan port and storage house, equipment maintenance in Tan Cang Cao Lanh and Cai Cui ports.

- **Waste management**

As the waste generated at the ports is small amount, central waste collection point at the port is considered not necessary. Despite the decree no. 38/2015/NĐ-CP on management of waste and discarded material, the waste segregation is not properly implemented. For example, the recyclable wastes which are not for sale or difficult for segregation such as nylon bag, food containers, etc. are generally mixed with food waste in the same container.

The Cai Cui port is the only port with the waste management plan, however, it is not well-informed allowing only related managing personnel to be aware.

- **Accumulation and cleanup activity**

Accumulated wastes were observed only one location, along the wharf for each port.

Although the waste accumulation is visible at the ports, the waste is not managed nor controlled by any unit (private company, local government, port personnel and resources). In addition, information on amount of waste, waste composition is still lacking.

Figure 5-54. Map of surveyed ports in Viet Nam

Table 5-9. Profile of 3 surveyed ports in Viet Nam

Port ID		10	11	12
Name		Tan Cang Cao Lanh port	My Tho port	Cai Cui Terminal port
Management		Private	Private	Private
Main purpose		Trade	Trade	Trade
Waste management				
Main source of waste		Office	Office	Office
System	Designated agency	X	X	X
	Management plan	-	-	X
	Awareness in personnel	-	-	-
Generation	Plastic [kg/month]	30	450	450
	Overall [kg/month]	750	930	600
Routine Collection	Overall [kg/month]	750	930	600
	Collection Bin	Land	Land	X
	Central Collection	-	-	-
	By	Private	Private	Private
	Segragation	Primarily	Primarily	Primarily
Accumulation and cleanup activity				
From upstream	Plastic [kg/month]	-	-	-
	Overall [kg/month]	-	-	-
At artificial barrier	Plastic [kg]	588	637	4410
Collection [time/month]		0	0	0

Main results and key challenges

- The CounterMEASURE II studied the composition and weight/volume of riverine debris both microplastics and macroplastics. Also, it has listed up the plastic accumulation hotspots such as illegal dumping sites, and plastic leakage hotspots such as artificial barriers with the details.
- Regarding macroplastics, the concentration varied from place to place. At all the points surveyed, PE was the most popular material, and Plastic wrapper was the most popular product showing the importance of revision of the packaging materials.
- Regarding microplastics, the concentration increased as it goes down the stream. At all the points surveyed, PP was the most popular material since its lowest density among all the plastics enables it to be carried for a long distance. PET with the high density was not seen as it sinks in the water and does not appear in the surface water.
- Plastic waste hotspots, which are Illegal dumping sites and artificial barriers, were found in the great quantity with waste accumulation along the riversides and roadsides. Types of products of plastic waste at artificial barriers did not show similarity, emphasizing the need for the individual treatment at each location. They are considered to be the main leakage source to the waterways, and their details often showed the lack of appropriate supervision and cleaning activities.
- While this information can be utilized for effective policy making processes, it still contains the room for development as a tool or a system for plastic pollution monitoring. To be specific, their collection methods (equipment, duration) and reporting methods (units, classification) used for data collection vary significantly making it impossible to compare the data within areas or over time. For appropriate monitoring, establishing the standardized/harmonized methods for data collection and compilation is essential.
- While these research results and public services do contribute to tackling the riverine plastic pollution, there needs to be a role-sharing system that maximizes the benefit of effort from each stakeholders. For the closer cooperation to effectively manage the riverine plastic debris, governmental organizations of MRC MCs need to work on establishing the regular activities on waste monitoring and collection in LMB.
- Most of the macroplastic debris found were the popular products in our daily lives. This means, raising awareness of the residents in the region as well as developing the appropriate SWM systems will be the keys to combating the riverine debris in the Mekong River.
- There was a significant difference in amount of both waste generation and waste accumulation among the survey locations, however, it did not show any correlation between each other. Because of the transboundary movements of riverine debris, it is highly possible that some locations bear the burden in managing the wastes from other area, in terms of both financial and human resources. This is nothing but one of the biggest problems of riverine plastic debris “unclear responsibility due to the transboundary movements”, which underlines the increased importance of clarifying the path of riverine debris movements.
- To appropriately address the riverine plastic debris problems in close cooperation within 4 MCs, the agreed concept and framework on managing the drifted debris is necessary. To do so, analyzing the path of riverine debris, systematic solid waste management, and role sharing considering the capacity of each country will play a crucial role.

6. Fishery Activities and the Impacts of Plastic Pollution to living organisms

The Mekong River system hosts one of the most diverse and prolific freshwater capture fisheries in the world, with the largest fisheries catch occurring in the extensive floodplain in central Cambodia and the Mekong Delta of Viet Nam (MRC, 2019). The abundant natural resources support the life in LMB. A recent review of MRC monitoring programme data and other studies from multiple sources estimated there are 1,148 fish species in the Mekong Basin, making the LMB one of the places with the highest fish biodiversity per square kilometre in the world (MRC, 2019).

Yet, the plastic pollution is said to cast various adverse effect on life in the water. The following chapters explain the fishery activity in LMB (***Chapter 6.1***), and impact on living organisms based on literature review and interview survey (***Chapter 6.2***).

6.1. Fisheries in the LMB

The overall unit value of capture fisheries in LMB is derived from first-sale prices of wide variety of fish species. Based on average first-sale prices in each of the four Member Countries, the economic value of the 2.3 million tonnes of annual capture fish production was calculated at about US$ 11.2 billion, representing about 65% of the total value of all types of fisheries production. Of this, the economic value from capture fisheries in Thailand is the largest at US$ 6.3 billion and Cambodia second at US$ 2.8 billion annually (MRC, 2019).

For sustainable use of water resources, national and regional organizations have worked closely on monitoring freshwater fauna. To start with, the MRC conducts 3 kinds of monitoring programmes including Fish Abundance and Diversity Monitoring (FADM), Fish Larvae and Juvenile Drift Monitoring (FLDM), and Dai (bag-net) fishery monitoring in Tonle Sap River. Specifically on the use of fish, MRC has integrated the monitoring results from various survey into one report “Integrated Analysis of Data from MRC Fisheries Monitoring Programmes in the Lower Mekong Basin” (MRC, 2013), where the contributions of fish species to the total catch weight have been analysed. The table below shows the species which contribute more than 1% of the total catch on the average within 4 MCs. Contribution Rank (CR) is based on the contributions to the total fish catch weight (average of 4 countries).

Table 6-1. Species that largely contribute to the catch in LMB

Species	Average contribution to the total catch [%]	CR [-]	Species	Average contribution to the total catch [%]	CR [-]
Henicorhynchus siamensis	5.9	1	*Macrobrachium* sp.	1.7	20
Clupeoides borneensis	5.7	2	*Pangasius macronema*	1.7	20
Cosmochilus harmandi	4.4	3	*Hemibagrus wyckioides*	1.5	23
Labeo chrysophekadion	4.1	4	*Bagarius yarrelli*	1.5	23
Cirrhinus lobatus	3.4	5	*Paralaubuca riveroi*	1.5	23
Hemibagrus spilopterus	3.3	6	*Helicophagus leptorhynchus*	1.5	23
Pangasius conchophilus	3.3	6	*Mystus mysticetus*	1.4	27
Hemibagrus nemurus	2.7	8	*Puntioplites proctozystron*	1.2	28
Phalacronotus apogon	2.6	9	*Hypsibarbus lagleri*	1.2	28
Puntioplites falcifer	2.5	10	*Macrognathus siamensis*	1.1	30
Poropuntius malcolmi	2.4	11	*Bagarius bagarius*	1.1	30
Anabas testudineus	2.3	12	*Labiobarbus lineatus*	1.1	30
Helicophagus waandersii	2.2	13	*Notopterus notopterus*	1.0	33
Wallago attu	2.1	14	*Pangasius djambal*	1.0	33
Barbonymus gonionotus	2.1	14	*Labeo erythropterus*	1.0	33
Cyprinus carpio carpio	2.0	16	*Channa striata*	1.0	33
Polynemus dubius	1.9	17	*Boesemania microlepis*	1.0	33
Scaphognathops stejnegeri	1.8	18	*Phalacronotus bleekeri*	1.0	33
Nibea soldado	1.8	18	*Syncrossus helodes*	1.0	33
Netuma thalassina	1.7	20			

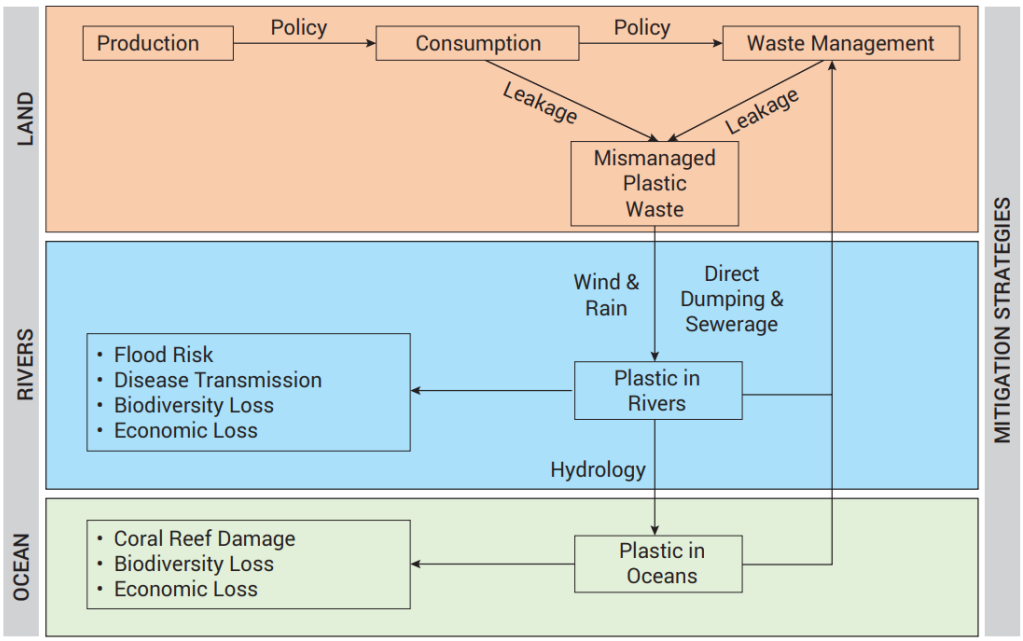
Source: Modified from "Integrated Analysis of Data from MRC Fisheries Monitoring Programmes in the Lower Mekong Basin" (MRC, 2013)

Monitoring of freshwater fauna are carried out on the national level as well, both by the government and in collaboration with MRC. Other monitoring programmes by each country are listed up in the ANNEX-1 "Riverine Environmental Monitoring Activities".

6.2. Impact of plastic pollution

Plastic pollution, emitted from land can be transferred into the environment as shown in ***Figure 6-2***, causing biodiversity loss in rivers and ocean, and also coral reef loss in the ocean.

For example, common issue with macroplastic is entanglement of species, and common issue with microplastic is ingestion. Despite plenty of reports of direct harm or mortality as a result of plastic entanglement or ingestion across a wide range of aquatic and terrestrial species, as yet there is little evidence available on long-term population-level impacts resulting from plastic pollution alone (CMS, 2021).



Source: UNEP (2020a)

Figure 6-1. Conceptual flow of plastic from production to consumption, waste management and leakage into the natural environment (land, rivers and ocean) with possible points of action for policies

6.2.1. The literature reviews

The literature review revealed the adverse effect of plastic debris to living organisms such as entanglement, ingestion of plastic. This plastic can even capture and accumulate the hazardous chemical substances in itself, then transfer to living organisms, further leading to Bioconcentration. Although the information below is not limited to the LMB, the knowledge will surely help us understand and take appropriate measure to prevent damage from plastic pollution.

Macroplastic - Entanglement

- Globally, Ryan (2018) reviewed literature and information on the internet using various combinations of search terms, bird groups (mainly waterbirds) as well as other terms such as 'plastic', 'balloon', 'six-pack ring', etc in 16 languages. He found that the proportion of affected seabirds increased from 16% of species to 25% over the last two decades in 2015. He further explored with Google Images and other web-based sources and found that at least 147 seabird species (36%), as well as 69 freshwater birds (10%) and 49 land birds (0.5%) from 53 families have been entangled in plastic or other synthetic materials. Fishing gear is responsible for entangling most species (83%) (Ryan, 2018).

Microplastic - Ingestion

- In India, Rochman et al. (2017) reported that an experimental study was carried out by feeding a range of environmentally relevant microplastics to the prey species Asian Clam (*Corbicula fluminea*), and subsequently feeding the clams to their natural predator, White Sturgeon. It was observed that feeding behavior was altered in the sturgeon exposed to clams that had ingested microplastics, with exposed sturgeon ingesting more food overall. Asian Clams are a key food source for a range of Acipenser species and therefore it is a

reasonable assumption that other species of sturgeon within the region of interest will also ingest microplastics through their prey and may show similar responses.

- Chi River is a major Mekong tributary in the Northeastern Thailand that drains into Mekong River in Ubon Ratchathani Province. Kasamesiri and Thaimuangphol (2020) examined 8 freshwater fish species from Chi River in Maha Sarakham Province. The fish species were across a wide range of habitats and feeding habits, and included *Labiobarbus siamensis*, *Puntioplites proctozyson*, *Cyclochelichthy repasson*, *Henicorhynchus siamensis*, *Labeo chrysophekadion*, *Mystus bocourti*, *Hemibagrus spilopterus*, and *Laides longibarbis* Out of 107 individuals examined, 78 individuals were found with microplastics in their digestive tracts. This is equivalent to 72.9% overall occurrence with 50.0% – 86.7% occurrence in each species. *Puntioplites proctozysron* had the highest occurrence rate (86.7%). Overall mean abundance of microplastics was at 1.76 ± 0.58 pieces per fish. There was no significant difference in mean abundance among these 8 fish species. In terms of microplastic characteristics, almost half (47.5%) of microplastics found in these samples were larger than 0.5 mm, which is the size frequently used in fishing lines or ropes (Kasamesiri and Thaimuangphol, 2020). Fiber-shaped microplastics (86.9%) was at the highest percentage among other microplastic shapes (5.8% rods, 4.4% pellets, and 2.9% fragments). Blue (56.9%) was the color with the highest percentage of microplastics among other colors (15.3% red, 10.9% black, 9.5% white, 5.1% transparent, and 2.2% brown). The results showed variations and possible diversity of microplastics that could be originated from various sources of plastics pollution.
- In Thailand, a study on the digestive tracts in fish was carried out in 10 stations around the Ubolratana Reservoir, Khon Kaen Province (Kasamesiri et al., 2021). The reservoir is one of the major reservoirs on the Chi River Basin. Fourteen fish species were examined from the reservoir including *Puntioplites proctozysron*, *Cyclocheilichthys repasson*, *Parambassis siamensis*, *Henicorhynchus siamensis*, *Pristolepis fasciatus*, *Labiobarbus leptocheilus*, *Barbobymus goniontus*, *Rasbora aurotaenia*, *Clupeichtys aesarnensis*, *Mystacoleucus marginatus*, *Osteochilus vittatus*, *Paralaubuca harmandi*, *Mystus mysticetus*, and *Hemibagrus spilopterus*. Ten out of 14 fish species were found with 100% occurrence, with overall 96.4% occurrence across all fish species (163 out of total 167 individuals). The abundance of microplastic in each fish ranged from 0 – 6 pieces per fish with overall mean of 2.92 ± 1.30 pieces per fish. These occurrence and abundance were higher than those of Kasamesiri and Thaimuangphol (2020) in the Chi River while the characteristics of microplastics (size class, color, and shape) were at the same trend as the study. One highlight from the study of Kasamesiri et al. (2021) was that the highest abundance of microplastics (3.79 ± 1.25 pieces per fish) among all sites in the reservoir was found at the station where a major tourist recreation spot is located. Meanwhile, the low-population site in th reservoir was found with the lowest microplastic abundance (2.20 ± 1.24 pieces per fish) This showed that human activities, especially tourism could be a risk factor in increasing microplastic pollution in aquatic ecosystems.
- Study from Songkla province in the Lower Gulf of Thailand that focused on the distribution of size classes of plastic debris, including microplastics, that were found in four marine fishes, Panna croaker (*Panna microdon*), Goatee croaker (*Dendrophysa russelli*), Sharpnose hammer croaker (*Johnius borneensis*) and Weber's croaker (*Johnius weberi*) (Azad et al., 2018). Most plastic debris found in the fish stomach was mesoplastics (between 5-25 mm, pelagic 68.57% and demersal 71.19%), followed by microplastics (smaller than 5 mm, pelagic 25.72% and demersal 28.81%) and macroplastics (larger than 25 mm, pelagic 5.71% and demersal 0%). Demersal and pelagic fish samples showed slightly differences in the percentages of the size plastic debris. These pieces of results showed that size distribution is possible and could be observed in other systems, and differences in fish habitat could yielded in size distribution too.

- In Viet Nam, studies of microplastic contamination were conducted in Asian green mussels from a brackish water zone in Thanh Hoa province and wild species of fishes and shrimps from the Long Tau river – downstream zone of the Saigon – Dong Nai River (Phuong et al., 2019; Kieu Le et al., 2021).
- In Dong Nai River system, Viet Nam, microplastic were found in all tested species with 99% of the microplastic being in the shape of fibers (Kieu Le et al., 2021). The tested species were wild shrimps and fish (*Metapenaeus ensis*, *Metapenaeus brevicornis*, *Cynoglossus puncticeps*, Family Scianidae, *Polynemus melanochir*, *Pseudapocryptes elongatus*, *Clupeoides borneensis* and *Glossogobius* sp.). In more detail, the average microplastic fiber concentration varied from 0.33 to 1.41 fibers per gram wet weight of organisms with the lowest and highest concentrations found in *Pseudapocryptes elongatus* and *Metapenaeus brevicornis*, respectively. Concentrations of fibers varied from 1.33 to 9.33 fibers per individual with the lowest and highest concentrations found in *Polynemus melanochir* and *Clupeoides borneensis*, respectively.

Accumulation of chemical substances

- Yamashita et al. (2011) investigated the short-tailed shearwaters, Puffinus tenuirostris, that were accidentally caught during experimental fishing in the North Pacific Ocean in 2003 and 2005. Although Plastic mass did not correlate with body weight, the ingested plastic mass correlated positively with adipose concentration of lower-chlorinated Concentration of polychlorinated biphenyls (PCBs) (Yamashita et al., 2011).

6.2.2. The primary data collection by interview

Interviews to the fishermen and fish vendors were conducted in 4 MCs aiming to clarify the plastic pollution status on freshwater fauna. The interview mainly focused on 2 points, the incidence of living organisms getting entangled by riverine plastic debris (hereafter referred as entanglement), and the incidence of species found with plastic debris in the digestive system (hereafter referred as ingestion).

The interviewed results visualized the impact of plastic pollution varying from place to place. While no incidences of entanglement nor ingestion was reported in Lao PDR, Striped Catfish, classified as endangered (EN), was found to ingest the Styrofoam in Viet Nam. Also, a fish vendor in Chiang Saen, Thailand, claimed that she frequently opened up fish stomach to clean them before selling. Apart from the entanglement and the ingestion, the fishermen in Cambodia have been facing the amount of plastic debris that exceeds the fish catch for the period of 5 years.

Nevertheless, the analysis on the effect of plastic debris on the freshwater fauna shows a serious lack. 4 countries have reported that there was no published report on the effect of plastic pollution on freshwater ecosystem in LMB nor in specific MCs. Some of the consultants pointed out that the most research put emphasis on analysing the marine ecosystems rather than on freshwater. Considering the fact that Mekong River ecosystem provides food and home to various species including human, clarifying both the distribution and significance of the risk of plastic pollution is necessary.

The table below shows the summary of the entanglement and ingestion reported in 4 MCs. Two columns on the left shows the scientific names and English common names. The right-next column shows the conservation status in IUCN red list, and in CITES. Then 4 right-next columns shows whether the entanglement or ingestion has been observed within 4 MCs. The right-most column shows the contribution to the total fish catch (average of 4 MCs).

From the interview surveys, it was found that the even species under the threat of extinction, such as *Bagarius bagarius* (Near Threatened: NT), *Wallago attu* (Vulnerable: VU), *Pangasius hypophthalmus* (Endangered: EN) are affected by entanglement or ingestion of plastic debris. On the

other hand, species that significantly contribute to the fish catch in the Mekong River are also affected by both entanglement and ingestion. This means that the lives of species that play critical role both on the environmental hierarchy and our daily lives, are at risk. Also, since the table shows the result from interviewing several fishermen from each country, the closer scientific observation of the ecosystem may possibly reveal the further adverse impacts. To say, the case of frequent ingestion of plastic debris seen in Chiang Saen, Thailand, could be happening anywhere in the basin. In this context, continuously monitoring the impacts of plastic pollution on freshwater fauna and comparing the results over locations and time, will surely enable us to take effective action towards the more sustainable use of freshwater resources.

Table 6-2. Impact from plastic pollution on freshwater fauna observed in interviews

Species	English Common Name	Conservation Status		Effect from plastic debris E: Entanglement, I: Ingestion								CR *1
				KH		LA		TH		VN		
		IUCN	CITES	E	I	E	I	E	I	E	I	
Bagarius bagarius	Goonch	NT	N/A						X			30
Barbonymus gonionotus	Common silver carb	LC	N/A						X			14
Channa striata	Snakehead Murrel	LC	N/A	X								33
Cirrhinus siamensis	Siamese mud carp	LC	N/A	X								-
Clarias batrachus	Philippine catfish	LC	N/A							X		-
Clarias gariepinus	African sharptooth catfish	LC	N/A							X		-
Cyclocheilichthys enoplos	Soldier river barb	LC	N/A							X		-
Cynoglossus microlepis	Smallscale tonguesole	LC	N/A							X		-
Datnioides microlepis	Finescale tigerfish	LC	N/A							X		-
Glossogobius biocellatus	Sleepy goby	LC	N/A	X								-
Hemibagrus nemurus	Asian redtail catfish/yellow catifsh	LC	N/A	X								8
Hemibagrus wyckioides	Asian Redtail catfish	LC	N/A							X		23
Kryptopterus micronema		LC	N/A	X								-
Oxyeleotris marmorata	Marbled Goby	LC	N/A	X								-
Pangasius hypophthalmus	Striped Catfish	EN	N/A							X	X	-
Pangasius larnaudii	Spot pangasius	LC	N/A								X	-
Rasbora borapetensis	Blackline Rasbora	LC	N/A							X		-
Rasbora hobelmani	kottelat rasbora	N/A	N/A	X								-
Wallago attu	Wallago	VU	N/A						X			14

Remark: *1 Contribution Rank based on the contributions to the total fish catch weight (average of 4 countries). Unnumbered species contribute less than 1 %. (Modified from MRC, 2013)

*2 IUCN red list of threated species (International NT: Near Threatened, VU: Vulnerable, EN: Endangered, LC: Least Concern)

*3 Convention on International Trade in Endangered Species of Wild Fauna and Flora (N/A: The specie does not appear on the list)

Cambodia

Local fishermen reported that total 7 kinds of fish species have been found trapped in plastic bags, but ingestion was not reported. Other problem with the plastic debris was the fish-trap often containing plastic waste such as plastic bottle, plastic bags, and plastic straws. Local fishermen claimed that sometimes they caught more plastic than fish, and they had been experiencing this problem for the last five years.

There is no data or existing research conducted on effect of plastic pollution on freshwater ecosystem in LMB or specific in Cambodia.

Lao PDR

In 3 interviewed areas, including Vientiane Capital, Luang Prabang, and Pak Beng, neither the entanglement nor the ingestion of plastic debris was common. Most of the interviewed person answered such cases were never seen, except seldom small pieces of waste debris, hook, or soap in fish were reported at the morning market of Luang Prabang. Fishermen in Luang Prabang reported that the only impact from waste debris they found is the entanglement of waste debris on their net.

Source: *Vatthanamixay Chansomphou*

Figure 6-2. Waste debris entangled on the net

So far, there is no study on impacts of plastic pollution on Mekong migratory species.

Thailand

Most of the interviewees in all 3 areas (Nakhon Phanom, Chiang Saen, and Chiang Kong) have not found any incidences of plastic entanglement or ingestions by freshwater fish nor waterbirds. No one interviewed has seen such fish nor bird samples that clearly ingested or entangled plastic waste by any means.

However, in Chiang Saen market, there was 1 incidence of plastic ingestion or entanglement reported when questioned. A fish vendor in Chiang Saen market reported that she frequently opened up fish stomach to clean them before selling. She has seen plastic bags in three fish species that were taken from Mekong River. These fish species were *Bagarius bagarius*, *Wallago attu*, and *Barbonymus gonionotus*.

There has not been official reports and news on the events of plastic ingestion or entanglement in fish and birds associated with freshwater systems that cause physiological abnormalities or deaths, either in national levels or in regional LMB.

Viet Nam

The interviewed results shows that at fishing area near My Tho port two fish species were reported to be entangled with plastic bags, including African sharptooth catfish and Fine-scaled tigerfish. Fish species entangled with plastic bags near Tan Cang Cao Lanh port are Striped Catfish, Spot pangasius Philippine catfish, Soldier river barb; and near Cai Cui port are Asian Redtail catfish, Small-scaled tonguesole, Blackline Rasbora, and Asian Redtail catfish. Besides, Styrofoam were ingested by the two species Striped Catfish, Spot pangasius Philippine catfish near Tan Cang Cao Lanh port. Of these species, Striped Catfish is classified as endangered (EN) in Vietnam Red Data book

Through the interview survey on plastic impact on water birds, there is no observed impact to the birds due to entanglement or ingestion. It is likely that macro plastic debris is accumulated mainly in riversides of populated areas and high activities of boat traffic. There areas are not the favourable feeding or resting places for water birds. Therefore, it is difficult to observe this impact.

To our best understanding, up to now there is no study of impact of plastic pollution on water bird in Vietnam. However, the impact of plastic pollution is expected due to food chain from accumulation of microplastic from fishes and other aquatic species to water birds.

Impacts of plastic pollution on Cetacean: Irrawaddy dolphins (*Orcaella brevirotis*) has distribution along the coast in the Mekong Delta. Two individuals were caught in a fishing net in An Giang Province, one in March 2002 (Bui and Dao, 2002) and one in October 2005 (Beasley et al. 2006) and one in Co Chien River of Ben Tre province in 2019 (VNexpress, 2019). Through the interview survey on plastic impact on cetacean, there is no observed impact to the Dolphin due to entanglement or ingestion.

Main results and key challenges

- LMB utilize its abundant freshwater resources for daily consumption and economic activities, therefore carries out the environmental/agricultural monitoring on both national and regional level.
- The interviews conducted in the 4 MCs targeting fishermen and fish vendors showed that the lives of species that play critical role both on the environmental hierarchy and our daily lives, are at risk of getting entangled by the riverine plastic debris and ingesting plastic debris.
- Although monitoring activities in LMB include the freshwater fauna, scientific insights on the adverse effect of plastic pollution in the LMB still shows a serious lack. Since the results discussed above are from interviewing several fishermen in each country, the closer scientific observation of the ecosystem may possibly reveal the further adverse impacts.
- Continuously monitoring the impacts of plastic pollution on freshwater fauna and comparing the results over locations and time, will surely enable us to take effective action towards the more sustainable use of freshwater resources.

7. Key Challenges and Opportunities for Riverine Plastic Pollution Management

Key challenges and opportunities for riverine plastic pollution management for MRC MCs as a whole are the followings.

a) Key Challenges

- There are no/ few regular monitoring systems for riverine plastic waste. (***Chapter 5***)
- There is no harmonized methodology available for monitoring plastic debris, making the data incomparable over time or location.
- The issue of riverine debris goes beyond the problem of solid waste management, 3R policies, therefore requiring cross-sectional cooperating system.
- Lack of public awareness of plastic waste impacts to water resources.
- There is no specific regulation for implementing riverine plastic waste monitoring (***Chapter 3***)
- The common weakness in the implementation for solid waste management such as waste segregation, collection, transportation, treatment, recycling, disposal (***Chapter 3***)
- It is not clear which organization should have the responsibility for riverine waste management. (***Chapter 3***)
- Investment in solid waste management is still limited, failing to meet the actual needs due to lack of financial resources.

b) Opportunities

- MRC's "Riverine plastic monitoring programme" will establish a detailed methodology of monitoring plastic debris in the Mekong River, that will help obtaining more accurate data and long-term trend. This will enable data comparison over location and time, helping to understand the amount, pathways of occurrence, which will then help determine the effective measures on reducing riverine debris based on scientific data and evaluate effectiveness of measures. This can be reflected in policy making process in the relevant countries.
- The data obtained in scientifically desirable way will also serve as scientific evidence to enhance regional cooperation, as emphasized in "ASEAN Framework of action on marine debris".
- UNEP's CounterMEASURE II conducted riverine monitoring in LMB. 4 MRC MCs are able to utilize the data from these riverine monitoring. (**Chapter 5**)
- There are already water quality monitoring stations and well-established water sampling points. Introduction of appropriate equipment and human resources may make these monitoring stations capable of conducting routine riverine plastic debris monitoring.
- The issue of waste management and plastic waste management gains attention from various stakeholders from domestic and international parties. Thus, several agencies support MRC MCs for improving waste management. Nevertheless, there is still lack of coordination and operation. (**Chapter 3**)

Key challenges and Opportunities for each MRC MCs are the followings.

7.1. Cambodia

a) Key challenges

Riverine plastic pollution is a new topic for Cambodia. So, to date, Cambodia is facing to some challenges such as:

- There is no comprehensive legislation on plastic waste and plastic pollution and monitoring for plastic leakage.
- Knowing limited about riverine plastic pollution management such as limited information on the amount of plastic used in manufacturing, the amount of plastic waste generation, plastic waste leakage into the environment and water bodies.
- Institutional capacity is also limited in term of monitoring and evaluation of the status of riverine plastic pollution and its adverse effect on human health and the environment, basically on biodiversity.
- There is no official or scientific based information on the current amount, trend and status of plastic pollution.
- There are no activities related to riverine plastic debris collection and monitoring taking place.
- Limited awareness on plastic wastes handling and disposal, as well as limited awareness on adverse impact of plastic pollution on human health, etc.

b) Opportunities

- Cambodia's National 3R Strategy for Waste Management in Cambodia (2008) outlines principles and actions for reducing, reusing, and recycling solid waste, however implementation of measures has been insufficient.
- The legislation and policies of Cambodia outline the leading role in waste management systems. Legislation dictates that responsibilities are highly decentralized, primarily to provincial level, with the option to further delegate to municipal, district and commune administration. However, the government actors expected to be involved in waste management can be unclear.
- There were some environmental campaigns have been taken place by government such as cleanup activities. However, there is no record on the amount of wastes including plastic wastes collected during this cleanup event.
- In Phnom Penh, part of plastic waste from land based are collected at sewage pumping stations and transported to dumpsites.

7.2. Lao PDR

a) Key challenges

The key challenges relating to plastic waste management in Lao PDR are as follow:

- The increasing amount of plastic waste associated with population growth, economic growth and changing lifestyle of Lao people.
- The majority of people are not aware of the impacts of plastic and solid waste on the environment, society and health; thus, they do not separate waste at source and still get rid of waste in the old-fashioned way - by burning and dumping inappropriately. Many

people dispose waste at illegal dumpsites, some of which are nearby waterways, streams or rivers.

- Waste collection service still does not cover all the place, leading to the existence of improper management of waste by some people (illegal dumpsites, and open burning).
- High cost of solid waste management operation.
- Poor technical capacity on landfill operation.
- Lao PDR still lacks clear policy and legislation for 3Rs (Reduce Reuse Recycle) promotion and implementation at the moment; therefore, the attempts to encourage waste segregation at source and waste-to-resource by international agencies and private sector are undermined.
- Low recycling rate of waste and debris.
- The enforcement of regulations and prohibitions are still weak in many areas.
- Riverine debris monitoring program do not officially exist.
- Lack of awareness of waste impacts on water resource.
- No specific regulations and prohibitions on littering waste into water resources.
- Low capacity and human resource to monitor waste littering into water resources.

b) Opportunities

Currently, solid waste management in Lao PDR is mostly collection and disposal, with limited recycling rate. Nevertheless, with the proper management, waste in Laos could be reused and utilized as a resource for other producing activities. Some opportunities relating to waste management in Lao PDR are as follow:

- Some regulations relating to waste management are already in place; therefore with the effective enforcement, improper waste disposal activities could be reduced. Nevertheless, the authority has to ensure that the appropriate waste collection system is established.
- At the moment, several international agencies are giving hands to the Lao government on raising awareness and improving waste management system. Nevertheless, there is still lack of coordination and operation.
- Currently, informal waste pickers are very active in the cities and towns, due to the presence of junkshops, waste dealers, and recycling factories. Integrating them into more formal waste collection system could help reduce the amount of plastic and solid waste.
- The presence of only media platform can help bring information about impacts of plastic waste on water resource to people.
- Many young volunteers from educational institutions are enthusiastic on awareness-raising activities. Having them involved in awareness-raising activities could help improve the public awareness of waste.
- Line ministries and government agencies are willing to cooperate in riverine plastic debris monitoring.

7.3. Thailand

a) Key challenges

- Despite the policy in place, implementation on reduction or avoidance is rarely practiced. Budgets from both public and private sectors are mostly allocated to waste segregation and recycling. Consumers are not incentivized either by economic influence or awareness to avoid using unnecessary plastic and to segregate waste.
- For those who are aware of the benefits, personally or environmentally, of waste segregation, it is sometimes confusing and inconvenient to properly segregate it due to several types of bins and plastic materials or lack of collection services. From the data available in Thailand, key challenges along the plastic pollution management phases can be summarized as follow:
    - **Production phase**: Without incorporating externalities, costs of plastic packaging are too low for producers to give up using plastic packages or change to alternative materials. Utilizing of recycled plastic to produce new products or packaging can be a challenge as it is limited by standards related to health and safety. Some producers have tried to introduce bioplastic or biodegradable plastic to the consumers. These plastic materials are intended to be degraded in industrial composting facilities and not for recycling. If mixed with normal plastic, recycling process will be challenged.
    - **Consumption and discarding phase**: Consumers become more aware of waste problem and willing to segregate waste (Vassanadumrongdee, 2017), but greener products are still not widely available and usually more expensive. Refusing plastic, especially SUPs, causes inconvenience to general consumers. The key challenge is, however, low segregation rate.
    - **Waste management phase**: As mentioned in ***Section 2***, plastic waste may leak from uncollected MSW, improperly recycling process and improperly disposal by open dump or burning. LAOs do not charge waste management fee to cover the disposal costs and every household is charged only with flat-rate garbage collection fee. After leakage to water bodies: Cleanup programs are not routine. The available equipment and technology are not sufficient to handle large volume of riverine plastic pollution. It is not clear who should be responsible organizations for the cleanup.
- Cleanup of riverine debris is not done regularly. In some rivers, there is not a cleanup activity at all. Garbage floating traps installed in some rivers are not effective as they are installed in just a small area of the river cross section. Once the garbage is fully trapped, transferring the garbage requires too much time or too many manpower.
- For monitoring of riverine plastic, national standard on plastic pollution as one of the parameters in water quality standard has not been developed. It is important to have standardized/harmonized sampling methodology, analysis methods and monitoring protocol. There are data collection in some place such as Rayong Province, but the data are not published. There is not a national or local policy on riverine plastic waste monitoring.

b) Opportunities

- In spite of numerous challenges, there are opportunities to improve riverine plastic pollution management in Thailand.

- The policy on banning free plastic bags at supermarkets and shopping malls from the beginning of 2020 has changed consumers' behavior to a certain extent. Attempts in innovation and technology have proven successful in several cases such as matchmaking between waste generators and waste collectors or recyclers. Artificial Intelligence will play more active role in analyzing consumer behaviors and supporting waste segregation by machines.
- For monitoring purpose, there are already water quality monitoring stations and well-established water sampling points around Thailand. Human resources who conduct monitoring activities are knowledgeable and skilled with many years of experiences. Sampling tools and analysis equipment are available, although limited. Procuring more necessary equipment is not beyond fiscal capacity with political willingness.
- With the policy to merge the Regional Environmental Offices with the Pollution Control Department, the new agency will hopefully be equipped with financial and human resources needed to set up new water quality standard on riverine plastic pollution and conduct routine monitoring.

7.4. Viet Nam

a) Key challenges

- Increased domestic consumption coupled with higher growth of manufacturing and service sector has led to higher waste generation in Viet Nam. Due to uncollected waste and the current waste collection, transportation and disposal practices, there is extensive leakage of plastic waste in water and wastewater ultimately leading to marine litter and plastic pollution (SEA Circular, 2020). Although there have been remarkable progresses, solid waste management still has many shortcomings. Solid waste has not been classified at source; Mitigation measures have not been strongly applied; The rate of rural domestic solid waste collection is low and there is no positive change; recycling is backward, polluting and the main treatment method is still landfilling (Nguyen *et al.*, 2019).
- The legal system and laws on solid waste management are incomplete and overlapping. The organization and assignment of responsibility for solid waste are still fragmented and lack of consensus, making it difficult for implementation. Meanwhile, the implementation of solid waste policies and legal documents still has difficulties and problems. Inspection and law enforcement are still limited, and sanctions on solid waste management are not deterrent enough (MONRE, 2015).
- On the other hand, the implementation of approved solid waste management planning in localities is slow (MONRE, 2017). Investment in solid waste management is still limited, failing to meet the actual needs due to lack of financial resources. Socialization is currently weak due to the lack of appropriate regulations to attract investment resources (MONRE, 2017)
- The problem of selecting optimal solid waste treatment technology is still a challenging problem for managers and scientists while there is currently no complete technological model of domestic solid waste treatment to achieve the technical, economic, social, and environmental issues (MONRE, 2015). Viet Nam's solid waste treatment technologies are not really modern and are on a small scale. Most imported solid waste treatment technologies are not consistent with the reality of solid waste in Vietnam because they

are not classified at the source. Domestic manufacturing is not synchronous and complete, so it cannot be disseminated and replicated (MONRE, 2017; Ngan, T., 2018).

- In addition, solid waste including plastic waste recycling is still small, spontaneous, and informal in craft villages, lacking the management and control of local environmental protection agencies. Most of the recycling facilities are small, the level of technology investment is not high, most of the technologies are outdated, the machinery and equipment are old, causing environmental pollution. Meanwhile, the State does not have clear regulations on the use of technology, and there are no targets and standards for appropriate treatment of equipment and technology (MONRE, 2017).
- Solid waste recycling technologies, including plastic waste, have not been fully documented and evaluated to provide guidance on the selection of recycling technologies in accordance with local waste characteristics. Meanwhile informal recyclers, with low-grade technology and lack of waste treatment infrastructure is dominant in plastic recycling. Therefore, formal recyclers cite difficulty in obtaining a steady supply of high-quality recyclable feedstock due to opaque market structure and incumbency of local informal networks. Poor quality and quantity of recyclable feedstock. Households in Vietnam (majority source of solid waste) do not typically practice sorting-at-source. There is also a significant lack of transparency on manufacturers and consumers of recycled plastic raw materials, especially given that most activity occurs in the informal sector.
- The waste collection at rural area is limited due to sparse distribution of pollution and lass access for collection means. Domestic waste or plastic waste in the rural are generally dumped into rivers or canals. Therefore, implementation of plastic control in the rural is more challenge and requires more effort.
- Currently plastic pollution is a hot issue not only in global scale but also in Vietnam and there are increasing funding on studies of plastic pollution. However, study on impacts of plastic pollution on aquatic ecosystem, and human health in Vietnam is in the early stage which should be paid more focus to draw people's attention on this issueUsers have habit of using plastic bags, mainly due to convenience of plastic bags such as they do not have to carry bags when shopping; The cost of plastic bags is also an in the integer of the people for users, it is difficult to change the habit of using plastic bags in their daily life. In addition, eco-friendly products are not widely sold, and these products need to be recognized as qualified for licensing standards.
- Lack of adequate funding for waste management or recycling infrastructure. Revenue from waste collection and transportation is insufficient to build an integrated waste management system, due in part to low solid waste management charges to households.
- Lack of human resources especially at commune level and in rural areas where one officer (normally the land administrative officer) take in charge of the waste management and other tasks.

b) Opportunities

- Tighter environmental regulation, with an increasing number of countries targeting higher recycling rates, stricter 3R policies at household level, circular design guidelines and stipulation of minimum recycled plastic content for certain products. Recently there are prompt action against the plastic pollution in Vietnam. Environmental policy and strategy are focussing on this issue. Ministry of Natural Resources and Environment on new points in the Draft Law on Environmental Protection (amended), in which the issue

of public concern is solid waste management, management hazardous waste. Specifically, the draft provides regulations on the collection, transportation and treatment of domestic solid waste which is calculated based on the generated volume (Clause 6, Article 79). The Minister of Natural Resources and Environment will guide the form of collection, transportation, and treatment of domestic solid waste according to the generated volume and type. This will motivate people to reduce the amount of waste generated because less waste obviously means less money. In line with the guidance from central government, some provinces have set the target to reduce the waste. For example, in Dong Nai province expected that in the period 2020-2025, the rate of landfill is reduced to 15%. This rate in HCMC is set at 20%.

- The issue gets attention from various stakeholders from domestic and international parties, which draw more investment and funding in technology development for the waste treatment. In addition, awareness campaigns and studies are increasing recently.

8. Recommendations

To assess the basin-wide status and trends of riverine plastic pollution and gather information and knowledge to inform decision making in effective and efficient management of riverine plastic pollution in the LMB, Recommendations on addressing the identified gaps and challenges and developing, monitoring system for riverine plastic pollution on each MRC MCs are followings.

- Conducting riverine debris monitoring rigidly following the protocol by MRC, and sharing the experience as well as data. This will enable the data compilation for scientific research and active involvement of stakeholders.
- Collaboration between government and academic or institute is required to conduct riverine debris monitoring, to maximize the outcome with the limited resources
- Providing capacity building for development of, definition and classification of riverine debris, sampling methodology, sample analysis and monitoring protocol. Monitoring program should include both macroplastic and microplastics in a cost-effective way.
- Developing and legalize national standards or targets on riverine plastic debris
- Identifying government authorities or research institutions suitable for conducting and maintaining monitoring activities in cooperation with related organization.
- Establishing and enforcing policies and regulations on waste littering, 3R, riverine plastic waste management including clear responsibility of national government, local government, private sector and community.
- Regular collection of riverine debris and appropriate treatment of collected debris.
- Raising public awareness regarding to impacts of plastic waste on environment and water resources.
- An integrated monitoring system that consolidates the monitoring activities and results of each organization.
- Through the recommended items above, results of riverine debris can be evaluated, and Material Flow Analysis and Inventory Analysis of plastic can be facilitated. These will also contribute to evaluating the effectiveness of the measure.

8.1. Cambodia

- Establish policies and regulations to address plastic pollution such as management and monitoring of plastic waste, and riverine plastic debris.
- Formulate an integrated management system for plastic manufacturing, plastic waste generation and plastic leakage to grasp plastic waste flow, through cooperation between government, private sector, and academia.
- Develop capacity for monitoring and evaluation for plastic pollution, especially riverine plastic debris monitoring on laboratories that belong to not only government but also university.
- Improve and enforce solid waste management on national and local level. Proper collection service will contribute to reduce plastic leakage. Also, segregation at source will accelerate its effectiveness.
- Clarify the responsibility of plastic waste management actors.
- Raise public awareness through implementing regular clean-up campaign by government.

- Strengthen implementation and enforcement of targets stipulated in the national 3R strategy.
- Collect plastic debris from trapping point like a sewage pump station and formulate reporting system regarding to collected plastic debris.

8.2. Lao PDR

- It is necessary to establish and promulgate the policies and regulations that support 3R principle;
- Establish and enforce regulation on waste littering into water resource;
- Implement waste reduction scheme using EU's waste hierarchy;
- Maximize waste-to-resource opportunities by encouraging separation at source;
- Raise awareness about impacts of plastic waste on environment and water resource;
- Set up source separation scheme and distribute waste bin in several public place; especially those near the water resources;
- Encourage and set up mechanism separation at source for households and business entities to ensure that plastic waste is well segregated;
- Increase business opportunity for waste recover/recycling entrepreneur; and
- Undertake regular plastic waste monitoring activities at critical locations.

8.3. Thailand

- Provide capacity building for development of, definition and classification of riverine debris, sampling methodology, sample analysis and monitoring protocol. Monitoring program should include both macro and micro plastics;
- Identify locations that can represent overall water quality in terms of riverine plastic pollution for the monitoring programme.
- Develop and legalize national standards on riverine plastic debris;
- Identify government authorities or research institutions suitable for conducting and maintaining monitoring activities. Sampling and analysis can be conducted by separate organizations;
- Legalize the new duty and set performance indicators for the selected organizations to implement and ensure sufficient fiscal budgets for the new assigned responsibilities;
- Upgrade existing monitoring stations and sampling tools and procure more equipment if necessary. For example, an A.I.-powered camera may be installed at the spot overflowing water to count the number of macroplastic pieces.

8.4. Viet Nam

- It is necessary to quickly revise legal regulations to implement the Government's Resolution on assigning the Ministry of Natural Resources and Environment to be the focal point for unified solid waste management. the Department of Natural Resources and Environment to act as the focal point and unify the solid waste management in all provinces and cities;
- Strengthen implementation and enforcement of 3R targets stipulated in the national strategy. Increase implementation of measures to minimize waste generation and promote sorting at source. Enterprises should be encouraged to apply cleaner production, waste

audit, product life cycle measures. Implement communication programs to promote sustainable consumption in the residential community;

- Strengthen management of rural domestic solid waste. Research, develop and issue separate documents on rural solid waste management; increase collection and disposal rates. Strengthen the responsibilities of local authorities at all levels in planning, budgeting and organizing the implementation of rural solid waste collection and treatment; strengthening inter-regional and local coordination in rural solid waste step by step develop the industry of waste recycling;
- Incentivize partnerships between state waste management company (URENCO), waste pickers, junkshops, recyclers and major companies looking to purchase recycled good;
- Investments into modernizing and integrating the informal recycling sector does not only increase environmental efficiency (water, energy) of their processes but reduce leakage of residual plastic waste into the environment; and
- Further research on quantification and monitoring of riverine plastic, as well as hotspots, would be useful. In addition, further improvement of understanding on sources and pathways, as well as the ecological, environmental, and socio-economic impacts within the country, could support decision- making in the adoption of adequate management measures. The monitoring may consist of monitoring plastic in surface water and in fishes or even in bivalves to evaluate the plastic pollution in aquatic ecosystem. It is expected that the monitoring will contribute to building some of the research capacity for the local research institutions.
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10. Annexes

ANNEX-1 Riverine Environmental Monitoring Activities

Description: on-going riverine environmental monitoring programs including water quality, sediment, fisheries, plankton, hydrology etc in the country (methodology, location, parameters, frequency, organizations etc), which will be potential activities for developing long-term/cost-effective riverine monitoring since the monitoring will be built upon in alignment with and possibly integrated int the on-going monitoring activities. These explanations are described one by one.

10.1.1. Cambodia

Table 1. Summary of riverine environmental monitoring activities in Cambodia

Organization	Type of monitoring	Budget	Items
MOWRAM	Water quality, sediment, hydrology	Fiscal year budget and MRC support	
MAFF, FiA	Fisheries, plankton,	Fiscal year budget and MRC support	
MOE	Water quality, i.e. BOD, COD, total nitrogen, TSS,	Fiscal year budget	
Tonle Sap Authority	Fish monitoring (has report on plastic survey at Tonle Sap)	Fiscal year budget and MRC support	

Source:

10.1.2. Lao PDR

Table 2. Summary of riverine environmental monitoring activities in Lao PDR

Organization	Type of monitoring	Budget	Items
MRC-LMNC	- Water quality	N.A.	- 11 sampling sites in the Mekong River flow through the country such as: Houakhong, LuangPrabang, Vientiane, Savannakhet, Pakse, Ban Hatkham, Ban Hai, HouayMakHioa, Ban Kengdone, Sebangfai and Sedone Bridge. - The monitoring is conducted annually. - The method employed follows Standard Operating Procedure of Water Quality Monitoring Network (WQMN). - The monitoring parameters include: * Basic parameters: Temp, pH, EC, TSS, Alkalinity, and DO * Major ions: Na^{+}, K^{+}, Ca^{+2}, Mg^{+2}, $SO4^{-2}$, C^{l-}

Organization	Type of monitoring	Budget	Items
			* Nutrients: $NH4^+$, $NO2,3^-$, T-N, T-P * Organic matter: COD * Microbiology: BOD (Vientiane station), Faecal coliforms - This monitoring is reported by annual report format.

Source: *Vatthanamixay Chansomphou*

10.1.3. Thailand

Table 3. Summary of riverine environmental monitoring activities in Thailand

Organization	Type of monitoring	Budget	Items
PCD	Monitor water quality and report WQI (The water quality indices).	Fiscal budget	- 76 automatic stations every 30 minutes - Manual sampling 4 times a year.
DWR	Report of hydrology, telemetry from Royal Irrigation Department (RID) and rainfall data from Meteorological Department daily.	Fiscal budget	- Daily
Hydro-Informatics Institute (Public Organization)	• Compile all data from all sources; and • Focus on integrating and analyzing hydroinformatics data system including research and development of advance tools and technologies for the application of other related organizations.	Fiscal budget	- Over 900 stations are deployed and operated 24/7 countrywide and the data are displayed in Internet GIS format at www.thaiwater.net.
Royal Irrigation Department	• Water Quality (especially salinity); and • Sediment – LL, PL, PI, Grain Density, particle size, Metals X-ray Fluorescence (XRF).	Fiscal budget and water consumption charge	- Report daily - 25 watersheds stations - 447 water reservoirs
Metropolitan Water Authority (MWA)	Monitor salinity	Fiscal budget and tap water fee	- More than 30 monitoring points along Chao Phraya River
Electricity Generating Authority of Thailand (EGAT)	Report of hydrology, telemetry of 11 dams	Fiscal budget and electricity fee	- 11 dams owned and operated by EGAT
Fishery Department	Project-based data collection on fish diversity, productivity, plankton diversity, etc.	Fiscal budget	-

Source: *Patarapol Tularak*

10.1.4. Viet Nam

Table 4. Summary of riverine environmental monitoring activities in Viet Nam

Organization	Type of monitoring	Budget	Items
The Strategic Master Scheme for Hydro-Meteorological Network (Southern Regional Hydrometeorological Center of MONRE)	Hydrology		- 6 key stations; namely, the Tan Chau, My Thuan, Chau Doc, Can Tho, Vam Kenh and Vam Nao stations - Since 2020 - real-time monitoring
The Strategic Master Scheme for Hydro-Meteorological Network (Southern Regional Hydrometeorological Center of MONRE)	Sediment		Tan Chau and Chau Doc stations 2 – 3 times/month
Provincial Center for Environmental Monitoring under DONRE	Water quality		- In Mekong delta there are 35 monitoring stations - quarterly basic - Method of sampling and analysis follow National standards – QCVN which is mainly based on international method such as Standard Methods for the Examination of Water and Wastewater - 15 basic parameters (pH, temperature, EC, TDS, DO, BOD_5, COD, TSS, Ammonium, Nitrite, Nitrate, Cd, Fe, Pb, CN)
The Centre of Water Quality and Environment, Southern Institute for Water Resources Planning, Viet Nam	Water quality	Vietnam National Mekong Committee (VNMC)	- 10 stations - monthly basis - Water sampling, sample preservation, sample transportation and storage, are carried out in accordance with methods listed in the Technical Guidelines for the Procedures for water quality PWQ (Technical guidelines for the procedures for water quality (TGWQ)) which have been prepared in accordance with the 21st edition of the Standard Methods for the Examination of Water and Wastewater or in accordance with national standards complying with the requirements of method validation of ISO/IEC 17025-2005 - Temperature, pH, Electrical conductivity, Alkalinity/ Acidity, Dissolved Oxygen (DO), Chemical Oxygen Demand

Organization	Type of monitoring	Budget	Items
			(COD), Total phosphorous (T-P), Total Nitrogen (T-N), Ammonium (NH_4-N), Total Nitrite and Nitrate ($NO_{2\text{-}3}$-N), Faecal Coliform, Total Suspended Solid, Calcium (Ca), Magnesium (Mg), Sodium (Na), Potassium (K), Sulphate (SO_4), Chloride (Cl), BOD5
Southern Institute of Ecology	Four aquatic groups including Benthic Diatom, Zooplankton, Littoral Invertebrates and Benthic Macroinvertebrates	under funding of VNMC	- There were 6 monitorings implemented at the years: 2008, 2011, 2013, 2015, 2017, and 2019.
Southern Institute of Ecology			- 8 sites on last parts of Mekong river belonging to Vietnam territory - Regular monitoring event every 2 years - method of MRC, 2010. Biomonitoring Methods for the Lower Mekong Basin
Research Institute for Aquaculture II (RIA2)	Fish		- at 7 locations in the Mekong Delta - every year - method of MRC (2010) Fisheries Programme 2011-2015. Programme Document

***Source**: Diep Dinh Phong*

ANNEX-2 Status of solid waste treatment/disposal facilities in 4 MRC MCs

Table 5. The number of solid waste treatment/disposal facilities in Cambodia

No.	Treatment/Disposal	No. of facilities	Capacity	Handling volume (ton/year)
1	Incineration with air pollution control system	0	0	0
2	Incineration without air pollution control system	35	N/A	N/A
3	Sanitary landfill	0	0	0
4	Controlled landfill with more than 50 t/d of MSW	3	N/A	N/A
5	Open dump	N/A	N/A	N/A
6	Open burning	N/A	N/A	N/A
7	Recycling facility	N/A	N/A	N/A
8	Others (compost, MBT (Mechanical and biological treatment), RDF)	N/A	N/A	N/A

Source:

Table 6. The number of solid waste treatment/disposal facilities in Lao PDR

No.	Treatment/Disposal	No. of facilities	Capacity	Handling volume (ton/year)
1	Incineration with air pollution control system	N/A	N/A	N/A
2	Incineration without air pollution control system	2	960 kg/day	350.4
3	Sanitary landfill	1	100 ha	131,400
4	Controlled landfill with more than 50 t/d of MSW	N/A	N/A	N/A
5	Open dump	N/A	N/A	N/A
6	Open burning	N/A	N/A	N/A
7	Recycling facility	N/A	N/A	N/A
8	Others (compost, MBT, RDF)	N/A	N/A	N/A

Source: *Vatthanamixay Chansomphou*

Table 7. The number of solid waste treatment/disposal facilities in Thailand

No.	Treatment/Disposal	No. of facilities	Capacity	Handling volume (ton/year)
1	Incineration with air pollution control system	11	N/A	N/A
2	Incineration without air pollution control system	72	N/A	111,942
3	Sanitary landfill	372	N/A	N/A
4	Controlled landfill with more than 50 t/d of MSW	7	N/A	1,581,140
5	Open dump	2,123	N/A	3,928,420
6	Open burning	55	N/A	51,720
7	Recycling facility	N/A	N/A	N/A
8	Others (compost, MBT, RDF)	26	N/A	N/A

Source: Patarapol Tularak

Table 8. The number of solid waste treatment/disposal facilities in Viet Nam

No.	Treatment/Disposal	No. of facilities	Capacity	Handling volume (ton/year)
1	Incineration with air pollution control system	N/A	N/A	N/A
2	Incineration without air pollution control system	50	N/A	N/A
3	Sanitary landfill	660, of which 204 is sanitary landfill	N/A	7,384,701
4	Controlled landfill with more than 50 t/d of MSW	N/A	N/A	N/A
5	Open dump	NA	N/A	N/A
6	Open burning	N/A	N/A	N/A
7	Recycling facility	N/A	N/A	N/A
8	Others (compost, MBT, RDF)	N/A	N/A	N/A

Source: MONRE, 2017 and World Bank, 2018

ANNEX-3 Waste management Data Collection Survey Template

[**Note to the surveyor:** Information for Questions 1 to 5 in this template should be obtained by interviewing relevant authorities of the ports/piers. Information for Question 6 should be obtained through visual inspection at the artificial barriers of the ports/piers]

<table>
<tr><th colspan="7">Waste Management Data Collection Sheet at a selected port in Mekong River basin</th></tr>
<tr><th colspan="2">Item</th><th colspan="5">Result</th></tr>
<tr><td colspan="2">1. Name of the Ports/Piers</td><td colspan="5"></td></tr>
<tr><td colspan="2">2. Location of the Site (with GPS and photo)</td><td colspan="5"></td></tr>
<tr><td colspan="2">3. Name of the interviewee(s)</td><td colspan="5"></td></tr>
<tr><td colspan="2">4. Roles and responsibilities of the interview(s)</td><td colspan="5"></td></tr>
<tr><td colspan="7">5. Basic Information of the Site</td></tr>
<tr><td>5.1</td><td>Managing Authorities</td><td>Port Authority, Municipality, Private, or others ( )</td><td colspan="4"></td></tr>
<tr><td>5.2</td><td>Operation Authorities</td><td>Self or contract, name of the company in case of contract</td><td colspan="4"></td></tr>
<tr><td rowspan="6">5.3</td><td rowspan="6">Responsibility/Activity</td><td rowspan="6">Rank activities from main activity to minor activity and estimate the volumes associated with each type of activity (e.g. Tourist (number of ship and tourist), Trade (number of cargo ship and container loading), Others ( )</td><td>Type of activities</td><td>Number of ships (operate /day)</td><td colspan="2">Number of passenger/cargo containers/volume of goods (per day)</td></tr>
<tr><td></td><td></td><td colspan="2"></td></tr>
<tr><td></td><td></td><td colspan="2"></td></tr>
<tr><td></td><td></td><td colspan="2"></td></tr>
<tr><td></td><td></td><td colspan="2"></td></tr>
<tr><td></td><td></td><td colspan="2"></td></tr>
</table>

5.4	Any other information			
6. Waste Generation and Management Information				
6.1	Waste management and collection practices	Is the waste being collected or is waste being openly disposed on street Request a copy if possible (if not take a photo)	Main source of waste (e.g. Port office, passing by tourist, ship operation, etc.)	1._____ 2._____ 3._____
			Are there collection systems (bins) for waste generated at the port (on land)?	☐ Yes ☐ No
			Are there collection systems (bins, specific disposal point) for waste generated by ships operating at the port?	☐ Yes ☐ No
			If waste collection systems exist, are waste separated?	☐ Yes ☐ No
			Is there a central waste collection point at the port?	☐ Yes ☐ No
			Is waste management plan available? <u>If the answer is YES, please request a copy (preferably electronic copy if possible)</u>	☐ Yes ☐ No
			Are port/piers personnel aware of waste management plan?	☐ Yes ☐ No
			Is there designated personnel/department for waste collection and management activities	☐ Yes ☐ No
6.2	Daily amount of wastes generated (t/d)	(Daily amount of wastes generated at the ports). If not recorded, what is the estimated amount?		
6.2	Waste composition or type of waste	If known (list all types of waste known and their estimated quantity) – for example, food waste, plastic, paper, oil (organic), etc.	Type of waste	Estimated daily amount
			Food waste	
			Green waste (garden and park waste)	
			Paper and cardboard waste	
			wood	
			Textiles	

			Nappies (disposable diapers)	
			Rubber and leather	
			Plastic waste	
			Metal	
			Glass, pottery and china	
			Face mask	
			Hydrocarbon waste (oil, etc.)	
			Electronic waste	
			Others	

6.3	Waste collection methods	What methods used to collect daily generated waste at the port?	Methods	Unit available	Collection frequency	Estimate amount per collection (kg or volume)
			Waste collection bins			
			Scheduled routine clean-up			
			Event based clean-up activities			
			Unscheduled clean-up due to the accumulation of waste			
			Open disposal of waste			
			Burning of waste			

6.4	Waste separation manner at port (primary collection points or onsite waste sorting facility)	If yes, what kind of materials are separated? (Are there separate bins for general waste and recyclable waste?)	Primary collection points ☐ Yes ☐ No	Types of waste separated:
			Port onsite waste sorting facility ☐ Yes ☐ No	Types of waste separated:

6.5	How is the waste removed/managed from port?	Municipality, private contractor, dumping in the river, recycling, frequency of clean-up, others	Waste types	Removal types/ authorities (municipality, private contractor, dumping in river, illegal dump site)	Frequency of collection	Collection fee	Estimate amount per removal
			General waste (landfill)				
			Recycle (plastic, metals, etc.)				
			Oil (organic)				
			Others				

			Others				
6.6	Any other information	Any report on waste management, take photo in the accumulation area					
7. Management of accumulated waste that is transported by the river from upstream							
7.1	Amount of (total) waste accumulation (per day, week, or year)	Estimation, Weighing, specify the unit per timeframe (i.e. per day, per week, per year)					
7.2	Proportion of plastic waste accumulated	Estimation, Weighing, specify the unit per timeframe (i.e. per day, per week, per year)					
7.3	Most common type of plastic waste observed	Specify which type is the most abundantly observed and estimate percentage out of all plastic waste types					
7.4	How is accumulated waste in river managed?	Engage private company? Clean-up by local government? Clean-up by port personnel and resources?					
7.5	Methods used for waste clean-up	Collected manually, collected by heavy equipment, not collected or just remove to the river					
7.6	Frequency of clean-up	How often does the clean-up occur?					
7.7	When is the last clean-up	Day/Month/Year, Any photos, others					
8. Visual observation of accumulated at the barrier of the port							
8.1	Take Photo (panoramic view) of the accumulated waste						

8.2	Estimate total amount of accumulated wastes	All type of waste should be considered (including plastic, glass, wood, etc.)			
8.3	Estimate total amount of accumulated plastic wastes	Estimation can be made either in total weigh or in proportion			
8.4	How many types plastic waste can be seen and what are the type?	Identify all type of plastic that be seen and list them all	**Type of plastic**	**Estimate weight or percentage**	**Take Photo**
			Food container		
			Plastic bottle		
			Plastic bag		
			Plastic cup, plate, spoon, knife, fork, etc.		
			Styrofoam		
			Other:		
			Other:		
			Other:		