Situation Assessment Report on

THE PREVENTION OF PLASTIC AND RESIN PELLET LEAKAGE FROM FORMAL AND INFORMAL RECYCLING FACILITIES

VIENTIANE, LAO PDR

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Regional Resource Centre for Asia and the Pacific

Regional Knowledge Centre for Marine Plastic Debris

ERIA
Economic Research Institute for ASEAN and East Asia

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This study was conducted for the Regional Knowledge Centre for Marine Plastic Debris (RKC-MPD), Economic Research Institute for ASEAN and East Asia (ERIA)

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Authors
Asian Institute of Technology Regional Resource Center
for Asia and the Pacific (AIT RRCAP):
Dr Guilberto B. Borongan, Director and Head,
Waste and Resource Management Cluster
Huno Solomon Kofi Mensah, Senior Programme Officer,
Waste and Resource Management Cluster

Vietnam Cleaner Production Centre Co., Ltd:
Dr. Le Xuan Thinh, Director
Do Thi Diu, Resource Efficiency and Cleaner Production Specialist
Do Thi Thuy Nhung, Communication Officer
Tran Thi Ngoc Mai, Resource Efficiency and Cleaner Production Consultant

Reviewers and Technical Advisors
Economic Research Institute for ASEAN and East Asia (ERIA)
Regional Knowledge Centre for Marine Plastic Debris:
Reo Kawamura, Director
Michikazu Kojima, Senior Research Fellow
Ayako Mizuno, Programme Manager

Layout and cover design
Lowil Fred Espada, Consultant

List of abbreviations

EIA	Environmental Impact Assessment
GGGI	Global Green Growth Institute
IEE	Initiative Environmental Examination
Lao PDR	Lao People's Democratic Republic
MOH	Ministry of Public Health
MOIC	Ministry of Industry and Commerce
MONRE	Ministry of Natural Resources and Environment
MPI	Ministry of Planning and Investment
MPWT	Ministry of Public Works and Transport
VCOMS	Vientiane City Office for Management and Services
OECD	Organisation for Economic Co-operation and Development
MSW	Municipal Solid Waste
DIH	Department of Industrial and Handicraft
ASEAN	Association of Southeast Asian Nations
PVC	Polyvinyl Chloride
NGO	Non-Governmental Organisation
PET	Polyethylene terephthalate
LDPE	Low Density Polyethylene
HDPE	High Density Polyethylene
JICA	Japan International Cooperation Agency
USD	United States Dollar
MOU	Memorandum of Understanding
PPE	Personal Protective Equipment

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Chapter 1

Introduction

1.1 Context and background

Global outlook

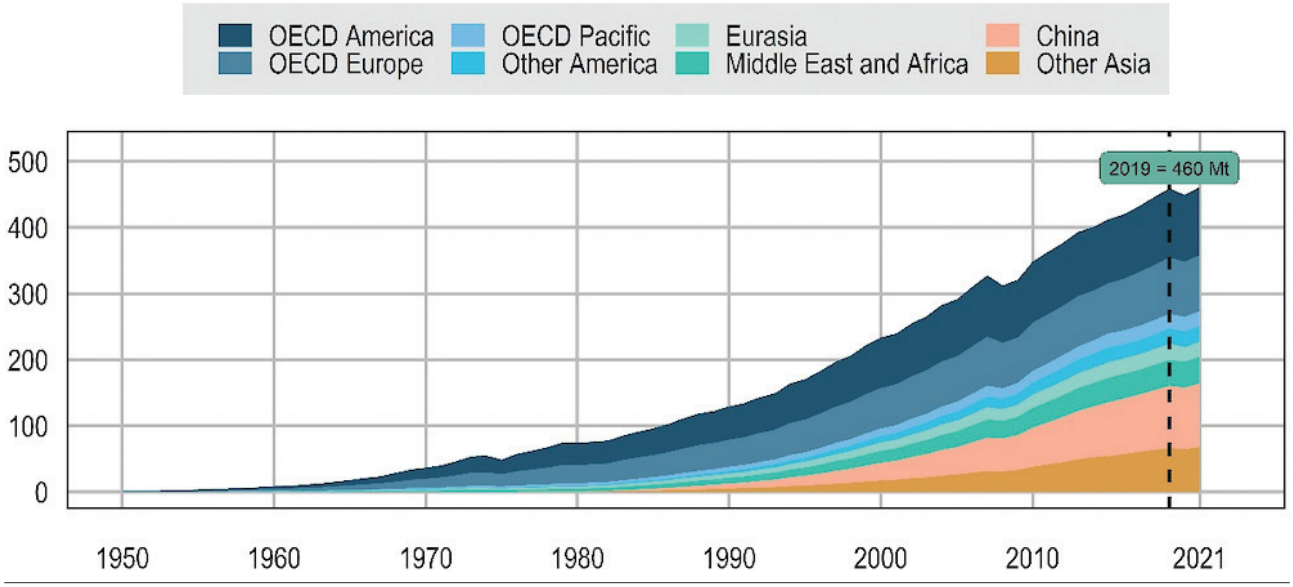
Plastics are one of the most universally used materials throughout the world, providing applications in a wide range of sectors including packaging, transportation and construction to electronics, textiles, consumer products and health care. The functionality, versatility and "cost-effectiveness" of plastics have helped inspire innovations and the development of products and solutions that could not exist without these materials. Following initial mass production in its early days, plastic consumption has quadrupled over the past 30 years, driven mainly by growth in emerging markets (Ramkumar et al., 2022). Key statistics on plastic production and use globally include the following:

- Global plastics production doubled from 2000 to 2019 to reach 460 million tons (OECD, 2022)
- Global plastic waste generation more than doubled from 2000 to 2019 to 343 million tons. If the historical growth trend of global annual primary plastic production were to persist, it would reach 1.1 billion tonnes by 2050 (Geyer, 2020).
- Plastics account for 3.4 per cent of global greenhouse gas emissions (Shen et al., 2020).
- Nearly two-thirds of plastic waste comes from plastics with lifetimes of under five years, with 40 per cent coming from packaging, 12 per cent from consumer goods, and 11 per cent from clothing and textiles (OECD, 2022).
- Many plastic items are single-use packaging (ca. 36%) designed to have a short lifespan (for example, bottles, food packaging and carrier bags). Such common plastic packaging includes items such as drinking straws and stirrers; disposable cups, plates, and cutlery; and meat and vegetable trays and containers (UNEP, 2023)

Plastic waste management in Vientiane

The economy of the Lao People's Democratic Republic (Lao PDR) has grown rapidly in recent decades, especially in the capital city of Vientiane

Figure 1. Global plastics use has quadrupled in 30 years, mainly driven by emerging economies (million tonnes) (Mt), 1950-2021 (OECD, 2022)



(hereafter referred to as Vientiane). This economic development has led to changing consumption and production patterns, which in turn has resulted in consistent annual increase in waste generation. Restaurants, cafés, and bars, particularly in tourist areas, are significant contributors to plastic waste in Vientiane. Single-use plastic items comprise most of this waste, with plastic bags, food containers, and caps also contributing substantially to plastic waste in Vientiane. Plastic waste, handled as part of Municipal Solid Waste (MSW) is usually collected from households, commercial entities, and public spaces. As of 2020, Vientiane residents generated about 970 tons of MSW per day, with only a 31 per cent collected and disposed of in the city's landfill. Plastic waste accounts for the second largest fraction (12%) of the MSW after organic waste (65%). The remaining fractions of the MSW comprises paper/cardboard (8.8%), and other materials such as glass, cans, textiles, metal, and aluminium (GGGI, 2022). Due to the limited waste collection rate in Vientiane, which stands at only 31 percent, plastic waste is often illegally burned, buried, or illegally dumped in some parts of the city. Burning and burial of plastics are environmentally unsustainable ways to manage plastic waste. Burning of plastic waste produces toxic substances that are harmful to the environment, while burying of plastics introduces harmful microplastic into the soil/land.

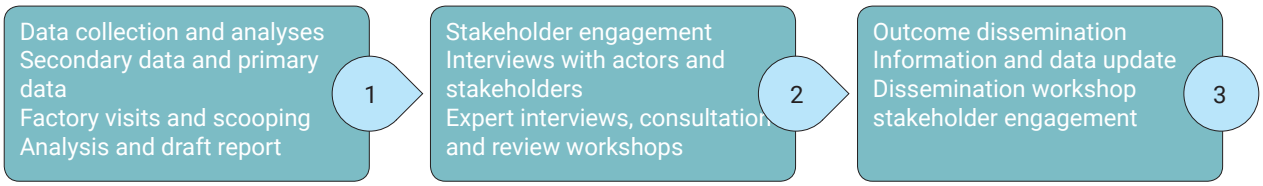
Recent effort to improve waste management are focusing on addressing existing challenges and increasing waste collection coverage and rates, as well as ensuring proper waste transportation (VCOMS, 2022). Plastic waste is often managed through recycling. Recycling plastic waste is one of the most effective ways to avoid environmental pollution and reduce the volume of plastic waste sent to the landfill. Plastic waste recycling is growing quickly in Lao PDR in response to the rise in plastic waste generation. There has been an increase in the number of plastic recycling facilities in Vientiane within the past 5-6 years, demonstrating the commitment of the city to recover and sustainably manage its plastic waste. However, the absence of segregation practices at the waste generation source is hampering the effectiveness of plastic waste recycling activities, which means that a high volume of plastic waste is still being transported to landfill or mismanaged.

Plastic pollution has impact on the environment, economy, and health of citizens in Lao PDR (World Bank, 2022). The release of plastic pellets (for example, pre-production pellets, flakes, fragments, and powders) during plastic handling during transport, storage, recycling, and disposal is a key source of microplastics in marine environments. In Europe for example, up to 167,431 tons of plastic pellets are lost annually with approximately 47 per cent entering our oceans (Eunomia-ICF, 2018). Similarly unaccounted micro- and macro-plastic leakages occur from formal and informal plastic recycling processes in major cities Southeast Asia. The mechanical recycling of plastics typically involves handling of plastic through various processes, including physical transformation processes such as size reduction, cleaning, and form transformations which often may results in risks of plastic fragments, powder, and pellet losses to the environment. Without proper measures to increase the awareness and capacity of recycling facilities and allied stakeholders on environmental stewardship in plastic recycling, the positive impacts of plastic recycling will not be realised.

Effective plastic waste management in cities located along major transboundary rivers like the Mekong River is vital to abate riverine plastic transport to the oceans. ASEAN coastlines and marine environments are exposed to land-based plastics micro- and macro-plastics transported by flooding, wind drift, human activities into from the Mekong (Haberstroh et al., 2021; MRC, 2022; Nguyen et al., 2023). Consequently, effective plastic waste management in Mekong cities is crucial to preventing marine plastic pollution. This highlights the relevance of Vientiane, a growing city along the Mekong, to this study. The study aims to understand recycling activities and associated plastic pollution in Vientiane. It qualitatively assesses the situation, mechanisms, and sources of plastic pollution from recycling to inform the design of effective countermeasures.

1.2 Approach of the report

This study was conducted following on a simplified three-step approach: 1) collect and analyse data and information relevant to plastic leakage from informal sector recycling; 2) engage with key stakeholders; and 3) disseminate the outcomes of the study.



1.2.2 Data Collection and Analysis

Desk study and preliminary data analysis

Relevant project reports, publications, directories, and databases concerning the plastic pollution and recycling landscape in Vientiane were reviewed. Key actors and stakeholders within the plastic value chain were identified and their roles mapped, alongside the policies and processes impacting plastic recycling in Vientiane. A preliminary mapping of recycling value chain configurations, ongoing initiatives and the socio-economic factors influencing informal recycling businesses was also conducted. Stakeholders and actors in the plastic recycling value chain were shortlisted based on data themes from desk studies and then engaged in the study.

Levels of stakeholder engagement and outcome dissemination

- Initial scoping and site visits to Vientiane were held to discuss and interview initial findings with shortlisted primary stakeholders and actors including government agencies, departments, city authorities formal and informal recycling enterprises, and factories, NGO's, etc. The project team conducted in-person discussions and interviews with the Vientiane City Office for Management and Services (VCOMS), Department of Environment (DoE), Department of Industrial and Handicraft (DIH), Zero Waste Laos, and other NGOs. Scoping visits and interviews were conducted at waste collection companies, junkshops, and medium and large-scale plastic recycling factories in Vientiane that produce pellets and flakes for domestic and internation markets.

- In-country expert consultation cum review workshop was held in Vientiane to review the findings of the study. Experts from government departments, city authorities, recycling enterprises and factories, and NGOs were invited to validate and refine the study's findings.

- A regional dissemination workshop was held to share, review, and gather feedback on project outcomes, featuring brainstorming sessions on key findings and challenges. Key experts actively participated, exchanging knowledge and best practices aimed at preventing plastic leakage in ASEAN cities.

1.3 Report structure

The report is divided into six chapters.

Chapter 1 introduces the report's background, data collection approach, and dissemination strategy.

Chapter 2 provides an overview of Vientiane's plastic value chain and waste flow.

Chapter 3 examined the enabling environment for plastic recycling in Vientiane.

Chapter 4 examines plastic recycling processes, mechanisms, and causes of losses and leakage.

Chapter 5 presents challenges and opportunities of plastic waste recycling industry from the perspective of the regulators as well as from the recyclers.

Chapter 6 concludes by summarizing the gaps and challenges in Vientiane's plastic recycling, focusing on policy, institutional arrangements, resources, and technology access.

Chapter 2

The plastic value chain in Vientiane

2.1 Plastic production and use Vientiane

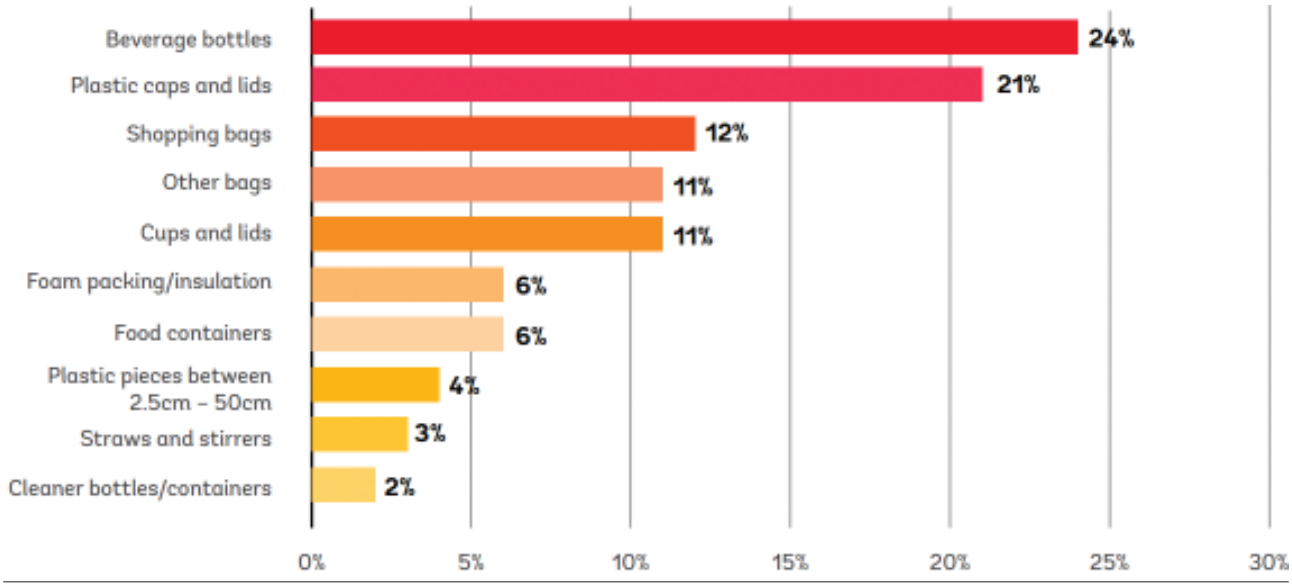
Although majority of plastics use in Lao PDR are imported into the country, there are a few companies that manufacture and process plastics domestically. According to previous studies by the World Bank (2020) and Bengtsson and Long (2022), there were 77 domestic manufacturing and plastic processing companies identified as of 2020. Among them, 39 are in Vientiane, while 17 of the recycling facilities are engaged processing of wastes products such as drinking bottles, carrier bags, other bags and sacks, furniture, baskets, rope, and cups, with a combined capacity of approximately 51,000 tonnes (Table 1). A total of about 170 000 tonnes of plastic pellets (granules), rubber products, construction materials are imported to Lao PDR in 2018 against a total of about 126 000 tonnes of export of plastic pellets (granules), bags, PVC tubes and construction materials.

Vientiane, like many urban centres, heavily relies on plastic packaging for various purposes. In Vientiane, the capital city of Laos, plastic packaging plays a significant role in daily life. Plastic packaging for food, drinks, personal care products and households is the most prevalent of plastic packaging used in Vientiane. Due to the perceived affordability and convenience, plastic packaging such as plastic bags, containers, and wrappers are predominantly used by consumers and vendors in marketplaces, supermarkets, and shops (Figure 2). Further, the

Table 1. Recycling Plastic Companies registered in Vientiane Capital (Source: DoE, 2023)

District	Number of factories	Final product	Export	Domestic use	Domestic and export
Xaythany	19	Plastic pellets	0	9	10
Sikottabong	5	Plastic pellets	1	0	4
Xaysetha	4	Plastic pellets	0	0	4
Hatsaiyfong	5	Plastic pellets	0	1	4
Chanhthabury	3	Plastic pellets	0	0	3
Naxaythong	3	Plastic pellets	1	3	0
Total	39		2	13	25

Figure 2. Top 10 plastic product items in Lao PDR (Source: World Bank 2022)



prevalent plastic packaging in waste streams in Vientiane includes food packaging, drinks bottles, disposal cups and plates, drinking straws and stirrers, etc. In terms of polymers, the top fifteen most-littered items by number, with PET, LDPE and HDPE being the most common polymers (World Bank 2020). There are opportunities to reduce plastic pollution by promoting sustainable practices, reducing plastic consumption, recovery and recycle of post-consumer plastics by and investing in waste management solutions.

2.2 Plastic waste flow in Vientiane

Plastic waste collection mechanism

Plastic waste represents the second largest fraction of municipal solid waste after organic waste in Vientiane. Plastic waste generated domestically originates from various sources, including households, markets, hotels, restaurants, cafes, and offices. It constitutes 27 per cent of the solid waste generated by households, restaurants, and markets (GGGI 2020). Waste collection companies are responsible for collecting plastic waste as part of municipal solid waste, which is then disposed of at KM32 landfill. This collection process is carried out by waste collection crews using trucks (Figure 4). Residents place their solid waste either in bins or plastic bags outside their homes or at designated collection points, with collections occurring weekly, on average. According to the Vientiane City Office of Management and Services (VCOMS), approximately 400 tons of daily municipal waste are collected as of 2019 (JICA, 2021).

Figure 3. Informal waste picker taking out plastic waste and sell to junkshop in Vientiane

Plastic waste, typically mixed with municipal solid waste, is transported to landfills where it is segregated by informal waste pickers. Currently, formal waste segregation practices at source are non-existent, with only 3 out of 481 villages initiating waste separation efforts since the beginning of 2022 through a pilot project. Plastic recycling in Vientiane is primarily driven by the formal waste management system. Informal waste pickers collect all types of recyclable materials from solid waste that is either awaiting collection by waste collection companies or bound for disposal.

During waste collection by waste collection companies, waste collection crews identify and set aside recyclable material that they can sell is an extra income for them. Scrap dealers are another part of the plastic waste value chain. They visit households and collect discarded or unused items that can be sold to junk shops. They also collect

Figure 4. Waste collection crews

Figure 5. Informal waste picker sort different type of plastic waste

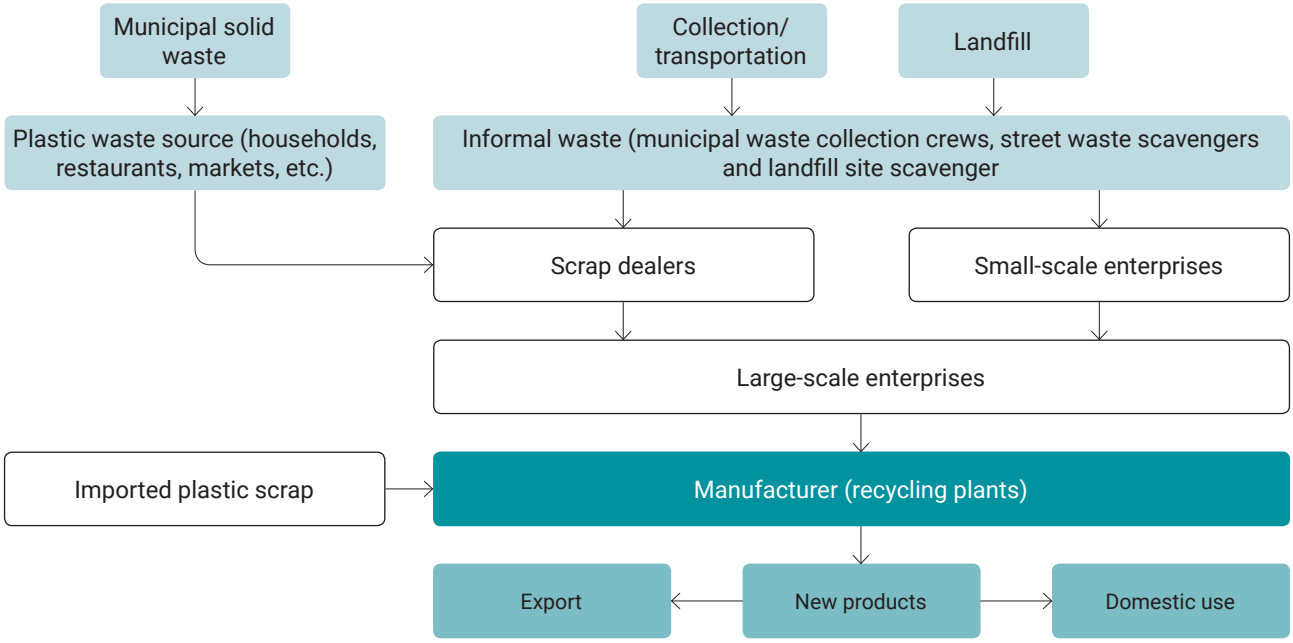
Box 1. Waste collection company A and Junkshop B

Waste Collection Company B operates within nine villages in Vientiane, boasting a team of 30 dedicated workers and a fleet of eight waste collection trucks. Their operations are intensive, with four trips conducted daily, resulting in the collection of approximately 20 tons of waste per day. Remarkably, their collection efforts commence late at night, starting from 11 PM and concluding at 4 AM. Each truck is manned by a driver and four waste pickers, showcasing the company's commitment to efficient waste management.

In terms of compensation, workers receive income based on their collection capacity, with the company paying 300,000 kip per trip or roughly 50,000 kip per ton of waste collected. Interestingly, the revenue generated from selling recyclable materials matches the collection fee, incentivizing workers to actively sort recyclables during collection. This strategy not only reduces waste volume but also minimizes tipping fees for the company. The company's director harbors aspirations to venture further into the waste recycling business, potentially creating additional revenue streams for workers by allowing them to sell recyclables directly to the company. Additionally, the company provides essential amenities for its workers, including dormitory accommodation and three meals a day.

Despite their commendable efforts, Waste Collection Company B faces several challenges. One significant obstacle is the ownership ambiguity of collected waste, making it challenging for the company to locate responsible parties. Furthermore, while the company provides personal protective equipment (PPE), adherence to safety protocols among workers remains a concern. Looking ahead, Waste Collection Company B advocates for increased government-led awareness campaigns to address waste management issues effectively. Additionally, the company grapples with time constraints and traffic congestion during collection, impacting their ability to sort recyclable materials efficiently. Nonetheless, they remain resilient, collecting an average of 125-300 kg of plastic per trip and contributing significantly to Vientiane's waste management efforts.

Figure 6. Plastic waste flow in Vientiane



recyclable materials of interest in lieu of cash, including plastic waste. After collecting recyclable material, informal waste pickers sell it to junkshops or small-scale enterprises (Figure 5), where these recyclable items are stored in bulk and later sold to large-scale recycling enterprises. Some informal waste pickers sort different types of plastic waste before selling them to junkshops or middlemen because they can add more value when they are sorted. In the case of the plastic waste value chain, the large-scale enterprises or wholesalers sort the plastic and prepare to sell them to a recycling factory. However, before being transported, some large-scale enterprises have workers who sort the plastic waste into various grades and qualities. Some also wash the waste and cut and shred it into chips. Recyclers can process these chips to produce granules that are used as raw materials by plastic manufacturers. Figure 6. shows the full plastic waste value chain in Vientiane.

Table 2. Informal actors in the plastic waste recycling sector

Actor	Description and roles
Informal waste pickers	Informal waste pickers are unauthorized people who sort through waste at landfill sites in order to find valuable items. In addition, some informal waste pickers also collect recyclable material directly from sources (mainly waste bins or bags in urban areas).
Scrap dealers	Scrap dealers run informal recycling businesses that have a relatively small waste collection capacities and tend to use tricycles or pushcarts. They buy recyclable material from the community on a door-to-door basis or buy it from informal waste pickers, and then sell it to recycling shops or small-scale enterprises.
Small-scale enterprises	In Vientiane (and in this context), small-scale enterprises are usually junkshops that buy plastic waste from informal waste pickers, and the local community. They do not have processing machines and the majority of them were not approved by MOIC or MONRE and have not been registered legally. The capacity of small-scale enterprises is less than 500 kg per day and most of the junkshops in Vientiane are owned by Vietnamese people.

Table 3. Formal actors in the plastic waste recycling sector

Actor	Description and roles
Medium-scale enterprises	Medium-scale enterprises are recycling businesses that receive plastic waste from scrap dealers, informal waste pickers and junkshops, as well as business entities. They carry out basic recycling processes such as compacting, washing, grinding or shedding. Their role is to reduce the volume of the material and the final product is sent to a large-scale recycling factory for further processing. In Vientiane, medium-scale enterprises have a capacity of between one and five tons per day. They are considered to be part of the formal recycling sector as they need to register and get approval from the Department of Environment and Department of Industry and Handicrafts.
Large-scale enterprises	Large-scale enterprises are businesses that carry out a wide range of processing steps such as shredding, washing, drying, melting, filtering and turning material into pellets. In addition, some large-scale factories have the ability to turn pellets into products (mainly bags). Large-scale enterprises buy plastic recyclables from medium-scale enterprises and junkshops or import them from other countries. They only deal with significant amounts of plastic waste and have the capacity to process more than five tons per day (some of the largest have the capacity to process 50 tons per day). Establishing a large-scale enterprise requires EIA, approval from MONRE and a business licence from MOIC. Therefore, such enterprises fall into the formal recycling sector.

Box 2. Waste collection company A

During an interview with the project team, Waste Collection Company A revealed insights into their operations. With a fleet of 12 trucks, they diligently service 18 villages across Vientiane. However, despite their capacity, only 8 trucks are presently operational, shedding light on the challenges they encounter in their daily operations. With 40 workers, averaging 4-5 workers per truck, they manage 2 compact trucks with a capacity of 5 tons per trip, alongside trucks for transfer containers with a capacity of 2-3 tons per trip, and 7 dump trucks carrying 5-6 tons each. Conducting 5 trips per day, the company employs a monitoring team to track significant changes in waste volume, adjusting collection fees accordingly. Waste collectors play a pivotal role in sorting recyclable materials during collection, including cardboard, cans, metal, and plastic, which are sold weekly, typically to a shop behind the national football stadium. Collectors earn approximately 500,000 kip weekly, translating to an average monthly revenue of 1.7 million kip per person, predominantly from plastic materials. However, the major challenges they faced was during the COVID-19 pandemic and periodic high inflation which leads to diminished profitability for the company. Additionally, the company advocates for community training on proper waste storage and separation to reduce the workload for collectors, as well as to address issues of littering and messiness at collection points, for which they often face unwarranted blame.

2.3 Plastic waste processing

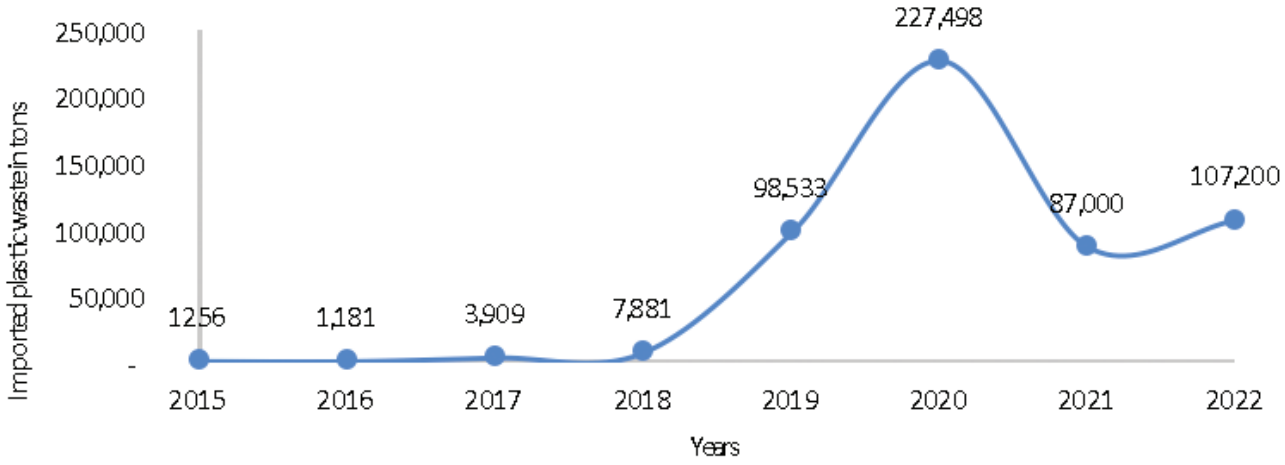
The global plastic outlook shows that only 9 per cent of plastic waste is recycled (15 per cent is collected for recycling, but 40 per cent is disposed of as residue). Another 19 per cent is incinerated, 50 per cent ends up in landfill and 22 per cent goes into uncontrolled dumpsites, is burned in open pits, or ends up in terrestrial or aquatic environments, especially in poorer countries (OECD, 2022). Plastic recycling factories have a high demand for post-consumer recyclable plastics. In Lao PDR, segregation of waste at the source is non-existent, and there are no comprehensive policies or regulations to ensure solid wastes are segregated at the point of generation. Recyclable plastic wastes are comingled with other waste streams, particularly food solid. This contributes to poor recovery and, in some instances, poor quality of recovered recyclable plastics from domestic waste. As a result, a huge amount of plastic waste is being imported for recycling at the country's plastic waste factories (Figure 7). The ripple effects of China's ban on the importation of plastic waste for processing in 2018 led to many additional recycling plants being established in Lao PDR and the amount of imported plastic waste increased from 7,881 to 98,533 tons in 2019 (World Bank 2022). According to information provided by the Department of Industry and Handicrafts under the Ministry of Industry and Commerce (MOIC), the amount of imported plastic waste increased even further in 2020, to 227,498 tons.

Table 4. Number and types of plastic waste factories in Lao PDR (Source: World Bank, 2022)

Type of factory	Number
Retailer/compacting	2
Crushing	9
Compacting and crushing	2
Recycling (producing pellets and granules)	4
Total	17

Owing to the large volume of plastic waste imports, there is a major concern in Lao PDR about how to control standards, which is only intensifying the existing waste pollution problem. The government responded to this challenge by banning the creation of new plastic waste processing plants and issuing a decree on plastic recycling factory controls in 2020. The Department of Industry and Handicrafts reported that some recycling factories need to conduct environmental impact assessments (EIAs)

Figure 7. Amount of plastic waste imported into Lao PDR



Box 3. Small junkshop and medium scale plastic recycling facility

Small scale junkshop

Established in 1990, this company initially focused on buying recyclable materials, shifting to pellet production in 2019. However, due to COVID-19 disruptions, exporting pellets became a challenge until 2022. Operating at a capacity of 3-5 tons per day for seven days a week, they primarily source plastic from junkshops, preferring compact plastics to reduce transportation costs. Despite financial hurdles like high loan interest rates and market inconsistencies, this model factory stands out for its minimal noise and odor pollution, injecting air pollutants into water. They face labeling issues in recycling and prioritize thicker plastics for processing, like PET bottles with a 7 mm thickness. Maintenance occurs 3-4 times a year for processes including shredding, washing, separating, drying, melting, cutting, and heating. With 30 staff, they solely use domestic plastic waste, processing 80% good quality plastic, 15% low quality, and 5% waste. Their monthly electricity bill amounts to about 1500 USD.

Medium scale plastic recycling factory

Since its inception in 2007, this recycling facility has been a key player in addressing plastic waste challenges in Vientiane. Utilizing primarily domestic plastic waste (70%) alongside imported materials (30%), they process a staggering 14 tons of plastic daily, including bags and bottles. Their water source comprises groundwater and recirculated wastewater post-treatment. The manufacturing process involves manual pre-screening, followed by crushing, washing, melting, stringing, and cutting, ultimately yielding PE, PP, and HDPE pellets. Remarkably, 80% of their output is exported to China and Spain, with only a fraction (20%) sold within Laos. However, washing, and shredding stages pose significant risks of loss and leakage. Plastic bottles fetch 3000 kip/kg, while unrecyclable waste is dispatched to landfills, incurring a fee of 500,000 kip per truck (2-3 tons). Electricity, the primary energy source, costs approximately 10,000 USD per month. Despite their environmental initiatives, noise and odour pollution remain challenges. Although they have applied for an Environmental Impact Assessment (EIA) since 2019, approval is pending, while past operations relied solely on environmental certification. With around 50 containers of plastic waste imported monthly and daily processing volumes ranging from 70 to 100 tons of domestic plastic waste, this facility remains a vital asset in Vientiane's plastic recycling landscape.

and improve processing standards to reduce their environmental impact, while a few need to be closed entirely. In addition, some local plastic waste is collected and processed by recycling factories in the form of pellet of PE, PP, HDPE before being exported to Thailand and China. They are exported as plastic bags or pellets for plastic production in that country. Approximately 80% of the final products are exported abroad (e.g. to China, Vietnam, and Spain) while only 20% are sold in Laos.

Chapter 3

Enabling environment for plastic recycling in Vientiane

3.1 Institutional and policy landscape

Multiple institutions perform complementary, and sometimes overlapping, roles that are crucial in regulating and supporting the plastic recycling industry in Vientiane. The **Department of Environment (DOE**) is responsible for developing policies on plastic recycling practices in Vientiane, in collaboration with other relevant organizations. Currently, only the Environmental Protection Law is available, but with support from the World Bank and the EU SWITCH-Asia, more comprehensive policies and guidelines are in the process of being developed. Notwithstanding, the DOE has been active in raising awareness and promoting initiatives to develop policies related to waste and plastics. While the DOE leads awareness campaigns through its Promotion Division, it does not handle monitoring responsibilities. Monitoring of plastic recycling activities is managed by the Department of Inspection and Monitoring under the Ministry of Natural Resources and Environment (MONRE). This division of roles means that the DOE focuses on the environmental impacts surrounding plastic recycling factories and intervenes when problems arise, while the Department of Industrial and Handicraft (DIH) is responsible for internal factory inspections.

The **Vientiane City Office for Management and Services (VCOMS)** is the key institution responsible for regulating and supporting the plastic recycling waste management in Vientiane. VCOMS oversees waste collection companies, ensuring they adhere to waste management regulations and policies. Although VCOMS handed over the operational aspects of waste management to a private waste collection company (Small B), it continues to supervise and regulate these activities, focusing on policy development and enforcement. Though a Sustainable Solid Waste Management Strategy has been developed for Vientiane, the city still faces a lack of comprehensive national policies and guidelines for waste management. VCOMS is working on developing by-law policies for waste management in collaboration with the Global Green Growth Institute (GGGI).

Monitoring of waste management is conducted through checkpoints at landfills. However, certain areas like Hadxayfong district pose significant challenges due to low waste collection rates and high potential for illegal dumping into the Mekong River. Informal waste collection services, often provided by families, operate without proper regulation, exacerbating the issue. The challenges of policy enforcement and awareness on plastic pollution are highlighted by insufficient waste collection services and high collection costs, which lead residents in some remote areas of Vientiane to resort to illegal dumping on vacant lands. To address these issues, VCOMS plans to regulate junkshops, which currently need district-level approval, by classifying their sizes and incorporating them under VCOMS control. Draft regulations for this initiative are being prepared. Through these initiatives, VCOMS aims to improve waste management practices, support the plastic recycling industry, and enhance overall environmental sustainability in Vientiane.

The **Ministry of Industry and Commerce (MOIC)** plays a crucial role in regulatory institution plays vital roles in overseeing, regulating trade and industrial activities of recycling factories and enterprises in Lao PDR. The MOIC noted that between 2017- 2020 years, a significant number of plastic recycling factories have been established in Laos, with many large factories importing plastic waste. In 2017, MOIC approved the establishment of 50 recycling factories. However, by 2019, the government of Laos halted the approval of new recycling plants. In 2020, a decree on plastic recycling was issued, which led to the closure of many large and small factories that failed to meet the new requirements. Additionally, the government increased the import tax on plastic waste to 200,000 kip per ton in 2021.

This regulation, alongside the requirement for imported plastic waste to have an 80% efficiency standard, has created challenges for the industry, particularly when factories receive very dirty waste. To address these challenges, MOIC has signed a Memorandum of Understanding (MOU) with the Ministry of Natural Resources and Environment (MoNRE) to reduce the import of plastic waste and increase the domestic recycling rate, as outlined in Decree 055 of 2012. Furthermore, MOIC has collaborated with KCL Cement Company to recycle plastic waste as Refuse-Derived Fuel (RDF) and has partnered with Kayama Japan Company to engage in industrial waste management. MOIC is also involved in promoting sustainable practices through initiatives such as the ECO labeling project with GIZ and plans to establish an Eco Industrial Park in the future. Despite these efforts, most plastic recycling factories have faced closures due to safety and environmental issues, inadequate waste treatment, and their location in sensitive areas.

Table 5-6 shows summary of regulatory institutions with their roles and responsibilities and regulatory and policy frameworks governing plastic recycling in Vientiane.

Table 5. Regulatory institutions with their roles and responsibilities

Stakeholders	Summary of relevant roles and responsibilities
Ministry of Industry and Commerce (MOIC)	MOIC facilitates the importing of equipment, machinery, seeds, and vehicles related to the development of renewable energies. The ministry plays an important role in approving, monitoring and inspecting factory processes to ensure they meet environmental standards. MOIC also works on the approval of import and export products, including plastic scrap.
Ministry of Public Works and Transport (MPWT)	MPWT provides construction guidelines for landfills and access roads in accordance with the Lao PDR Transport Sector Policy Framework Strategy. The ministry also certifies and oversees construction guidelines for waste sorting and processing plants and introduces appropriate guidelines for the use of waste transport vehicles.
Ministry of Natural Resources and Environment (MONRE)	MONRE conducts research on environmental issues and collaborates with other organizations. The ministry enforces guidelines and laws to minimize the environmental and social impacts of renewable energy development, oversees initiative environment examination (IEE) and environmental impact assessment (EIA) implementation, and develops environmental laws and regulations. MONRE also plans to create a national solid waste management master plan with international support.
Ministry of Planning and Investment (MPI)	MPI is responsible for developing strategies and plans for economic management, and the promotion of investment in Lao PDR. The ministry approves large public and private investment projects, while smaller investments fall under provincial- and district-level departments. MPI also develops and promotes the National Green Growth Strategy.
Ministry of Public Health (MOH)	MOH oversees the disposal of infectious waste from hospitals and clinics in Vientiane, ensuring proper separation and storage. The ministry also disseminates and monitors the implementation of its decisions relating to hospital waste management.
VCOMS	VCOMS oversees municipal solid waste management, including collection, treatment and landfill dumping. The office creates and improves legislation and develops pricing structures and new mechanisms for waste collection fees in compliance with regulations. VCOMS also has a public–private partnership module with companies in the private sector, and monitors and evaluates their performance.

3.2 Policies and regulations

Table 6. Relevant policies and regulations

Policies and regulations	Summary of relevant policy provisions
National Socio–Economic Development Plan (2021–2025)	This plan aims to promote green growth and climate action, including improving waste management, through awareness-raising, financing, and infrastructure development. A circular economy model will be implemented to reduce reliance on natural resources and mitigate environmental degradation, with a focus on waste reduction, recycling, and pollution control. Domestic and foreign investment in waste-related business activities will be encouraged to create jobs and reduce resource use.
Environmental Protection Law 2012	This law sets regulations and measures for environmental management, control, preservation, and rehabilitation to mitigate pollution from human or natural causes. Operators must comply with regulations for the release, disposal, burning, burying or demolishing of waste and toxic chemicals. It is prohibited to release wastewater or dispose of waste without treatment based on technical standards.
Processing Manufacturing Law 2013	This law promotes manufacturing while considering environmental protection. Chapter 6 covers green industry, risk assessment, environmental standards, and pollution control. Industries must control pollution from wastewater, air, solid waste and noise to meet environmental standards.
Industrial Waste Discharge Regulation (No. 180/MOIC, 1994)	This regulation aims to manage threats from the disposal of industrial waste or wastewater that can detrimentally impact water quality, health, and human life (article 1). Any solid materials, including plastic bags, are prohibited from being disposed of within the environment and public water sources (article 3). Additionally, industries treating their waste should follow the standards set by the regulation (article 8).
Plastic Recycling Factory Decree (No. 682/MOIC, 2020)	MOIC has issued a decree to regulate plastic waste processing plants in order to reduce the impact of activities on worker health and the environment. The decree has 14 articles covering plant set-up, waste treatment, transportation and import requirements. Key points include: • EIA or IEE, certificates and licences are required for set-up. • The storage of waste outside the plant is prohibited. • Treatment systems and wastewater must meet MOIC standards. • Imported plastic waste must be clean and at least 80 per cent recyclable. • The plant location should be at least 100 metres from a community and 250 metres from a watercourse.
Environment Impact Assessment Decree (2018)	This decree outlines rules and regulations for conducting EIAs to ensure transparency and protect the environment. The first step is to screen investment projects to determine whether a preliminary or comprehensive EIA is required. Preliminary EIAs are for projects with minimal impact, while comprehensive EIAs are for projects with significant impact on the environment and society.

Chapter 4

Preventing plastic loss and leakage

4.1 Plastic recycling operational process and losses

In the plastic recycling process, several stages present a high risk of microplastic leakage, contributing to environmental pollution. These potential leakage points are numerous and complex, requiring proper management and mitigation strategies to minimize their impact. Effective management of these stages is essential to prevent further environmental pollution. The key steps within the plastic recycling process (Figure 8):

Figure 8. Mechanical recycling process of post-consumer plastics (Source: Delvar et al., 2019)

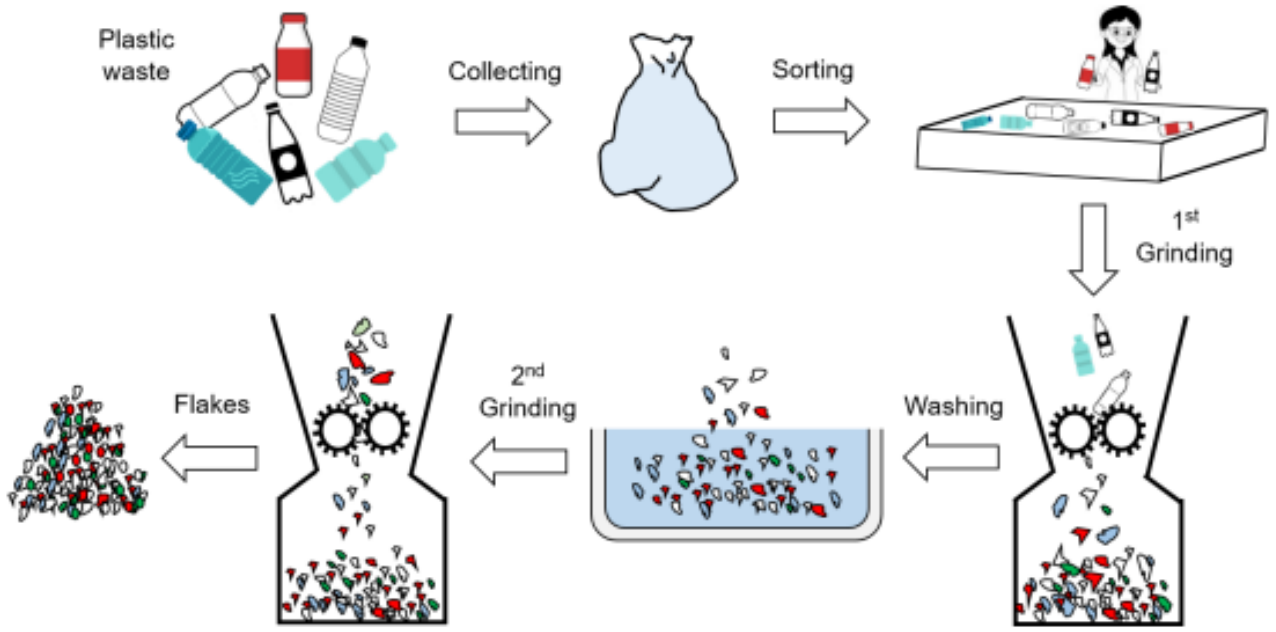


Table 7. Summary description of mechanical plastic recycling processes

Recycling process	Description
Collecting	Before the recycling process can begin, informal waste pickers, and scrap dealers collect plastic waste from landfill sites and local sources or buy it from their community. Some of these actors also sort plastic items depending on the plastic code in order to make a greater profit when they sell the materials to small-scale enterprises.
Sorting	The actual plastic recycling process starts with sorting. This is where manual methods or specifically designed machines are used to sort different plastics based on colour, resin content and plastic recycling code. Identifying and eliminating contaminants is also a part of this stage.
Shredding	After the sorting process is completed, the plastic goes through a process where a shedder is used to grind it into tiny pieces. The heavier and lighter plastics are then separated using specially designed machines. Microplastics can be generated during the shredding and grinding processes if there is no proper containment. These microplastics are easily released into the environment.

Continued next page

Table 7 continued

Recycling process	Description
Primary and secondary washing	Next, the pieces of plastic are thoroughly washed with detergents to remove any remaining contamination. They are then subjected to moderate heat so that they can dry. Microplastics can also be released during the washing process, due to the plastic materials rubbing against each other and the washing equipment. Large amounts of microplastics are often released into wastewater treatment systems, contributing to environmental pollution.
Dewatering and drying	The drying stage is also a potential leakage point, particularly in informal recycling facilities without containment walls. A common practice observed is the drying of wet flakes in open spaces, roadsides under direct sunshine and near drainages.
Melting, compounding, and pelletising	To enable the plastic to be reusable, the processed granules are compressed into tiny pellets (otherwise known as nurdles). Being in pellet form means that similar types of plastics can be stored easily, based on colour or type of resin, for quick distribution. Regulated temperatures are then applied to the plastic pieces so that they will melt but not destroyed. Once melted, the pieces are extruded and resized to be processed into granules.
Melting, compounding, and pelletising	To enable the plastic to be reusable, the processed granules are compressed into tiny pellets (otherwise known as nurdles). Being in pellet form means that similar types of plastics can be stored easily, based on colour or type of resin, for quick distribution. Regulated temperatures are then applied to the plastic pieces so that they will melt but not destroyed. Once melted, the pieces are extruded and resized to be processed into granules.

4.2 Factors contributing to plastic leakage

As mentioned previously, the plastic recycling industry in Lao PDR has grown significantly over the last several years, particularly in the wake of neighbouring countries introducing bans on importing plastic waste. From the interviews and field visits conducted as part of this study, plastic recycling processes leak micro- and macro-plastics into waterways and soils around recycling facilities. Plastic leakage from recycling facilities in Vientiane poses significant environmental challenges. The primary source of leakage is the disposal of residual plastics that cannot be processed for recycling. These residuals are often dumped in open landfill sites where they can be blown by the wind, burned (releasing toxic pollutants such as persistent organic pollutants), or even dumped in nearby waterways to avoid disposal fees. Additionally, many recycling facilities operate with limited environmental controls and low-tech machinery. For example, during the washing stage, small plastic pieces can be washed directly into waterways due to inadequate wastewater treatment.

Figure 9. Potential of Leakage Points of Plastic in Recycling facility


ALWAYS KEEP
DOOR
LOCKED.
DRY CHEMICAL

Table 8. Potential and occurrence of plastic leakage from recycling facilities visited in Vientiane.

Recycling facility	Handling & transport	Sorting & segregation	Processing & treatment	Storage & containment	Disposal & residual waste	Waste water management	Odour and air quality
Facility A							
Facility B							
Facility C							
Facility D							
Facility E							
Facility C							

The location of many recycling factories exacerbates the problem, as these facilities are often established in peri-urban and outskirts of Vientiane close to watercourses, in marshy areas. In remote locations like these, municipal government officials and other monitoring and regulatory agencies face significant challenges in effectively overseeing and enforcing environmental controls. Moreover, the exact number of plastic recycling facilities operating within special economic zones remains undocumented which further complicates regulatory efforts and environmental management challenges.

Plastic wastes can leak into the environment during transit and storage at recycling facilities due to adverse weather conditions and poor management. The risks of plastic leakage in plastic recycling facilities are compounded by poor housekeeping and inadequate waste management systems. These issues highlight the urgent need for improved capacity building supports, awareness raising, improved regulation, better infrastructure, and more effective waste management practices to mitigate plastic leakage from recycling facilities in Vientiane. Table 8 shows the result of a rapid map potential and occurrence of plastic losses and leakage of various process operations of some facilities visited in Vientiane.

Vientiane, Lao PDR

Table 9. Key/Legend: Criteria for grading operational activity potential micro-macro-plastic loss points to environment

Key/grade	Criteria	Description
		Not applicable
High potential for Leakage (Red)	Handling and Transport	Frequent spills or losses during loading, unloading, and transport.
	Sorting and Segregation	Inefficient sorting with significant quantities of plastics escaping containment.
	Processing and Treatment	High risk of leakage from processing equipment and poor containment.
	Storage and Containment	Poorly maintained storage facilities with frequent leaks or spills.
	Disposal and Residual Management	Inadequate disposal practices leading to significant environmental contamination
	Waste water treatment	No/poor wastewater treatment processes in place, resulting in direct discharge of untreated water.
	Odur and air quality	Strong odors and poor air quality due to inadequate ventilation and filtration systems
Medium potential for leakage (Yellow)	Handling and Transport	Occasional spills or losses that are managed but still present a moderate risk.
	Sorting and Segregation	Some inefficiencies in sorting, leading to moderate levels of plastic escape.
	Processing and Treatment	Moderate risk of leakage with some containment measures in place but not fully effective.
	Storage and Containment	Adequate storage facilities with occasional leaks or spills.
	Disposal and Residual Management	Fair disposal practices with some risk of environmental contamination.
	Waste water treatment	Basic wastewater treatment processes in place, but not fully effective.
	Odur and air quality	Noticeable odors and some air quality issues, with partial ventilation and filtration
Low potential for leakage (Green)	Handling and Transport	Minimal or no spills during loading, unloading, and transport with effective management practices.
	Sorting and Segregation	Highly efficient sorting with minimal plastic escape
	Processing and Treatment	Low risk of leakage with robust containment measures in place.
	Storage and Containment	Well-maintained storage facilities with no significant leaks or spills.
	Disposal and Residual Management	Excellent disposal practices with minimal risk of environmental contamination.
	Waste water treatment	Advanced and effective wastewater treatment processes in place, ensuring clean discharge
	Odur and air quality	Minimal or no odors and good air quality maintained by effective ventilation and filtration systems

Chapter 5

Challenges and opportunities for plastic recycling in Vientiane

5.1 Challenges

The plastic recycling industry in Vientiane faces numerous challenges that may hinder its growth and effectiveness. A significant issue is the lack of a formal sorting system, which hinders the maximum recovery of high-quality domestic recyclable plastics from municipal solid waste (MSW) as feedstock for local recycling factories. This limits the quantity of post-consumer recyclable plastic materials flow among the actors in the upstream of the recycling value chain (waste pickers, waste collectors, small junkshops, etc). As a result, large-scale recycling factories are compelled to import plastic waste from abroad, increasing their production costs. However, plastic waste import restrictions and licensing quotas limit the number of factories that can access imported plastic waste. Additionally, the quality criteria for importing plastic waste pose a challenge for recyclers. While these regulations protect the country and recyclers from low-quality plastic waste dumping, the actual quality and composition of imported waste sometimes fall below the declared values. This discrepancy increases costs for recyclers and hampers the city's waste management efforts.

The challenges of the plastic recycling industry are also compounded by the absence of partnerships and working groups within the industry, hindering coordination efforts and the sharing of best practices. Limited communication and information exchange among stakeholders restrict the dissemination of innovative solutions. This lack of coordination may lead to duplicated efforts or conflicting goals, among recyclers, and their interface with other stakeholders such as regulatory and policy making agencies, donors, etc., resulting in inefficiency and resource wastage. Moreover, without formalized partnerships, resources remain fragmented, hindering the industry's overall capacity for growth and improvement. The absence of established collaborations or formal agreements between different entities in the plastic recycling industry, resources such as funding, expertise, and infrastructure are not pooled together or utilized efficiently. Each organization or entity operates independently, leading to duplication of efforts, inefficient use of resources, and a lack of coordination in addressing common challenges or pursuing shared goals. As a result, the industry's overall capacity for growth and improvement is hindered because resources are not maximized and synergies between different stakeholders are not fully realized. Formalized partnerships can help consolidate resources, foster collaboration, and facilitate coordinated efforts towards achieving common objectives, thereby enhancing the industry's ability to grow and innovate. Addressing systemic issues becomes challenging in the absence of collaborative efforts, potentially impeding progress in plastic waste management. Additionally, the industry may miss out on opportunities for innovation, as collaborative environments are conducive to the development and implementation of new technologies or approaches. Thus, the absence of partnerships poses significant obstacles to achieving sustainable plastic waste management in Vientiane.

Additionally, the price of plastic, influenced by inflation rates, is impacting the profitability of recycling operations. Fluctuations in the price of plastics in domestic and international market, are vulnerable to factors such as inflation rates and market demand, directly affecting the financial viability of plastic recycling businesses. For example, when the cost of raw plastic materials increases due to inflation, recycling operations may face higher expenses for acquiring these materials. This can squeeze profit margins or even lead to losses if the prices of recycled plastic products do not rise proportionately to compensate for the increased input costs. The situation described was echoed by all the recycling facilities interviewed. Conversely, if the market price of recycled plastic products decreases due to changes in demand or other market factors, while input costs remain stable or increase, recycling operations may struggle

to maintain profitability. Fluctuations in plastic prices, influenced by inflation and market dynamics, thus present a significant challenge for recycling operations. These fluctuations directly affect the financial performance and long-term sustainability of plastic recycling businesses in Vientiane.

Many recycling facilities lack access to technical assistance and supportive financial policies necessary for their growth and development. Formal and informal plastic recycling facilities in Vientiane face significant barriers in terms of acquiring the technical expertise and financial support needed to expand and improve their operations. Recyclers in Vientiane lack access to technical assistance, including guidance, training, and expertise in critical areas such as waste management, remediation technologies, cleaner production, improved recycling processes, and technology adoption. Without access to technical assistance, recycling facilities may struggle to optimize their operations, address challenges effectively, or implement best practices to safeguard the environment.

Supportive financial policies, on the other hand, include government incentives, grants, subsidies, or favorable loan programs designed to encourage investment in recycling infrastructure and promote sustainable waste management practices. Lack of access to such policies means that recycling facilities may face financial constraints or be unable to access the necessary capital for investment in equipment upgrades, expansion projects, or research and development initiatives. In a nutshell, the absence of technical assistance and supportive financial policies presents a significant obstacle to the growth and development of recycling facilities in Vientiane. These facilities may be unable to unlock their full potential or keep pace with evolving industry standards and regulations, ultimately hindering progress towards sustainable waste management practices.

The disposal of residual plastics that cannot be recycled presents another challenge, as it can create environmental and health-related hazards. Disposing of plastics that cannot be effectively recycled poses risks to both the environment and human health.

Box 4. Large scale plastic recycling facility

Established in 2012, this recycling facility once processed an impressive 1000 tons monthly during its heyday in 2016-2017. However, the present landscape tells a different story, with the company facing formidable challenges and minimal profitability, merely striving to stay afloat. In 2022, its processing capacity dwindled to a mere 100 tons per month, indicative of the industry's harsh realities. The exorbitant cost of Environmental Impact Assessments (EIA), totaling nearly 60,000 USD, adds to the burden, especially considering the lengthy application process spanning multiple years. The factory grapples with various issues, including inflated costs due to the inflation rate, soaring transportation expenses, and a labor shortage exacerbated by a significant workforce migration to Thailand. Operating only 10-15 days monthly further compounds its struggles. Additionally, high contamination levels drive up operational costs, impacting the market price of low-quality plastic waste. Despite employing 50 staff presently (down from almost 500 in the past), the factory's profitability remains precarious. Its reliance on imported plastic waste (60-70%) and domestic waste (30-40%) underscores shifting dynamics, with each presenting unique challenges and opportunities. While imported plastic waste yields lower efficiency (60-70%), domestic waste offers higher quality (80%) albeit with increased landfill and contamination rates. Groundwater and six ponds serve as primary water sources for operations, Shedding and washing processes result in significant plastic losses, highlighting the need to support the facility's commitment to environmental sustainability. Safety measures, including biannual fire prevention drills, underscore the director's commitment to employee well-being. Despite these efforts, challenges persist, emphasizing the need for comprehensive solutions, capacity building support for the company to balance profitability and environmental sustainability.

These residual plastics may end up in landfills, where they can release harmful chemicals into soil, and water, contributing to pollution and potentially causing health problems for nearby communities. Some recycling operations also process plastics without proper environmental controls, contributing to pollution and other environmental problems. Improper handling of hazardous materials, inadequate waste management practices, or insufficient pollution control technologies. As a result, these operations may inadvertently contribute to pollution and environmental degradation, exacerbating existing environmental problems. The disposal of non-recyclable plastics and the inadequate environmental controls in some recycling operations pose significant challenges for environmental sustainability and public health. Addressing these issues requires implementing proper waste management practices, improving recycling technologies, and enforcing environmental regulations to minimize negative impacts on the environment and human health.

The location of recycling operations plays a crucial role in their effectiveness. Facilities situated far from plastic waste sources or too close to communities face logistical and operational challenges. Furthermore, inadequate management of transport and stockpiling of plastic waste exacerbates these issues, especially in areas lacking sufficient waste management systems. Monitoring systems to track the effectiveness of recycling operations are often absent, and many factories lack Environmental Impact Assessments (EIAs) to evaluate their environmental impact. Addressing these gaps and challenges is crucial for the plastic recycling industry of Vientiane to grow and become more effective. However, this will require collaboration among key stakeholders, investment in infrastructure and technology, and the development of policies and regulations to support sustainable plastic recycling practices in Lao PDR.

5.2 Opportunities

Despite the challenges by the plastic recycling industry in Vientiane, several opportunities exist for growth and improvement in environmentally sound plastic recycling. The growing emphasis on recycling and the rising demand for eco-friendly products, including recycled plastic, fueled by heightened awareness of plastic waste's environmental impact, offers a substantial opportunity for the industry. Through consultation and stakeholder engagement exercises, the project team observed a clear indication of this increasing demand, which creates a favourable market for recycled products and encourages further recycling activities.

One of the significant opportunities for the plastic industry lies in enhancing the quantity and quality of recovered plastic waste segregation at its source. Additionally, improving access to low-cost input factors of production such as water, electricity, labour, and technology can further bolster this opportunity. By recycling domestic plastic waste, the industry can reduce importation/manufacturing costs and increase profitability. Additionally, government support and policies are increasingly favouring sustainable waste management practices. In Lao PDR, as in many other countries, regulations and incentives are being implemented to support recycling efforts, creating a conducive environment for industry growth.

The recycling industry also has the potential to contribute significantly to job creation and economic development of Vientiane. As the demand for waste management services grows, so does the potential for generating employment opportunities and stimulating local economies. Furthermore, the environmental benefits of recycling plastic waste can be derived from increasing diversion of plastic waste from landfills. Recycling industry can play a crucial role in mitigating environmental pollution. To fully capitalize on these opportunities, the plastic recycling industry in Vientiane needs to invest in technology and infrastructure to enhance efficiency and capacity. A key leverage area is the development of partnerships and collaborations within the industry and with external stakeholders can foster knowledge sharing and innovation. Further, continuous adaptation to changing market conditions and embracing new technologies will be key to sustaining growth and success in the recycling sector. By focusing on these strategic areas, the plastic recycling industry in Vientiane can unlock significant growth potential and contribute to a more sustainable and economically vibrant future.

Chapter 6

Conclusions

6.1 Institutional and regulatory gaps and challenges

One of the significant challenges faced by the DOE is the lack of cooperation and data sharing among various stakeholders, including other line ministries. Additionally, the DOE struggles with capacity issues for conducting awareness campaigns and has a shortage of skilled human resources. For instance, out of the 13 staff members in charge of environmental pollution, most lack specialized knowledge in waste management or plastics, possessing only a general understanding. In Laos, there are about seven large plastic recycling factories. The DOE oversees the environmental impacts these factories have on their surroundings, but ensuring effective regulation and support for the industry remains a complex task due to these ongoing challenges.

VCOMS also provides subsidies for tipping fees in remote areas, reducing the standard fee of 40,000 kip per ton to 15,000 kip per ton in specific cases. However, the payment mechanism poses challenges as VCOMS struggles to collect all fees, with some households combining waste collection contracts. Additionally, the waste collection fee, initially based on a fuel price of 7,000 kip per liter, has not increased despite a doubling of fuel costs, further complicating the financial sustainability of waste collection services. The increased import taxes have further compounded the problems, leaving only 4-5 factories approved to import plastic waste this year. MOIC faces several challenges, including limited data systems, a lack of guidelines, and no laboratory to monitor air pollution. The ministry requires support in developing guidelines and capacity building to address these issues. Currently, only two factories have wastewater treatment facilities that meet the required standards. Through these regulatory measures and collaborative efforts, MOIC aims to support and stabilize the plastic recycling industry while.

6.2 Gaps and challenges faced by recycling facilities

In the plastic recycling sector of Vientiane, efficiency, sustainability, precision, safety, and cost-effectiveness are vital considerations for recycling facilities. The adoption of improved sorting practices and technologies, along with more effective process configurations and cleaner production measures, can significantly enhance these aspects. Machine-sorting technology provides a more precise sorting process, ensuring accurate material sorting and processing while reducing manual labor costs and maintenance expenses, ultimately contributing to cost-effectiveness.

However, despite the potential benefits of implementing these measures, recycling facilities in Vientiane face various challenges. Operational inefficiencies are prevalent among informal waste workers, small, medium, and large recycling enterprises, and family-operated factories, leading to microplastic release into the environment. These entities often prioritize profit over environmental stewardship, resulting in losses and leakage throughout the recycling value chain. Medium and large facilities encounter plastic waste quality issues, leading to the rejection of low-value or contaminated plastic waste received from various sources. Failure to properly manage and dispose of such residual or rejected plastic wastes exacerbates the problem of plastic losses during recycling. Outdated machinery and inefficient recycling technologies further contribute to these losses. Additionally, the informal nature of many recycling enterprises allows for the employment of unskilled workers with low awareness of environmental impacts, compounding the issue.

Moreover, additional challenges arise from factors such as the limited availability of raw materials, consumer demand, global market prices, government regulations, technology availability,

Figure 10. Summary of gaps and challenges identified recycling actors and stakeholders in Vientiane

Regulators and monitoring agencies

Policies and regulation

- Inconsistent enforcement of existing regulations on plastic waste management and recycling.
- Lack of comprehensive policies addressing plastic pollution and recycling.
- Absence of strict regulations on plastic waste management.
- Need for policies to promote clean and high-quality domestic post-consumer recyclable plastics.
- Expansion of policy frameworks to recognize and include informal waste workers.

Institutional framework

- Inadequate resources for enforcing environmental controls by city governments and regulatory agencies.
- Fragmented coordination among stakeholders engaged in plastic waste management.
- Insufficient technical support and incentives for formal recycling enterprises.
- Overlapping mandates among institutions leading to enforcement lapses.
- Inadequate technical capacity and logistics for monitoring and control.

Access to resources

- Limited availability of high-quality recyclable plastics, resulting in price increases.
- Consumer demand and global market prices influencing plastic type prioritization.
- Limited infrastructure for waste collection and sorting.
- Challenges in sourcing specific types of plastic for recycling due to scarcity.
- Lack of access to incentives and financing, such as tax incentives and loans.
- Limited access to training and capacity-building programs on environmental awareness, treatment options, and leakage prevention.

Technology

- There is a need for investment in innovative recycling technologies to enhance efficiency.
- Access to training and capacity-building programs is essential for workers to adapt to new technologies.
- Limited availability and reluctance to invest in advanced recycling technologies are evident.
- There is heavy reliance on rudimentary and inefficient technology for recycling processes.
- Lack of knowledge and awareness of treatment and remediation options persists.
- Operational inefficiencies are observed among informal waste workers and recycling enterprises

Plastic recycling facilities

and competition among recyclers. Limited availability of raw materials or specific plastic types can drive up prices and necessitate importing materials. Consumer demand and global market prices also influence plastic type prioritization and technology choices. Strict government regulations or the potential restriction of single-use plastic items may require manufacturers to adapt their processes. The availability of technology, predominantly sourced from China due to affordability, influences technology choices. Competition among recyclers further impacts plastic type prioritization and processing technology, as well as plastic purchasing prices.

6.3 Potential interventions

Insights from factory visits reveal that the implementation of commendable best practices and housekeeping measures can significantly reduce plastic leakage from recycling facilities in Vientiane. When both formal and informal recycling facilities, including enterprises like junkshops, consolidators, aggregators, and recycling factories, implement and adhere to consistently high standards of operational practices and maintenance, they can effectively reduce the amount of plastic waste that leaks or is improperly disposed of during the recycling process.

This underscores the importance of implementing and enforcing robust protocols and procedures within recycling facilities to mitigate environmental pollution and contribute to sustainable waste management practices.

Appropriate operational and storage facilities, with plastic leakage prevention and containment measures are essential to organize and transfer recyclable plastic materials safely and efficiently. These interventions ensure that plastic materials are stored in an organized manner, reducing the risk of accidents, losses, and leakage. In the facilities, it is essential to ensure proper allocation of working spaces, labelling, segregation, and handling of materials are crucial aspects of effective storage practices. Proper labelling, segregation, and handling of materials help prevent accidents and minimize the risk of contamination and losses. Labeling ensures that materials are clearly identified, making it easier for workers to distinguish between different types of plastic polymer categories and handle them accordingly. Segregation involves separating plastic materials based on their properties, such as hazardous versus non-hazardous materials, to prevent cross-contamination and ensure proper handling, effective transfer, and recycling.

Effective management of waste or residue generated during sorting and washing processes is crucial. Apart from the residual plastics, wastes such as solid waste, hazardous waste substances, sludge management and wastewater must be properly managed and disposed of in an environmentally sound manner. Despite potential gaps in monitoring by regulatory authorities, it's crucial that in-house containment and treatment measures for such waste are conducted in a manner that does not pose threats to the environment or public health. This means that even if regulatory oversight might be lacking or inconsistent, it's essential for organizations to take responsibility for managing their waste in a manner that aligns with environmental and health standards. Proper containment and treatment measures within facilities are essential to prevent the release of harmful substances into the environment and reduce risks to public health. Therefore, it is imperative to raise awareness, provide training, and enhance the knowledge of recyclers on the impacts of poor waste management practices in plastic recycling facilities. Capacity-building initiatives and awareness programs on environmental management, treatment options, and cleaner production methods are essential for long-term sustainability. This educational effort should aim to empower recyclers with the information and skills necessary to implement effective waste management strategies, thereby mitigating environmental and health risks associated with plastic recycling operations.

Technological interventions for waste wash water treatment and for controlling odour-emitting melting processes are important. Measures like water and air filtration systems, regular equipment and facility cleaning, and proper material handling and storage can help in odour control. Implementing good housekeeping practices is key. This involves instituting routine equipment and facility cleaning, proper waste disposal, and ensuring employees are trained to maintain a safe and clean work environment. These measures collectively contribute to reducing plastic leakage and promoting a more sustainable recycling process in Vientiane's recycling facilities. Addressing these challenges requires ensuring access to information on recycling materials market prices, technologies, and environmental management practices. By carefully assessing and understanding these factors' roles and influences, effective strategies can be developed to mitigate plastic and pellet leakage from recycling facilities in Vientiane.

ANNEX:

High potential for leakage

Table A1. Map of loss and leakage points for macro- and microplastics in Vientiane's plastic recycling operations

Mechanisms and causes and of micro- and macro-plastics losses and leakage	
Off-site pre-sorting and dismantling	Release of fugitive scraps (macro and microplastics) into the soil, surrounding areas, and workspaces.
	Poor pre-sorting and containment conditions, including use of improper tools.
	Poor handling, mismanagement, and illegal disposal of non-recyclable/low value plastics
	Poor sorting techniques & insufficient knowledge of market demand on the types of recyclable plastics in demand.
Temporary/offsite storage	Poor storage and containment space warehousing
	Exposure to contaminants and dispersal agents (e.g. wind, flooding, etc.)
	Inappropriate storage sacs and bulk storage
Transportation	Poor loading, transport, conveyance techniques offsite and in facility. (trucks, tricycles, human, forklifts, conveyor belts, tipping)
Material reception and staging areas, dismantling bulk multi-component plastic materials	Leakage of micro and lightweight plastics from poorly defined reception areas.
	Reception areas unpaved areas without containment berms.
	Reception and staging areas prone to dispersal agents (wind, flooding).
	Poor paving of working (compacting and baling) areas/granite aggregates paved areas with vegetations.
Compaction and baling	Fugitive plastic (hard plastics) fragments from compaction in old leaky compactor hoppers/chambers.
	Lack of trappers and containment berms
	Lack of pallets to prevent abrasion release and easy transfer.
De-baling, on site primary/pre-sorting, label scraping	Plastic breaks off from rough handling of bales by forklifts
	Poor handling of labels/films, rejects, films, caps, and seals
	Non-paved sorting areas prone to plastic fragment losses.
	Overloading of conveyor belts and sorting tables.
	Sorting at areas prone to wind, flood, and other dispersal agents.

Medium-potential plastic leakage leakage

No observation

	Informal waste pickers	Waste collectors & crew	Junkshops (S/M/L)	Aggregators	Consolidators & brokers	Recycling factories (S/M/L)

Continued next page

Table A1 continued

Shredding and grinding	Plastic fragments release/losses at the loading, discharge points, connection points.
	Old and low efficiency shredders leak plastics from shredding process.
	Top/side fed shredders without safety curtains on the inlet hopper often splash out microplastics.
	Griding/shredding without proper dust suction measures leaks plastic powder.
	Overloading of shredders contributing to release of microplastics and low efficiency.
Washing and density-based floatation separation	Plastic fragments and microplastic residues discharged in waste wash waters.
	Overloading wash tanks spills water and microplastics at working areas.
	Without paved working areas and appropriate containment systems to trap and collect plastic flakes during washing
	Drains without screens/meshes or filters.
Dewatering and drying	Plastic loss or leakages occur during transfer/handling of wastewater.
	Open air drying by the roadside, near drains or waterways, or in areas with vegetation increases risks of losses.
Compounding and pelletising	Losses and spills occur during material handling and transfer (e.g., spillage, dust, and fine particles)
	Losses occur during hopper loading and variations in feeding rates or (e.g., overflows and leaks, inefficient feeding, blockages during loading)
	Overflows and leaks during compounding, cooling and cutting
	Losses due to equipment malfunctions, human errors, contamination, material degradation
Bagging and storage and warehousing	Poor storage conditions can lead to degradation or contamination of compounded materials and pellets.

	Informal waste pickers	Waste collectors & crew	Junkshops (S/M/L)	Aggregators	Consolidators & brokers	Recycling factories (S/M/L)

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