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Solid Waste Management in Vientiane, Lao P.D.R

Situation assessment and opportunities for waste-to-resource



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Abbreviations

AD	Anaerobic digestion
ASEAN	The Association of Southeast Asian Nations
CBO	Community-based organization
ECCDA	Environment Conservation and Community Development Association
EPR	Extended Producer Responsibility
GGGI	Global Green Growth Institute
JFPR	Japan Fund for Poverty Reduction
JICA	Japan International Cooperation Agency
KOICA	Korean International Cooperation Agency
LAK	Lao Kip
LPPE	Laos Pilot Program for Narrowing the Development Gap towards ASEAN Integration, Environmental Management Component
MAF	Ministry of Agriculture and Forestry
MBT	Mechanical Biological Treatment
MPH	Ministry of Public Health
MPI	Ministry of Planning and Investment
MPWT	Ministry of Public Works and Transport
MoNRE	Ministry of Natural Resources and Environment
MRF	Material Recovery Facility
NGO	Non-governmental organization
OPP	Oriented polypropylene
PDR	People's Democratic Republic
PET	Polyethylene terephthalate
PP	Polypropylene
PVC	Polyvinyl chloride
RDF	Refuse Derived Fuel
SDG	Sustainable Development Goal
tpd	Metric ton per day
UDAA	Urban Development Administrative Authority
USD	United States Dollar
VCOMS	Vientiane City Office for Management and Service

Summary

Solid waste management is one of the priority areas identified as part of GGGI's green cities programme in Vientiane, the capital of Lao People's Democratic Republic (Lao PDR). Current waste handling practices in Vientiane are based on a "collect and dispose" only approach that overlooks significant opportunities for turning waste into resources. There is thus the potential to adopt a paradigm change from a waste management to a resource management approach.

In Vientiane, the main government body responsible for solid waste management is the Vientiane City Office for Management and Service (VCOMS). VCOMS oversees the collection, transport and disposal of solid waste generated in Vientiane. No precise figures exist on waste collection coverage, but it is estimated that 30-50% of the waste generated in the city is collected by VCOMS or any of the eight private collection companies contracted by VCOMS. The main ambition of VCOMS with respect to the solid waste management sector is to provide full collection coverage in the city by 2020. One of the main challenges to achieving this goal lies on the high collection fees charged by VCOMS (or any of its contractors) for the provision of these services. Individual households, for instance, are charged 5 USD/month for a weekly collection service. This is markedly different from the realities observed in cities of countries with a similar level of socio-economic development as Lao PDR, where fees tend to be considerably lower than those charged in Vientiane, with the provision of these services often being partly subsidized by local government authorities. Other challenges identified to achieve a higher waste collection coverage are the low accessibility of some areas by waste collection trucks, especially in low income areas, and the limited awareness of the population in general to the need of collecting and properly handling waste.

Recyclable materials found in solid waste streams are routinely recovered in Vientiane. In fact, a small recycling rate exists in Vientiane as a result of the activities of both informal and formal stakeholders. Informal actors include waste pickers, scavengers and VCOMS workers who collect and sell recyclables. Formal participants consist of recycling buying centres, recycling workshops and processing companies, which are legally licensed to operate and conduct profit-driven activities with recyclables. It is observed, however, that there is limited value-added creation by Lao-based stakeholders along the recyclables value chain, as recovered materials are ultimately processed in recycling facilities located in neighbouring countries or processed materials are sold overseas, in particular China and Vietnam. Yet, the existence of small and medium sized enterprises that partly process recyclables into secondary materials – which are reused as final products or further processed by other recycling facilities downstream – indicates there is a potential for value added creation on the recycling industry in Lao PDR.

There are no policies or regulations, either at the national or city level, in support of waste-to-resource approaches or the principles of Reduce, Reuse, Recycle (3R). The major policy barrier that could hinder the deployment of waste-to-resource approaches is the restriction of using compost produced from municipal solid waste in agricultural crops. While the Ministry of Agriculture and Forestry could lift this restriction in case compost is produced from source segregated waste, this should nonetheless be noted as a potential barrier to be addressed where composting is considered a waste treatment option to promote in Vientiane. Policies and regulations that could be considered to support waste-to-resource approaches include, *inter alia*, the formulation of a city-wide strategy for the management of solid waste, the introduction of "polluter pays" schemes (e.g. by imposing fines to

entities or individuals that dump their waste or to major generators that do not adopt segregation practices), or extended producer responsibility practices to industries utilizing materials that can be reused and recycled.

A number of potential intervention areas for the adoption of waste-to-resource opportunities in Vientiane were considered and discussed. These include options for biodegradable organic waste (e.g. composting, anaerobic digestion, “swill feeding”), recyclable materials (e.g. the adoption of waste bank concepts), unsegregated waste (e.g. the deployment of material recovery facilities) and undifferentiated waste (e.g. provision of decentralized waste collection services through micro-enterprises). As an outcome of two field missions to Vientiane conducted in February and August 2017, GGGI’s Green Cities Thematic Unit and Laos Country Team shortlisted the following opportunities as those with the highest impact potential in the Vientiane context:

1. Distribution of home composting units;
2. Decentralized waste composting facilities;
3. Decentralized secondary waste collection points with the participation of micro-enterprises;
4. Community-driven waste banks with the organization of waste pickers cooperatives.

The suggested ideas could be piloted in conjunction with the preparation of a solid waste management strategy for Vientiane. In case the experiences of piloting these resource recovery facilities are successful, replication and upscaling will be considered.

For the way forward, it is recommended that lessons learned from projects implemented by other international organizations in Lao PDR can be properly studied and understood (a case in

point is the LPPE programme implemented by JICA and the ASEAN Secretariat), and that synergies with other sectors – especially wastewater treatment and faecal sludge management – can be considered and assessed in detail.

Introduction

This report was prepared in support of GGGI's Green Cities Development Program in Lao PDR. Following a request of the Lao People's Democratic Republic (henceforth Lao PDR) Government, GGGI has been conducting a green city pilot program in the capital city, Vientiane, to demonstrate how this concept could be implemented in the Lao context. Based on a number of consultations with local stakeholders, GGGI identified solid waste management as a priority area of the green cities initiative and aims to identify intervention areas and practical measures that can address issues identified in the sector. These opportunities are expected to be aligned with approaches that are innovative, pro-poor and support the conversion of waste into resources.

Against this backdrop, this report presents situation assessment of the solid waste management sector of Vientiane and discusses opportunities for the adoption of waste-to-resource approaches. The report was prepared based both on primary and secondary sources of data. Primary data was obtained in the course of a field missions to Vientiane organized by GGGI. The missions took place from 21 to 23 February and 28 August to 1 September 2017 and included meetings and discussions with stakeholders involved in Vientiane's solid waste sector. Secondary data was obtained through desk research, with all sources used in the preparation of the report being duly acknowledged throughout.

The report is organized into two main chapters, as follows:

Chapter 1 presents a characterization of Vientiane's solid waste sector based on the findings of both the field mission and the desk research. This characterization was structured in relation to the

main stages of the solid waste sector value chain. In addition to these, the role of the informal sector and a brief account of the policy and institutional framework of the sector are also analyzed. The chapter closes with a discussion of strengths, weaknesses, opportunities and threats of the sector in relation to the potential adoption of waste-to-resource approaches.

Chapter 2 discusses opportunities for the adoption of waste-to-resource approaches in Vientiane. To this end, potential "intervention areas" were firstly identified based on the findings of the desk research, illustrations by solid waste management specialist, and good practices identified in cities of developing Asian countries with similar characteristics to those found in Vientiane. This initial mapping and the outcomes of the field mission served as a basis to the GGGI team for shortlisting four "impactful initiatives". These initiatives are then discussed in relation to the risks associated with their implementation.

The findings of this report are expected to form the basis of a follow-up deliverable, consisting in the elaboration of an implementation roadmap for a sustainable and inclusive solid waste sector in Vientiane and the preparation of project proposals.

Two important implications from this is that, firstly, the analysis presented on this study is restricted to the solid waste sector and, secondly, potential synergies with closely related areas or topics – e.g. sanitation, wastewater management or integrated approaches in the scope of a green cities programme – have not been researched or actively explored in this report.

1. Solid Waste Management in Vientiane: Situation assessment

1.1 City overview

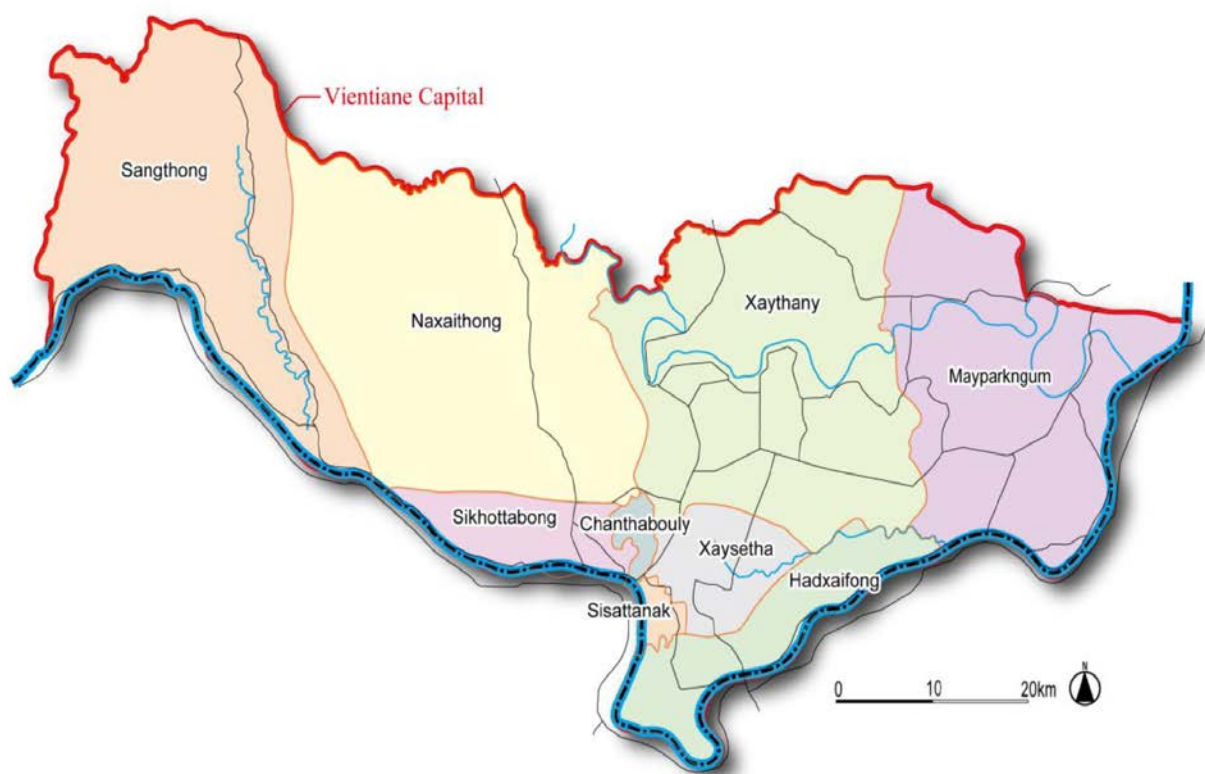
Vientiane is the capital city of Lao PDR, a landlocked country that shares borders with Cambodia, China, Myanmar, Thailand and Vietnam. Exhibiting one of the fastest growing economies in the region, Lao PDR has a resource-based economy which is driven by its agriculture, forestry, hydropower and minerals sectors. Yet, it is still one of the poorest countries in the region, with a GNI of 1,740 USD per capita, thereby ranking as a lower-middle income country (World Bank, 2017; OECD, 2014).

Lao PDR is still a predominantly rural country, with two thirds of the population living in rural areas (MPI, 2015). Most of the urban population is concentrated in Vientiane, which was estimated to have, in 2015, a population of 820,900 people, or

approximately 12.7% of the country's total. Of Vientiane's population, 77.9% is considered urban, and 22.1% as sub-urban (MPI, 2015). The city enjoys a tropical climate, with two main seasons distinguished: monsoon (May to October) and dry season (November to April). Temperature ranges from a low of 12°C in the coolest months of December to February, to a high of 38°C in the hottest months of March to May. Relative humidity typically ranges between 65%-80% (CCAC, 2015).

Vientiane is divided into 9 districts, as displayed in the figure below. The districts of Chanthabouly, Sikhottabong, Xaisethha, and Sisattanak form the central part of the city and can be considered as its metropolitan core.

Figure 1.1 – Vientiane and its 9 districts



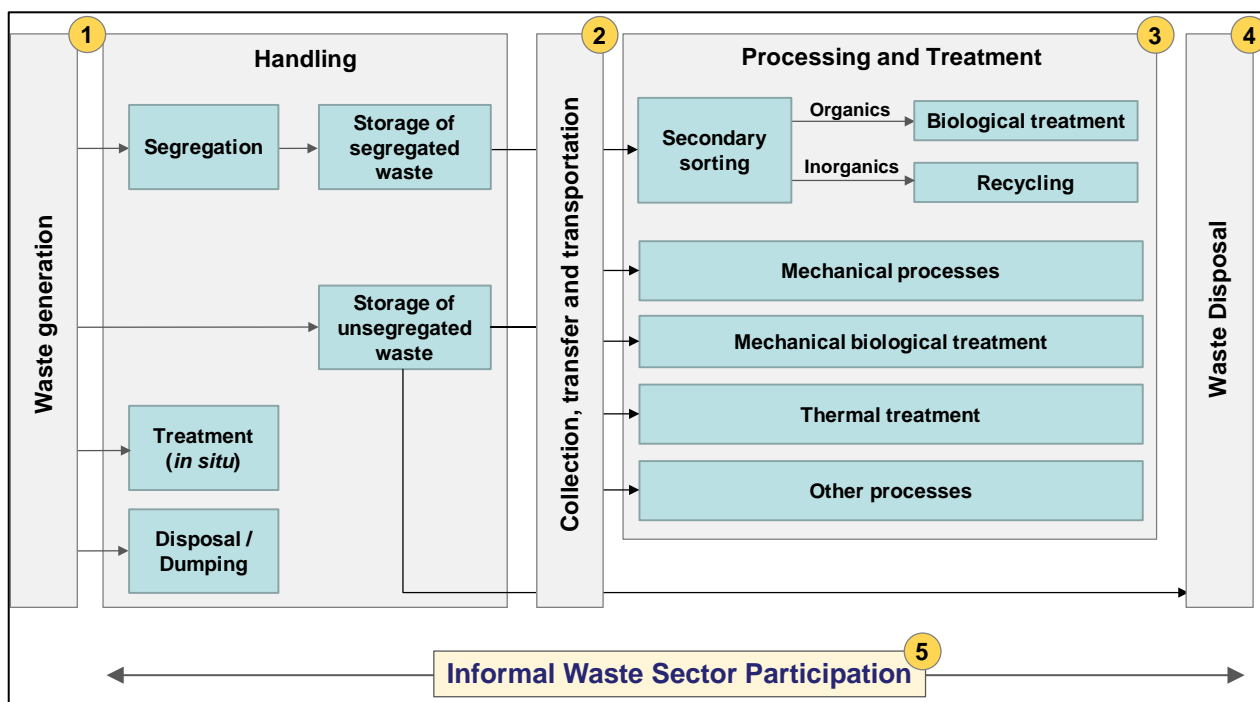
Source: (JICA, 2011a)

1.2 Solid waste management in Vientiane: value chain analysis

According to CCAC (2015), there is no official definition of municipal solid waste¹ in Lao PDR. Yet, according to the same source, solid waste is understood as the discarded solid materials from both residential and commercial buildings², with the following streams assumed to be included: food waste, paper, textile, plastics, wood/bamboo, leather/rubber, metals, glass/ceramics. This is in line with the solid waste definitions adopted in most countries of the region³. An implication from this is that some waste streams that require dedicated handling approaches and which, in some circumstances, are considered as part of urban solid waste have not been analysed here. This includes, for example, medical waste and electronic waste.

An analysis of the current status of Vientiane's solid waste sector is presented in the sections that follow having as basis a value chain analysis. Figure 1.2 below displays the value chain that was taken as reference, where the following stages were singled out: i) waste generation and handling; ii) waste collection, transfer and transportation; iii) waste processing and treatment; iv) waste disposal; v) informal sector participation. With respect to the fifth stage, while informal sector participation should not be considered in itself as a sequential step in a waste management system, the role and relevance of informal workers throughout the whole value chain suggests the need for a separate analysis.

Figure 1.2 – Solid waste management value chain⁴



¹ Henceforth, and unless otherwise stated, municipal solid waste will be referred to simply as "solid waste".

² Residential buildings include single and multi-storey buildings, whereas commercial areas encompass shops, restaurants, markets, office buildings, hotels, stores, auto-repair shops.

³ The region considered here is South-East Asia. See, for example, AIT/UNEP (2010) or Aleluia and Ferrão (2016).

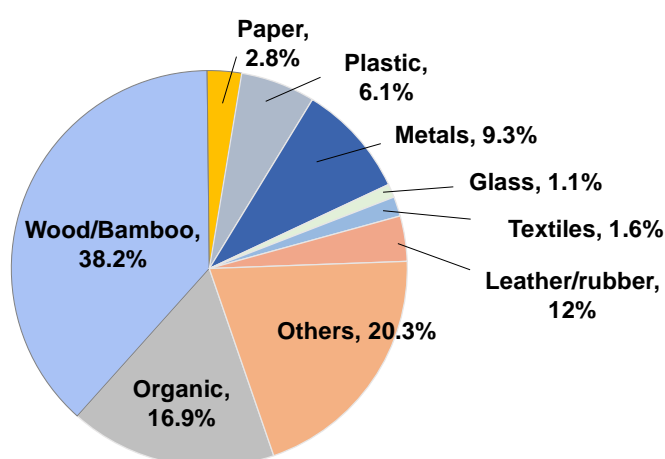
⁴ The figure is elaborated by GGGI solid waste management consultant, Joao Aleluia.

1.2.1 Waste generation and handling

There are no reliable or accurate figures concerning the physical composition of solid waste generated in Vientiane. This is acknowledged, for example, by reports quoting government sources⁵, and can be confirmed by inconsistencies reported in different studies. According to data gathered by CCAC (2015), the composition of solid waste in Vientiane is dominated by wood/bamboo (38.2%), others/undifferentiated (20.3%), and food waste (16.9%), as displayed in the graph of Figure 1.3. The same study indicates different waste compositions

depending on the source of the waste generated (e.g. households, markets, restaurants, etc.), as indicated in Table 1.1⁶. A report prepared by IGES (2012), referring to data from a study conducted in 1998, indicates that “food, vegetables” account for 30% of the total waste, “wood/grass/trees/leaf” for 19%, and “others” for 21%. Different figures are also collected during GGGI’s field missions in August 2017, which indicated that the organic fraction is typically in the range of 30-37%.

Figure 1.3 – Average composition of solid waste generated in Vientiane



Source: (CCAC, 2015)

Table 1.1 – Solid waste composition by source in Vientiane

Composition	Resident (%)	Shop (%)	Market (%)	Office (%)	Hospital (%)	Sweep (%)
Organic	16.9	43.3	61.7	5.9	47.1	0
Paper	2.8	20	7.3	32.2	13.3	3.7
Textile	1.6	0.3	0.5	0	6.2	0
Plastic	6.1	7.9	4.3	4.3	9.4	8.3
Wood	38.2	8.8	13.2	13.2	36	55.9
Leather	1.1	0.3	0.3	0.3	1.2	0
Metal	3.7	5.9	5.9	1.9	2.6	0.8
Glass	9.3	6.7	6.7	1.9	5	0
Other	20.3	7.2	7.2	9.1	7.9	31.5

Source: (CCAC, 2015)

⁵ See, for example, RRC.AP (2015).

⁶ This table is an indication of the low level of reliability of available data on solid waste in Vientiane, as the average solid composition assumed for the whole city is assumed to be the same as the resident’s waste composition in the same report.

Two important aspects related to solid waste compositions require a closer review. Firstly, the high share of wood/bamboo, which accounts for more than one third of the total share of waste, is quite atypical for urban waste. A possible explanation may lie on the fact that waste generated by timber industries or construction/demolition operations (assuming wood-based construction) may have been included as part of the estimate or survey conducted. The second aspect is the share of biodegradable organics, which in countries with a similar level of economic development of Lao PDR is usually in the 50-70% range. In Vientiane the figure is atypically low (16.9%)⁷. According to some sources (e.g. IGES, 2012), the comparatively low content of organics should be understood in light of the relatively large proportion of food waste that is utilized as animal feed, which mainly applies to suburban districts and areas that are not formally served by waste collection services. It can also be hypothesized that recyclable materials such as plastic or paper may be lower than actual reported figures, in case these are recovered by the informal sector and hence not included as part of official statistics. Also, with respect to the physical properties of waste, no data was found with regards to the calorific value, moisture content, density or the chemical properties

of solid waste. It is however assumed that studies assessing these properties have been conducted in the past, even if they have not been made publicly available⁸. Knowledge of the physical properties of waste is essential to determine which are the most appropriate and cost-efficient ways of managing waste. For example, knowledge of the calorific value of waste is a key parameter to consider in relation to the adoption of thermal treatment approaches.

Waste generation per capita in Vientiane is estimated at 0.65 kg per person per day (CCAC, 2015). Having in consideration the city's population, recent estimates reported by GGGI (2017) put current waste generation figures as 600 ton per day (tpd). This figure is roughly in line with those reported in meetings conducted during the fact-finding mission organized by GGGI in August 2017.

Segregation at source is not commonly practiced in Vientiane⁹, and no bins (for the collection of segregated or unsegregated waste) have been observed in public spaces. Waste that is collected by municipal services is temporarily stored in plastic bags or bamboo bins, which are typically placed in sidewalks or roadsides. Waste that is not collected is disposed through open burning, burying or littering in roadsides, drains or vacant land.

1.2.2 Waste collection, transfer and transportation

The collection of solid waste in Vientiane is handled by a public company established under the Vientiane City Office for Management and Service (VCOMS) and eight private companies directly contracted by VCOMS. No accurate figures exist regarding waste collection rates in Vientiane. Recent estimates indicate that 30-50% of the waste generated is collected and transported to the city's landfill site. According to VCOMS, its waste

collection company collects 40-50% of the total waste collected.¹⁰ The remaining is collected by the 8 private companies. VCOMS aims to achieve a 100% collection rate by 2020, and this is the main (tangible) objective stated by the municipality with respect to the solid waste sector.

Fees are charged to the individuals and entities serviced by waste collection services. These fees are

⁷ See, for example, Aleluia and Ferrão (2016) for a detailed analysis of the topic.

⁸ For example, it was shared with the author the work-in-progress version of a study that assessed the feasibility of adopting RDF production facilities in Vientiane, which included the analysis of technical parameters related to the waste characteristics (e.g. calorific value; moisture content). However, the study does not appear to have been published or made available to the public.

⁹ A few exceptions exist, however. The Crowne Plaza Hotel, for example, segregates waste generated within its premises, in particular, organic waste (which is kept until collection by municipal services in a refrigeration chamber). These segregation practices are conducted not in response to policy or regulation, but in order to comply with international standards of the IHG Hotel Group.

¹⁰ The figure transmitted by VCOMS during the field mission conducted by GGGI in August 2017.

regulated and determined by decrees issued by Vientiane's Governor. Fees charged to households were recently updated by governmental decree and were increased from 3 USD/month to 5 USD/month¹¹ (i.e. from 25,500 LAK/month to 41,550 LAK/month). Different charges are applied to other users, even though it was not possible to obtain the most updated figures. As of 2015 (CCAC, 2015), offices were charged 30,000-50,000 LAK/month (3.5-5.8 USD/month), markets 150,000-180,000 LAK/container (17.7-21.2 USD/container), and foreign residents 100,000-120,000 LAK/container (11.8-14.1 USD/container) or a flat fee of 40,000-60,000 LAK/month (4.7-7.1 USD/month).

Private companies providing collection services are allowed to charge these fees directly to their customers. They are allowed to charge the fees defined through governmental decree. The private companies are contracted by VCOMS on the basis of annual contracts, which specify the districts where they are allowed to operate as well as minimum performance standards.

Regardless of whether the services are provided by VCOMS or any of the private companies, waste generated by households is usually collected on a weekly basis. Larger generators – such as restaurants, markets or hotels – are provided these services at a higher frequency, ranging from a few times per week to daily collection.

A noteworthy finding from the field mission conducted in August 2017 is that waste collection services provided by VCOMS appear to be financially viable, with waste collection fees enabling full recovery of any operational costs incurred in the provision of these services. It should be noted that this is a markedly different reality from that observed in countries with a similar level of economic development, where waste management is seen as a public service and as a recipient of some sort of financial support from local government authorities. According to the World Bank (2014),

these costs can correspond up to 50% of municipal budgets.

Operational costs of VCOMS in the provision of solid waste management services were indicated to be 1 billion LAK/month, for an average waste collection rate of 165 tpd. This corresponds to an average cost of 202,020 LAK/ton (24 USD/ton), assuming waste is collected 7 days per week. Similar cost figures were identified in relation to a private waste collection service component whose representatives were met during the field trip of August 2017. This company reported an average waste collection of 25 tpd at a cost of 120 million LAK/month. This corresponds to an average cost of 161,500 LAK/ton (19 USD/ton). While it was not possible to determine the revenues generated either by this company or VCOMS, a quick estimate taking into account an average generation of 0.65 kg per capita a household composed of 5-6 people and a waste collection fee of 5 USD/month indicates that revenues generated just from the charge of collection fees would comfortably cover operational expenditures¹². However, it should be noted that after the increase in the waste collection fee from 3 to 5 USD/month, many households decided not to continue their contract for waste collection services.

Waste that is collected by VCOMS or any of the private companies is transported to the disposal site, which is located 32 km away from the city centre. Of the waste collected by VCOMS, an estimated 90 tpd are first brought to a transfer station located midway (12-16 km) between the city centre and the disposal site. At this transfer station, which was built with the technical and financial support of JICA and commissioned in January 2016, incoming waste is reloaded to larger trucks before transportation to the disposal site. The transfer station only functions as an unloading and reloading point, and no compaction or additional sorting occurs at this stage. On the other hand, workers at the transfer station are allowed to collect any recyclables they are able to recover from the

¹¹ Information transmitted by VCOMS during the field trip conducted by GGGI in August 2017. An exchange rate of 1 USD to 8,500 LAK was used on this report.

¹² In addition to collection fees, VCOMS charges operating licenses to the private waste collection companies and

disposal fees for the waste disposed by these companies in the landfill site.

transfer station. No informal waste sector members are allowed to work within the premises of the transfer station. In addition, none of the private companies is able to use the transfer station, as only the trucks of VCOMS meet the standards required for this purpose.

The transfer station project has enabled VCOMS to significantly improve its waste collection fleet. Through the project, approx. 50 waste collection trucks were provided to VCOMS, which now has a

fleet of 65 trucks. The vehicles sourced by the Japanese government through JICA consist of 40 compactor trucks, 2 dump trucks, 4 skip loaders and 1 vehicle for medical waste collection (JICA, 2014). According to VCOMS, this led to an improvement in the collection coverage in Vientiane from 100 to 150 villages¹³. However, it could not be confirmed whether the improvement in the waste collection fleet led to an increase in the number of households with a contract with VCOMS for waste collection services.

Figure 1.4 – Waste collection trucks operated by VCOMS



Figure 1.5 – Vientiane's transfer station



Weighbridge at the transfer station



Loading and reloading point at the transfer station

1.2.3 Waste processing and treatment

¹³ In meetings conducted with the author and other GGGI representatives, VCOMS indicated that there was a clear cost benefit from the operation of the transfer station, although a precise figure could not be provided. A cost/benefit analysis was conducted in the feasibility study prepared by JICA

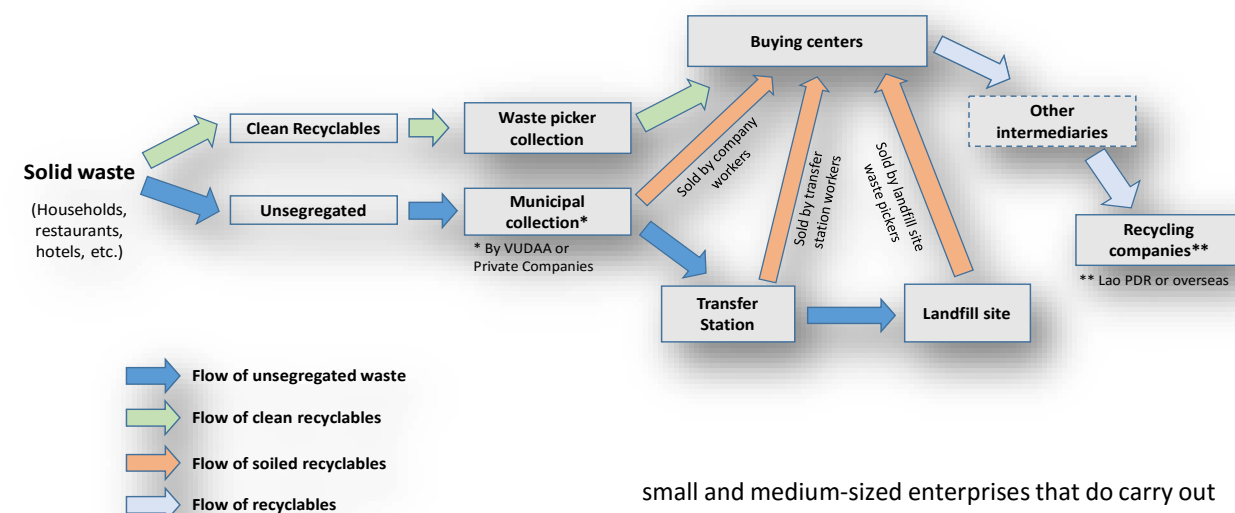
(2014) prior to the project implementation. But on this document no details are available on how costs and benefits were determined.

Waste that is formally collected in Vientiane by VCOMS or any of the 8 private companies is not subject to any form of treatment or processing. An exception to this practice are the recyclable materials – e.g. plastics, paper, metals – that are collected by informal workers. As observed in countries with a similar level of development to that of Lao PDR, informal waste sector members are found active in the collection of recyclables wherever these opportunities exist, either at the source of generation (e.g. households, hotels), streets or the final disposal site. A survey conducted by JICA in 2011 indicated a “small” recycling rate of 8.7% in Vientiane¹⁴. The collection of these recyclables is therefore rendered informally rather than as a result of policy or regulation.

Recyclables collected are transacted from buyer to buyer until they reach a final destination point,

where they are processed into other products. Research conducted by GGGI, as well as findings from the field mission of August 2017, revealed the existence of several transactions along the recyclables value chain, with limited added value throughout the exchange process. For example, waste pickers engaged in door-to-door collection would buy recyclables from households and then sell them to recyclables buying centers. Subsequently, the buying center would sell those recyclables to another buyer at a higher rate, with washing and/or compaction being the only activities with some value creation potential added to the process. One of the challenges of a business model that relies on limited added-value creation is a higher vulnerability to fluctuations in the prices of recyclables. An overview of the recyclables value chain¹⁵ is presented in the figure below.

Figure 1.6 – Overview of the recyclables value chain in Vientiane¹⁶



No major recycling industries are reported to exist in Lao PDR¹⁷. It was, however, noted the existence of

small and medium-sized enterprises that do carry out some sort of processing/treatment of recyclables. For example, the Lantieng Recycling Company, manufactures a number of different products from

¹⁴ This was reported in JICA (2015), in the scope of the LPPE programme: “Laos Pilot Program for Narrowing the Development Gap towards ASEAN Integration, Environmental Management Component”. No details were provided, however, on the methods adopted and details of the results from the survey.

¹⁵ The elaboration of this value chain was loosely based on the findings of the GGGI field mission to Vientiane that was conducted in February 2017.

¹⁶ The flow chart is elaborated by João Aleluia based on findings from GGGI-led field mission conducted in August 2017.

¹⁷ This was confirmed in the course of a meeting with representatives of the Ministry of Public Works and Transport, who pointed out the lack of such industries as one of the challenges associated with the development of the recycling business in Lao PDR.

washing, crushing and breaking up recyclables into smaller pieces (e.g. in the case of this company PET, PP and OPP are the original materials). The final products of the company are used as raw materials to other industries and are either sold directly or through middlemen. Uses of these products are, for example, the production of bags for fertilizers or as a “foam” type of material for sofas. It should nonetheless be stressed out that the manufacturing processes of these companies tend to be relatively simple and rudimentary, and thus limited added value to the recyclables value chain. Recyclable materials recovered in Lao PDR are usually exported to neighbouring countries for final processing or treatment, in particular China and Vietnam.

With regards to biodegradable organics, no formal approaches were observed or reported to exist for treating these waste streams. On the other hand, and as mentioned above, some studies suggest that food leftovers are frequently recovered and reused as animal feed. Moreover, in circumstances where larger quantities of such waste are generated (e.g. restaurants), animal feed companies are reported to collect (and, in some cases, even pay) for the collection of such waste. Yet, very limited information or data is available about such practices, including the waste processing approaches adopted or the stakeholders involved.

Figure.1.7 – Lantieng Recycling Facility



Manufacturing process at the Lantieng Recycling Facility



Sample of the final products

1.2.4 Waste disposal

Waste collected is disposed in the city’s landfill site, located 32 km from the city centre. The site can be considered a semi-controlled landfill rather than as an open dump, in light of the fact that a few controls and engineering measures are reported to exist. The landfill is owned and operated by VCOMS and has four main functions: 1) safe disposal of medical waste; 2) disposal of urban waste (e.g. from households, hotels, etc.); 3) treatment of leachate; 4) treatment of faecal sludge. The latter function is no longer fulfilled at the landfill site, as these activities were shifted to a recently commissioned

faecal sludge treatment plant that is located adjacent to the transfer station.

Among the measures and controls of the landfill, a weigh bridge exists to monitor quantities of incoming waste, which also enables the determination of the disposal fee that is charged to each of the private companies. This fee is set at 40,000 LAK/ton (i.e. 4.7 USD/ton), and this payment is made directly to VCOMS. This is a recently approved fee, which was revised from a previously existing one of just 15,000 LAK/ton (1.8 USD/ton).

Trucks owned by VCOMS do not pay this fee.

Leachate generated in the landfill is treated through a system of stabilization ponds, along 3 treatment stages. It is not certain how effective the treatment system is during the field trip. Soil cover is regularly applied but only during the dry season. Incoming waste is subject to minimum compaction, so as to enable its arrangement in layers in a configuration of 100 m (width), 200 m (length) and 3 m (depth). According to the representatives, the lifetime of the landfill site is not known.

As further elaborated in the next section, it is estimated that 150 informal waste sector members recover recyclables from the landfill site. This is the

only resource extracted from the landfill. Landfill gas is currently not captured or utilized. In addition, a feasibility study was reported to be underway by a Lao-Thai-Israeli consortium in order to assess the potential of generating biogas from organic waste available/disposed in the landfill site. A concession agreement was signed between VCOMS and this consortium, but according to VCOMS progress on this project appears to have come to a standstill.

It has also been reported that VCOMS has plans to develop three new landfill sites in the next few years in order to cope with increasing quantities of waste generated. No further details are available about specific projects.

1.2.5 Informal waste sector participation

As in many other cities in developing Asian countries, in Vientiane informal workers are present and active throughout the waste management value chain. Two “categories” of informal waste sector members can be distinguished: i) those who collect recyclables from the source of generation; ii) those who recover recyclables from unsegregated waste.

Members of the first category are waste pickers conducting door-to-door collection who usually obtain clean recyclables (i.e. segregated from other waste streams). It was found that sources of solid waste generation – such as public buildings, households or hotels – typically conduct some type of segregation and sell clean recyclables to waste pickers. Recyclables collected are sold to buying centers, usually in the same day they are recovered. Waste pickers are therefore subject to the daily rate of recyclables set by the buying center and are usually deprived of any mechanisms protecting them from declining rates or sharp fluctuations in market prices. This system makes waste pickers a particularly vulnerable group.

No statistics exist on the number of waste pickers that make out a living from the door-to-door collection of recyclables, but evidence from the field trip suggests that these are active in the whole city and whenever the potential to obtain clean recyclables exist. A few initiatives have been implemented in Vientiane in order to improve the work and living conditions of the waste pickers. A local NGO named “Environment Conservation and Community Development Association” (ECCDA), has been working with waste pickers as part of a program on social protection to informal economy workers funded by OXFAM. ECCDA has supported waste pickers in a village of Vientiane in the coordination and organization of their activities, and in providing basic training on waste segregation, health care and hygiene. Those impact of these activities appears to have been marginal or limited so far¹⁸, OXFAM is expected to continue funding similar type of activities over the next 5 years to three more districts, which opens up opportunities for networking waste picker groups for empowerment. Moreover, the number of waste pickers supported by ECCDA was considered too

¹⁸ Based on a meeting with OXFAM, waste pickers do not see much benefit from being organized, and it is usually challenging to engage them on activities that distract them from their core work of collecting recyclables. Other challenges in supporting waste pickers in Vientiane are

attributed to the fact that: i) waste pickers are scattered throughout the city without an organizing body; and ii) few local NGOs operate in the waste sector.

small for formalization in cooperatives or associations.

With regards to the second “category” of waste pickers, as noted in the section above it is estimated that approx. 150 people (consisting mostly Vietnamese immigrants) work within the premises of the landfill scavenging in search for any material that can be sold. Unlike collection at the source, recyclables recovered this way are soiled or unclean, and are exchanged at considerably lower rates than clean recyclables. A recycling buying center operates in the landfill site, as informal waste sector members are not allowed to take waste beyond the premises of the landfill. In effect, these waste pickers are directly employed by the buying center¹⁹. In order to operate in the landfill, the buying center pays a fee of 2 million LAK/month (235 USD/month) to VCOMS.

This buying center was established in 2005 with the support of the Government of Japan in the context of the JFPR²⁰ program (ADB, 2008). It was noted by the GGGI team that buying centers managed by VCOMS are required to pay monthly fees to VCOMS.

Other opportunities exist along the waste sector value chain for the collection of recyclable materials in an informal or semi-formalized manner. It was noted above, for example, that workers at the transfer station are allowed to recover and sell any recyclables they are able to obtain at the station. In a similar vein, one of the private companies contracted by VCOMS for the collection of waste also allows its workers to take ownership of any recyclables they recover in the course of the waste collection services provided by the company.

1.3 Policy and institutional framework for solid waste management

At the national level, two main bodies are responsible for issues related to solid waste management: The Ministry of Public Works and Transport (MPWT), and the Ministry of Natural Resources and Environment (MoNRE). Similarly, to the realities observed in other countries of the region, in Lao PDR the main responsibilities on solid waste management are delegated to provincial authorities and district offices. Urban Development Administrative Authorities (UDDAs), at the provincial level, are the main bodies tasked with solid waste management issues, with national ministries such as MPWT or MoNRE having more of a regulatory, supervisory and supporting role to the work of UDAAs.

Traditionally, MPWT has been the main ministry regulating the solid waste management sector in Lao PDR, especially in view of the fact that MoNRE is a relatively new ministry, which was established in

2011 as the result of a “spin off” from MPWT. MoNRE’s main tasks and responsibilities include the preparation of environmental laws and regulations. Few of these, however, specifically target the solid waste sector. This is, for instance, the case of Lao PDR’s national environmental standard, issued by the Ministry in February 2017, which defines emission limits for a number of substances, even if none of these regulations is specifically directed to municipal solid waste streams. Nonetheless, MoNRE intends to come up with a masterplan for solid waste management, which would include urban industrial and medical waste. Despite its relatively minor role in the sector, MoNRE has been the national counterpart to some international support programmes in the solid waste sector. Of particular relevance among these is the LPPE programme: “Laos Pilot Program for Narrowing the Development Gap towards ASEAN Integration, Environmental Management Component” (see Box 1 below).

¹⁹ A detailed account of the activities of informal waste sector members working at the landfill site was prepared by the GGGI team who conducted a field visit to Vientiane in February 2017 (see GGGI, 2017).

²⁰ The programme consisted of a 1 million USD grant for the improvement of the environmental conditions and solid waste management practices in Vientiane.

Box 1 – the LPPE Programme

The “Laos Pilot Program for Narrowing the Development Gap towards ASEAN Integration, Environmental Management Component” (LPPE) was a project conducted in Lao PDR by MoNRE with the technical and financial assistance of the ASEAN Secretariat and JICA.

The main purpose of the programme was the promotion of environmentally sustainable cities in Lao PDR, with three main outputs developed: i) the preparation of guidelines on environmentally sustainable cities; ii) improvement of solid waste management practices through the implementation of pilot projects in three pilot cities; iii) promotion of environmentally sustainable community-based solid waste management in three pilot cities. These cities were Vientiane, Luang Prabang and Xayabouri.

Even though the major outcome of the programme was the preparation of guidelines on sustainable cities, it is important to note a number of initiatives aligned with the principles of Reduce, Reuse, Recycle (3R) that were piloted in the three cities. Of relevance among these: i) home composting was tested in 4 villages of Vientiane; ii) a pilot initiative was carried out to instil behaviour change among households in order to reduce the consumption of plastic bags; and iii) in Luang Prabang food waste was separately collected from 30 hotels and restaurants for composting in an off-site facility. The results of these activities were considered as positive/satisfactory according to the project completion report prepared by JICA.

Source: (JICA, 2015)

Other national government bodies with a stake, direct or indirect, in Lao PDR solid waste sector are as follows:

- **Ministry of Public Health:** this ministry regulates the handling of medical waste, including its collection and storage. According to a decree of the ministry (No. 1706 /MOH, 2/7/2004), waste generated in health care facilities needs to be separated into three fractions: infectious, sharp and general waste (CCAC, 2015).
- **Ministry of Agriculture and Forestry (MAF):** The Ministry has an indirect role in Lao PDR’s solid waste sector, as under its purview is the issuance of policies and regulations that can support the utilization of compost in agriculture. Currently, a regulation of the Ministry restricts the utilization of compost from municipal solid waste for agricultural crops. There is, however, the possibility of compost produced this way being utilized in agriculture as long as solid waste is segregated at the source.
- **Ministry of Energy and Mines:** this ministry does not currently have a role, direct or

indirect, in Lao PDR’s solid waste sector. It may however play an instrumental role in case waste-to-energy approaches that have urban solid waste as a feedstock are promoted.

As noted above, in Vientiane the main body in charge of solid waste management is VCOMS. The legislative basis for the sector is defined by provincial decree, through which for example responsibilities to specific agencies or committees are allocated, and fees charged to households, government offices or commercial enterprises are set (UNCRD, 2016).

The main priorities of VCOMS regarding solid waste management in Vientiane are as follows:

- i) Increase waste collection coverage to 100% by 2020;
- ii) Formulate a solid waste management strategy for the city;
- iii) Explore opportunities for converting waste into resources, in particular “waste-to-energy”.

As noted in section 1.2.1, there are no policies or regulations in place to support the segregation of waste at source in Vientiane, for instance in the form of incentives or penalty schemes. Such mechanisms, in case combined with other supporting measures – e.g. educational programmes

in schools, mass-media awareness campaigns or an “end-to-end” approach for handling waste in the form of resources – could be important to support the adoption of waste-to-resource approaches in Vientiane.

1.4 Summary of findings

The table below is an overview of the most salient features of Vientiane’s solid waste management sector:

Table 1.2 – Overview of the solid waste sector of Vientiane

Solid waste generation	➤ Est. 600 tpd
Solid waste collection coverage	➤ Est. at 30-50% of the total waste generated
Solid waste composition	<ul style="list-style-type: none"> ➤ Limited reliable estimates exist, and the share of the different fractions can significantly vary depending on the type of generator (e.g. hotel, household, market). ➤ Biodegradable organics are estimated to account for the highest share of the total (approx. 30-37% according to recent figures). ➤ High potential for the recovery of recyclable materials.
Collection and transportation	<ul style="list-style-type: none"> ➤ Waste is collected by VCOMS and 8 private companies contracted by VCOMS. VCOMS handles approx. 50% of the total waste collected. ➤ A transfer station has been operating since January 2016, currently processing an average of 90 tpd. ➤ Recyclable materials are collected at the source of generation by informal workers. They are also recovered in other points of the value chain (e.g. at the landfill site). ➤ Relatively high collection rates charged to end users (5 USD/month to households for a weekly collection service).
Treatment and processing	<ul style="list-style-type: none"> ➤ Waste that is formally collected by VCOMS or any of its contractors does not undergo any type of treatment. ➤ Recyclables recovered by informal waste sector members are sold to recycling buying centers and ultimately to recycling facilities, mostly located in China and Vietnam. A value chain thus exists for recyclables. ➤ A few recycling facilities exist in Lao PDR. Most of these employ relatively simple techniques which process recyclables into final products (e.g. crushed PET). These products are subsequently sold and utilized as raw materials in other industries.
Solid waste disposal	➤ Semi-controlled landfill site, with limited controls and/or pollution alleviation measures.

With regards to the policy framework, it was found that few policies and regulations exist in relation to the solid waste management sector, either at the national or city level. In particular, there is not a framework in place to support the adoption of waste-to-resource approaches. In fact, there is a regulation that restricts the use of compost produced from solid waste in agriculture, provides a significant policy barrier that would need to be overcome in case one of the most suitable approaches for converting waste into resources – composting. The policy and regulatory framework in Vientiane is also notorious for the absence of restrictions or penalties to littering and open dumping, as well as the lack of mechanisms to promote the segregation of waste at the source, the cornerstone of any sustainable waste-to-resource approach.

In order to better understand the present status of the sector and the potential for the introduction of waste-to-resource approaches, it is useful to map out strengths (S), weaknesses (W), opportunities (O) and threats (T). In this connection, the SWOT analysis below attempts to synthesize the main features of the sector:

Strengths

- Established and financially sustainable business model of VCOMS as well of that of the 8 private collection companies, where operational costs are recovered based on the charge of collection fees.
- Existence of a small recycling rate based on informal networks of informal workers and the existence of a number of small and medium-sized companies working with recyclables along the recyclables value chain.

Weaknesses

- Lack of a strategy, vision and goals for Vientiane's solid waste sector, including targets for the conversion of waste into resources.

- Waste management paradigm based on a “collect and dispose only” approach, with limited experience in the operation of waste treatment facilities.
- Low waste collection coverage, especially in low-income settlements and peri-urban areas.
- Low frequency of municipal waste collection services for households (weekly service).
- Limited value added by actors in Lao PDR throughout the recyclables value chain, as recyclable processing industries are located in neighbouring countries.
- Lack of leadership at the grassroots and community levels on activities related to the management of solid waste.

Opportunities

- The potential for leveraging informal waste sector members as a vehicle to support the adoption of waste segregation practices and in order to expand waste collection coverage.
- Some waste segregation practices (albeit limited) already exist, which could be leveraged and up-scaled, both formally and informally.

Threats

- Low affordability/willingness of households to pay for waste collection services.
- Lack of a policy and regulatory framework supportive of waste-to-resource approaches.
- Limited awareness of residents and the population at large on 3R principles.
- Limited experience existent in the country in implementing waste-to-resource approaches.
- Increasing population and higher waste generation rates per capita motivated by migration to cities, population growth, and economic growth.

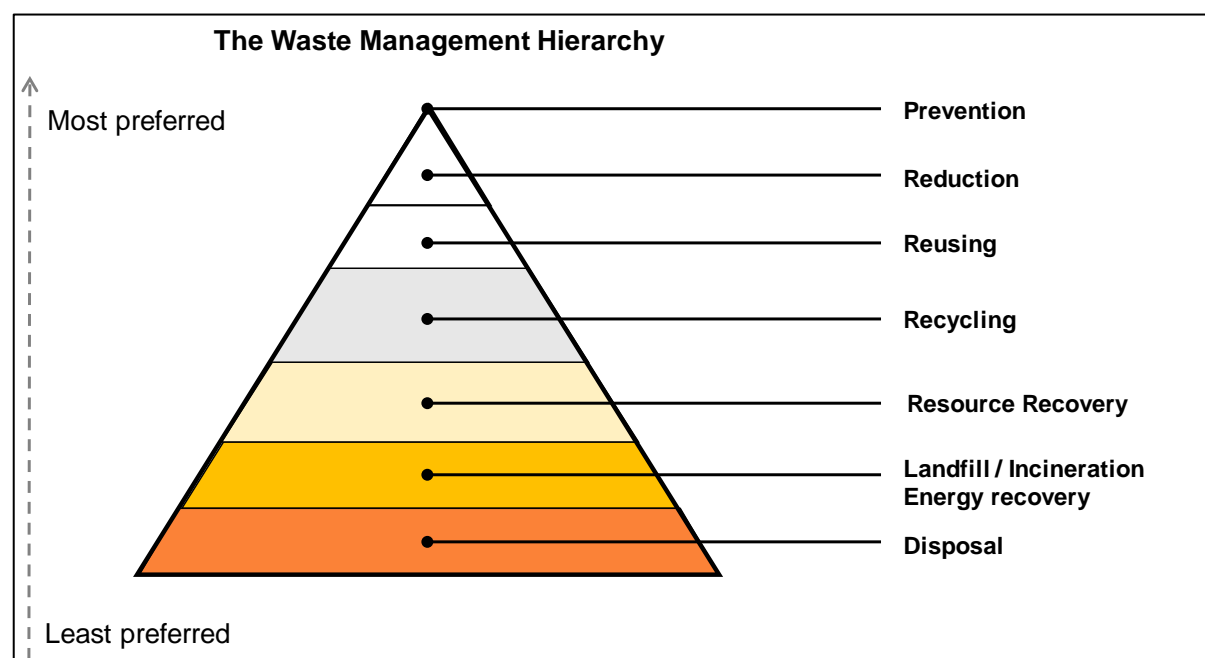
2. Opportunities for “waste-to-resource” initiatives in Vientiane

2.1 The context for “waste-to-resource” opportunities

Current solid waste management practices in Vientiane are primarily based on a “collect and dispose” approach that overlooks the enormous potential for converting waste into resources. Having as basis the situational analysis outlined in Chapter 1 and taking into account the specific economic and social circumstances of Lao PDR, this chapter discusses opportunities for “waste-to-resource” initiatives in Vientiane.

These opportunities were identified based on the assumption that initiatives to be prioritized are aligned with the principles of Reduce, Reuse and Recycle (3R), and that they are at the top of the waste management hierarchy pyramid (see figure below).

Figure 2.1 – Waste management hierarchy



Source: Modified based on Hoornweg and Bhada-Tata (2012) and UNEP (2013)

This discussion also takes into account the effects of any “waste-to-resource” solution into areas beyond the solid waste sector itself, such as poverty alleviation, organic agriculture or sustainable energy. In this respect, it should be noted that the adoption of waste-to-resource approaches have the potential of contributing to national development priorities, in addition to the fact that these are in support, direct and indirect, of several of the United Nations Sustainable Development Goals (SDGs). For instance, a cleaner environment resulting from improved solid waste management practices could

support healthier lives and the well-being of populations (SDG 3). Waste-to-resource approaches are also at the cornerstone of SDG 12, which aims to ensure the adoption of sustainable consumption and production patterns. Other SDGs could be indirectly promoted through sound waste management practices, such as SDG 7 (on affordable and clean energy, in case solid waste is harnessed in the form of energy), SDG 8 (on decent work and economic growth, with the creation of job opportunities and improved working conditions for the informal sector), and SDG 13 (on climate action, as the

adoption of waste-to-resource approaches has the potential of reducing emissions of methane, a greenhouse gas, from disposal sites). These contributions to SDGs could be acknowledged or even incorporated as part of Lao PDR's National Development Plan.

At the core of any sustainable and long lasting “waste-to-resource” approach is the ability to ensure a certain level of segregation, preferentially at source, of waste streams that can be converted into a product. Taking this into consideration, the ensuing discussion is based on the assumption that approaches requiring some degree of segregation at the source should be preferred and prioritized. On the other hand, it was still considered useful to shed light on some waste-to-resource approaches that could be employed to process unsegregated solid waste streams even if, in principle, these should not be the major solutions to be pursued by policymakers or other stakeholders involved on solid waste management issues. In this context, the discussion in this section is organized in relation to the following waste-to-resource opportunities:

- i) Recovery and recycling of recyclable materials;

- ii) Conversion of waste into compost;
- iii) Recovery of waste as animal feed;
- iv) Waste-to-energy conversion through anaerobic digestion;
- v) Resource recovery options for mixed waste.

It should be noted that waste-to-resource opportunities that could be identified at the end of the solid waste management value chain – e.g. landfill gas recovery or landfill mining – have not been discussed in the scope of this study. Moreover, approaches which are unlikely to be technically and economically feasible in lower-middle income countries just like Lao PDR, including thermal treatment methods (e.g. incineration, gasification), were not analyzed on this study. It has also been excluded the analysis of waste types that require dedicated handling approaches, such as medical waste and electronic waste.

The section closes with a discussion of specific “intervention areas” that could be adopted in Vientiane.

2.1.1 Opportunities for enhancing recovery and recycling of recyclable materials

It was noted in Chapter 1 that recyclable materials entering solid waste streams in Vientiane, such as plastics, paper or glass, are routinely collected and transacted through informal and formal networks. As depicted in the flowchart of Figure 1.6, informal actors include waste pickers, scavengers and VCOMS workers who collect and sell recyclables. Formal participants integrating these networks consist of recycling buying centres, recycling workshops or processing companies, which are formally licensed to operate and conduct profit-driven activities with recyclables.

While a market for recyclables is in place and operates with limited public policy intervention, opportunities do exist to increase collection rates and address some challenges identified along the

recyclables value chain. Four challenges are highlighted as follows:

1. **Vulnerability of all stakeholders in the value chain to market price instability.** This is attributed to the fact that the recycling industry has become a truly globalized business since the early 2000s. An implication is that any fluctuation in the price of virgin or secondary materials is quickly disseminated and usually has an immediate impact on recyclable markets globally. This vulnerability is further exacerbated by the low value added of Lao stakeholders in the different stages of the recyclables value chain.
2. **Vulnerability of informal waste sector members.** Waste pickers that press out a

living from daily door-to-door collection of recyclables are the most vulnerable actors in the recyclables value chain. They usually work independently, do not benefit from any type of social protection scheme, and are subject to the contingencies of the market by selling any recyclables they collect at the daily rate set by buying centres. Besides, their margins are marginal as they also have to buy recyclables from households and business entities.

3. **Lack of segregation practices.** No formal waste segregation practices exist in Vientiane. The introduction of such practices could result in an increase in the share of recyclable materials entering the recyclables value chain, as well as a reduction in the disposal of these materials.
4. **Limited infrastructure.** There is limited infrastructure to segregate and store recyclable materials at scale. The transfer station, where a large volume of municipal waste is processed, does not currently have a mechanism for material sorting, beyond opportunistic and small-scale activities by operational staff. Recyclables are mainly collected and sorted at the buying centers operated by informal sector members, with

poor facilities. Most buying centers are in need of cleaning machines which would increase the value of recyclables as well as their revenue, but these facilities are absent due to lack of finance and basic infrastructure. As such, much potential waste is not segregated and collected, and revenue is lost.

A number of initiatives could be considered by policymakers and practitioners in Vientiane with a stake in the sector in order to address these challenges. Among these are, for example, the conduct of awareness campaigns to sensitize populations to the need of segregating waste including recyclables; the introduction of mechanisms (incentives or penalties) to encourage large generators of waste to segregate solid waste; the organization of waste pickers into groups or cooperatives; the piloting of waste bank models to stimulate waste segregation practices at the community level; the introduction of social protection mechanisms to reduce the vulnerability of waste pickers to the hazards of their work (e.g. health risks, market price risk); the adoption of policy mechanisms to stimulate private sector investments in recycling industries, etc.

2.1.2 Opportunities for converting organic waste into compost

Composting is the process of biodegradation of organic matter into a humus like material named compost through the activity of microorganisms that operate in the presence of oxygen. Composting is a natural decomposition process that takes place under controlled conditions, where the volume of organic waste can be reduced up to 85% of the original.

Several methods exist for composting solid waste, ranging from small to large-scale applications (see Figure 2.2 below). The smallest plants consist of composting baskets that can be adopted by families or individuals at the household level. The largest are industrial-size composting facilities that rely on machinery to process large quantities of solid waste

Figure 2.2 – Illustration of different composting methods



The adoption of composting as a solution to treat organic solid waste could be a “win-win” opportunity in the Lao PDR context in general and in Vientiane in particular. On one hand, it is an approach that addresses a solid waste management issue by treating a certain type of waste – organic waste – into a final product. On the other, the resource obtained can be utilized for agriculture purposes and partly substitute the consumption of chemical fertilizers. This can be of national and strategic relevance as Lao PDR is a country whose major economic sector and source of employment is agriculture. More so if one takes into consideration that the national Government considers agriculture as the basis for economic growth, poverty reduction and food security (FAO, 2011).

Even though a market for compost from solid waste does not exist yet in Lao PDR – in fact, current

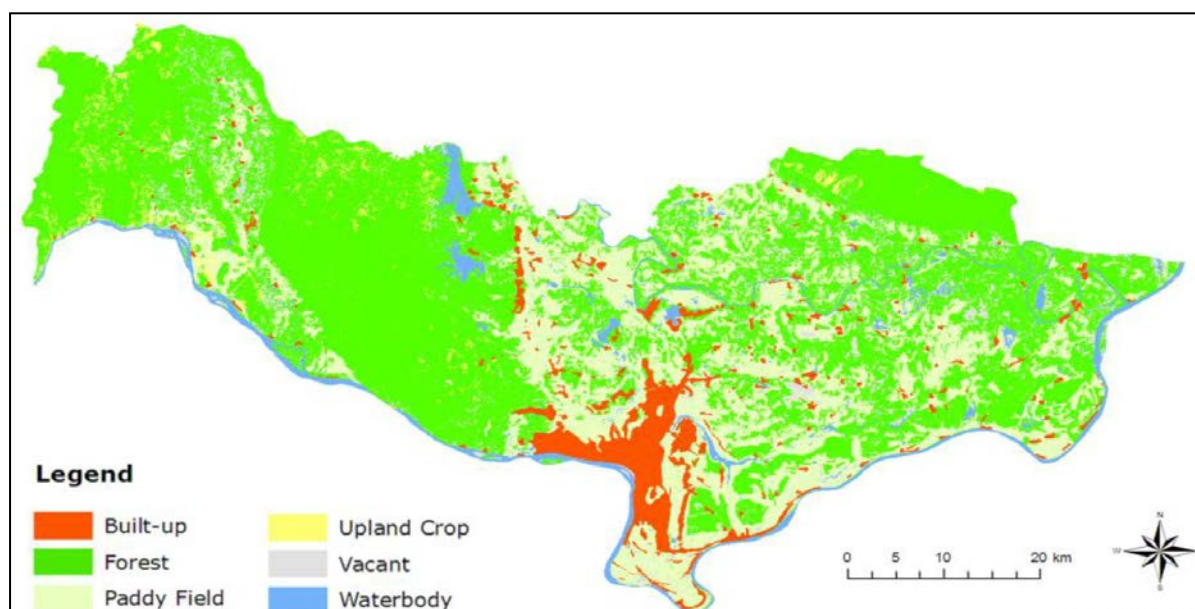
regulation from the Ministry of Agriculture and Forestry forbids the utilization of compost from urban wastes in agricultural crops – opportunities for creating a market do exist. First of all because Lao PDR exhibits the lowest use of fertilizer per hectare of arable land in the region²¹, and thus there is a potential for improved crop productivity with more fertilizer made available and utilized. Secondly, compost is an organic fertilizer that brings several benefits to agricultural practices, as it can contribute to a higher retention of nutrients in soils by reducing losses from leaching. Thirdly, all chemical fertilizers consumed in Lao PDR are fully imported, the dependency that could to an extent be reduced with the application of an indigenous resource in the form of compost. Lastly, the promotion of clean agriculture and organic farming is a national development priority, and the utilization of compost could be an element supporting this strategic

²¹ In Lao PDR, fertilizer consumption is 22 kg per hectare of arable land, which compares with 152 kg/ha in Thailand and 397 kg/ha in Viet Nam (Trading Economics, 2017).

direction. To have an idea of the potential of compost as a resource that could be harnessed from solid waste, it may be observed from the figure

below that agricultural practice is one of the main land uses in Vientiane Capital City.

Figure 2.3 – Land-use in Vientiane Capital City (2005)



Source: (JICA, 2011a)

Compost produced from solid waste does not necessarily need to be used for agricultural purposes: it can be used in nurseries, public gardens, or even as landfill soil cover (in case the compost produced is low in quality). Findings from the field mission conducted in August 2017 indicate that positive experiences in the production of organic fertilizer in Lao PDR exist, and that as long as

products meeting certain quality parameters can be produced, there is an opportunity for creating a demand for such product. It was also indicated by MAF that the segregation of waste at source would be a necessary condition for market creation and the lifting of any regulatory restrictions in the use of compost produced from solid waste in agriculture.

2.1.3 Opportunities for recovering organic waste as animal feed

The feeding of animals with food waste – also known as “swill feeding” – is a common practice in South-East Asian countries. The existence of animal feeding practices in Vientiane has been acknowledged in several studies (e.g. IGES, 2012; AIT/UNEP, 2010), but fairly limited data exists on the extent, dimension and formal recognition of these practices²².

Notwithstanding the above, it needs to be noted that there is a potential for recognizing, regulating and expanding grassroots “waste-to-resource” practices, and which could also be in support of other national development goals, for instance in the form of enhanced food security and a reduction in the exposure of the country and its industries to

²² This was confirmed in meetings with VCOMS and MPWT during the field mission of August 2017.

the volatility of international markets of grain and other animal feeds.

The regulation of animal feed produced from food waste is an opportunity that could be considered in the Lao PDR context. For instance, while feeding to household livestock is relatively low-risk in terms of health hazards, such risks are higher in case food scraps are routinely provided in commercial or industrial facilities. A foot-and-mouth disease outbreak in the UK in 2001 was attributed to swill feeding²³. These hazards to animal health could be reduced with the introduction of regulatory, certification and standardization measures. Countries like Japan or the Republic of Korea recycle approx. 40% of their food waste as animal feed

(AAF, 2016). Yet, in these countries such practices are tightly regulated, with food scraps having to undergo a standardized heat treatment and a sterilization process before being provided to animals. Thailand is another country where these industries are reported to exist.

This waste-to-resource opportunity may be considered in the context of Vientiane's solid waste sector. Nonetheless, the actual potential of the approach is unknown, and the conduct of a baseline study would be an important step in order to properly understand the value chain, business models, and volumes of organic waste that are processed this way.

2.1.4 Waste-to-energy opportunities through anaerobic digestion

Among the opportunities for converting solid waste into energy, the anaerobic digestion (AD) route is, in principle, the most suitable to the Lao PDR context. AD is a biological treatment method whereby the organic fraction of waste is decomposed into biogas due to the activity of anaerobic bacteria. The biogas generated can be used as a heating fuel or converted into electricity. The deployment of AD approaches in Vientiane could therefore increase the supply of an indigenous, clean and renewable energy source. It could also support the access of local populations to cleaner forms of energy. These opportunities appear to be more significant in the case of heating fuel supply rather than electricity supply, as 65% of the country's urban population still relies on traditional biomass for their heating and cooking needs, while access to electricity in urban areas is 97% (IEA, 2016).

The AD processing of urban solid waste is still a relatively novel and fairly untested approach in most developing Asian countries. One of the main challenges associated with the technology is the need to ensure a relatively high level of segregation of the organic fraction to be treated, otherwise the

AD process can be significantly hampered and eventually fail. In this context, in the short to medium run it may be reasonably expected that AD approaches could only be deployed in relatively small-scale settings in Vientiane, with the assumption that any biogas generated would be consumed locally and in proximity to the waste treatment facility. Nonetheless, it was reported during the field mission of August 2017 (see point 1.2.4) that a Lao-Thai-Israeli consortium was assessing the feasibility of deploying AD facilities for processing organic waste collected from hotels, restaurants and markets. While a concession agreement had been signed between VCOMS and this consortium, no information was available on when such project would in fact be implemented.

²³ A report by FAO (2011) indicates a relatively high incidence of foot-and-mouth disease in Lao PDR. However, no

evidence is available to establish a linkage between the disease and the practice of swill feeding.

2.1.5 Processing and treatment options for mixed waste

A brief overview of three options that could be deployed to treat unsegregated waste streams is discussed below. These consist in the deployment of material recovery facilities, the production of refuse-derived fuel, and mechanical biological treatment.

Material recovery facilities (MRFs) are processing units where incoming waste streams are sorted out for the recovery of valuable materials. Fractions with market value that are recovered can be sold to end-users and/or dispatched to recycling facilities for further processing. On its most simple designs, MRFs can consist of a sorting table and a weighing scale, with its operation relying on manual labor. Larger MRFs are automated and more complex in design, usually involving the operation of payloaders and forklifts, as well as equipment such as conveyor belts, magnetic separators, trommel screens or balers. MRFs tend to be associated with high capital and operational costs, and it is usually advised the preparation of a business feasibility study prior to any investment decision (ADB, 2011).

Refuse-derived fuel (RDF) is produced through the processes of shredding, drying and densifying solid waste streams into a pelletized fuel. On a typical RDF production plant, input waste is separated into

its combustible and non-combustible components. The combustibles are crushed and shredded into a uniform size, dried and compacted into the final RDF product. RDF can be used as a fuel in industrial boilers, such as cement factories or brick kilns. The harnessing of solid waste for RDF production has been assessed in Vientiane, but the outcomes of such study has not been publicly disclosed²⁴.

Mechanical biological treatment (MBT) designates several methods of pre-treating waste which are usually carried out prior to landfill disposal. In general, an MBT system includes manual and/or mechanical sorting facilities where large inorganic items such as recyclables and hazardous materials are separated, while the organic fraction is partly decomposed through composting. MBT can reduce the volume of waste disposed to landfills and facilitate the recovery of recyclable materials, even if these are soiled/unclean recyclables. MBT facilities are usually large-scale and installed in close proximity to disposal grounds. Due to the scale of these plants and the mechanization involved, MBT tends to be associated with high capital and operational costs. Nonetheless, it was suggested by officials from VCOMS that MBT was being considered as an option for Vientiane's landfill site.

2.1.6 Summary and discussion of potential intervention areas for waste-to-resource opportunities in Vientiane

The matrix presented at the end of this section discusses specific “intervention areas” for waste-to-resource opportunities that could be adopted in Vientiane. These intervention areas, in case implemented, would result in tangible changes – i.e. they lead to “on the ground” interventions – to the way solid waste is currently handled and/or managed in Vientiane.

The matrix characterizes and briefly discusses each intervention area proposed, whereby:

- Each area was organized in relation to four main types of waste: i) biodegradable organic; ii) recyclable materials; iii) unsegregated waste; and iv) undifferentiated waste. The latter pertains to opportunities that can be pursued regardless of the type of waste considered.

²⁴ The author had access to the draft version of a technical study which assessed the feasibility of RDF in Vientiane based on solid waste collected at the source. The results of the study were, however, inconclusive, as for example the

calorific value of solid waste was only analyzed for the dry season.

- Expected impacts of each intervention area were considered along the solid waste sector value chain, with three main stages considered for this purpose²⁵: i) waste generation & handling; ii) waste treatment/processing; and iii) marketing of the resources recovered or generated from waste.
- It is assumed that MPWT, MoNRE and VCOMS would have a direct or indirect role in the development and/or implementation of any of these intervention areas, and therefore they were not indicated in the stakeholders' column.
- A number of actors whose presence in Lao PDR could not be confirmed were either not mentioned in the stakeholders' column (e.g. technology providers) or were stated in a generic manner (e.g. NGOs, waste transportation companies, etc.).
- Benefits and challenges from harnessing the opportunity(ies) associated with each intervention area were indicated with a different color scheme (green and red, respectively).
- Intervention areas were classified in relation to "ease of implementation" (either as low, medium or high), which broadly takes into account investment and operational requirements, implementation timeframes, and type of stakeholders that would need to be involved, their likelihood to resist to changes from current practices, etc.
- The overall impact potential of each intervention was considered either as marginal, incremental or transformational.
- To summarize the assessment, each intervention area was ranked from the highest (1) to the lowest priority level (3) in the last column of the matrix.

It needs to be noted that the intervention areas identified should not be considered in an isolated or mutually exclusive manner, and in fact they could be combined or streamlined as part of an integrated solid waste management plan or approach.

²⁵ This is, in effect, a simplification of the value chain that was used in Chapter 1 to characterize Vientiane's solid waste sector. As here it is taken a "waste-to-resource" perspective, the disposal stage is replaced by the marketing of the

resources recovered or generated from waste, regardless of whether the demand for such product already exists or needs to be created.

Table 2.1 – Potential intervention areas for Vientiane’s solid waste sector

Waste Type	Intervention area	Description and rationale for the intervention	Value chain impact			Stakeholders	Benefits/Challenges expected in development and implementation	Ease of implementation	Global Impact Potential	Overall Rank
			Generation & Handling	Processing	Market develop.					
ORGANIC BIODEGRADABLE	Deployment of home composting units	Fully-decentralized option for treating solid waste, where home-composters are used to process organic waste generated in households. The compost produced would be utilized by households themselves.	✓	✓		<ul style="list-style-type: none"> Local communities and residential households Community Based Organizations (CBOs) NGOs 	<ul style="list-style-type: none"> Cost savings in the collection, transportation and disposal of waste Waste treatment and utilization of the resource would be fully addressed upstream Several households in Vientiane already recover organic waste (e.g. for animal feed) Many discrete composting units necessary to achieve a transformational change 	Medium	Transformational	1
	Deployment of small/ medium scale composting facilities	Decentralized solid waste management approach whereby the organic fraction of waste is segregated, collected and transported to small and/or medium-sized composting facilities. The compost produced could be utilized in agricultural crops, plant nurseries or purchased by VCOMS for utilization in the city’s public gardens.	✓	✓	✓	<ul style="list-style-type: none"> Sources of waste generation: households, public buildings, markets, hotels, small businesses, etc. Waste collection companies Ministry of Agriculture and Forestry Wholesale and retail sellers of fertilizers Farmers 	<ul style="list-style-type: none"> Leveraging of a locally available resource in the form of fertilizer, in a country where agriculture is the major economic sector and utilization rates of fertilizer are amongst the lowest in the region Relatively simple technology for treating the organic fraction of waste Technology untested and immature in the Lao context Relatively long lead times necessary to fully develop the whole value chain, from waste generation to compost use Use of compost produced from solid waste in agriculture is currently banned in Lao PDR 	Medium	Transformational	1

	Formalize and streamline the recovery of organic waste as animal feed	Reports indicate that organic waste is, to some extent, already recovered in Vientiane, albeit informally, for use as animal feed. This intervention would aim at improving and maximizing these opportunities, for instance by increasing collection rates, fostering business opportunities and certifying feed products produced.	✓	✓	✓	<ul style="list-style-type: none"> • Sources of waste generation: communities, households, public buildings, markets, hotels, small businesses • Ministry of Agriculture and Forestry • Animal feed companies and business associations 	<ul style="list-style-type: none"> • Option for harnessing the organic fraction of waste which appears to already exist, even if through informal networks • Limited experience and good practices found in developing countries on this “waste-to-resource” option • Limited information exists about these practices in Vientiane and limited interest expressed by stakeholders on this waste-to-resource opportunity. 	Medium	Incremental	2
	Harnessing opportunities for waste-to-energy conversion through anaerobic digestion (AD) treatment	Decentralized waste management intervention where organic waste is segregated and converted into biogas through AD processing, with the biogas generated used as a heating fuel or electricity.	✓	✓	✓	<ul style="list-style-type: none"> • Local communities and residential households • CBOs 	<ul style="list-style-type: none"> • From a technical standpoint, AD is the most feasible “waste-to-energy” approach for solid waste in the developing country context • Opportunity for improving energy access, especially among the urban poor • The AD process requires as input a very well segregated organic fraction of waste • Demand for the energy generated needs to be located relatively close to the treatment facility • Limited experience with biogas generation in Lao PDR (regardless of the feedstock) 	Low	Aspirational	3

RECYCLABLE MATERIALS										
	Testing and deployment of the “waste bank” model targeting both informal sector members and local communities	Waste banks consist of banks that accept waste – mainly inorganic waste – as a deposit. It is a community focused concept that encourages households to segregate waste and exchange it for cash or a deposit in a savings account. Informal waste sector members could also play a role in the implementation of such model by, for example, providing door-to-door collection services or establishing their own waste bank.	✓	✓		<ul style="list-style-type: none"> • Local communities and residential households • Informal waste sector members • CBOs • Recycling companies • Local banks 	<ul style="list-style-type: none"> • High potential for improved livelihoods of informal waste sector members • Promotes waste segregation and the collection of clean recyclable materials • Potential for developing innovative business models, such as micro-finance schemes • Potential resistance to formalization by informal waste sector members • Risk that informal waste sector members may be bypassed with the adoption of the approach in case communities sell recyclables directly to recyclable buying centers through waste banks 	Medium	Incremental	1
	Strengthening existing recyclables value chains through technical and financial assistance	Conducting an integrated approach throughout the value chain, with the introduction of targeted measures along the recyclables value chain. A “package” of measures could include, for example, the introduction of extended producer responsibility (EPR) models, support to the establishment of waste pickers cooperatives, awareness programmes to promote the segregation of waste at source, policies to attract “value-added” recycling industries to the country, etc.	✓	✓		<ul style="list-style-type: none"> • Informal waste sector members • NGOs • Companies producing materials that can be recycled • Business associations • Recycling companies 	<ul style="list-style-type: none"> • Limited disruption to a value chain that appears to already function with limited public support • Potential for enhancing the recovery of recyclable materials and livelihood improvement • Reduced potential for transformational impact as the focus is on small interventions along the recyclables value chain • Potential resistance to formalization by informal waste sector members 	High	Incremental	1

	Implementation of a system of collection points for recyclable materials	Intervention area where households, small business and other actors generating solid waste segregate recyclables and bring them to secondary collection points in the city. Informal sector participation, integration and formalization could be explored through the creation of opportunities for the establishment of micro-enterprises for recyclable collection and/or other roles.	✓			<ul style="list-style-type: none"> Sources of waste generation: communities, residential households, public buildings, markets, hotels, small businesses, etc. CBOs and NGOs Waste collection companies Recycling companies 	<ul style="list-style-type: none"> Potential to significantly increase the collection of source segregated recyclable materials Risk of interference in informal sector networks, raising issues about waste ownership High investment and operational costs associated with the development of an infrastructure of waste collection points for different recyclable materials and a dedicated collection and transfer system Long lead times for implementation in view of the number of stakeholders involved, investment requirements, community participation, etc. 	Low	Incremental	3
UNSEGREGATED WASTE	Deployment of material recovery facilities to increase the recovery of recyclables	Implementation of one – or more – material recovery facility to enhance the recovery of recyclable materials from unsegregated waste, with possible sites being the location adjacent to the transfer station or the city's disposal site. This was one of the improvement opportunities identified by GGGI in the field mission conducted in February 2017.		✓		<ul style="list-style-type: none"> Waste collection & transportation companies Recycling companies 	<ul style="list-style-type: none"> Enhanced opportunities for the recovery of recyclable materials Limited deployment of MRF facilities in developing Asian countries due to high investment and operational costs, and the risk that the most valuable recyclables are collected upstream by informal sector members Not in support of transformational “waste-to-resource” measures whereby a higher value from resources is to be obtained from source segregated waste 	High	Aspirational	3
	Deployment of opportunities for the production and utilization of refuse derived fuel (RDF)	RDF could be produced from unrecyclable waste fractions that are combustible (e.g. textiles, paper, wood), with the fuel generated used in industrial boilers (e.g. cement kilns) or for electricity production. Waste could be collected from the landfill site, and the RDF production facility deployed in tandem with MBT of mixed waste.		✓	✓	<ul style="list-style-type: none"> Industrial facilities using industrial boilers (e.g. cement kilns) 	<ul style="list-style-type: none"> Option for harnessing waste in the form of energy Potential for toxic emissions in case materials such as PVC are not removed from the waste fraction recovered for RDF production Limited “pro-poor” impact of the intervention Limited impact along the whole waste sector value chain 	Medium	Aspirational	3

UNDIFFERENTIATED	WASTE									
	Increasing waste collection rates by decentralizing collection services through small-scale operators (micro-privatization of waste collection)	This intervention would aim at fostering opportunities for the establishment of small-scale operators, such as micro-level enterprises or CBOs, in order to extend waste collection coverage to the whole city. It would support the achievement of two goals: full waste collection coverage, and savings in collection costs. This intervention area could be articulated with initiatives supporting the segregation of waste at source.	✓			<ul style="list-style-type: none"> Communities, residential households, public buildings, markets, hotels, small businesses CBOs NGOs Informal waste sector members 	<ul style="list-style-type: none"> Two major challenges currently identified in the city could be addressed simultaneously: low waste collection coverage and low levels of waste segregation at source Strong pro-poor component, in light of the opportunities to formalize informal waste sector activities, job creation among the urban poor and provision of collection services to low-income settlements Opportunities for introducing “polluter pays” principles through the creation of business models where communities served pay directly to the companies providing the collection service. The intervention area in itself falls short of a “waste-to-resource” component and would need to be combined with complementary measures Unwillingness of communities or participants to pay for the services provided 	Medium	Incremental	2
	Implementation of measures to minimize waste generation rates at source	Implementation of measures to minimize waste generation rates at the source (e.g. reduction in the consumption of plastic bags) through education and sensitization programs, including reward and penalty schemes.	✓			<ul style="list-style-type: none"> Communities, residential households, public buildings, markets, hotels, small businesses CBOs 	<ul style="list-style-type: none"> Reduced costs incurred with collection, transportation and disposal of waste Difficult to set a baseline and the specific contribution of the measures adopted to the reduction of solid waste generated Intervention only focused in the initial stage of the solid waste value chain, with the potential to only alleviate – and not fully address – major issues identified in the sector. 	Medium	Aspirational	3

2.2 Proposed waste-to-resource initiatives for Vientiane

It is concluded that two types of initiatives would be prioritized: i) the development of a solid waste management strategy for Vientiane, and ii) the deployment of resource recovery facilities. With regards to the latter, the following opportunities were shortlisted by the GGGI team as those associated with a more visible and potentially higher tangible impact:

1. Distribution of home composting units;
2. Decentralized waste composting facilities;
3. Decentralized secondary waste collection points with the participation of micro-enterprises;
4. Community-driven waste banks with the organization of waste pickers cooperatives.

Home composting is an approach supported by national and local government officials in Vientiane. More specifically, representatives of MPWT have noted that a Dutch organization had previously identified this method as one of the approaches with the highest chances of success in the Vientiane context. Reasons for this are, *inter alia*, the infrequent or non-existent provision of municipal waste collection services, which prompt many households to separately handle the biodegradable fraction (e.g. for animal feed or by simply burying it in households' backyards), which tends to quickly decompose in the context of a tropical climate such as that of Vientiane. It can thus be hypothesized that the adoption of this approach would not require a major behavioural change to current waste handling practices of households. It also needs to be noted that home composting has been piloted in 4 villages in Vientiane as part of the LPPE programme. It is therefore recommended that lessons learned from these experiences can be properly studied and understood before GGGI ventures with its own home composting projects or initiatives.

The deployment of **decentralized waste composting** facilities is, in principle, a particularly well-suited solution to treat organic waste generated in large

facilities or buildings (e.g. restaurants, hotels, markets, government offices, schools) or even households that are unwilling to adopt home composting units. By "decentralized" it is meant that these facilities would be located in relative proximity to the sources of waste generation, thereby saving costs incurred with the collection/transport of waste. However, several challenges can be identified with respect to the deployment of this approach. Among these the need to ensure that the organic fraction of waste meets certain segregation standards, and that waste collection and transport procedures are in place in order to ensure that the segregated fractions reach the composting facility without being mixed up with other waste streams. Another noteworthy challenge concerns the creation of a market or demand for the compost produced, including the processes of having it tested in laboratory and certified by an official certification body. In this regard, it needs to be emphasized the regulation of MAF that restricts the use of compost in agriculture, even though the Ministry has left open the possibility of allowing such practices if compost is produced from source segregated waste. Against this setting, it is recommended as a first step that a small-scale (e.g. a facility with a processing capacity of 1-2 tpd) decentralized waste composting unit could be piloted and tested for treating waste generated from business entities. Upscaling and replication would subsequently be decided based on the outcomes and lessons learned from piloting activities.

Implementing **decentralized secondary waste collection points with the participation of micro-enterprises** is an option that could be trialled in order to simultaneously address two major challenges in Vientiane: low waste collection coverage and low waste separation rates at source. One of the root causes for the low collection rates observed in Vientiane lies on the high fees charged by VCOMS (or any of the eight private companies). If waste collection could be organized by the community itself (e.g. at the district or village level) at more affordable prices, for instance by leveraging existing networks of informal waste sector members

or the establishment of micro-enterprises, it is an approach that, in case successful, would have the potential for replication city-wide. If considered in tandem with “waste-to-resource” approaches, decentralized collection could be conceptualized from the beginning alongside methods to collect segregated waste at the source. Decentralized collection has been adopted with considerable success in several cities in developing countries, especially in suburban areas and low-income settlements²⁶. A key success factor for waste management concepts such as these to effectively work is the need to ensure a reliable source of income to the micro-enterprises providing these services, which could be in the form of direct payments from VCOMS, or an indirect charge to households through the water or electricity bill.

Community-driven waste banks with organization of waste pickers cooperatives is an option that could be pursued in order to enhance the collection of clean recyclables while seeking ways of improving

the livelihoods of informal waste pickers. Several experiences exist in developing Asian countries in the adoption of waste bank concepts, but few have been as successful as those in Indonesia (so-called “bank sampah”). Waste banks are grassroots, community-run facilities that accept recyclables (and, in some cases, organic waste) in exchange for cash or a bank deposit. Models such as this, or similar, could be tested in Vientiane, either operated by communities themselves or informal waste sector groups. In case informal sector members are organized into cooperatives, waste banks could increase their bargaining power in relation to buying centres, or even enable these to be bypassed altogether. This concept could be first piloted, for example, in the communities that were part of the LPPE programme, in case such experiences are considered positive.

Table 2.2 below indicates the main target groups of the four shortlisted initiatives and discusses risks associated with their adoption.

Table 2.2 – Main target groups and risks associated with the implementation of the four impact areas shortlisted

Initiative		Main target groups	Main risks identified
1.	Home composting units	<ul style="list-style-type: none"> Households 	<ul style="list-style-type: none"> Unwillingness of households to adopt home composting units. Unwillingness of households to mobilize their own resources to purchase home-composting units. Potential competition from other approaches currently adopted by households (e.g. organic waste being utilized as animal feed).
2.	Decentralized waste composting facilities	<ul style="list-style-type: none"> Medium-sized generators of waste, such as hotels, restaurants, markets, public buildings, schools, etc. Pilot districts where decentralized collection points will be established. 	<ul style="list-style-type: none"> Unknown uptake of waste segregation attempts in a city with limited experience on these practices. Restrictions in the use of compost in agriculture not lifted by MAF. Lack of know-how and experience in Lao PDR with composting solid waste in “off-site” small-scale facilities. Large quantities of segregated organic waste (e.g. from hotels or markets) could be diverted to purposes (e.g. by animal feed companies) other than composting, thereby affecting the processing capacity of a given composting plant. Business model of composting plants is not expected to be financially sustainable without some form of public support (e.g. a share of the waste collection fee charged would need to revert to the operation of the facility).

²⁶ See, for example, the cases of Maputo, Mozambique (Stretz, 2012) or Surabaya, Indonesia (Premakumara, 2012).

Initiative(cont.)		Main target groups(cont.)	Main risks identified(cont.)
3.	Decentralized secondary waste collection points with the participation of micro-enterprises	<ul style="list-style-type: none"> Households, small shops/businesses Micro-enterprises Informal sector members 	<ul style="list-style-type: none"> Unwillingness of communities or households to pay for door-to-door collection services, even if these are cheaper and more frequently provided than those through VCOMS. Lack of leadership at the community level for the development of a decentralized waste collection approach. Unwillingness or resistance of village leaders to assign waste collection services to micro-enterprises. The establishment of micro-enterprises at the grassroots level cannot be guaranteed (e.g. due to the lack of interest on such ventures, lack of seed capital, lack of access to finance, etc.). The activity of micro-enterprises may be hindered by the lack of regulation. The successful adoption of an initiative along these lines could imperil the current business model for waste collection services of VCOMS and the 8 private companies.
4.	Community-driven waste banks with organization of waste pickers cooperatives	<ul style="list-style-type: none"> Communities Households Informal sector members 	<ul style="list-style-type: none"> Lack of leadership or interest at the community level to the establishment of waste banks. No benefit perceived by informal waste sector members regarding their organization into groups or cooperatives. Lack of funding and operating capital to initiate the activities of a waste bank. Bargaining power of buying centres could squeeze out of business grassroots initiatives such as waste bank models.

2.3 Conclusion

The assessment conducted indicates that there is a significant potential for the adoption of waste-to-resource initiatives in Vientiane. As the approaches prioritized by the GGGI team are relatively novel in the Lao PDR context and imply a change in the way solid waste is conceived (i.e. a transition from a waste management to a resource management approach), it is recommended to first pilot such approaches in small-scale settings prior to making a decision of advancing into upscaling and replication. It is also recommended that the proposed approaches are implemented in the context of an integrated and holistic framework, whereby interventions in one end of the value chain (e.g. segregation of waste at the source) have correspondence with similar interventions in other points of the waste handling process as a whole (e.g. ensure that segregated waste streams are collected and processed in a separate manner).

In addition, it is suggested that the implementation of any of the four shortlisted initiatives can be complemented with a portfolio of measures to support addressing issues of a more strategic and cross-cutting nature. The most salient of these has, in fact, already been identified as a priority by GGGI: the preparation of a solid waste management strategy for Vientiane. Other options that could be considered:

- Provide technical assistance to improve the sector's policy and regulatory framework, including mechanisms for enforcing compliance and monitoring implementation of "waste-to-resource" approaches. Policies and regulations that could be considered include, *inter alia*, the introduction of "polluter pays" schemes (e.g. by imposing fines to entities or individuals that dump their waste or to

- major waste generators that do not segregate waste), or extended producer responsibility (EPR) practices to industries utilizing materials that can be reused and recycled.
- Preparation of a city-wide waste segregation program, which could include options for the collection and treatment of the waste streams recovered.
- Conduct of a financial-economic assessment with the aim of: i) obtaining a thorough understanding of costs currently incurred in handling solid waste; ii) estimating benefits/costs from the adoption of “waste-to-resource” and “pro-poor” approaches, including co-benefits and costs of inaction; and iii) coming up with financially sustainable models, including economic instruments, to support the deployment of these approaches.
- Provide technical assistance in the establishment of partnership modalities for service-delivery (e.g. public-private partnerships, NGO-public partnerships, concessions, open tenders, etc.).
- Provide technical assistance in the design and implementation of “social” instruments to reach out to communities and businesses, such as communication campaigns, education programs and capacity building training sessions.
- Set-up a program to support the creation of a market for compost generated from solid waste, which could include, for example, the lifting of existing restriction to its use in agriculture, a trial program for farmers, and the certification and testing of the final product.
- Design of a financial plan to assist local stakeholders raising funds from financial institutions, in particular multilateral development banks, to support large-scale investments in Lao PDR solid waste sector.

As a final remark, even though this report had a specific focus on the solid waste sector, it is recommended that GGGI considers potential synergies between this and other sectors, in particular sanitation and hygiene, where opportunities for integrated approaches could be leveraged and jointly pursued. Also, further assessment on waste-to-energy project at the landfill site which VCOMS has signed consortium will be required in order to avoid duplication but to create synergies with the proposal on decentralized composting facilities. It is also recommended to make further efforts to assess potential options for landfill improvement such as landfill gas recovery and landfill mining in conjunction with waste-to-resource initiatives proposed in this report.

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