

ANALYSIS OF SEPARATION OPTIONS FOR
COMPOSTING MARKET WASTE IN
VIENTIANE, LAO PDR

by

Genevieve Rachel Wong

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ABSTRACT

Analysis of Separation Options for Composting Market Waste in Vientiane, Lao PDR

Genevieve Rachel Wong

Master of Engineering, 2004

Department of Civil Engineering, University of Toronto

Three markets in Vientiane, Lao P.D.R were involved in a pilot study on the introduction of composting to their waste management systems. This report evaluates three composting options, regarding waste separation and transportation, based on stakeholder identified criteria.

Option A1 involves on-site waste separation and processing organic waste at decentralized facilities located at each market. Option A2 involves on-site separation with organic waste processed at an off-site centralized composting facility. Option B involves waste transportation to an off-site facility for both separation and processing of organic waste. In all options, inorganic waste would be transported to the landfill.

Results suggest that while Option A1 meets most stakeholder raised concerns, initial set up costs and potential odour problems need consideration. Option A2 meets some stakeholder concerns, while Option B presents little change to the existing practices. Major drawbacks of Options A2 and B include additional transportation costs and tipping fees.

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1.0 INTRODUCTION

1.1 General Overview of Laos

The Lao People's Democratic Republic (Lao PDR) is a landlocked country located in Southeast Asia (Figure 1.1 Map of Laos website). The People's Republic of China borders Lao PDR to the north, Cambodia (or Kampuchea) borders to the south, Vietnam to the east, Thailand to the west and Myanmar to the northwest. The Mekong River, which marks the western border, is the country's main transportation channel and runs the entire length of the country. The Mekong



also serves as the country's main source of fish, with its tributaries used for hydroelectric power generation (DEFAIT 2003). The population of Lao PDR was reported to be 5,921,545 as of July 2003 (CIA 2003), with the population of Vientiane, the capital city of Lao PDR being approximately 600,000. Vientiane is located along the western border in the central area of the country, and has an annual growth rate of 4.7%, more than double that of the country's growth rate of 2.45% (Phissamay and Rootham 2002).

Figure 1.1 Map of Laos

Administratively, the country is divided up into three major regions of North, Central and Southern Laos, and further sub-divided into 18 provinces or 'khouengs'. Politically, the land is divided again into villages and districts, or 'bans', and 'muongs' (CIA 2003). The research conducted for this report was completed within Vientiane.

Geographically, the landscape of the country is very mountainous in the north and northeast, with plateaus and plains located in the central and southern regions. The plateau and plain

regions are heavily populated compared to the northern regions; however a number of hill tribes still inhabit the northern areas. There are two distinct seasons in the country, the rainy or wet season from May to November, and the dry season from December to April. During the wet season, areas of greater altitude can receive annual rainfall of more than 3000 mm. Vientiane receives between 1500 mm to 2000 mm due to its relatively low altitude. Average high temperatures for the dry and rainy seasons are roughly 24°C and 27°C, respectively. This combined with elevation patterns and other geographical features makes the country susceptible to monsoons (Cummings 2002).

From an economic perspective, the country depends heavily on foreign aid, and imports the majority of its manufactured goods, medicine and machinery (DEFAIT 2003). The country's GDP is attributed primarily to the agricultural sector, which employs over 80% of the population. The fertile flood plain valleys found in Vientiane and Savanakheth are the areas of greatest production, given the dense population and their proximity to the Mekong River (Phissamay and Rootham 2002). Laos' primary growth crop is rice; however corn, vegetables, tobacco, and coffee are also grown and sold (CIA 2003). Currently, Laos exports electricity, wood products, coffee and tin, however government intentions are to expand this to include raw timber, gypsum, and gold (DEFAIT 2003).

1.2 Local Waste Management History and Project Background

Waste in Vientiane has historically been disposed of through informal burning and direct dumping into the Mekong River. This changed in 1994 when a private Thai-Lao joint venture company, known as the Lao Garbage Society (LGS), was developed. This company was the first waste management organization established in Lao PDR and was responsible for the collection and disposal of waste for 18 villages in the Xiassetta district. Waste management in this area involved removal of waste from residential and commercial locations, and transport to the local landfill (Kamsithon 2003). The LGS was the sole company responsible for waste management in Vientiane until 1997, when an agreement was made between the Lao Government and the Japanese International Corporation Agencies (JICA). This agreement resulted in the creation of a second waste management organization known as the Urban Cleaning Service (UCS). The agreement also included a donation of USD \$2.7 million to the Lao government from JICA to be

used for the construction of the UCS building, upgrades to the landfill, and acquisition of a variety of waste collection vehicles. UCS is currently responsible for 90% of waste collection and management in Vientiane, with the LGS responsible for the remaining 10% (Meksavanh 2003).

The Vientiane landfill is located approximately 20 kilometres from the centre of Vientiane and is commonly referred to as Km 18. This site has an estimated lifespan of approximately 15 years and a maximum capacity of 90 000 tons. The projected closure date of the landfill is forecast to be 2010, at which point a new landfill, which has already been sited at Km 36, will be opened. Examination of previous studies conducted on the waste generated in Laos indicate that a large quantity of organic solid waste is generated in local markets and sent to the landfill for final disposal (SWTC 2002).

Promotion of Integrated Waste Management (IWM) is the primary focus of the Waste-Econ program, funded by the Canadian International Development Agency. This five-year program is operated by a number of partnered organizations, including universities, government organizations and non-governmental organizations (NGOs). The program's aim is to support a waste economy that provides enhanced earnings and working conditions, while promoting sustainability, waste reduction and recycling (Waste-Econ 2003).

As part of the Waste-Econ program, a pilot project in Vientiane, Laos, began in May 2003 to determine the feasibility of establishing a permanent program for composting organic wastes from Vientiane markets. Throughout Vientiane there are numerous markets located within most population centres. Markets were chosen for this research, as previous studies indicated that they are large producers of organic waste (SWTC 2002, Chopra 2004). This pilot project involved the University of Toronto, the National Science Council of Laos, and Nabong Faculty of Agriculture in the National University of Laos.

Composting is a process that involves the natural biological decomposition of organic matter in the presence or absence of oxygen (Nebel and Wright 1998). In the presence of oxygen, organic matter decomposes aerobically through enzymic oxidation by microorganisms, and leads to the

production of a humus like material rich in minerals, along with carbon dioxide and water (Ellis and Mellor 1995). Studies have shown an increasing awareness of the value which lies in the organic portion of waste, as it can be converted into compost or an organic fertilizer that improves the ability of soil to retain water and resist soil erosion, as well as reduce the need for chemical fertilizer (Enayetullah and Sinha 2002). Establishment of the composting program could also divert a considerable amount of organic waste from the current landfill, thereby increasing its lifespan.

Depending on the scale of the composting program, potential processing technologies range from simple back yard decomposers to more advanced procedures requiring mechanical mixers. Given the goal of sustainability for the permanent composting program, experts have recommended simple, more labour intensive procedures versus mechanical ones (Haight and Taylor 2000).

The quality of the end product largely depends on having adequate environmental conditions, such as temperature and pH, together with the right ratio of carbon and nitrogen sources. For this reason, effective separation of organic waste from inorganic waste is imperative to ensure these decomposition conditions as well as to prevent contamination of the end product.

Prior to the development of a composting program, a number of factors affecting the program's feasibility need to be examined. These include:

- The availability and quantity of organic waste produced for the process,
- The manner in which this waste would be separated, and transported to a composting facility(ies),
- The location of the facility(ies),
- The method for processing the organic waste into useable compost, and
- The delivery and potential sale of the end product to potential users of compost.

Information about each of these factors and their related economic costs and benefits would then enable decision makers to make informed decisions towards the development of a permanent

composting program with a sustainable future (Martin *et al.* 1995). The focus of this research report is on the second bulleted factor above.

1.3 Project Objectives and Structure of Report

In order to understand how composting could be introduced into markets, this research has four main objectives:

- to understand and assess the current system for waste management for markets in Vientiane,
- to understand the concerns and objectives of the stakeholders for waste management in the markets, which includes market managers, vendors, market cleaners and waste collectors,
- to identify and examine alternative methods for waste separation, and
- to carry out a preliminary evaluation of these methods as they pertain to meeting stakeholder identified objectives.

The markets in Vientiane range in size from small collections of vegetable stands to larger scale markets organized into distinct regions for fresh produce, meat and fish, packaged goods, prepared food, clothing and others. Larger markets were the focus of this research, as they produced higher quantities of organic waste and the market managers expressed interest in participating in the pilot project. A more in-depth discussion of these markets and their waste management practices can be found in Section 3 of this report.

The mode of separation chosen for compost preparation can have a great effect on the efficiency of the composting process. Studies conducted on composting in developing countries indicate that source separation is the only feasible method for profitable and sustainable composting (Gtz n.d.). However, this study examines the effects of several separation methods that could be employed in Lao markets.

Information provided in the report can be used together with information obtained from other related studies, to aid future researchers and decision makers tasked with implementing a

composting program. While the focus of this research is on markets located within Vientiane prefecture, the analysis was completed in such a way that the results can be applied to markets of similar scale and organization in other prefectures of Lao PDR. Further, the analysis completed is based on market conditions as they were in the summer of 2003. While market systems are continuously changing, general conclusions are drawn to anticipate changes and remain applicable.

The methodology followed for the collection of information on current waste management practices in the markets of Laos, together with the desired outcomes of the project as communicated by stakeholders such as market managers, market vendors and waste management companies currently in operation, is explored in Section 2 of this report. Section 3 provides a description of the markets studied, along with a discussion of the current waste management system found at each market. This is followed by a description and comparison of alternatives for handling and separation. Section 4 provides a preliminary analysis of the separation alternatives. This can be used as a starting point for further studies relating to the implementation of a composting program. Finally, a summary and recommendations for future work are found in Section 5.

2.0 METHODOLOGY

During the months of June and July 2003, the waste management system that existed at the markets in Lao PDR was examined in depth, along with assessment of how the system came to be and where stakeholders would like to see it develop further. This section describes the selection of the markets that were studied, how information was gathered through questionnaires, visual observations and interviews, and the separation options that were considered.

2.1 Market Selection

Three major markets, Thalat Khuadin (Khuadin), Thalat Thong Khankham (TKK) and Thalat That Luang, were selected for study within Vientiane prefecture, based on size, organic content and willingness to participate in the potential composting program.

The three markets are within a three (3) km radius of each other. Each of these markets can be found in the map shown in Figure 2.1 (Map of Vientiane website). Two of these markets operate as ‘early morning’ markets, between the hours of 4 a.m. to 8 a.m., and then as regular day markets operating from 8 a.m. to 6 p.m. All markets operated these schedules seven days a week. The following descriptions provide general information about each market studied; however, more detailed descriptions of each market can be found in Section 3 of this report.

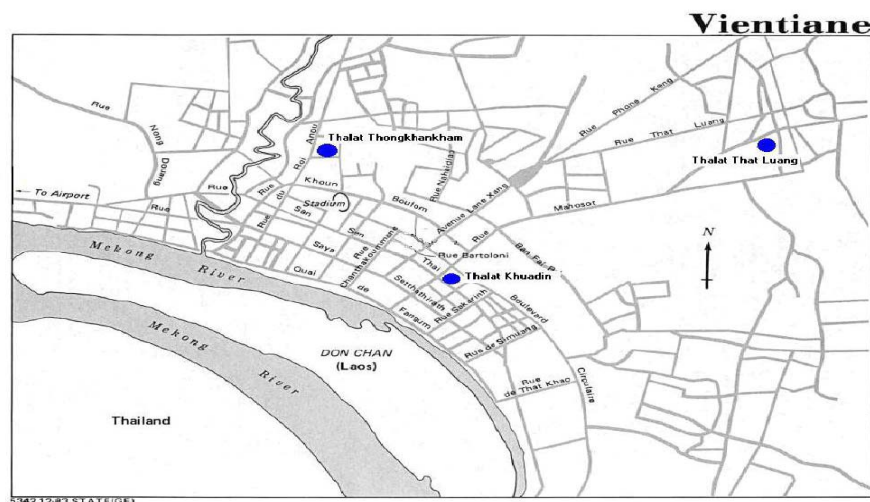


Figure 2.1: Market Locations

2.1.1 *Thalat Khuadin*

Khuadin market is located less than one kilometre from the Patouxi monument found in the centre of Vientiane. This market is adjacent to another large Vientiane market, Thalat Sao or the Morning Market. Khuadin market is relatively new, being at this location since 1997. It is comprised of a variety of packaged good vendors, cooked food vendors, and fresh fruit, vegetable and meat vendors.

2.1.2 *Thalat Thong Khankham*

The TKK market is located within the Chantabury district, roughly 3.5 km from the Patouxi monument. This single storey market was established in 1989 and is privately owned. The market is home to both an early morning market and a daytime market. The early morning market sells primarily fresh food products while the daytime market sells a variety of food, clothing and textile items. A separately owned and managed early morning market is located just across from TKK, separated only by a narrow mud path.

2.1.3 *Thalat That Luang*

This market is located in the district of Sisatah, roughly 4 km from the Patouxi monument. It was established in 1991 and is privately owned. Similar to the previous two markets, That Luang also has an early morning market that sells only fresh food products, such as fruits, vegetables, meat and fish. The main market sells a variety of food, clothing, textiles and packaged goods.

2.2 Questionnaire



Figure 2.2: Research assistant conducting survey with coconut vendor

Specific details of how the existing waste management system of Vientiane operated, along with what methods of waste separation were in place, was determined using a prepared questionnaire. The questionnaire was designed to examine the operation of the market using factual information gained from market vendors.

The survey was written in English and delivered in Lao language by research assistants proficient in doing sight translations of the survey (Figure 2.2). Verbal responses were given in Lao language and translated to written English. Due to the extensive language abilities of the research assistants working on the project, it allowed for additional questions not on the survey to be asked of vendors, in order to gain further clarification of responses given. These additional questions were not opinion based and factual only. A copy of the questionnaire used can be found in Appendix I.

2.2.1 Questionnaire Design

The questionnaire was structured into two segments. The first section contained questions dealing with the general background of the market, such as hours of operation, years of operation, and at some markets, vendor movement within the market. Vendor specific questions, such as the products sold at each stall, seasonal variances, and daily rental payments, were also included in the first part of the questionnaire in order to understand operational practices of the market outside of waste management. This information was used to gain an overview of market operations; it did not play a direct role in the development of the separation options or evaluation criteria.

The second part of the questionnaire focussed on the details of the market's waste management system and the vendors' role within it. Vendors were asked how they handled waste generated throughout the day and how they stored it prior to collection. Handling of items that were unsold or had gone bad within the day was also explored, as these could be major sources of compostable waste for the pilot facility. The degree of separation that vendors were accustomed to was determined by inquiring about practices followed with non-organic waste, such as product packaging. Questions relating to fees paid for waste management were also assessed in the second component of the questionnaire. Similar to the first part of the questionnaire, responses were used to gain an overview of the current waste management system.

2.2.2 Questionnaire Distribution

Information obtained from these questionnaires was not intended for use in statistical analysis, but rather to gain a qualitative overview of market operations. As such, questionnaires were not completed using a pre-determined sample size. Instead, vendors were selected for questioning on the basis of the following considerations:

- The type of goods sold by the vendors
- The type of material the vendor's stall was constructed of (wooden floor crates, large tables, tarp laid on the ground)
- The height the stall was off the ground
- The type of overhead coverage for the vendor's stall
- Where the vendor was located in the market with respect to proximity to the main entrance and areas of high traffic

Any factor that differentiated one group of vendors from another was considered, and samples of these 'types' of vendors were questioned, depending on the size of the grouping.

Khuadin market housed approximately 600 vendors in the morning and daytime markets combined; approximately 60% of these produced organic compostable waste. Over 10% of each vendor type was surveyed within Khuadin market in order to gain a holistic and representative understanding of the market operation and waste management practices. At TKK market, between 50-60% of the more than 900 different vendor stalls produced primarily compostable waste. More than 5% of each vendor type was surveyed. Finally at That Luang market approximately 50% of the 370 daytime vendor stalls and roughly 100% of the early morning market stalls¹ produced compostable waste. Approximately 3% of this market was surveyed due to time limitations. In addition, That Luang exhibited similar trends to those noted in surveys completed for previously surveyed markets.

¹ The number of early morning market vendors for this market was not determined.

In total, 120 surveys were completed and uncovered important issues to consider prior to introducing composting into the existing waste management system. During the surveying process, each vendor was provided with an explanation of the research work and the purpose of the questionnaire. Summary tables of data obtained can be found in Appendix II.

2.3 Visual Observations and Interviews

At each of the markets examined, visual observations of daily market life and waste movement took place. Observations allowed for information on existing methods of waste separation, collection and transportation to be gathered, along with collection and transportation frequency.

Informal discussions and interviews with the aid of a translator proved to be the most appropriate means of gathering information relating to the viewpoints of stakeholders, including market managers and waste collectors. Open-ended questions were used to obtain information related to:

- views on the efficiency of the current waste management process,
- areas for improvement,
- important aspects for the successful implementation of the new system, and
- factors affecting participation (i.e. incentives and/or roadblocks)

Interviews of Members of the Urban Cleaning Service and waste truck operators from the Lao Garbage Society were used to determine historical practices, tonnage of waste transported and truck maintenance schedules. Waste collectors (responsible for collection of waste and transport to the landfill) were also interviewed at Khuadin and That Luang markets; however, this was not completed for the other market as its waste collectors were not as willing to be interviewed.

In addition, comments made by vendors during completion of the previously mentioned questionnaires were also used as input into the development of stakeholder views. Overall, information gathered in this part of the research was used to develop a series of criteria to evaluate waste separation options.

2.4 Separation Options Analysis

Three separation options were considered for each of the markets based on information gained during observations, interviews and questionnaires. A series of criteria to evaluate these options was also established from data gathered.

Since the separation options are related to the siting of the compost facility, three potential areas were considered, based on approximate travel distances from the central market area. These include a location at each individual market, a location along the edge of Vientiane, and a location along the outskirts of Vientiane. These areas were visually assessed to ensure that potential sites were available in these areas, looking at features such as the amount of physical space available and ease of accessibility.

These locations will only be discussed in the context of comparing the separation options. A more detailed explanation of the methodology used for the analysis of separation options can be found in Section 4 of this report.

3.0 EXISTING WASTE MANAGEMENT SYSTEM



Figure 3.1 – General Appearance of Markets

This section of the report describes in detail the waste management system of the three markets examined as it was in the summer of 2003. Data used in this section comes from the results of vendor-distributed questionnaires and interviews with members of the waste management industry. Generally, vendors were grouped into one of three main

categories 1) clothing and textiles, 2) packaged goods and, 3) fresh products such as fruits, vegetables, meat or fish. In the majority of market systems, vendors purchased a permanent location to sell their products, though they were still required to pay a daily rental fee for the location, along with various other payments such as taxes, overnight guarding of un-sold goods, waste collection and utility fees. For each of the three markets studied, the existing situation is summarized using the following information:

- 1) a detailed description of the physical layout and general operation,
- 2) the method by which waste is generated and managed in the various parts of the market,
- 3) the role of market-employed waste cleaners,
- 4) the role of the waste collection company, and
- 5) the fees associated with the processes presented.

There appeared to be a relatively consistent level of activity in each of the markets on a daily basis (Figure 3.1), seven days per week, despite any extreme weather conditions such as heavy downpour or scorching sun. The only noticeable change was a decrease in activity on weekends in the areas of the market where prepared food was sold. These areas were predominantly busy from Monday to Friday by members of the working class eating lunch or dinner.

3.1 **Thalat Khuadin**

3.1.1 Physical Layout and General Operation

Khuadin market covers an area of approximately 32,000 m² and is located at the corner of Mahosot Road and Khou Vieng Road in central Vientiane. The market is adjacent to Thalat Sao, or The Morning Market, and while it sells a variety of product items, it is most popular for the sale of fresh food. The main division in the market is a curved unpaved road running the length of the market, separating it into a western and eastern section. The western portion of the market includes a large building located adjacent to the Vientiane bus station. It houses predominantly textile, jewellery and some packaged good vendors. These vendors sell products on elevated wooden crates, placed on a concrete floor with galvanized metal overhead coverage. On the eastern side of the market most of the fresh fruit, vegetable, meat and packaged good vendors are located. These vendors sell their products on 91 X 91 cm wooden floor crates placed on a mud/gravel floor, with overhead coverage consisting of galvanized metal roofing in only a small portion of the area, and a mixture of tarps and tent coverage in the remaining areas.

Within the west half of the market, vendor tables are set up side by side in designated rows and are identified by number. The eastern portion of the market also houses vendors placed side by side, however rows are not as organized. Some stalls begin as rows and end by curving around permanent objects. As well, having vendors set up on the floor in any available space forms seemingly randomly placed clusters of vendors in the market, possibly optimizing usage of floor space. A general schematic drawing of the daytime market layout is shown in Figure 3.2. Food vendors located in the eastern portion of the market would generate organic waste for this market; these vendors were chosen for interviews and filling out questionnaires. Overall, there appeared to be approximately 600 vendors within the market¹.

Operation of the early morning market occurs between the hours of 4 a.m. and 8 a.m. These vendors are located along the centre divide of the market. This market sells mainly fresh fruits, vegetables and meat. At 8 a.m., early market vendors are required to leave their stalls in order to

¹ Vendor counts are all approximate values as vendor attendance within the market was not consistent during the research period.

accommodate the daytime vendors. However, when the early morning market closes, those vendors who have not sold all of their goods are given the option to rent a stall in the eastern portion of the daytime market, where overhead coverage is available. Daytime market vendors operate between the hours of 8 a.m. and 6 p.m., selling a mixture of food items as well as textiles, clothing and packaged goods.

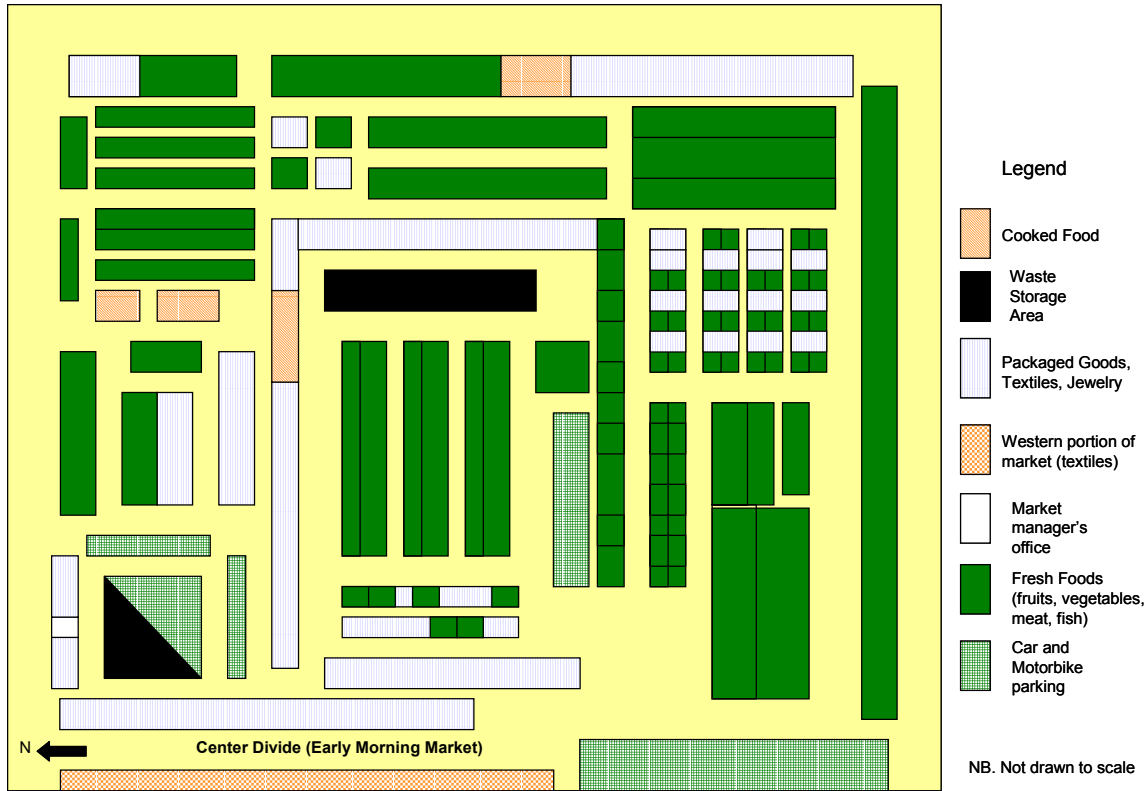


Figure 3.2: Schematic Drawing of Khuadin Daytime Market

The departure of those vendors from the early morning market who have sold all of their goods, together with the arrival of the daytime market vendors, and customers throughout the market creates considerable congestion. As well, road traffic is increased in this location as market traffic combines with the traffic of daily commuters working in the vicinity.

Another selling period found at this market is between the hours of 7 p.m. and 4 a.m. when the Evening Market operates. During this time, the parking area of Khuadin becomes occupied with vendors and wholesalers selling organic products. The managers of Thalat Khuadin do not run this evening market; it is operated by the regional district of Vientiane, and they take full

responsibility management of any waste generated. As they were not contacted for involvement with the pilot project, details relating to the waste management practices of this market were not examined.

3.1.2 Waste Generation and Management

On average, Khuadin market produces 3 tonnes of waste per day, as reported by weigh scale operators at Km 18 landfill (Lampone 2003). Waste generated in the early morning market is disposed of in the same manner as waste generated in the daytime market. Minor variation in the waste storage and disposal patterns were observed in various regions of the market, depending on the type of overhead coverage (e.g. galvanized metal roof versus a nylon tent) and floor type (e.g. soil and rocks versus concrete). Many fruit and vegetable vendors selling products on tarps on soil ground were more inclined to place waste material on the ground around the perimeter of their stall as it was generated throughout the day. This could partially be due to the availability of additional soil filler to vendors to cover the ground surrounding their stalls, thereby levelling



out the surface and covering up holes. Some vendors who generate large quantities of waste (such as cabbage and coconut vendors) store it in large wicker baskets or in piles at their stalls (Figure 3.3), while a small percentage who generate moderate amounts of waste store it in wicker baskets or plastic bags at their stall.

Figure 3.3: Coconut shells left at vendor stall

Recyclable materials such as metal cans and plastic bottles are not usually found in the waste stream, however all other waste materials are included. Separation of these recyclable items is done either by the informal sector (waste pickers) or by end of day waste collectors. At market close, the majority of vendors generally collect the waste scattered around their stall and group it into piles for collection by market cleaners and eventual disposal at the landfill.

3.1.3 Role of Waste Cleaners

At the official closing of each market, market-employed waste cleaners are responsible for the collection and transport of waste from each vendor stall to one of two designated collection areas; one dedicated waste storage area and the second being the parking lot, as shown in Figure



3.2. Waste is collected using brooms and dust bins (Figure 3.4), and placed into large wicker baskets or wooden trolley carts for transport to these central areas. Waste collection occurs twice per day. The first collection occurs at the close of the early morning market and the second, at the close of the daytime market. Waste from the early morning market is stored in the dedicated waste storage area and waste collected after 6 p.m. is placed in the parking lot storage area.

Figure 3.4: Waste Cleaner at Khuadin market

A total of 15 individuals are hired as market cleaners for Thalat Khuadin. Responsibilities include clean up of vendor stalls when the two respective markets are closed, collection and transport of waste material to the central pick-up areas, and loading of waste material into one of two dump trucks for transport to the landfill site. While collecting waste from the various areas, market cleaners were observed to remove recyclable materials from the collected waste. These were likely sold to the local recycle bank for supplemental income, as market cleaners were observed leaving the market at the end of their shift with canvas bags of recyclable water bottles and corrugated cardboard.

3.1.4 Role of the Collection Agency

The Lao Garbage Society (LGS) is contracted by Khuadin market for collection and transport of waste to the landfill site. Truck collection takes place on a daily basis between the hours of 8 p.m. and 9 p.m. Two trucks arrive at the market each night, one 3 tonne open top pick up, and



Figure 3.5: Waste Cleaners at Khuadin market assist with loading waste truck

the second, a 6 tonne side entry cylindrical dump truck (Figure 3.5). These trucks travel directly to the landfill from the market after evening collection. On occasion however, if a truck was not filled to capacity, stops would be made along the route to the landfill in order to fill the truck to its maximum capacity.

3.1.5 Waste Management Fees

The cost of waste management at Khuadin market involves the labour costs for market cleaners, and the cost for contracting the LGS to transport waste to the landfill. Each market cleaner is paid the sum of 750,000 KIP² per month, and the contract held between LGS and Khuadin market is for roughly 7 million KIP per month. These funds are generated by market owners through fees collected from vendors. Vendors are required to pay a daily fee for waste collection, which totals from 27,000 to 60,000 KIP per month. This is collected from over 600 vendors, totalling on average 26 million KIP per month, covering the waste management fees for the market. Reasons for the difference in monthly waste collection fees among vendors was not evident from data collected, as no significant trend among vendor types or stall location was noted.

² 10000 KIP = USD \$1 (approximate)

3.2 Thalath Thong Khankham

3.2.1 Physical Layout and General Operation

The Thong Khankham (TKK) market is located on Thongkhankham Street in central Vientiane, and encompasses an area of greater than 16,120 m². This market houses over 900 vendor stalls, comprising a mix of packaged goods, cooked food, textiles, and fresh fruit, vegetables and meat products. The physical layout of the market consists of an outdoor portion called the early morning market (Figure 3.6), and a primarily enclosed building known as the daytime market. A general schematic drawing of the market layout is shown in Figure 3.7. A narrow mud path separates the early morning market (EMM) from another separately owned market, referred to as



Figure 3.6: Early Morning Market vendors at TKK

the night market. The daytime market of TKK is constructed primarily of a cement slab floor, with some wooden plank and mud/rock flooring along the perimeter stalls. Walls of the building are made from brick on concrete, with supported galvanized metal roofing over the cement floor portions of the market, and tent coverage in areas of wood or mud/rock flooring.

The early morning market consists of vendors selling predominantly fresh fruits, vegetables and meat on wooden floor crates or pieces of tarp organized into rows on a mud/dirt floor. There is no overhead coverage for vendors selling in this area, however some have erected umbrellas or tarps for protection during times of heavy rain. Wooden floor crates vary in elevation from the ground and are positioned side by side and in rows. Organization of the daytime market is such that three distinct regions are visible, depending upon the types of tables items are sold on, floor cover and the overhead coverage. Meat, fish and cooked food products are sold in one area, constructed of concrete floor and galvanized metal roofing. Textiles and some packaged good vendors also sell products in a large section of the market near this area with the same flooring and overhead coverage.

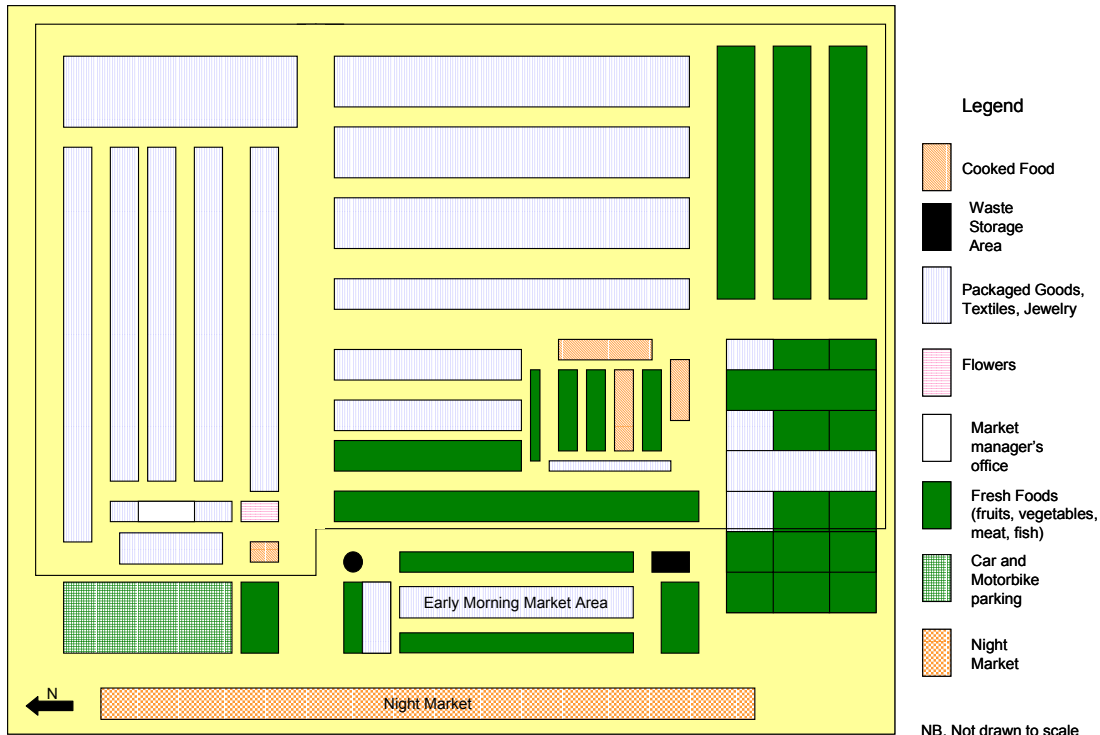


Figure 3.7: Schematic Drawing of TKK Market

Surrounding the meat, fish and cooked food area is a mixture of packaged goods vendors selling



items on elevated wooden crates. Fresh fruits and vegetables are sold in two main areas, one with wooden plank flooring and nylon tent coverage, and a second near the front entrance of the market on uniform wooden tables with galvanized metal roofing. There is a marked difference between the waste management practices of vendors in these two areas; those selling products at the front entrance of the market keep waste out of customer eyesight in bags or baskets under their tables (Figure 3.8), while vendors selling products on wooden crates scatter waste on the ground around the perimeter of their stalls.

Figure 3.8: Waste stored under vendor table, placed on mud/rock floor

Operation of the early morning market occurs between the hours of 5 a.m. to 11 a.m., and the daytime market from 8 a.m. to 5 p.m. The early morning market sells primarily fresh food products while the daytime market sells a variety of food, clothing and textile items. Unlike

Khuadin market, early morning market vendors do not continue to sell products in the daytime market, as vendors successfully sell their products by the time of market close.

3.2.2 Waste Generation and Management

Typically, TKK market generates 3.3 tonnes of waste per day in the dry season, and 3.8 tonnes per day in the rainy season, as reported by weigh scale operators at Km 18 landfill (Lampone 2003). The variation between dry and rainy season values is a result of precipitation adding weight to waste stored in uncovered waste containers/dumpsters. Waste management practices varied at this market depending on the type of overhead coverage of the vendor stalls and the ground surface upon which they were situated. As stated above, three distinct regions were noted in this market, and waste management practices in these areas differed as well. Vendors with metal roof overhead coverage, concrete floor ground surface and standardized tables collected waste generated throughout the day in plastic bags stored at their stalls. Several wicker baskets were seemingly randomly placed between several stalls. However, these were not market provided, but rather purchased and owned by specific market vendors. Recyclable materials such as metal cans and plastic bottles were not often found in the waste, as they are removed by the informal sector, waste collectors, or in some cases, kept aside by vendors for their own sale. At market close, vendor cleaned up their stalls and placed their waste near their stalls for later pick up by market cleaners. Overall, this market was noted to be considerably neat and well kept.

3.2.3 Role of Waste Cleaners

The TKK market has a waste cleaning staff of 20 individuals. Responsibilities of the cleaners involve clean up of the stalls and transport of waste to the dumpsters for collection. These dumpsters are designed such that cleaners are not required to be present at the time of pick up for any loading activities.

At the end of each market day, market-employed waste cleaners collected waste from the vendor stalls and transported waste to a central location where dumpsters (both open and closed) donated by the Japanese International Corporation Agencies (JICA) were located. Waste cleaners in this market collected waste and cleaned the market using brooms, wicker baskets and

wooden trolley carts, similar to Khuadin market. However, the general condition of the market is significantly cleaner, requiring less effort on the part of the cleaners.

3.2.4 Role of the Collection Agency

The Urban Cleaning Service (UCS) is contracted by the market managers to collect waste each evening. This is accomplished using a hydraulic lift truck, which removes full dumpsters and replaces them with empty ones for the following day's waste. Dumpsters collected were driven directly to the landfill. Excess waste unable to fit into the TTK dumpster was stored in the dumpster for the neighbouring night market, as this does not always fill to capacity. However, as reported by the market manager of TTK, if there is ever a considerable amount of excess waste, UCS could be requested to make an additional trip to the market for collection.

3.2.5 Waste Management Fees

Waste management at this market involves a monthly payment of 300,000 KIP per month to each waste cleaner, and a 7 million KIP per month contract with UCS to transport full dumpsters to the landfill on a daily basis. These funds are generated by market owners through a combination of fees collected from vendors. Vendors are required to pay a daily fee for waste collection, which totals from 21,000 to 90,000 KIP per month. Reasons for the difference in monthly waste collection fees among vendors was not evident from data collected, as no significant trend among vendor types or stall location was noted. Waste collection fees are obtained from over 900 vendors, totalling roughly 34 million KIP per month, covering the waste management fees for the market.

3.3 Thalath That Luang

3.3.1 Physical Layout and General Operation

That Luang market occupies an area of approximately 9,000 m², and is located on a major road south of Rue That Luang in Vientiane. The market is comprised of two separate buildings, a larger building where the daytime market is operated and a smaller building to the south of the daytime market where the early morning market is operated. The morning market is similar in appearance to an open paved parking lot, with many vendors selling fresh fruits, vegetables and meat on 91 X 91 cm wooden crates or pieces of tarp. Overhead coverage in the area consists of tarps and tent to shield from sun and rain.

The main daytime market is divided into three distinct sections or zones. Zone 1 is the location of clothing and textile vendors found within the main building with concrete floors and supported galvanized metal roofing. Zone 2 is the region for sale of grocery items or packaged goods. This group of vendors are found lining the walls of Zone 1 with wooden plank flooring and galvanized metal roofing. Zone 3, is constructed of a mixture of galvanized metal roofing and tent or tarp overhead coverage. Flooring consists of a mixture of wooden planks, concrete slab and exposed mud and rocks. Vendors in this zone sell products on elevated wooden crates and tables. The division of vendors into zones 1, 2 and 3 facilitates the different waste management practices that occur in each zone throughout the day. A total of 370 vendors are located in the daytime market, selling a variety of packaged good, cooked food, fresh fruit, vegetable and meat, as well as textiles. A total vendor count was not obtained for the early morning market, however this market sells primarily fresh fruit, vegetables and meat. A general schematic drawing of the daytime market layout is shown in Figure 3.9. The EMM is located south of the daytime market and is not shown in the figure.

Operation of the early morning market occurs between 3 a.m. and 9 a.m., however vendors are allowed access to the area from as early as 1 a.m. The hours of the main market's operation are between 5 a.m. and 7:30 p.m. Similar to the TKK markets, vendors from the early morning market generally do not sell in the daytime market as well.

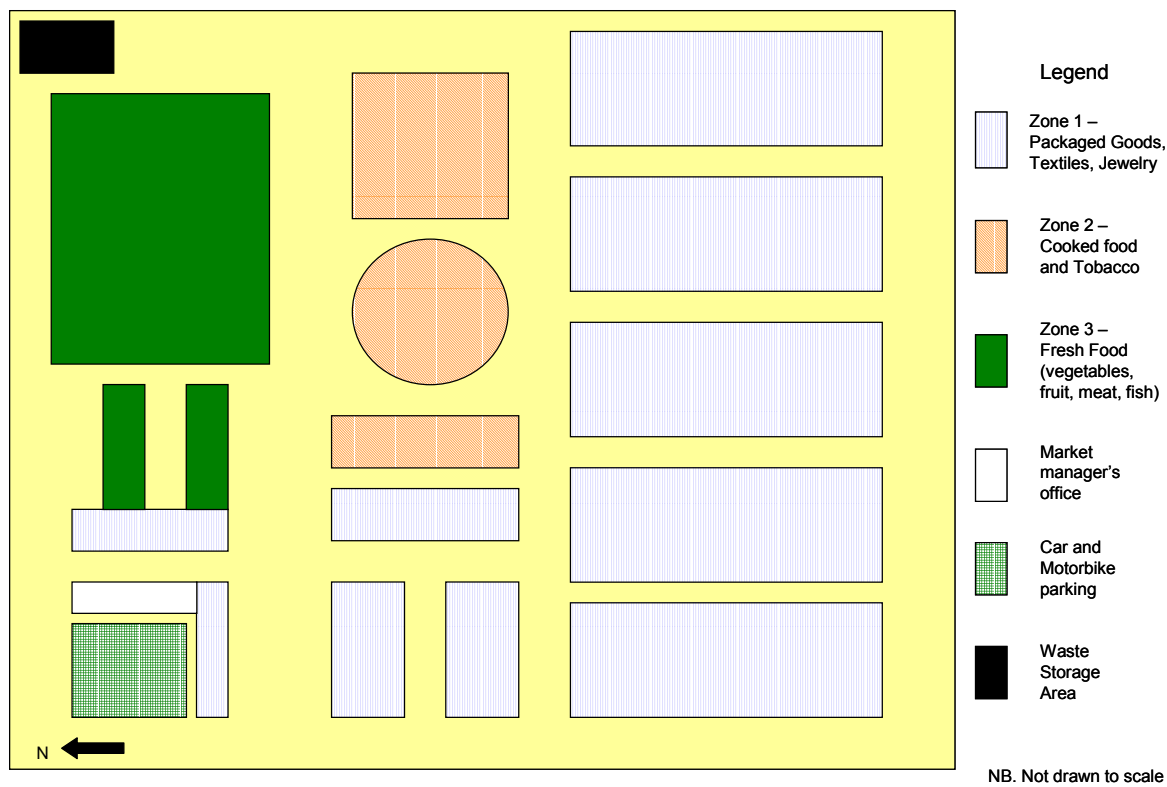


Figure 3.9: Schematic Drawing of That Luang Daytime Market

3.3.2 Waste Generation and Management

That Luang market was reported to generate an average of 3.9 tonnes of waste per day³, as conveyed by weigh scale operators at Km 18 landfill (Lampone 2003). Waste management at this market is quite different from the methods observed in the other two previously discussed markets. The early morning market and the daytime market have separately assigned waste cleaners. Waste is generated and stored at the stalls of the early morning market in a similar manner to those at Khuadin market and the vendors located on wooden crates with tent coverage at TTK market. Waste scattered among vendor stalls is collected at market close and brought to the landfill. In the daytime market, however, waste is collected differently in each zone. There is no visible waste on the floor other than food and paper waste found in the area where cooked food is purchased and served. Recyclable materials are kept separate from the regular waste stream by vendors and waste collectors. Interviews with vendors revealed that these recyclable materials are occasionally given to the less fortunate at the end of the day or personally delivered to the recycle bank. As well, waste cleaners were observed to sort through bags of waste in order

³ This includes waste from both the daytime and early morning markets.

to remove recyclable cardboard and plastic bottles. In sum, this market was noted to be extremely neat and well kept.

3.3.3 Role of Waste Cleaners

The early morning market of That Luang had a total of three dedicated waste cleaners. Duties



involved waste pick up from individual vendors and placement into a central location for collection shortly after. Waste was collected at 9 a.m. each day, and cleaners would assist in piling waste into the dump truck for disposal at the landfill. In the main market, a team of five waste cleaners (Figure 3.10) periodically travelled through Zones 2 and 3 of the market, removing waste from the area it was generated.

Figure 3.10: Waste cleaner collects waste throughout the day

While collecting waste, recyclable materials were removed from the bags and kept in a location separate from other waste. All other collected waste material was placed at the back of the market in a JICA dumpster. These dumpsters were emptied three times per day, in the early morning, the afternoon and the early evening. Market cleaners collected waste from Zone 1 only at market close as this region of the market sold primarily textiles and clothing, and thereby produced a minimal amount of waste.

3.3.4 Role of the Collection Agency



Urban Cleaning Service (UCS) is the agency responsible for waste collection at the That Luang market. In the early morning market, daily scheduled waste collection takes place from a central location by a 3 tonne open-ended pick-up truck between 9:30 and 10:30 a.m. Waste cleaners aid in the filling of the truck, which then travels directly to the landfill. In the daytime market,

Figure 3.11: Hydraulic lift truck drops off empty bin and takes full bin to landfill

waste was brought to the dumpster periodically throughout the day in order to fill the dumpsters for the three scheduled collection times at this market. The dumpster removal and replacement was completed with one hydraulic lift truck (Figure 3.11), and driven directly to the landfill without stops. Overall, a total of four waste collections are scheduled for the That Luang market, one from the EMM and three from the daytime market.

3.3.5 Waste Management Fees

Waste management at this market is the most costly of the three markets studied, despite the market employing the least number of waste cleaners. A monthly fee of 450,000 KIP is paid to each waste cleaner, however the UCS contract set up with this market is for 15 million KIP per month, given the greater frequency of trips to and from the landfill. This is also reflected in the higher daily waste collection fee that vendors pay, ranging from 45,000 to 60,000 KIP per month. The market generates roughly 19 million KIP per month in waste management revenues, covering the waste management fees for the market. Reasons for the difference in monthly waste collection fees among vendors was not evident from data collected, as no significant trend among vendor types or stall location was noted.

3.4 Summary

The following table provides a summary of the different waste management features among the three markets studied.

Table 3.1 – Summary of Market Details

Market Name	Khuadin	TKK	That Luang
Hours of Operation	4am - 8am; 8am - 6pm	5am - 11am; 8am - 5pm	3am - 9am; 5am - 7:30pm
What they sell	Fresh FVM; PG, Textiles, Cooked Food	Fresh FVM; PG, Textiles, Cooked Food	Fresh FVM; PG, Textiles, Cooked Food
Number of vendors	~ 600	~ 900	~ 370 (daytime market only)
# of waste cleaners on staff	15	20	8
Amount of waste generated	~3 tonnes per day	~3.3 tonnes per day (dry) ~3.8 tonnes per day (wet)	~3.9 tonnes per day
Payment to cleaners	750,000 KIP/mo	300,000 KIP/mo	450,000 KIP/mo
Collection company	Lao Garbage Society	Urban Cleaning Service	Urban Cleaning Service
Payment to company	7 million KIP/mo	7 million KIP/mo	15 million KIP/mo
Truck type used	3 tonne and 6 tonne pick up	Hydraulic lift truck	Hydraulic lift truck; pick up
Range of vendor paid waste collection fees	27,000 - 60,000 KIP/mo	21,000 - 90,000 KIP/mo	45,000 - 60,000 KIP/mo
Floor Coverage	Fresh items, PG, Cooked food: mud/rock Textiles: concrete and wood	Mixture of mud/rock, concrete and wood	Fresh items, PG, Cooked food: mud/rock Textiles, PG: concrete
Overhead Coverage	Fresh items, PG, Cooked food: tent/tarp Textiles: galvanized metal	Mixture of tent/tarp, galvanized metal	Fresh items, PG, Cooked food: tent/tarp Textiles, PG: galvanized metal

4.0 ANALYSIS OF SEPARATION OPTIONS

In order to assess the feasibility of separation options, a framework for analysing each option must be developed. This framework should identify the options, and then employ a set of criteria to evaluate each option.

4.1 Views of Stakeholders

Separation options and evaluation criteria were determined through the interviews with market managers and other members of the waste management sector, along with comments made by vendors while completing the questionnaires.

A review of vendor comments reveals that vendors in the market were interested in introducing composting to the existing waste management system. It appeared to be a method of improving the current level of sanitation at the markets and a good effort to reduce the amount of waste going to landfill. Furthermore, composting was also viewed as being potentially profitable, since the product could be sold to help farmers.

The manner in which waste is separated is an important factor to consider, as it affects both the efficiency of the composting process and the quality of the final product. Both on-site separation and off-site separation were considered in this research. Two major issues with vendor participation in waste separation were uncovered during informal discussions with vendors. The first was that vendors felt their work day schedules were already very busy. As a result, additional work that would be associated with separating waste could be inconvenient. Moreover, some vendors claimed that they were not interested in this extra responsibility during their work day, especially when they already paid a fee for the clean up of their stall area. Finally, vendors were unwilling to incur additional costs in the event that waste separation was implemented at the site.

Interviews with market managers provided specific points that needed to be incorporated into evaluation criteria. While each market functions somewhat differently and market managers

expressed concerns that related to the operation of their own markets, the general consensus among the market managers was that their primary focus is to minimize potential additional costs associated with composting.

When market managers were questioned specifically about separation options, such as organics separation, responses varied, with only two of the three managers agreeing that separation at the source was a possible option. Further, when discussing the possibility of asking vendors to source separate organics, market managers generally felt that vendors could be asked to do so; however whether or not they would conscientiously separate waste was questionable. It was then suggested to market managers that vendors might be more willing to comply if the existing fee paid for waste management was reduced. One manager was adamantly opposed to the idea of altering the collected fee; however the others said that they would consider altering the fee schedule if any of the following conditions were met:

- 1) The market receive financial assistance from other agencies for other market expenses,
- 2) A portion of the profits made from either sale of waste to the composting facility or the sale of final compost product be given to the market, or
- 3) Waste collection agencies were willing to decrease their fees accordingly.

Market managers further stated that if waste separation were to become an additional responsibility for market cleaners, then market cleaners would need to be trained on proper separation methods, and as such, have their salaries increased to reflect the additional workload. This would be another reason for the request for additional financial assistance in order to make up for lost revenues or increased costs.

4.2 Criteria Development

Using the information gathered from meetings, interviews and questionnaires, a set of criteria was developed for the evaluation of the various waste separation options. Criteria were grouped into the following three categories: *Economic, Convenience and Ease of Implementation, and Health & Environmental.*

1. Economic criteria address the costs and benefits to the various stakeholders. These include costs to market managers, such as those associated with waste transport¹ and disposal, and on-site separation; costs to market vendors and changes in income to market cleaners.
2. Convenience criteria consider how each alternative could potentially impact on the current degree of effort put forth by market managers, vendors and market cleaners. Further, the ease with which each of these options could be implemented, from the perspective of the market managers, vendors and market cleaners, are examined.
3. Health and Environmental considerations focus on how each alternative could affect the overall aesthetics and level of sanitation in the market.

Therefore, the following criteria were considered during the evaluation of each separation option:

Economic

- Costs to Market Manger
 - Cost of transportation and disposal
 - Labour and Equipment
 - Tipping Fees
 - Off-site composting facility
 - Landfill
 - Cost of on-site separation
 - Land
 - Equipment
 - Labour
- Costs to vendor
- Income to market cleaners

Convenience and Ease of Implementation

- For market manager
- For vendor
- For market cleaner

¹ It is important to recall that the transportation and disposal of waste (which includes collection) are currently the responsibility of private companies contracted to provide this service. Therefore, these are only factored for consideration as they relate to potential changes in cost affecting contracts with market managers.

Health and Environmental

- Market Aesthetics & Sanitation

As the value of the compost produced is based on the mode of processing and should not be significantly affected by the method of separation, compost quantity and value are assumed to be constant for all options, but will affect the net costs and tipping fees of the composting facility.

4.3 Separation Options and Analysis

Several basic separation options, as illustrated in Figure 4.1, were identified and evaluated using the above criteria. Two main options are based on the location where separation of organics and inorganics would take place, either on-site (at each market, Option A) or off-site (Option B). The on-site option is then further subdivided; after the waste is separated on-site, the organic waste could either be composted on-site (decentralized composting, Option A-1), or be shipped to an off-site composting facility (centralized composting, Option A-2).

With the on-site separation option, either market vendors or market cleaners could be given the task of separating the organic waste from the inorganic waste. For example, vendors could separate the waste at their stalls throughout the day in between customers, and if market cleaners are given the responsibility, they could separate waste as they collect it.

Finally, for all options, the inorganic (non-compostable) waste would be transported to the landfill approximately 20 km from the market.

The remainder of this chapter consists of a preliminary evaluation of the three basic options on the basis of the criteria discussed above. As shown in Figure 4.1, one of the important differences between the options relates to the transportation of organic and inorganic wastes to the composting facility and the landfill.

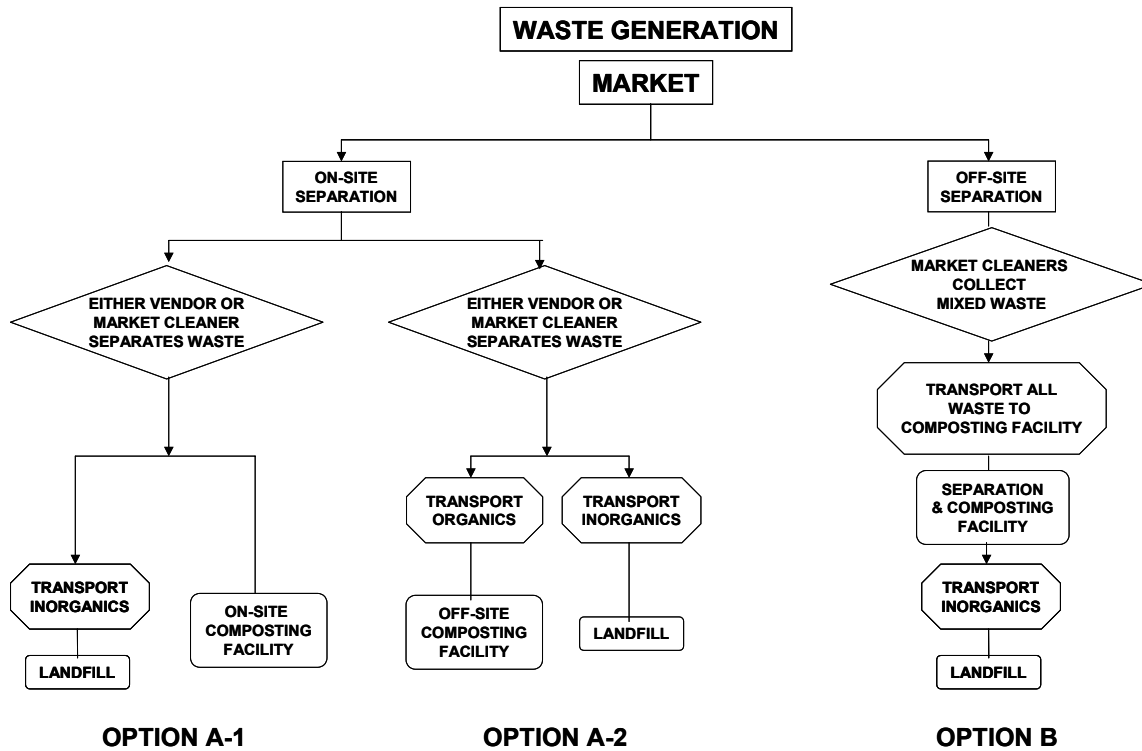


Figure 4.1: Separation Options

The location of the facility relative to the market area and landfill is a major cost factor. With on-site separation and composting, the organic waste material would not need to be moved from the market to a composting facility. The cost associated with off-site composting depends on the distance that waste would have to be transported to reach the facility. To address this, two basic alternative distances were considered for the off-site facility: 1) a distance along the edge of the city, and 2) along the outskirts of Vientiane, as shown in Figure 4.2. For comparison purposes, the existing system is also shown in the diagram.

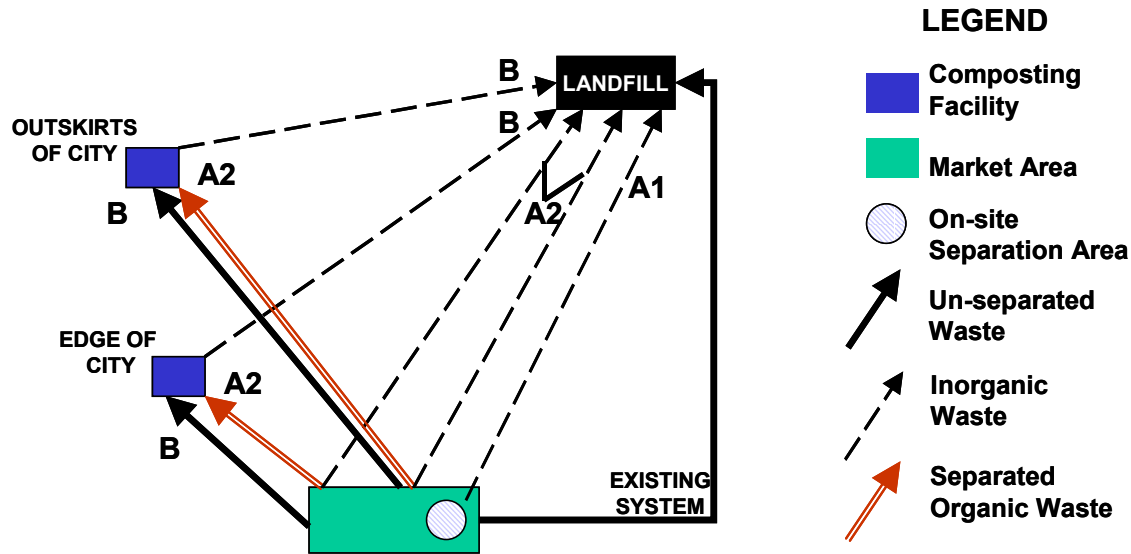


Figure 4.2: Location Options for Composting Facility

The directional arrows in Figure 4.2 show the movement of waste for each of the three options considered. While transport of the final compost product could also be a cost factor, it is not included in this analysis as it depends on variables such as location of end-product users, which was not examined in this research.

The first option, A-1, involves on-site separation of organic and inorganic wastes and on-site processing of organic waste. Only inorganic waste would be transported, and therefore this option of decentralized composting involves the least amount of transportation of wastes. The second option, A-2, also involves on-site separation of organic and inorganic waste, however it would also include transport of organic waste to a centralized off-site composting facility, and transport of inorganic waste to the landfill. This option would require more waste transportation than the first. The final option, B, does not involve any on-site separation or processing. All market-generated waste would be shipped “as is” from the market to the centralized composting facility for separation and processing, and then inorganic waste would be shipped to the landfill. Compared to option A-2, a greater load is initially transported to the composting facility, as waste is not separated.

4.3.1 Changes in Costs

Assessment of the separation options from the perspective of changes in costs incurred by market managers, which would be passed on to vendors and in some cases market cleaners, used the following generic equation.

$$C = C_{T1} + C_{T2} + C_{SL} + C_S + C_{CF} - C_E \quad \text{Equation (1)}$$

where:

C = Change in costs incurred by market managers (KIP/month)

C_{T1} = Transport and disposal cost for waste, W_{CF} , shipped to the off-site composting facility (KIP/month)

C_{T2} = Transport and disposal cost for separated inorganic waste, W_L , shipped to the landfill (KIP/month)

C_{SL} = Labour costs associated with vendors or the market cleaners for on-site separation of waste (KIP/month)

C_S = Cost of storage devices for separated waste not immediately shipped out to one of the waste facilities (KIP/month)

C_{CF} = On-site composting facility net costs, including set-up and operation of the facility, minus revenue from compost sales (KIP/month)

C_E = Existing costs for transportation and disposal of all waste, W , to landfill (KIP/month)

As shown in the previous equations, total waste, W , is comprised of waste going to landfill and waste going to the compost facility. This gives us the following relationship:

$$W = W_L + W_{CF} \quad \text{Equation (2)}$$

It is important to recognize this when considering the quantity of waste being transported to the various facilities.

Each cost variable is discussed in greater detail below as it relates to the specific option being assessed, including the key variables necessary for consideration in the three different separation

options. It is important to note that these are not intended as an exact quantification of economic factors; rather, they are a means of organizing and considering the variables involved in the evaluation and comparison of the three options.

4.3.2 ON-SITE SEPARATION – OPTION A-1

SEPARATED ORGANIC WASTE COMPOSTED ON SITE, AND INORGANIC WASTE TRANSPORTED TO LANDFILL

This option involves waste separated at the market by either vendors or market cleaners, with the organic component composted at an on-site facility operated by the market cleaners, and the inorganic component shipped to landfill.

Given that organic waste is separated and processed on-site, C_{T1} is 0 and can be removed from equation (1). Therefore, the equation for this alternative becomes:

$$C = C_{T2} + C_{SL} + C_S + C_{CF} - C_E$$

where:

$$C_{T2} = [(N_{T2} \cdot D_L \cdot C_{OM}) + (W_L \cdot TF_L) + C_{misc}] \quad \text{Equation (3)}$$

in which:

N_{T2} = the number of truck trips per month used for one way transport (trips/month)

D_L = distance travelled to the landfill facility (km/trip)

C_{OM} = maintenance and operation costs, such as fuel and repair costs per unit distance travelled (KIP/km)

W_L = total mass of the load dropped off to the landfill facility in one month period (kg/month)

TF_L = tipping fee for drop off of waste to the landfill facility (KIP/kg)

C_{misc} = any miscellaneous fees accumulated in one month period (such as labour) determined by the transport company when calculating fees for transportation contract with market (KIP/month)

² Included in both C_{T1} and C_{T2} are tipping fees associated with the composting and landfill facilities, respectively, and operating and maintenance on trucks used for transport. Tipping fees include the cost of land, labour and equipment for these facilities. Details of these can be found in the following sections.

If the market cleaners complete waste separation, then C_{SL} is as follows:

$$C_{SL} = N_{MC} \cdot C_{Si} + C_{Tn} \quad \text{Equation (4)}$$

in which:

N_{MC} = the number of market cleaner employees required for separation of the waste (no units)

C_{Si} = the monthly salary increase associated with the responsibility of waste separation being added to their existing duties (KIP/month)

C_{Tn} = monthly cost for training that would be required for market cleaners on proper separation techniques (KIP/month)

If market vendors complete waste separation, then C_{SL} is as follows:

$$C_{SL} = C_D + C_{Tn} \quad \text{Equation (5)}$$

in which:

C_D = the additional monthly costs paid by market managers based on a reduction in waste collection fees for vendors (KIP/month)

C_{Tn} = monthly cost for training that would be required for vendors on proper separation techniques (KIP/month)

This alternative would require storage of inorganic waste on-site, as the quantity generated may not warrant daily collection. Based on observations at the markets examined, popular waste storage devices include disposable wicker baskets or metal JICA bins. Both of these options could have monthly fees such as monthly replacement of wicker baskets and rental fees for metal JICA bins.

Thus:

C_S = cost for a storage device for inorganic waste not immediately shipped to the landfill (KIP/month)

The net monthly cost of the on-site composting facility, C_{CF} , is given by:

$$C_{CF} = \overbrace{C_L + C_{Eq_i}}^{\text{Initial Costs}^3} + C_{OL} + C_{EQ_o} - R \quad \text{Equation (6)}$$

in which:

- C_L = the one time cost of land for the facility (KIP/month)³
- C_{Eq_i} = initial equipment costs for operational items (which may include pitch forks, shovels, sorting tables, and bins for storage of final product) (KIP/month)³
- C_{OL} = cost for facility operation labour, paid as a monthly salary (KIP/month)
- C_{EQ_o} = ongoing equipment costs for replacement of damaged tools, storage bins, and daily disposable items such as masks, and gloves (KIP/month)
- R = revenue from sale of compost (KIP/month)

In order to evaluate the change in costs associated with this option, we deduct the current costs:

$$C_E = \text{Existing costs for transportation of all waste to landfill (KIP/month)}$$

Therefore, substituting equation (3), (4), (5), and (6) into equation (1) gives the overall equation as follows:

$$C = \left[(N_{T_2} \cdot D_L \cdot C_{OM}) + (W_L \cdot TFL) + C_{misc} \right] + \overbrace{N_{MC} \cdot C_{Si} + C_{Tn}}^{\text{MarketCleaner}} \text{ or } \overbrace{C_D + C_{Tn}}^{\text{Vendor}} + C_S + \left(\overbrace{C_L + C_{Eq_i} + C_{OL} + C_{EQ_o} - R}^{\text{Initial Costs}^3} \right) - C_E \quad \text{Equation (7)}$$

³ An annualization factor would need to be applied to these values in order to spread out costs on a monthly basis. For example, if land for the facility is purchased for \$10,000 USD, financed at an interest rate of 8% and has an expected life of 10 years, the annualization factor would be 0.15, which would result in annual costs of \$1500 or \$125/month.

4.3.2.1 Economic Impacts

Costs to Market Managers

Using equation (7), the changes in monthly costs to each market manager can be determined for this option in which composting takes place at an on-site facility, with inorganic waste shipped to the landfill.

Costs associated with the initial start up of an on-site composting facility include land and purchase of equipment required for operation. While full payment for these items may be required at the time of purchase, in order to keep all costs comparable, these can be spread over the life of the facility to evaluate all variables on a monthly basis.

On-site land could be costly, with cost relating to the actual purchase cost of land in or around the market facility, or relating to the loss of revenue that could result from having to remove or re-organize vendors in the market to accommodate the on-site facility. The amount of land required and the allowable proximity to the market sales areas would be dependant upon the composting method chosen. Further, the land chosen would have to be well drained in order to prevent excessive pooling during periods of rain. The facility would also need to be located away from any drinking water sources, to avoid odour and contamination issues (Haight and Taylor 2000). Storage of the finished product would also require land or specialized containers, depending on the method chosen to prepare the compost. However, this is dependent upon both the rate of compost production and its sale.

A second important cost factor would involve obtaining the necessary tools and equipment to begin operation of the facility. Again, the specific tools required would depend on the composting technology chosen. If a simple process were chosen, tools used in gardening and farming would be appropriate and relatively inexpensive to obtain. This suggests a more labour intensive processing method, however studies have shown these methods to have greater success in smaller developing countries (Enayetullah and Sinha 2002, Gtz n.d.) and so should be effective in Laos.

Operational labour is another cost to be considered with an on-site facility. This could require hiring additional market cleaners or an increase in salaries for existing cleaners due to increased responsibilities.

There are a number of financial benefits that could also be derived from having an on-site facility. Elimination of organic waste transportation and disposal costs is a major benefit to this option. Transportation of inorganic waste still remains a cost for market managers. However, since less waste would need to be transported to the landfill, the rate at which collection bins would reach their capacity would decrease, thereby reducing the required frequency of transportation trips. With reduced frequency, there should be reduced transportation and disposal fees (tipping fees) to the landfill, compared to those currently paid by markets. Further, processing organic waste on-site would allow for market managers to gain direct benefit from the sale of the manufactured compost product. As well, having the product produced at the market could also increase chances for the sale of the finished product, assuming that the clientele for compost is located in the area of these markets and not at a great distance away (e.g. closer to farms). This would be beneficial not only to market managers, but vendors as well if profits from sales are great enough to assist with reductions in waste collection fees or incentives for efficient separation of waste.

Economic Effects on Vendors and Market cleaners

With the added responsibility of waste separation, both vendors and market cleaners' roles could change. Having market vendors separate waste would require that they be responsible for waste only from their stall. Thus, training would not be very complicated. As well, involving market vendors would make overall market improvement a communal effort, which might satisfy market vendors who were concerned about their level of participation in the composting process during interviews. However, the additional responsibility could take time away from sales. The vendors could be compensated for the added responsibilities through a reduction in waste collection fees.

The other option of having market cleaners responsible for the separation task is an equally viable option; though as stated previously, the added responsibility of operating a composting

facility may require additional employees or a proportional increase in salary. As well, training may be more complex than training for vendors as the variety of waste being separated would increase. In either situation, the decision of who separates the waste depends on which group the market manager feels that he/she can obtain the most efficient and reliable results for funds spent. Regardless of who is responsible for the work, financial assistance to cover either the reduction in waste fees or hiring of additional employees could be provided by the profits from compost sales. This factor, however, would not play a major role in deciding among the various separation options since the costs associated with either party are not anticipated to be major cost elements.

Storage devices would also be required with this option, depending on who is responsible for waste separation. Organic waste separated throughout the day or at the end of the day by market cleaners would not require storage, as waste could be brought to the compost pile immediately. Inorganic waste would need to be stored; however, this could be compiled on-site until a large enough quantity (i.e. the capacity of a waste truck) is obtained to require collection. Existing storage or purchase/rental of additional baskets or JICA bins could be used.

If vendors are given the responsibility of separation, this could require a storage device for each vendor stall for separated waste, or a larger device to be shared among several stalls. In both instances, the type of storage device required is dependent upon the quantity of organic waste generated by the vendor, as some may find plastic bags adequate for storage, whereas others may need wicker baskets. Existing storage may be appropriate, however the purchase of plastic bags and wicker baskets may be required. Overall, the waste storage costs with this option should be relatively low.

In the event that the composting facility does not prove to be as profitable as intended, this would pose a concern to both vendors and market cleaners, as the transfer of set up and operation costs could be passed down. Vendors may experience increased vendor fees and market cleaners could have decreased salaries and/or a reduction in staff.

4.3.2.2 Convenience and Ease of Implementation

An on-site composting facility would result in market managers having the additional responsibility of managing the operation of the compost facility, as well as ensuring buyers for the final product. As well, managers would have to oversee the separation completed by either market vendors or cleaners to ensure it is completed to the desired standard, which may change current levels of job convenience.

Market cleaners would experience a change in their job, as responsibilities would expand to include developing and maintaining the compost pile and potentially separation of waste. This would require training for the various new tasks, however given market cleaners familiarity with generated waste, implementation is not anticipated to be difficult.

If vendors were given the responsibility of waste separation, given the number of vendors that would require training and an overall change in daily behaviour required, this could be considerably difficult to implement. Vendor convenience would also be compromised if given the additional responsibility of separation, along with potential inconvenience if changing stall location in order to make room for the compost facility is needed.

4.3.2.3 Health and Environmental Impact

From a health and environmental perspective, the location of the facility would need to meet local guidelines or regulations associated with odour and water contamination issues. If compost piles are properly maintained, there should not be significant negative health and environmental problems associated with having the facility on site. However, a compost pile that is not properly operated could create significant odour problems. This could be detrimental to customer attendance at the on-site market, especially to those vendors with stalls closest to the compost pile. Further, odour issues may be an indicator of additional problems associated with improper pile management such as pests.

Aesthetically, existing market concerns over organic waste scattered around vendor stalls could be reduced by implementing this option. Given the economic value placed on organic waste, the tendency to throw organic waste on the ground should lessen, in an effort to make more compost

for sale. In addition, the potential for discussion of the saleable compost being produced from what was previously regarded as invaluable waste would likely increase with an on-site facility. Thus, from both an aesthetic and environmental perspective, on-site composting could improve existing conditions.

4.3.3 ON-SITE SEPARATION – OPTION A-2

SEPARATED WASTE TRANSPORTED TO AN OFF-SITE COMPOSTING FACILITY

This option involves waste separated at the market by either vendors or market cleaners, with the organics shipped to an off-site composting facility and the inorganics to the landfill. Since composting takes place at an off-site facility, C_{CF} is 0 and can be removed from equation (1). Therefore monthly cost changes expected with this option are as follows:

$$C = C_{T1} + C_{T2} + C_{SL} + C_s - C_E$$

where:

$$C_{T1} = [(N_{T1} \cdot D_{CF} \cdot C_{OM}) + (W_{CF} \cdot TF_{CF}) + C_{misc}] \quad \text{Equation (8)}$$

in which:

- N_{T1} = the number of truck trips per month used for one way transport (trips/month)
- D_{CF} = distance travelled to the composting facility (km/trip)
- C_{OM} = maintenance and operation costs, such as fuel and repair costs per unit distance travelled (KIP/km)
- W_{CF} = total mass of the load dropped off to the composting facility in one month period (kg/month)
- TF_{CF} = tipping fee for drop off of organic waste to the facility for composting (KIP/kg)
- C_{misc} = any miscellaneous fees accumulated in a one month period (such as labour) determined by the transport company when calculating fees for transportation contract with market (KIP/month)

C_{T2} is defined by equation (3).

If the market cleaners complete waste separation, then equation (4) defines C_{SL} . Similarly, if market vendors complete waste separation, then equation (5) defines C_{SL} .

C_S and C_E remain unchanged from equation (1).

Substituting equation (8), (3), (4) and (5) into equation (1) gives the overall equation as follows:

$$C = \left[\underbrace{(N_{T1} \cdot D_{CF} \cdot C_{OM})}_{\text{MarketCleaner}} + \underbrace{(W_{CF} \cdot TF_{CF})}_{\text{Vendor}} + C_{misc} \right] + \left[(N_{T2} \cdot D_L \cdot C_{OM}) + (W_L \cdot TF_L) + C_{misc} \right] \quad \text{Equation (9)}$$

$$+ \underbrace{N_{MC} \cdot C_{Si} + C_{Tn}}_{\text{or } C_D + C_{Tn}} + C_S - C_E$$

4.3.3.1 Economic Impacts

Costs to Market Managers

Using equation (9), it is possible to quantify the change in monetary costs that would be experienced by the market if on-site separation of waste for shipment to the appropriate facilities were implemented.

Recalling Figure 4.2, which shows the potential distances that the waste would be transported to an off-site facility, both the mass of waste transported and the distance travelled by trucks are major considerations affecting the cost of this option. Transportation contract fees would include a component of maintenance and repair fees for general wear and tear on transport vehicles, both of which would be a function of distance and mass transported. Currently, these fees are paid for transport of waste to the landfill, located approximately 20 km from the market area. Thus, if the permanent composting facility were to also be located along the outskirts of Vientiane, a payment of similar magnitude could be expected.

Costs associated with the construction and operation of the permanent composting facility would be factored into tipping fees paid by the private transportation company hired by the market to transport waste. These fees would indirectly become a market cost, as they would be included in the transportation contracts between markets and transportation companies. Organic waste given to the facility by markets will become the source of profit for the facility. As such, markets

could be compensated for this by a reduction in tipping fee, based on how much organic material is brought to the market and the revenues from compost sale associated with it.

Costs associated with transporting inorganic waste to the landfill must also be considered, and this will depend on the location of the composting facility in relation to the landfill.

While there are additional transportation costs associated with this option compared to option A-1, the on-site facilities, there are also benefits to having a facility located centrally. Expansion of the facility to include processing of waste from a greater variety of participants, such as hotels and households, could likely be accommodated in the future whereas this may not be possible at facilities located at each market. Another benefit of having an off-site facility, provided that there are several options to consider, is that the facility can be located in such a way as to minimize the distances for both the producers of organic waste and the potential purchasers of the finished composted product. Having a minimized distance for both parties has been shown in composting studies conducted in developing countries, to be a major economic consideration with respect to the success and profitability of the project (Gtz n.d.).

Economic Effects on Vendors and Market cleaners

Similar to the previous option, involving market vendors in waste separation would satisfy those vendors wanting to take an active role in the composting program. However, this would require considerable change in daily vendor behaviours and also reduce the amount of time vendors could devote to sales, and so discounted waste collection fees may be required. If market cleaners are given the responsibility of separating waste, this would increase daily responsibilities and so either an associated increase in salary or the hiring of additional employees would be expected.

While both market vendors and cleaners could effectively complete the separation task, the decision would depend upon the market manager's preference and confidence in the ability of the selected group to separate effectively and efficiently for the payment offered by market management. Generally, this latter factor should not play a major role in deciding among the

various separation options, as compensating either group for the responsibility is not expected to be a large cost.

The need for storage devices could be a potential issue with this option, depending on who is responsible for separation. Market cleaners who collect waste at the end of each day can separate waste at this time and ship organics to the off-site facility. This leaves the need for storage of inorganics, which may be piled on-site until a large enough quantity (i.e. the capacity of a waste truck) is obtained to require collection. This could be achieved using existing storage or purchase/rental of additional baskets or JICA bins.

For those market cleaners that collect and separate waste throughout the day, additional storage for separated waste may be required. Similarly, vendors given the responsibility of separation may require a storage device for each vendor stall for separated waste, or a larger device to be shared among several neighbouring vendors. In both instances, the type of storage device required is dependent upon the quantity of organic waste generated for the market. Existing storage may be appropriate, however the purchase of plastic bags and wicker baskets may be required. Overall, the waste storage costs are not anticipated to be significant enough to heavily impact the choice of this option, given that existing storage devices or low cost storage can be used.

Both the financial costs and benefits associated with this option would affect market vendors and cleaners, as increases in costs will likely result in market managers increasing monthly fees, cutting market cleaner salaries or releasing excess market cleaners. However, savings experienced by market managers are also expected to be passed down to vendors and market cleaners.

4.3.3.2 Convenience and Ease of Implementation

This option is not anticipated to severely impact the convenience of market managers, however vendors or market cleaners could experience changes in convenience depending on which part is given the responsibility of separation. As with the previous option, if vendors are required to separate waste, this may be challenging to implement, as it would require training of a large

number of vendors compared, a change in daily behaviour and loss of time for product sales. If given to market cleaners, training on proper separation techniques would be more involved given the greater variety of waste to handle, however ease of implementation is expected to be high as market cleaners are already familiar with market waste. As well, market managers would have to oversee the separation completed by either market vendors or cleaners to ensure it is completed to the desired standard. Overall, this option, compared to A-1, would be easier to implement and have fewer effects on convenience since the need to run an on-site facility is removed.

4.3.3.3 Health and Environmental Impact

As with the previous option A-1, placing an economic value on organic waste could assist in clean up around vendor stalls and reduce the amount of scattered waste. If the composting initiatives are well communicated to market vendors and customers, it is expected that those scattering waste would have greater interest in market cleanliness. This would have a positive impact on market aesthetics. Further, this option would not immediately pose any perceived direct impacts on health or the environment since potential odour and water contamination issues associated with option A-1 would not be present.

4.3.4 OFF-SITE SEPARATION – OPTION B

ALL WASTE GENERATED AT THE MARKET IS SHIPPED AS IS TO THE COMPOSTING FACILITY FOR PROCESSING

Option B involves existing waste collection practices employed at the markets. All of the waste is then sent to an off-site composting facility rather than the landfill. Since the cost of an on-site facility would therefore be 0 in this option, equation (1) is modified as follows:

$$C = C_{T1} + C_{T2} - C_E$$

where equation (8) defines C_{T1} and equation (3) defines C_{T2} .

Substituting equation (8) and (3) into equation (1) gives the overall equation as follows:

$$C = \left[(N_{T1} \cdot D_{CF} \cdot C_{OM}) + (W_{CF} \cdot TF_{CF}) + C_{misc} \right] + \left[(N_{T2} \cdot D_L \cdot C_{OM}) + (W_L \cdot TF_L) + C_{misc} \right] - C_E \quad \text{Equation (10)}$$

4.3.4.1 Economic Impacts

Cost to Market Manager

Using equation (10), the change in monetary costs can be quantified for this option, in which separation and composting takes place at an off-site facility.

In the other options, A-1 and A-2, costs of labour, storage and land were considered. This is not the case in option B, as these variables would not be direct costs to market managers. Rather, these costs would be included in tipping fees paid through transportation contracts. Similar to option A-2, processing organic waste off-site raises concerns regarding the distance from the market to the composting facility and related costs. Waste could be transported to the composting facility using a truck of the same carrying capacity as what is currently being used to take waste to the landfill. Referring back to Figure 4.2, it is apparent that if the facility is located closer to the market area than the landfill, then a decrease in transportation costs relative to the existing costs would ensue since the load would be transported a shorter distance.

There is also the added cost of transporting the inorganic waste to the landfill. Similar to option A-2, fees associated with this are dependant upon the proximity of the composting facilities to the landfill. Since waste is separated at the off-site facility, it is possible that inorganic waste from a number of other markets will be combined in order to ship full loads to the landfill. As such, waste transportation contracts between market managers and waste collection agencies may include fees for transportation to both facilities in one contract. Therefore, although Equation 9 divides transport costs and tipping fees into organic and inorganic components, the possibility of being charged only one fee for shipment of both organic and inorganic waste exists. For example, in equation (10), TF_L could equal 0 and be included in TF_{CF} , and so should not be double counted.

Tipping fees at the composting facility will depend on a number of factors, including the cost of separating the organic and inorganic waste, revenue from sale of compost and the cost of disposal of inorganic waste at the landfill. Compared to option A-2, the tipping fee for this option would be greater due to the cost of separation.

Similar to option A-2, the off-site facility could be easily expanded to include processing of waste from a greater variety of participants, such as hotels and households. And when siting the facility, the final location can be optimized to minimize the distances for both the producers of organic waste and the potential purchasers of the finished composted product, increasing the success and profitability of the project (Gtz n.d.).

Economic Effects on Vendors and Market cleaners

Based on the discussions above, the cost incurred by market managers may increase or decrease compared to current costs, since these are highly dependant upon the location and development of the off-site composting facility. Any increase or decrease in this cost would likely be passed on to market vendors and market cleaners, as stated in the previous two options.

4.3.4.2 Convenience and Ease of Implementation

Option B would be fairly easy to implement by the markets in terms of convenience and ease of implementation since it requires little or no change from existing waste management practices at the markets.

4.3.4.3 Health and Environmental Impact

Given that there are no changes in market operation with this option, there are no perceived changes in health and environmental factors at the markets. However, these may be concerns at any new site. While the economic importance of organic waste still holds true in this option, the fact that the market does not play a direct role in the separation or composting process may make the economic value of organic waste less obvious to those at the markets. However, this option does remove any concerns with odour and water contamination issues that were present with option A-1.

4.4 Income to Waste Pickers

Many waste pickers in the area are interested in locating materials such as recyclables and/or products that are found in good reusable shape. These are commonly found in waste at the markets and at the landfill. Therefore, the separation of inorganic material from the waste stream would initially not appear to cause a significant problem and could simplify the job of the waste picker. However, while conducting this study, it was found that some waste pickers were also interested in finding organic food scraps in good condition for personal consumption. For these individuals, this process could cause indirect economic problems since they may need to spend more money to purchase food, rather than locating it in market waste. In addition, organics separation from inorganic waste may result in easy identification of recyclable and reusable material by the employees of the composting facility. This could then remove these items from the waste that reaches the landfill, which may cause a loss in income to those waste pickers located at the landfill. However, this would only be a major issue if recyclable materials form market waste comprised a large component of total recyclables. Overall, implementation of organic waste separation options could result in economic costs to the income of the waste picker.

4.5 Options Summary

The following table summarizes the various options and allows for comparisons between them to be made.

Table 4.1: Separation Options Summary

	Option A-1	Option A-2	Option B
Criteria for Consideration	On-site separation and composting.	On-site separation with shipment of separated waste to off-site facilities	Off-site separation and processing of all wastes.
ECONOMIC CONSIDERATIONS			
Costs to Market Manager	<ul style="list-style-type: none"> *Major cost include those associated with the development of the on-site facility such as land, equipment and labour; savings include reduced tipping fees at the landfill *Managers need to appoint either vendors or market cleaners the responsibility of separation and compensate the group accordingly *Inorganic waste needs to be transported to the landfill, however frequency of trips would be reduced from current conditions *Organic waste transportation costs eliminated *Market directly receives revenue from sale of compost 	<ul style="list-style-type: none"> *Depending on the location of off-site facility, transportation costs (including tipping fees) could be much higher than current costs or within the same range *Managers need to appoint either vendors or market cleaners the responsibility of separation and compensate the group accordingly *Inorganic waste needs to be transported to the landfill, however frequency of trips would be reduced from current conditions *Facility location can be optimized to ensure highest profitability 	<ul style="list-style-type: none"> *Depending upon the location of the facility with respect to both the markets and the landfill, transportation costs (including tipping fees) could be higher or lower than existing costs *Facility location can be optimized to ensure highest profitability
Costs to Vendor	<ul style="list-style-type: none"> *Changes will be passed on from Market Manager, whether market operation fees increase or decrease *If given the responsibility of separation, potential loss of time for sales (with potential for compensation through reduced fees) 	<ul style="list-style-type: none"> *Changes will be passed on from Market Manager, whether market operation fees increase or decrease *If given the responsibility of separation, potential loss of time for sales (with potential for compensation through reduced fees) 	<ul style="list-style-type: none"> *Changes will be passed on from Market Manager depending on their fee increase or decrease.
Costs to Market cleaner	<ul style="list-style-type: none"> *An increase in salary if given the additional responsibility of operating the composting facility and/or waste separation; or income could remain the same if additional market cleaners are hired for the task 	<ul style="list-style-type: none"> *Changes will be passed on from Market Manager whether market operation fees increase or decrease; could result in higher salaries if separation responsibility given to them, or a reduction in salary and/or the number of staff if not 	<ul style="list-style-type: none"> *Changes will be passed on from Market Manager depending on their fee increase or decrease.
CONVENIENCE AND EASE OF IMPLEMENTATION			
For Market Manager	<ul style="list-style-type: none"> *Managers would need to oversee that the new facility is running efficiently and find buyers for end product *Managers need to assign waste separation task to either vendors or market cleaners and oversee that separation is completed to desired standard 	<ul style="list-style-type: none"> *Managers need to assign waste separation task to either vendors or market cleaners and oversee that separation is completed to desired standard 	<ul style="list-style-type: none"> *No change in waste management practices
For Vendor	<ul style="list-style-type: none"> *If vendor responsible for the separation of waste, a large number of vendors will need to be trained and have less time to complete daily tasks; however if not, no expected change 	<ul style="list-style-type: none"> *If vendor responsible for the separation of waste, a large number of vendors will need to be trained and have less time to complete daily tasks; however if not, no expected change 	<ul style="list-style-type: none"> *No change in waste management practices
For Market cleaner	<ul style="list-style-type: none"> *If market cleaners used for operation of the composting plant, training would be required for the new job responsibilities; this could potentially include training for waste separation as well 	<ul style="list-style-type: none"> *If market cleaner responsible for the separation of waste, they will need to be trained for the new responsibility added to their daily tasks; however if not, no expected change 	<ul style="list-style-type: none"> *No change in waste management practices
HEALTH AND ENVIRONMENTAL			
Market Aesthetics and Sanitation	<ul style="list-style-type: none"> *Having the facility on site could improve market sanitation as the economic value of organic waste would be more easily seen by market vendors and customers, resulting in fewer organic waste scraps scattered among stalls *Potential odour and water contamination issues associated with having composting piles on-site 	<ul style="list-style-type: none"> *Having either vendors or market cleaners involved in the separation of waste could add to the awareness of the economic value of organic waste, which could lead to fewer organic waste scraps scattered among stalls and an increase in overall aesthetics 	<ul style="list-style-type: none"> *Despite increased economic importance placed on organic waste, market aesthetics and general environmental condition not expected to improve as vendors and cleaners not actively involved in the process

5.0 SUMMARY AND RECOMMENDATIONS

Using information gathered from sections three and four, a number of advantages and disadvantages were identified for the three waste separation options considered.

5.1 Summary of Findings

Key areas of concern identified by market managers, vendors and market cleaners included a general improvement in the level of sanitation at the market, compensation for either vendors or market cleaners if additional responsibilities were given to them, and most importantly, an overall minimization of additional costs for market operation.

In option A-1, where waste would be separated on-site and organic waste composted at an on-site facility, the major concerns raised by stakeholders are largely met. Having the facility on-site employs a number of market cleaners and allows for the greatest amount of market and community involvement in the process. As well, separation of waste on-site by vendors or market cleaners would also help to increase community participation, and achieve a more uniform awareness of the economic value of organic waste. This could result in an increase in market sanitation. Implementation of this option would result in a reduction in the amount of waste transportation required, which in turn reduces market operation costs. Having a decentralized compost system is generally labour intensive, however this would be effective in the Laos market environment. Market cleaners could be employed for operation of the facility and the need for imported materials and advanced technology would be removed. Further, this option allows for markets to receive direct revenue from sale of compost.

However, there are also areas of concern with this option, including initial set up of the facility and potential odours coming from the facility. The financial feasibility of starting a composting facility may appear challenging to market managers, as well as finding funds to compensate those given more responsibility. It may be possible to recover these costs could be through revenue generated from sales of the compost product, depending on demand and the price at which the compost product is sold.

Option A-2, in which waste would be separated on-site and organics and inorganics are shipped to separate off-site composting and landfill facilities, respectively, presents some similar advantages to option A-1. This includes market community involvement with separation of waste, which could help to improve the level of sanitation at the market through general awareness. As well, the location of the off-site facility can be optimized to ensure minimal distances for compost producers and end-product consumers, which would increase profitability of the facility. However, also associated with this option are increased waste transportation fees relative to option A-1. In addition, tipping fees at the off-site facility would also be a significant cost-contributing factor to consider.

Option B, where all waste would be shipped to the off-site facility for separation and composting, appears to meet some of the concerns expressed by market stakeholders. Since this option does not assign additional responsibilities to vendors or market cleaners, there is no need to financially compensate either stakeholder. Like option A-2, the location of the off-site facility can be optimized to ensure minimal distances for compost producers and end-product consumers, which would increase profitability of the facility. However, market sanitation levels are not expected to change, as there would be no visible change in existing waste management practices. The perceived value of organic waste may not be as apparent as in options A-1 and A-2 and so, the incentive to no longer throw organic waste on the ground would not be present. In addition, costs could increase, as waste is shipped without separation, resulting in a greater load being transported to the off-site facility, along with potentially higher tipping and processing fees.

Overall, examination of these three options uncovered that while the method of waste separation is an important factor to consider, the location of the composting facility is equally as important. Waste transportation costs are a major cost contributing factor, influenced directly by the load of waste transported and the distance travelled. Therefore, both separation and facility location are necessary components to consider with respect to the feasibility of the composting program.

5.2 Recommendations

As a result of the findings from this research, when making decisions as to what next steps should be taken towards the implementation of composting into the market systems of Vientiane, the following points should be considered:

1. There needs to be some degree of certainty in the market for organic compost. If a high quality, reasonably priced organic compost product is produced, and its sale relatively ensured, then the success of the initiative is increased considerably.
2. For on-site composting, suitable land would need to be found and acquired. If the market does not currently own such land for the development of the facility, funding might be obtained through donations from foreign development agencies, or through partnerships with local non-governmental organizations (NGOs) that are in a position of aid.
3. If a centralized composting facility option is chosen, close attention needs to be paid to the location of the off-site facility, as this can affect the sustainability of the project. As well, frequency of trips to the landfill for organic waste, which is a factor in all options considered, should be examined in an effort to reduce costs and maximize efficiency.
4. Intangible benefits that would come from a compost facility, such as employment opportunities for members of the community other than market cleaners, would enhance the income of the poor and members of the informal waste sector and need to be considered.

5.3 Areas for Future Work

In order to address all of the concerns raised by stakeholders, and assist decision makers responsible for the composting program, the following areas of research are recommended for further study:

- An in depth cost-benefit analysis using variables identified in the equations presented in Chapter 4, along with further information pertaining to transportation costs, maintenance fees and potential tipping fees. Having this information would enable decision makers to make informed decisions as to what the best and most sustainable composting facility option would be.
- An investigation on the potential purchasers and users of the compost end product is needed in order to estimate the amount of revenue that can be expected. As well, when determining the price for the compost product, it would be useful to determine the current costs of chemical fertilizers in order to ensure that the price set for compost for the end users (farmers, gardeners) is not higher than the price for comparable organic or chemical fertilizers.
- A study on the siting of the facility is also much needed, as this will determine the distance to be travelled for waste being transported. As this appears to be a key determinant in the cost of the project, this information would need to be included in the cost-benefit analysis. Further, the location of the facility should also aim to minimize both the distance between waste producers and the composting plant and between the composting plant and the compost purchaser. This information would also be useful to studies conducted on end users of compost.
- One of the most effective methods to ensure sustainability of new initiatives involves increasing the awareness of waste producers and waste workers on the economic value of organic waste and the benefits that come from proper separation. Educational efforts should also be extended to farmers and other potential end users of the compost, highlighting their environmental benefits compared to chemical fertilizers and additives.

With respect to landfill cost savings, the amount of money saved on tonnage to the landfill should also be highlighted, as ecological advantages would be beneficial on a macro-economic scale.

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APPENDIX I

QUESTIONNAIRE

Questionnaire for Market Vendors

Market Name: _____

Vendor Location: _____

Vendor Information

1. How long have you been selling at this market?

2. What days do you work? (check all that apply)

- | | |
|------------------------------------|-----------------------------------|
| <input type="checkbox"/> Sunday | <input type="checkbox"/> Thursday |
| <input type="checkbox"/> Monday | <input type="checkbox"/> Friday |
| <input type="checkbox"/> Tuesday | <input type="checkbox"/> Saturday |
| <input type="checkbox"/> Wednesday | |

2a) What time do you start work? _____

2b) What time do you end work? _____

3. Do you sell only in this area for the whole time?

- Yes
- No

4. If no, where do you go?

What time?

5. How far do you travel to get to this market everyday?

- | | |
|-----------------------------------|-----------------------------------|
| <input type="checkbox"/> 0-5 km | <input type="checkbox"/> 16-20 km |
| <input type="checkbox"/> 6-10 km | <input type="checkbox"/> 21-25 km |
| <input type="checkbox"/> 11-15 km | <input type="checkbox"/> 26-30 km |
| <input type="checkbox"/> > 30 km | |

(please specify)

6. How much do you pay for this space (KIP)?

- Per day
 - Per month
 - Per year
-

7. What type of product do you sell? (check all that apply)

- | | |
|--|---|
| <input type="checkbox"/> Fruits and Vegetables | <input type="checkbox"/> Baked goods (bread and cakes) |
| <input type="checkbox"/> Meat | <input type="checkbox"/> Soups and other cooked food |
| <input type="checkbox"/> Fish | <input type="checkbox"/> Packaged goods / Grocery Items |
| <input type="checkbox"/> Rice | <input type="checkbox"/> Kitchen Items |
| <input type="checkbox"/> Eggs | <input type="checkbox"/> Garlic/Onions, Paa Daek |
| <input type="checkbox"/> Noodles | <input type="checkbox"/> Other (please list) |
| <input type="checkbox"/> Blood | |
-

8. Did you grow / catch or bake these products for sale?

- Yes
- No

9. If no, where did you get these items for sale?

- Purchased directly from a farmer
- Purchased from another vendor
- Purchased from another country
- Purchased from a wholesaler/company (middle man)
- Other (please explain) _____

10. If you sell fruits or vegetables:

What do you sell in the dry season?

In the rainy season?

Waste Management

11. What do you do with any of your products that have gone bad in the day?

(For example, fruits that are rotten or meat that has gone bad)

- Throw away
- Someone working at the market collects it
- It is given away to someone not working at the market (please specify)

- It is sold to someone not working at the market (please specify)

- Other (please explain) _____

12. Do the products you sell come in any special packaging (i.e. boxes for your fruits and vegetables)?

- Yes
- No

13. If yes, what do you do with the packaging?

- Throw away
- Someone working at the market collects it
- Store it for later use
- It is sold to someone working at the market (please specify)

- It is sold to someone not working at the market (please specify)

- It is given away to someone not working at the market (please specify)

- Other (please explain) _____

14. What do you do with unsold items at the end of the day?

- Throw away
- Someone working at the market collects them
- Items are brought home
- Items are stored and guarded at the market for _____ KIP per _____
- Items are given away to someone not working at the market (please specify)

Items are sold to another vendor (please specify)

Other (please explain) _____

15. What do you do with waste as it is generated throughout the day?

- Store it at the stall
- Throw away periodically
- It is picked up by someone working at the market periodically
- Other (please explain) _____

16. Where does all of your waste go at the end of the day?

- I place in a central location
- It is picked up from my stall by market employees
- It is picked up by a waste company I have hired
- It is taken home with me
- Other (please explain) _____

17. If a central authority or private company picks up the waste from you, do you have to pay for this service?

- Yes
- No

18a. If yes, how much do you pay for this?

18b. How do you pay this amount?

- Price per day
- Price per basket of waste
- Price per kg of waste

Thank you very much for you time! Khop Chai Lai Lai!

APPENDIX II

SUMMARY TABLES
OF QUESTIONNAIRE RESULTS

Khuadin Market

	Vendor Types				
Khuadin	Cooked Food	Meat/Eggs/Fish	Fruits & Vegetables	Noodles, Blood & Rice	Packaged Goods / Textiles
# of each surveyed?	5	10	31	7	7
Days worked?	Everyday	Everyday	Everyday	Everyday	Everyday
Distance travelled?	6 - 20 km	6 - 20 km	6 - 20 km	6 - 20 km	6 - 20 km
Daily rental fee (KIP)	~2000	1000-5000	1000-8000	1000-2000	1000-3500
Change location?	No	Sometimes	Sometimes	No	No
Time of change?	Not applicable	After 3 pm	After 9 am	Not applicable	Not applicable
Grow/Catch sale items?	No	No	Some	Some	No
Where did sale items come from?	Ingredients purchased from wholesaler / company	Purchased from a 'middle man' (in between farmer and wholesaler)	Some purchased from a 'middle man' (in between farmer and wholesaler); some grow their herbs	Some purchased from wholesaler (noodles); blood is made	Purchased from wholesaler / company
Seasonal Variation?	None	None	None (vendors reported to sell the same items in both dry and wet seasons as items that are not locally available in one season are imported from Thailand (through 'middle man' so year round, the same items are sold	None	None
What do you do with....					
Products gone bad?	Some bring home for dogs; others throw away	Throw away	Majority throw it away, some sell it at a lower price if possible	Majority throw away, some rice vendors bring rice home to feed chickens	Not applicable
Packaging?	Bags are thrown away with some kept for waste or to bring home items	Bags are thrown away, cartons/boxes for eggs are re-used until broken	Some products come in wicker baskets, boxes and plastic bags - those in good condition stored for later use, others that are broken/soiled are thrown away	Bags in good condition kept for later use, the rest are thrown away	Boxes in good condition are sold to meat vendors in the market to place under their meat, others are kept for later use; plastic wrapping is thrown away

Khuadin Market

	Vendor Types				
Khuadin	Cooked Food	Meat/Eggs/Fish	Fruits & Vegetables	Noodles, Blood & Rice	Packaged Goods / Textiles
Unsold Items?	Thrown away or given to beggars	Stored at the market and guarded for a fee	Stored at the market and guarded for a fee; some stated that they keep reducing the price of items until all things are sold	Stored at the market and guarded for a fee	Stored at the market and guarded for a fee
Daily guarding fee (KIP)	1000 - 3000	1000 - 2000	1000 - 4000	1000 - 2000	1000 - 2000
How do you store waste generated in the day?	In a plastic bag	In a plastic bag	In a plastic bag or basket (NB. vendors with waste scattered around the stall did not report storing waste at the stall, but always in a bag or basket)	In a plastic bag	In a plastic bag or basket
End of day waste?	Leave at stall for collection	Leave at stall for collection	Leave at stall for collection	Leave at stall for collection	Leave at stall for collection
Daily collection fee (KIP)	1000 - 2000	1000 - 2000	1000 - 2000	1000 - 2000	1000 - 2000

Thong Khankham Market

	Vendor Types				
Thong Khankham	Cooked Food	Meat/Eggs/Fish	Fruits & Vegetables	Noodles, Blood & Rice	Packaged Goods / Textiles
# of each surveyed?	3	7	26	5	5
Days worked?	Everyday	Everyday	Everyday	Everyday	Everyday
Distance travelled?	0.5 - 10 km	0.5 - 10 km	0.5 - 10 km	0.5 - 10 km	0.5 - 10 km
Daily rental fee (KIP)	500 - 1000	1000-3000	3000 - 15000	3000 - 10000	3000 - 18000
Change location?	No	No	No	No	No
Time of change?	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable
Grow/Catch sale items?	No	No	Some	Some	No
Where did sale items come from?	Ingredients purchased from wholesaler / company	Purchased from a 'middle man' (in between farmer and wholesaler)	Some purchased from a 'middle man' (in between farmer and wholesaler); some grow their herbs	Some purchased from wholesaler (noodles); blood is made	Purchased from wholesaler / company
Seasonal Variation?	None	None	None (vendors reported to sell the same items in both dry and wet seasons as items that are not locally available in one season are imported from Thailand (through 'middle man' so year round, the same items are sold	None	None
What do you do with....					
Products gone bad?	Some bring home for animals; others throw away	Throw away; occasional sale to farmers for animal feed	Majority throw it away, some sell it to people who purchase it for animal feed	Majority throw away, some rice vendors bring rice home to feed chickens	Not applicable
Packaging?	Bags are thrown away with some kept for waste or to bring home items	Bags are thrown away, cartons/boxes for eggs are re-used until broken	Some products come in wicker baskets, boxes and plastic bags - those in good condition stored for later use, others that are broken/soiled are thrown away	Bags in good condition kept for later use, the rest are thrown away	Boxes in good condition are sold to meat vendors in the market to place under their meat, others are kept for later use; plastic wrapping is thrown away

Thong Khankham Market

	Vendor Types				
Thong Khankham	Cooked Food	Meat/Eggs/Fish	Fruits & Vegetables	Noodles, Blood & Rice	Packaged Goods / Textiles
Unsold Items?	Thrown away or given to beggars	Taken home	Most vendors reported that they sold all items brought to the market, some stated that they stored items at the market for guarding (those vendors selling on wooden tables at the front of the market pay the higher end guarding fees)	Stored at the market and guarded for a fee	Stored at the market and guarded for a fee
Daily guarding fee (KIP)	400 - 2500	None	1000 - 12000	1000 - 2000	1000 - 7000
How do you store waste?	In a plastic bag	In a plastic bag	In a plastic bag or basket (NB. some vendors who sold items like bamboo or cabbage would collect all waste and keep it in a designated basket or bag, separate from other packaging waste - this was common at stall near the front of the market)	In a plastic bag	In a plastic bag or basket
End of day waste?	Leave at stall for collection	Leave at stall for collection	Leave at stall for collection	Leave at stall for collection	Leave at stall for collection
Daily collection fee (KIP)	1000 - 2000	1500 - 2000	1500 - 2000	1500 - 2000	1000 - 2000

That Luang Market

	Vendor Types				
That Luang	Cooked Food	Meat/Eggs/Fish	Fruits & Vegetables	Noodles, Blood & Rice	Packaged Goods / Textiles
# of each surveyed?	2	3	6	1	2
Days worked?	Everyday	Everyday	Everyday	Everyday	Everyday
Distance travelled?	0.5 - 20 km	0.5 - 20 km	0.5 - 20 km	0.5 - 20 km	0.5 - 20 km
Daily rental fee (KIP)	1000 - 3000	3000 - 7000	2000 - 5000	~2000	3000 - 10000
Change location?	No	No	No	No	No
Time of change?	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable
Grow/Catch sale items?	No	No	Some	Some	No
Where did sale items come from?	Ingredients purchased from wholesaler / company	Purchased from a 'middle man' (in between farmer and wholesaler)	Some purchased from a 'middle man' (in between farmer and wholesaler); some grow their herbs	Some purchased from wholesaler (noodles); blood is made	Purchased from wholesaler / company
Seasonal Variation?	None	None	None (vendors reported to sell the same items in both dry and wet seasons as items that are not locally available in one season are imported from Thailand (through 'middle man' so year round, the same items are sold	None	None
What do you do with....					
Products gone bad?	Some bring home for dogs; others throw away	Throw away	Majority throw it away, some sell it at a lower price if possible	Majority throw away, some rice vendors bring rice home to feed chickens	Not applicable

That Luang Market

	Vendor Types				
That Luang	Cooked Food	Meat/Eggs/Fish	Fruits & Vegetables	Noodles, Blood & Rice	Packaged Goods / Textiles
Packaging?	Bags are thrown away with some kept to store waste generated in the day	Bags are thrown away, cartons/boxes for eggs are re-used until broken	Some products come in wicker baskets, boxes and plastic bags - those in good condition stored for later use, others that are broken/soiled are thrown away	Bags in good condition kept for later use, the rest are thrown away	Boxes in good condition are sold to meat vendors in the market to place under their meat, others are kept for later use; plastic wrapping is thrown away
Unsold Items?	Thrown away or given to beggars	Stored at the market and guarded for a fee	Stored at the market and guarded for a fee	Stored at the market and guarded for a fee	Stored at the market and guarded for a fee
Daily guarding fee (KIP)	1000-2000	500 - 1000	1000-2000	1000-2000	1000-2000
How do you store waste?	In a plastic bag	In a plastic bag	In a plastic bag or basket	In a plastic bag	In a plastic bag or basket
End of day waste?	Leave at stall for collection	Leave at stall for collection	Leave at stall for collection	Leave at stall for collection	Leave at stall for collection
Daily collection fee (KIP)	1500 - 2000	1500 - 2000	1500 - 2000	1500 - 2000	1500 - 2000