RRR-Project
From Research to Implementation
Component 1 – Waste Supply and Availability
Report – Hanoi

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Abbreviations

Abbreviation	Explanation
Agro-Industrial Waste	AIW
Animal Waste	AW
Biological Oxygen Demand	BOD
Chemical Oxygen Demand	COD
Clean Development Mechanism	CDM
Department of Natural Resources	DONRE
Effective Micro-organisms	EM
Faecal Sludge	FS
Faecal Sludge Management	FSM
General Statistics Office	GSO
Hanoi Sewerage and Drainage Limited Company	HSDC
Hanoi University of Civil Engineering	HUCE
Institute of Environmental Science and Engineering	IESE
Japan International Cooperation Agency	JICA
Joint Stock Companies	JSC
Market Waste	MW
Municipal Solid Waste	MSW
Sequencing batch reactor	SBR
Settleable Solids	SS
Solid Waste	SW
Solid Waste Management	SWM
Total Nitrogen	TN
Total Phosphorous	TP
Urban Environmental Company	URENCO
Ventilated Improved Pit	VIP
Wastewater Treatment Plant	WWTP
Watewater	WW

1. Introduction

This report was completed by Sandec as part of the “Resource, Recovery and Reuse – From Research to Implementation” project, and presents results of the “Waste Supply and Availability” analysis that was conducted in Hanoi, Vietnam. This chapter gives an overview of the considered waste streams, objectives of the analyses and sources of information. Chapter 2 contains background information on Hanoi’s population size and density. The following chapters then present results of the analysis for each of the following waste streams:

- 3: Municipal solid waste (MSW)
- 4: Market waste (MW)
- 5: Craft village waste
- 6: Agro-industrial waste (AIW) and animal waste (AW)
- 7: Wastewater (WW)
- 8: Faecal sludge (FS)

The specific objectives of the analyses that were conducted in Hanoi was to:

- Calculate quantities and characteristics of the defined waste streams
- Analyze and summarize the current waste management of Hanoi
- Present the accessibility of the defined waste streams, and provide preliminary findings on the potential for the implementation of waste-based business models

The information for this report was collected through review of secondary data, interviews, field observations and collection of primary data. Sources included:

- Existing reports from research institutes working in the field of waste management and sanitation,
- Reports from the National Government, translated from Vietnamese into English
- Conducting interviews with experts,
- Field data measurements for characteristics of FS

2. Overview of Hanoi

This chapter presents background information on Hanoi to provide a general understanding of the size, population density, geographical location and layout of the city.

2.1 Population and city boundaries

Greater Hanoi has a population of 6,844,000 (GSO, 2012), 40% of which live within the nine urban districts that formed Historic Hanoi (refer to Figure 1) prior to the expansion of its boundaries in 2008. The nine districts of Historic Hanoi have a total area of 180.6 km^2, which is 5.4% of the total Hanoi area (3,344.7 km^2). It was determined that the analyses should be focused on Historic Hanoi as it represents 40% of the population concentrated in 5.4% of the total area. In addition, data is also mostly available for Historic Hanoi. Data that was available and collected beyond is clearly stated. Ha Dong was classified as one of the urban districts in 2008 during the expansion of the administrative boundaries, while Tu Liem was included in December 2013 and is now divided into Bac (North) Liem and Nam (South) Liem. As a result, Urban Hanoi now has 11 districts but throughout this report Hanoi is referring to the nine districts of Historic Hanoi, if not stated differently. Table 1 defines the different terms in use in this report. Figure 1 shows the population densities of Greater Hanoi. A very clear distinction between dense urban, moderate populated peri-urban and less populated rural areas can be observed. Population densities range from 575 ppl/km^2 up to 37,160 ppl/km^2 (GSO, 2009). Historic Hanoi is broken up into 128 wards which are sub-sections of administrative units that play an important political role in Hanoi, as they all have their own People's Committee, which in urban areas governs all aspects of the commune, including socio-economic development, health care, education and police. This will be further elaborated in the institutional analysis component of RRR.

Table 1: Definition of terms in use for Hanoi and its administrative boundaries

Term	Definition
Historic Hanoi	nine urban districts prior to expansion in 2008
Urban Hanoi	nine urban districts of Historic Hanoi plus Ha Dong and Tu Liem, which joined in 2008 and 2013
Greater Hanoi	All urban, peri-urban and rural districts

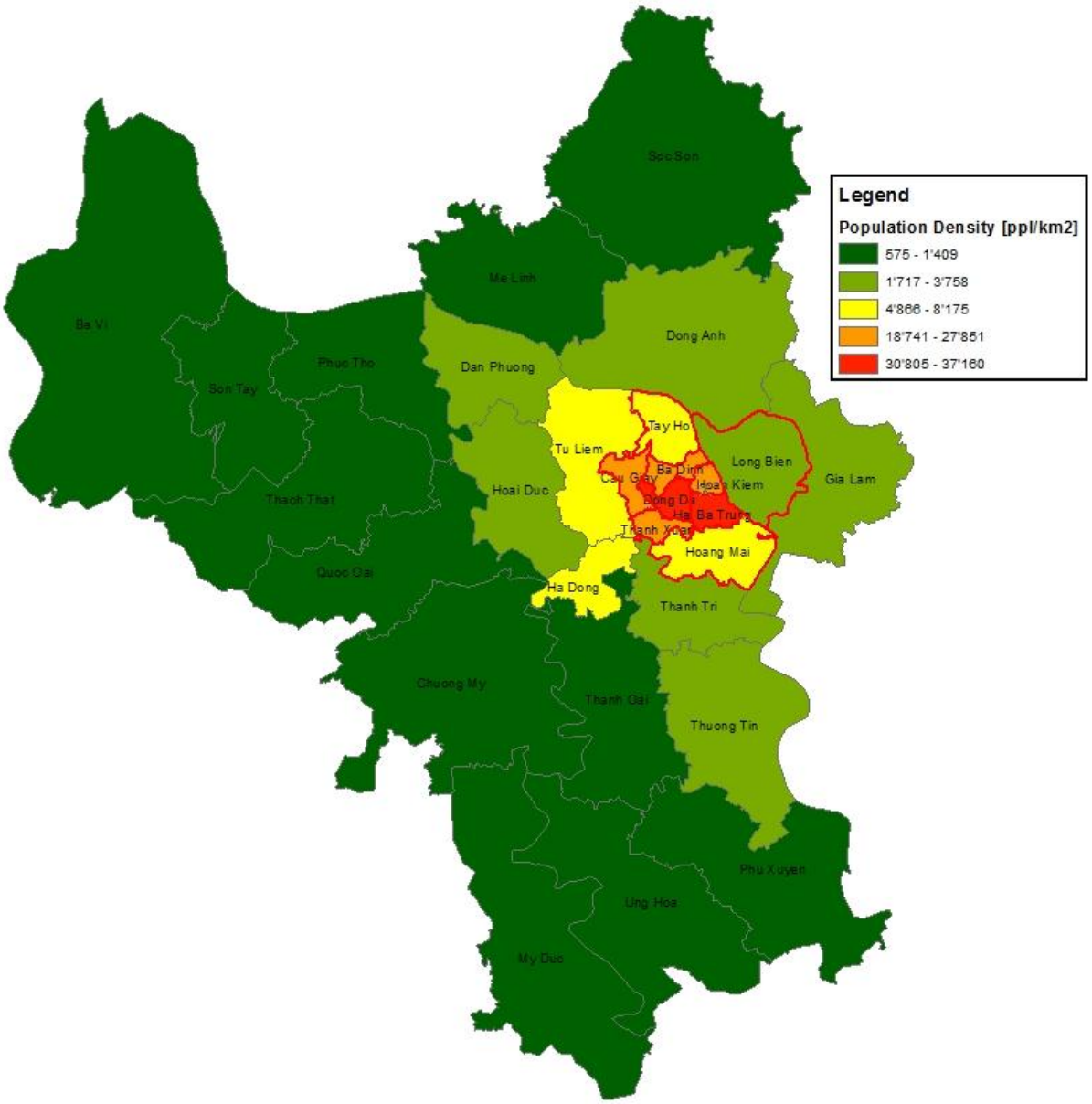

Figure 1: Population density of Greater Hanoi, Historic Hanoi consists of the areas that have red edging.[1]

2.2 Stakeholder mapping

In Hanoi, almost all stakeholders involved in the management of solid and liquid waste are state-owned companies or corporations. Stakeholders that have a clear mandate in waste management are described in the respective sections.

3. Municipal Solid Waste

This chapter summarizes data collected regarding MSW. As mentioned above, detailed information was available for Historic Hanoi, while quantities could only be estimated for Greater Hanoi. The characteristics of MSW are presented, and the productivity of treatment facilities.

3.1 Solid Waste Management (SWM): Collection and organization

The Urban Environmental Company (URENCO), a state-owned company, is responsible for the collection of MSW in the four most populated districts of urban Hanoi; Hoàn Kiếm, Ba Đình, Hai Bà Trưng, Đống Đa. The total population that is served in these four districts is around one million people (GSO, 2009). It is therefore the most densely populated area of Hanoi with a total area of 34 km^2. In an urban area with 30,000 inhabitants/km^2, clearly an organized and well planned solid waste (SW) collection and transport is necessary.

Rules and regulations for collection of MSW are described in “The regulation on general solid waste management in Hanoi City, 2010”. It stipulates that MSW must be collected daily, can only be discharged by the household or business at designated times and places, and is not allowed to be left on the pavement in front of businesses or households [2]. Waste containers are placed along the main streets with a distance of approximately 300 to 500 m, in which citizens can place their waste. Where collection trucks cannot access due to narrow roads, handcarts are used by collection workers from Hanoi URENCO. They ring a bell to inform the household that it is time for the waste collection. The waste is then transported to temporary dump sites and official transfer stations. From there it is collected by trucks and transported to the Nam Son Landfill, which is approximately 50 km north of the centre of Hanoi [2].

Along this whole chain the informal sector of so called “junk buyers” and “waste pickers” plays an important and vital role for the SWM of Hanoi. Recyclable inorganic waste can create a sufficient source of income while organic waste, especially from hotels and restaurants, serves as a good source of animal feed for farmers. As illustrated in Figure 2, the informal sector is highly involved within the collection of MSW. Four main points of informal waste recycling along the collection chain were identified by Kawai et al. [3]. The first point are junk buyers who visit households for the collection of recyclable waste. Secondly, waste pickers pick up recyclable waste from the street or temporary dump sites. This could be household, restaurant, shop and hotel waste. Thirdly, MSW collection workers from Hanoi URENCO recover recyclable waste during the collection of waste with handcarts. Lastly, waste pickers at landfills and composting sites are recovering recyclable waste that up until this point was not recovered. The results of the Kawai study show that junk buyers are responsible for the recycling of 8.8% of MSW by weight or 26.0% by volume. These collection activities greatly reduce the amount of MSW that Hanoi URENCO has to manage at landfills [3].

The collection of MSW in the other five urban districts as well as peri-urban and rural districts of Hanoi is managed by Cooperatives and Joint Stock Companies (JSC). All stakeholders involved in the collection and transport of MSW are listed in Table 2.

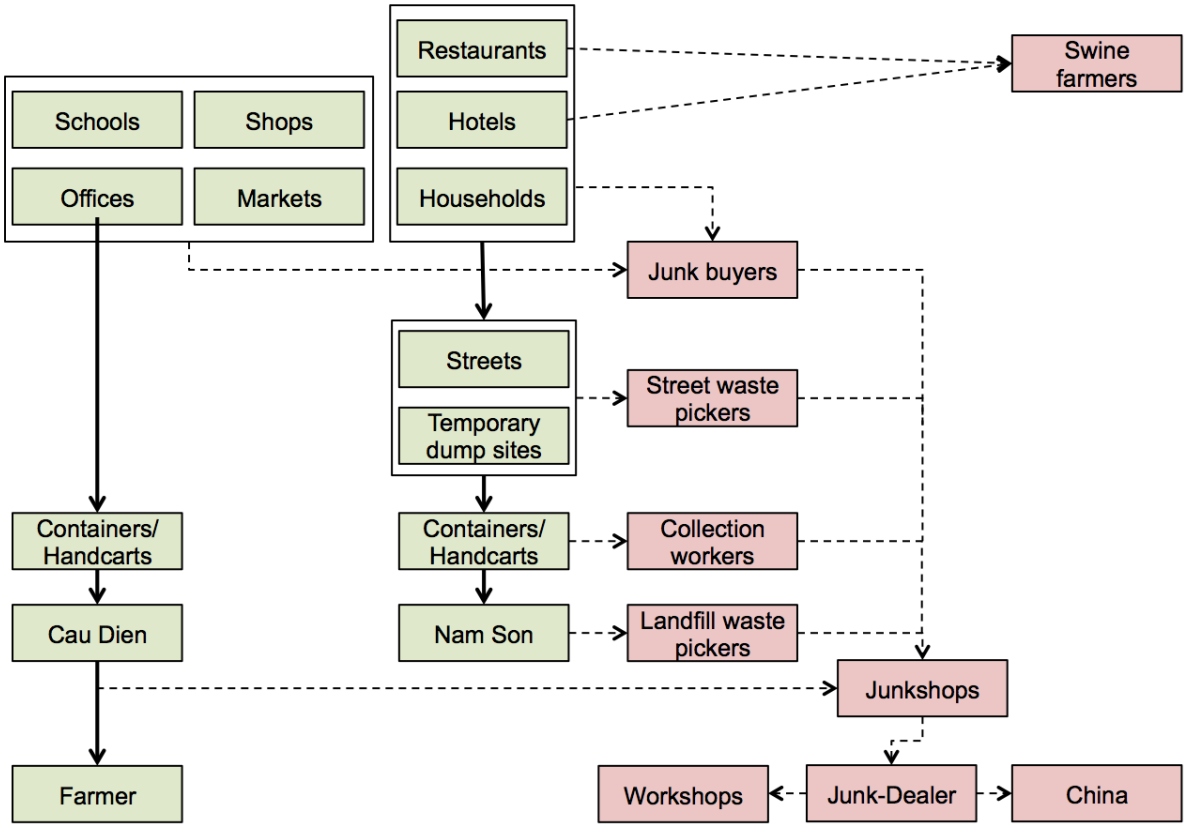

Figure 2: Sources of MSW, including the SWM collection and transport chain and the informal sector. The formal sector is marked in green, the informal in red. Adapted from [2]

Table 2: Companies managing MSW in Greater Hanoi. Urban districts are marked in bold [4].

Name of company	**Type**	**Collection area**
Urban environment one member state-owne limited company (URENCO Hanoi)	**State-owned company**	**4 districts: Hoàn Kiếm, Ba Đình, Hai Bà Trưng, Đống Đa)**
Thăng Long environment JSC	**JSC**	**5 districts: Hoàng Mai, Tây Hồ, Cầu Giấy, Long Biên, Thanh Xuân**
Tây Đô environment JSC	**JSC**	
Green environment JSC	**JSC**	
Ecological environment and technology JSC	**JSC**	
Thành Công cooperative	**Cooperative**	
Hà Đông environment JSC	**JSC**	**Hà Đông district**
Urban construction and environment JSC Sơn Tây	JSC	Sơn Tây town
Xuân Mai Urban environment Company	State-owned company	Chương Mỹ district
Red river environment JSC	JSC	Mê Linh district
Nội Bài commercial JSC	JSC	Sóc Sơn district

Name of company	Type	Collection area
Mai Dinh cooperative	Cooperative	Sóc Sơn district
Từ Liêm urban environment enterprise	**State-owned company**	**Từ Liêm district**
Thanh Trì urban environment enterprise	State-owned company	Thanh Trì district
Gia Lâm urban environment enterprise	State-owned company	Gia Lâm district
Đông Anh urban environment enterprise	State-owned company	Đông Anh district
Sóc Sơn urban environment enterprise	State-owned company	Sóc Sơn district

3.2 Quantities of MSW

In total 6,500 tonnes of MSW are generated in Greater Hanoi daily. It is estimated that 3,500 tonnes are coming from Historic Hanoi only. In addition another 1,950 tonnes of industrial solid waste are generated, of which around 15% is hazardous waste [5]. The collection rate of the four districts serviced by URENCO is 95% and 83% in all districts of Historic Hanoi, while the outer peri-urban districts have a collection rate of only 60%. The quantity of SW in Urban Hanoi increases on average by 15%/yr and the per capita production is as high as 0.9 to 1.0 kg/day [5, 6]. The results are summarized in Table 3. If SW keeps increasing with a rate of 15%/yr, the quantity of generated waste will double every five years.

Table 3: Quantities of SW generation in urban and peri-urban Hanoi [5].

No	Type of SW	Quantity t/d 2011
	MSW	6500
1	Urban Hanoi	3500
	Peri-urban Hanoi	3000
	Industrial SW	1950
2	Urban Hanoi	750
	Peri-urban Hanoi	1200
	Medical Waste	15
3	Urban Hanoi	5
	Peri-urban Hanoi	10

3.3 Characteristics

Characterizing MSW that is generated in Historic Hanoi is very difficult as quantities and characteristics of SW are variable based on peoples living habits, living standards, the economy development rate and the awareness around reducing and recycling of waste that has recently been generated. Several studies have looked into the composition of MSW in Hanoi and the results are summarized in Table 4. These studies have either studied the waste of households at the point of generation or at the level of disposal at the landfill. Depending on where the sampling has taken place, characteristics can differ significantly. Table 5 shows the results of a study that was conducted by URENCO, analysing the differences of SW composition for urban and peri-urban Hanoi. It becomes clear that in urban Hanoi less organic waste is produced, while the proportion of plastics and construction waste is much higher than in peri-urban Hanoi.

The Japan International Cooperation Agency (JICA), which has extensive experience in analysing the physical composition of MSW all over the world, has analysed the components of MSW at the input of landfills in Hanoi. Table 6 shows the results of these analysis. Nam Son landfill shows less organic and more plastic material than Xuan Son landfill. This can be explained by the contribution of more urban solid waste at Nam Son Landfill.

Table 4: MSW characterization studies, adapted from [3]

JICA (1999)		**World Bank (2004)**		**Ishigaki et al. (2008)**	
Category	**%**	**Category**	**%**	**Category**	**%**
Kitchen	42.0	Organic	49.1	Garbage, grass, leaves	39.4
Bones, shells	1.3	-	-	Bones, shells	0.4
Paper	5.3	Paper and textiles	1.9	Paper	6.2
Plastic, rubber	7.2	Plastic	15.6	Plastic	8.4
Glass	1.4	Glass	7.2	Glass	0.9
Metal, tin cans	0.6	Metal	6.0	Metal	0.3
-	-	-	-	Textiles	2.2
Others	40.5	Others	19.3	Others	41.9

Table 5: MSW composition in urban and sub-urban Hanoi (URENCO, 2008)

Type of waste	**Urban area**	**Sub-urban area**
Biodegradable/Compostable organic matter (vegetable, fruit, leave, residue food, animal carcasses)	38.0	56.0
Papers	4.9	2.0
Plastic, nilon, rubber, leather	16.6	9.2
Clothes, woods	5.2	4.1
Glass	2.8	1.3
Metals	2.0	0.4
Ceramics	7.4	0.7
Bricks, stones, concrete, slag, soil	23.0	12.2
Other impurities difficult to classify	-	14.1

Table 6: Components of MSW delivered to Nam Son and Xuan Son landfill (JICA, 2011)

Type of waste	**Nam Son landfill**	**Xuan Son landfill**
Organic waste	53.81	60.79
Paper	6.53	5.38
Fabric	5.82	1.76
Wood	2.51	6.63
Plastic	13.57	8.35
Leather and rubber	0.15	0.22
Metal	0.87	0.25
Crystal	5.07	1.69
Ceramics	0.39	1.26
Soil and Sand	6.29	5.44
Coal residues	3.10	2.34
Hazardous	0.17	0.82
Mud	4.34	1.63
Others	0.58	0.05

3.4 Treatment and Disposal

The main treatment and disposal method for MSW in Hanoi is sanitary landfills. There is one existing composting plant in Cau Dien, however of the 6,500 tonnes of MSW generated daily, it only receives 50 tonnes. All treatment facilities in urban and peri-urban Hanoi are summarized in Table 7. With a daily capacity of 3,000 ton/day, the Nam Son Landfill, approximately 50 km north of Hanoi, receives waste from the urban and five sub-urban districts. Furthermore, no transfer stations for MSW exist, which greatly increases transport costs. Next to the existing landfill, another treatment facility is under construction with a design capacity of 2,000 ton/day, which aims at producing compost and recycling inorganic material (e.g. plastics) that could be exported and sold. The research team visited the Nam Son landfill, but was not provided with any information about the construction of the new composting site. During the visit, the research team was not allowed to take any pictures and answers to questions were only given very limited.

Three more landfills exist in the peri-urban areas of Hanoi, each with a capacity of 100 ton/day. Waste from Gia Lam, Ha Dong and Thanh Oai is disposed of at the Nui Thong landfill, which is currently closed. Son Tay town has its own landfill and waste from the Gia Liam district is disposed of at the Kiêu Kỵ landfill .

In addition to the Cau Dien composting plant, it was reported that two more MSW treatment plants exist that produce compost. A field visit was made to the Seraphin treatment plant of Son Tay town, but it was found to be not operational. Interviews revealed that the treatment of MSW did not work as planned and that future plans are to reconstruct the treatment plant into a waste incinerator, which shall produce electricity through heat.

It is expected that Nam Son Landfill will soon reach its full capacity. Hanoi is facing serious issues with SWM due to the expected increase of SW generation and the potential of more MSW being collected from peri-urban areas. Therefore, a solid waste management master plan was developed which includes the construction of new, and expansion of existing solid waste treatment facilities until 2030 with a vision to 2050. Table 8 presents details of the master plan whereas planned treatment facilities are marked in bold. Most facilities will apply sanitary landfill as the treatment technology, while it is planned to also apply nutrient and energy recovery through incineration and composting. Phu Dong SW treatment complex will apply these technologies with a total capacity of 550 t/d in 2020 and serve Long Bien district, Gia Lam district and party support Viet Hung SW treatment complex. Detailed information was not available for the other planned treatment facilities.

In October 2010, E.ON Climate & Renewables and Bionersis have implemented a project under the Clean Development Mechanism (CDM) at the Nam Son landfill site to capture and flare the generated methane gas. This significantly decreased the impact of the landfill on the environment and a second phase is planned which includes the installation of biogas to energy valorisation units and is expected to generate five megawatts of electricity [7].

Table 7: SW treatment facilities receiving waste from urban and peri-urban Hanoi.

Name of facility	Management unit	Serviced area	Area (ha)	Situation
Landfill sites				
Nam Sơn SW treatment complex (Sóc Sơn district)	Hanoi URENCO	10 urban districts and 5 suburban districts	83.5	- Capacity: ~3,000 ton/day.
Nam Sơn SW treatment factory (construction) (Sóc Sơn district)		Sóc Sơn	140-160	- Capacity: 2000 ton/day - Production: compost, recycling materials
Kiêu Kỵ SW landfill (Gia Lâm district)	Gia Lam Urban Environment Enterprise	Gia Lam rural district	14	- Capacity: 100 ton/day.
Nui Thong landfill site	Xuan Mai Urban Environment Enterprise	Ha Đong, Chuong My, Thanh Oai		Temporarily closed
Xuân Sơn SW landfill (Sơn Tây town)	Son Tay URENCO	Son Tay town, Ba Vi district	5	Capacity: 100 ton/day
Viet Hung SW treatment site		Dong Anh district and partly support for Nam Son SW treatment complex	8.75	Capacity: 300 ton/day
Composting facilities				
Cầu Diễn composting plant (Từ Liêm district)	Hanoi URENCO	Organic waste from four inner districts (mainly from markets)	3	- Design capacity: 120 ton/day. - Treatment efficiency: <50% (receive: 50 ton/day) - Product: organic fertilizer: 8

Name of facility	Management unit	Serviced area	Area (ha)	Situation
				ton/day
Kieu Ki composting plant	Gia Lam Urban Environment Enterprise	Waste from Gia Lam district		- no detailed information available
Seraphin (Sơn Tây town)	SERAPHIN	Waste from Ha Dong district and collected waste by Thanh Cong Cooperative		- Capacity: 200 ton/day - Currently not operating

Table 8: Capacity and area of solid waste treatment facilities after the solid waste management master plan to 2030 and vision to 2050.

Name and district of facility	2020		2030		2050	
	Area (ha)	Capacity (ton/day)	Area (ha)	Capacity (ton/day)	Area (ha)	Capacity (ton/day)
Nam Son (Soc Son)	157	4500	257	6000	280	7000
Viet Hung (Dong Anh)	8.75	300	8.75	600	8.75	600
Kieu Ki (Gia Lam)	14		14	550	14	1000
Phu Dong (Gia Lam)	**7.5**	**550**	**12.5**	**850**	**20**	**1200**
Cau Dien (Tu Liem)	3.9	300	3.9	300	3.9	300
Chau Can (Phu Xuyen)	**7.5**	**450**	**13**	**800**	**20**	**1000**
Cao Duong (Thanh Oai)	**6.0**	**400**	**9.0**	**500**	**15**	**750**
Hop Thanh (My Duc)	**2.0**	**150**	**6.0**	**450**	**13**	**850**
My Thanh (My Duc)	1.0	100	2.5		5.0	
Van Dinh (Ung Hoa)	3.0	150-200	5.0		7.0	
Dong Lo (Ung Hoa)	2.0	150-200	2.5		5.0	
Xuan Son (Ba Vi)	26	700	57	1600	73.5	2500
Dan Phuong (Dan Phuong)	**2**	**150-300**	**5**		**5**	
Nui Thong (Chuong My)	3	200	7.5	450	10	450
Lai Thuong (Thach That)	**4**	**300**	**6**	**450**	**11.8**	**700**

Dong Ke (Chuong My)	**5**	**350**	**11**	**600**	**21**	**1200**
Tay Dang (Ba Vi)	**1**	**100**	**2**		**3**	

3.4.1 Cau Dien Composting Plant

The Cau Dien composting plant is the only MSW treatment plant currently converting organic waste into compost. The final product is a nutrient enriched compost which can be used as an organic fertilizer. Cau Dien receives waste from restaurants and markets of four urban wards (Phan Chu Trinh, Nguyen Du, Thanh Cong, Lang Ha). The composting plant used to also receive waste from households in these districts during a source-separation campaign which is no longer on-going, but provided households with different containers for organic and inorganic waste (i.e. kitchen waste, plastics). The campaign is further explained in Section 3.4.2.

The treatment plant currently receives around 30 tons of solid waste per day. FS from public toilets is also treated at this facility, which is described in detail in Section 9.5. The plant produces around 60 to 70 tons of compost per month.

A small part of the produced compost is dumped at the main landfill, depending on demand. The remaining part of the compost is enriched with nitrogen and phosphorous and sold as an organic fertilizer. The fertilizer is sold to forestry, horticultural and flower industries. The Ministry of Agriculture advises not to use this organic fertilizer for agriculture, although it could possibly be used if fulfilling the Vietnamese standards for the use of organic fertilizer in agriculture based on heavy metal, nitrogen, and phosphorous concentrations, total carbon, moisture content and pathogens such as *E.coli*. Analyses of the organic fertilizer are done by independent laboratories, which inspect the Vietnamese quality standards. Cau Dien is managed by URENCO No. 13, a branch of URENCO. They do not make any profit through the sale of fertilizer, as the treatment costs are much higher than the revenues that are generated. Not being able to guarantee a consistent quality of the organic fertilizer, due to high variations of the input quality, was identified as one of the main bottlenecks for not selling more fertilizer.

Composting process

The composting facility is equipped with a mechanical separation belt, which separates the organic part of the delivered waste from the inorganic part. During a visit to the facility in June 2013, it was observed that the belt is not operating and the waste is separated manually. Windrow-composting is employed, and the primary composting process takes about 28 days with a 14 day turning cycle. Bio-Additives, which are received from the Biotechnology Department of the Sien Tien University are added during the primary treatment. For the control of moisture, liquid effluent from the FS treatment is added during the aerobic processes. When the primary processes are completed, the compost is left for maturation and undergoes a final screening before it is enriched with nutrients and packaged for sale.

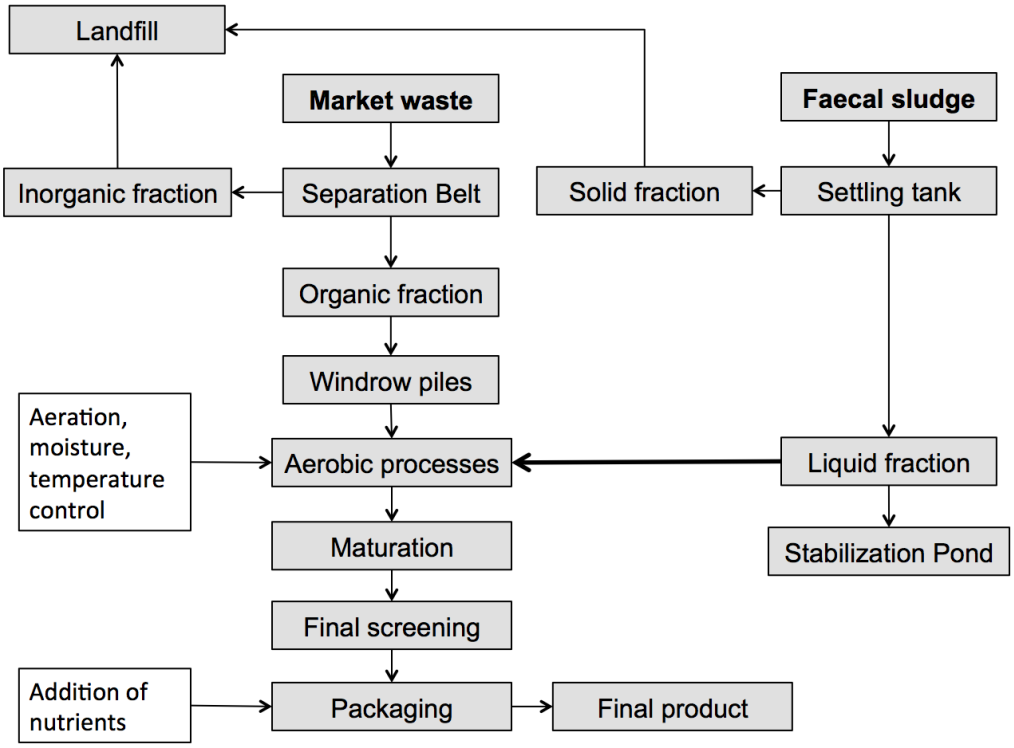

Figure 3: Process flow of the Cau Dien composting plant

3.4.2 The 3R (Reduce, Reuse, Recycle) initiative

The 3R project was sponsored by JICA in 2007 to promote the separation of organic and inorganic solid waste at source. The project was implemented in Phan Chu Trinh ward (Hoan Kiem district), Thanh Cong ward and Lang Ha ward. A total of 18,000 households were involved in the initiatives which included awareness raising and education. The organic waste was transported to the Cau Dien composting plant, while the inorganic part was transported to the Nam Son landfill. The project resulted in a decrease of MSW generation in the participating wards by 31 to 45%. Even though the project was successful, it was not expanded and could not be up-scaled due to the lack of financial resources for equipment, infrastructure and education. Today, it is reported that the 3R project is not on-going and that waste sorting at source had stopped. Interviews and reports have shown that people since had increased doubts that source-separation is effective, as it was reported that most waste after it had been sorted was dumped together in the same truck and transported to the landfill.

3.4.3 Tien Yen commune (case study)

In June 2013, Tien Yen commune in the rural district Hoai Duc was selected as a pilot city for the recovery of nutrients from organic SW. The project was implemented by the Hanoi Farmers Association and the Department of Natural Resources (DONRE) Hanoi. The waste generation within the targeted area is five tons of SW per day, of which one ton is generated from vegetable production, three tons from animal husbandry and one ton as inorganic material from these activities.100 out of 200 total households in the commune were selected and were provided two containers for the separation of organic and inorganic waste. In addition, each household was supplied with one litre of effective micro-organisms (EM), which is a mixture of natural predominantly anaerobic micro-organisms that is supposed to increase the decomposition of organic waste. Farmers were trained by

the Viet-Nhat Technology company on the benefits of waste separation and decomposition at source and applying the method of EM for organic waste treatment. Results of the project have shown that the decomposition of organic waste had improved after 15 to 20 days of treatment with EM and the final product could be used as a soil conditioner. Farmers have reported increased plant growth compared to commercial fertilizer, and waste reduction at the household level was 40 to 50%. The long-term success of the project is not yet proven, and as it is based on household level use of soil conditioner would not be applicable in urban Hanoi.

3.5 Conclusions

The collection and transport of MSW in urban Hanoi is functioning well, while resource recovery from MSW at present is minimal. The landfills are reaching maximum capacity and volumes of SW are increasing. Waste is not source-separated but “junk buyers” and “waste pickers” contribute informally to sorting of the waste. MSW formally belongs to URENCO as they are managing the landfill and the composting facility. The Cau Dien composting plant could be renovated, however, there is only one road leading to the facility which was often blocked, and residents complained about this nuisance. SW collection in peri-urban and rural Hanoi is less developed and hence it might be easier to implement new management structures in these areas. A decentralized model would be difficult to implement, as master plans for the next 20 years are already in place and space is very limited in Hanoi. However, the importance of resource recovery was recognized and the master plan includes plans for nutrient and energy recovery through the application of composting and incineration technologies. in which energy recovery would be applied in most of new plants.

4. Market Waste

Hanoi has multiple systems for food distribution to markets. This chapter describes the two main distribution systems and presents estimates for quantities of waste at the biggest wholesale food market in Hanoi. More detailed information on markets was not available, and is difficult to evaluate as Hanoi has hundreds of small markets scattered around the city. The market network is also currently being reorganized which greatly complicates any future projections.

4.1 Food distribution system

The traditional distribution system is that vegetables and fruits are transported from the producer to wholesalers and then to retail locations. The modern distribution system goes through wholesalers and processors and then directly to supermarkets and consumers, leaving out the retail link. The traditional distribution system still exists and is used by the majority of the local population, while future plans are focussing on implementing the modern distribution system [8].

Wholesale and retail food distribution system

Food items are transported from peri-urban areas and other nearby provinces into the city by various intermediaries. For the case of vegetables, it is normally one farm family member that brings them to the market. Wholesale markets operate during the night and it is mainly women who transport the vegetables with rickshaws to the market. During the night, small traders, market retailers, small shops and street vendors come to the wholesale market to buy the products in bulk, while consumers who want to buy fresh products also come during the early morning hours.

The only information that could be found was from 2002. At that time several wholesale markets existed in the following areas [8]:

- “Southern Wholesale Market” in Hai Ba Trung (mainly vegetables)
- “Dich Vong Wholesale Market” in Tu Liem District (was planned in 2002)
- Nga Tu So
- Bac Qua
- Cau Giay

Mainly fruits:

- Long Bien
- Hang Da
- Informal market on Lang Rd

The retail food distribution system consisted of more than 120 retail markets and purchasing points in all over Hanoi. 26 were planned retail markets, 32 were temporary markets and 62 were purchasing points. In addition to that, there was a large number of street vendors [8].

4.2 Restructuring of the wholesale network

Long Bien is the biggest wholesale market in Hanoi, which opens twice a month on the 1st and 15th day of the lunar calendar. The market is located in Phuc Xa ward, Ba Dinh district with an area of 27,148 m^2. The total number of households trading in the market is 1,087. Vegetables account for 39% of the market share, while fruits account for 38%. The total quantity of products that are sold is around 300 tons/d and it is estimated that the amount of waste production is between 16 and 27

tons/d. It is planned to transform the market into a retail market due to overcrowded and unsanitary conditions [9].

On 11 November 2012, the Hanoi People's Committee signed the Decision Decree No. 5058/QD-UBND, which regulates the planning of a retail and wholesale network for 2020 with an orientation to 2030. This decision is important as existing markets will be upgraded, new markets will be constructed and hypermarkets (large supermarkets) are planned for the distribution of food products. A full list of all included markets can be found in Appendix 13.3 [10].

As the city boundaries have expanded and the urban area is no longer important for the production of agricultural products, it is planned to move the wholesale markets further out of the urban city boundaries. The four districts are Me Linh (north), Phu Xuyen/Thuong Tin (south), Hoa Lac/Thach That (west) and Gia Lam (east). The restructuring includes the construction of new hyper- and supermarkets within all urban districts. This will contribute to less fruits and vegetables being traded at retail markets and by street vendors within the city [10].

4.3 Quantity

Besides the currently traded goods at the Long Bien market, information about the quantity of waste volumes does not exist.

4.4 Conclusions

Little data was available on the markets in Hanoi and collection of data is complicated as hundreds of small markets (and many big markets) are spread throughout the urban and peri-urban areas of Hanoi. The waste management is either managed by the market vendors themselves or by URENCO in Historic Hanoi. Competition for market waste exists, as it is a good source of animal feed due to its low impurities and high organic content. It was reported that the Cau Dien composting plant receives most of the market waste that is not reused as animal feed and collected from the urban districts.

5. Craft Village Waste

In Hanoi, there are currently 280 craft villages and it is estimated that around 100 tons of solid waste are generated per day, which mainly remain untreated. Craft Villages are a traditional term for the production of items for sale at local small-scale. The products range from pottery, over traditional crafts for tourists to food production. Twelve of the major food craft villages producing organic waste were identified and are presented in Table 9. Duong Lieu village is around 20 kilometres away from Hanoi and lies within the Hoai Duc district. It is the main vermicelli and cassava starch producing hub for sale in Hanoi and other surrounding provinces. With a capacity of 52,000 tons of cassava each year, the craft villages generate up to 105,768 tonnes per year of waste residue [5]. It is estimated that another 13,694 m^3 WW are generated daily and remain untreated. As reported in Section 3.4.3, a pilot project in the Tien Yen commune was implemented for the treatment of SW whereas it is planned within the same project to set-up treatment facilities for SW and WW in Duong Lieu village. Data on waste quantities for the other craft villages was not existing and is therefore not documented here.

Table 9: Major food craft villages producing organic waste in Hanoi [11].

Craft village	Products	District
Vong village	Green rice pellets	Cau Giay district
Le Mat village	Snake	Long Bien district
Uoc le village	Mince pork cakes (gio cha)	Ha Tay district
Thanh Khuc village	Sticky Rice cake (banh trung)	Thanh Tri rural district
Phu Do noodle village	Rice noodle (bun)	Tu Liem rural district
Duong Lieu village	Vermicelli (mien)	Hoai Duc rural district
Minh Khai village	Vermicelli (mien)	Hoai Duc rural district
Thanh Tri	Rice roll (banh cuon)	Thanh Tri rural district
Phu Dien village	Mien and grilled rice cake (bánh đa)	Thanh Tri rural district
Yen Vien village	Rice noodle (bun)	Gia Lam rural district
Cat Que village	Food processing	Hoai Duc rural district
Nhi Khe village	Sticky rice cake	Thuong Tin rural district

5.1 Conclusion

Craft village waste appears to be an untapped source of organic material. Many craft villages in peri-urban Hanoi are in need of treatment solutions as negative health and environmental impacts within

the villages increase. In addition the villages are in peri-urban areas of Hanoi, which would decrease transport costs to farmers for use of treatment products in agriculture.

6. Agro-Industrial and Animal Waste

6.1 Quantities

The generated AIW from Historic Hanoi is minimal, as it is a dense urban area. Most AIW in Greater Hanoi is produced from farming activities in peri-urban areas and rural areas. Presented in Table 10 is estimate summary of the total waste generated in greater Hanoi per year. Product yields for the main cultivated crops and numbers of livestock were extracted from the Hanoi 2012 socio-economic report [12]. Two sources were used to estimate the unit of waste that is generated per ton of crop or head of livestock [13, 14].

Table 10: Estimated AIW from peri-urban Hanoi [12-14]

Source	Yield in 2012	Unit Waste generated	Total waste (ton/year)
Cultivation	**ton/year**		**1,394,190**
Rice	1,200,000	1	1,200,000
Corn	99,900	1	99,900
Sweet potato	41,300	0.8	33,040
Cassava	40,200	0.8	32,160
Sugar cane	2,900	1	2,900
Soya bean	19,400	0.9	17,460
Peanut	9,700	0.9	8,730
Husbandry (#)		ton/head/year	**3,969,925**
Buffalo	24,200	7.37	178,323
Cow	141,700	5.91	837,801
Pig	1,400,000	1.41	1,970,500
Chicken	14,500,000	0.05	725,000
Duck	4,300,000	0.05	215,000
Musk duck (ngan)	605,000	0.05	30,250
Quail	2,400,000	0.01	12,000
Geese	15,000	0.07	1,050
Total			**5,364,115**

6.2 Treatment of AW

From 2002 to 2012 a nationwide project was carried out which constructed 124,000 biogas plants in 53 provinces. Some animal husbandry farms in around Hanoi also benefited from this project. The Vietnam Biogas Project was initiated by SNV Netherlands Development Organisation with the support

of the Vietnamese and Dutch governments. From 2012 onwards the project focused on moving away from international aid, and moving towards a market-driven and sustainable commercial sector approach [5, 15]. Currently, most of Vietnam's animal husbandry is at household scale and treated via anaerobic digestion. It is estimated that 19% of animal husbandry waste is discharged untreated into the environment [5]. Using animal and livestock manure for aquaculture is another common practise in Vietnam. Also, waste from large scale production facilities is also used to raise worms for fish feed [5].

6.3 Location

Most of the animal waste produced in Hanoi is from the sub-urban and rural districts. Table 11 presents the number of pigs, cows and poultry per district. The source of data is from 2009, but it is reasonable to assume that districts with a high number of animals in 2009 are still contributing significantly to the number of animals in 2014. In the case of poultry, data was only existing for four districts. Districts with the largest number of animals are Chuong My, Thanh Oai, Thuong Tin, My Duc, Ba Vi, Soc Son and Dong Anh. Data about the average number of animals per farm did not exist, but it is reported that most animal husbandry in Hanoi is at self-business household scale [15]. Three major livestock factories in the peri-urban areas of Hanoi are shown in Table 12. The same factories were investigated as part of a final report of industrial investigation for the preparation of WW treatment guidelines and manuals for livestock, hospitals and the electronic industry. The Institute of Water Engineering and Environmental Technology has assessed the WW characteristics and the treatment systems of the three livestock factories in Table 12. The results of WW characteristics are not presented, but Table 12 shows a summary of the applied treatment technologies for the generated quantity of WW. All three facilities at least partly use anaerobic digestion for the co-treatment of generated wastewater and generated livestock manure.

Table 11: Number of pigs, cows and poultry in the districts of Hanoi in 2009.

Dsitrict	Pigs	Cows	Poultry
Soc Son	127,107	28,941	-
Dong Anh	98,892	10,594	2,190,000
Gia Lam	54,304	9,385	-
Tu Liem	8,355	592	-
Thanh Tri	24,937	1,354	-
Me Linh	84,368	12,061	-
Son Tay	43,650	9,850	-
Ba Vi	260,084	45,008	1,580,000
Phuc Tho	78,787	6,379	-
Dan Phuong	51,215	2,191	-
Hoai Duc	63,548	4,452	-
Quoc Oai	87,940	5,892	1,330,000
Thach That	74,814	7,216	-
Chuong My	110,539	19,519	2,240,000
Thanh Oai	107,523	6,248	-
Thuong Tin	117,871	4,560	-
Phu Xuyen	64,022	3,488	-
Ung Hoa	72,770	8,161	-
My Duc	99,780	8,606	-
Cac quan	48,317	2,783	-
Sum	**1'678'823**	**197'280**	**7'340'000**

Table 12: Outline of some major livestock factories in peri-urban Hanoi [16]

Company	Location	Established	No. of animals	Quantity of WW /$m^3 \cdot d^{-1}$	Treatment process
National pig research and development center	Thuy Phuong Commune, Tu Liem district, Hanoi	1969	Type of animal: Pig (feeding and multiplication). 7,000-8,000 pig head/year	120	Wastewater and manure from pig cages → biogas tank → facultative biological pond → catfish ponds, with EM
Hanoi domestic animal breeding Center	Nguyen Trai District, Ha Dong, Ha Noi	1972	Type of animal: Pig, poultry 2,500 pig head/year	100	Biogas tank
Co Dong service and livestock co-operative	Co Dong, Son Tay Town, Ha Noi	2006	Type of animal: Pig, 1,600 pig head/year	30	Wastewater and manure from pig cages → biogas tank → aeration tank → Lake of aquatic plants

Figure 4 and Figure 5 show the spatial distribution of vegetable and rice production in 2009. The districts south of Hanoi are very characteristic for rice production, while the majority of vegetables are produced in the north, close to the urban boundaries. Ba Vi, which lies at the western boundaries of the whole administrative area of Greater Hanoi not only plays an important role in animal production but also rice and vegetable production. While not a lot of rice is produced within the urban boundaries, Figure 5 shows that the production of vegetables was comparatively high. It can be assumed that

small-scale urban agriculture at household scale growing their own vegetables is the reason for this.

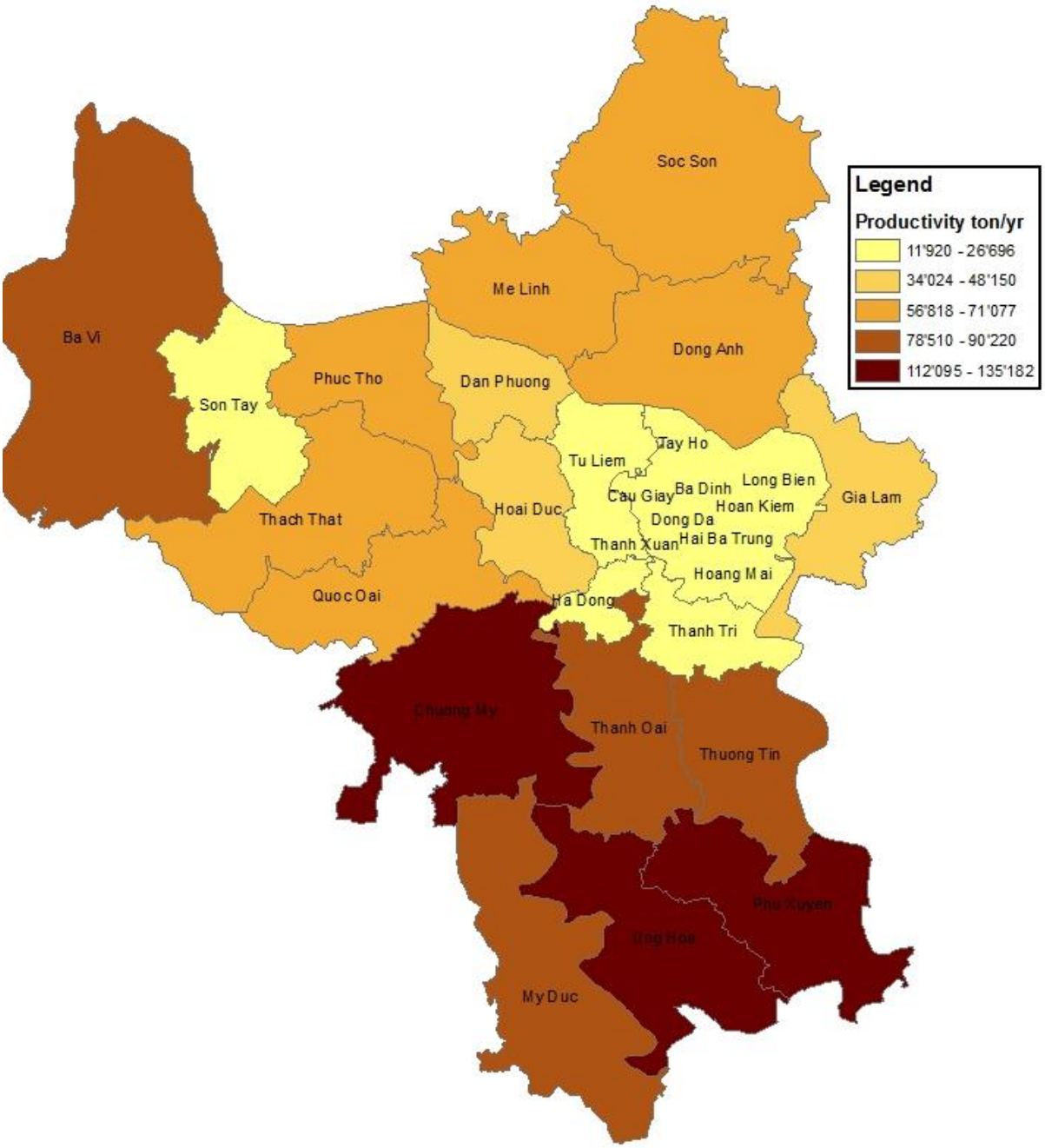

Figure 4: Production of rice in 2009.

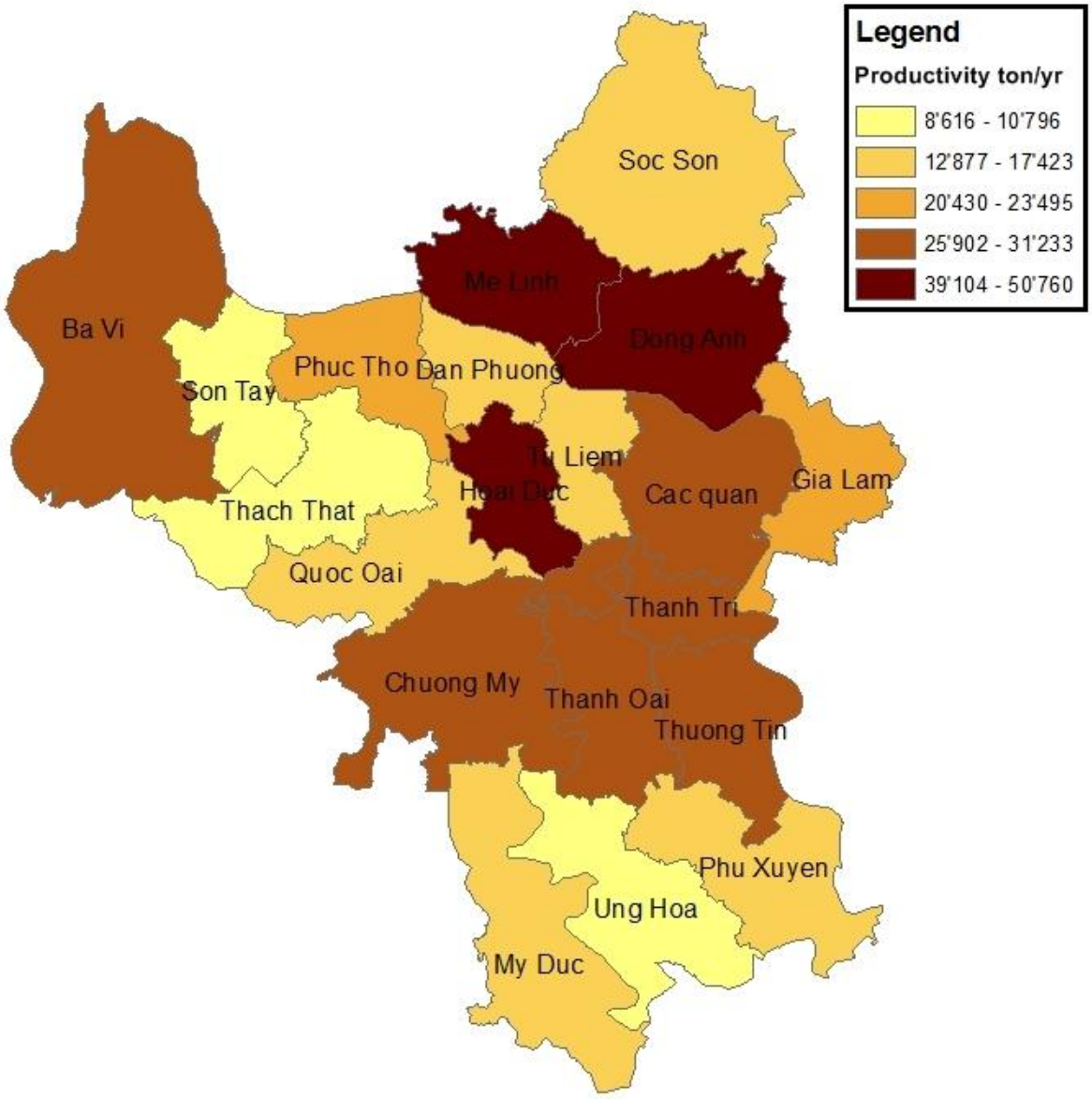

Figure 5:Production of vegetables in 2009.

7. Conclusions

Agriculture and animal breeding are a significant part of Vietnam and Hanoi's economy. Peri-urban and rural areas of Hanoi supply the city with these products. The application of anaerobic digestion technologies has been successful in Hanoi and there is potential to further expand and up-scale the anaerobic treatment of AIW and AW. The future demand for meat and vegetables in Hanoi will continue to increase, increasing the management need of accumulating wastes. As there is interest by animal breeding companies to reduce their costs, they would potentially be interested in applying technologies that result in cost recovery. However, further research is needed to determine the waste characteristics to accurately design anaerobic treatment facilities.

8. Wastewater

This chapter presents the current status of WW management in Hanoi, including treatment capacity and the influent and effluent characteristics of the existing treatment plants. Future plans for the expansion of the WW infrastructure and estimates of the WW volumes for 2013 are also presented. Current WW reuse is covered briefly, and is mainly informal without regulations.

8.1 Existing infrastructure

Hanoi's drainage and sewerage network is a combined wastewater and rainwater system. Wastewater from households, industries and hospitals is mixed with rainwater in the sewerage system. 10% of wastewater flows through open channels and undergoes no treatment, and 90% comes from septic tanks at the household level and is transported in a combined rainwater and wastewater sewer system [17]. 99% of septic tanks receive only blackwater and almost 100% of the urban population utilizes flush toilets, with dry toilet systems such as VIP latrines being almost non-existent [18].

Almost all households in Hanoi are connected to septic tanks, which are constructed underneath the houses. They are often inaccessible without breaking interior floors, as they are completely closed off and tiled over. The septic tanks serve as a primary treatment step whereas the effluent goes into the open drainage and sewer lines of the city. Septic tank management falls under the section of faecal sludge (Chapter 9).

In new urban development areas, separate wastewater and rainwater systems are being constructed. However, due to the fact that these areas are still connected to the old areas the collected wastewater enters the combined sewerage network. Only in areas where the entire wastewater infrastructure is newly constructed, including a wastewater treatment plant, separate systems could be applied.

8.2 Location and treatment capacity

Hanoi was the first large urban area in Vietnam with a WW infrastructure. Figure 6 shows the location of the existing and planned WWTPs in Urban Hanoi. The capacity of the treatment plants is summarised in Table 13. Two WWTPs, funded by JICA, including drainage and sewerage collection systems were commissioned in 2005. Kiem Lien and Truc Bach with treatment capacities of 3,700 m^3/d and 2,300 m^3/d respectively were constructed as demonstration facilities for the provision of a better understanding how urban sanitation could be applied [19].

Another JICA-funded project in north Hanoi, Bac Thang Long WWTP, was constructed to serve 150,000 inhabitants. The treatment plant was commissioned in 2009, but the sewer lines were never constructed as this it was reliant on local funds, which were not made available. As it was not possible to connect households to the WWTP, primary treated WW from the nearby industrial park was diverted to the treatment plant with a total flow of 7,000 m^3/d, which accounts for 17% of the total capacity [19].

A recent addition to the Hanoi WW infrastructure was the Yen So WWTP with a total capacity of 200,000 m^3/d. The treatment plant receives water from the Kim Nguu River (125,000 m^3/d) and the Set River (75,000 m^3/d), both of these rivers are the main receiving body for urban WW that has been discharged without treatment. There is no other influent than the rivers, or existing sewerage connected to the Yen So WWTP, it is only treating the polluted river water. Due to the long retention time of WW in the river a reduction of the Biological Oxygen Demand (BOD) occurs, which creates an imbalance to the carbon to nitrogen ratio of the influent WW and therefore results in operational difficulties at the WWTP [19].

Within the Master Plan of Hanoi Capital Drainage 2030, vision up to 2050 it is planned to expand the treatment capacity to 1,808,300 m^3/d by 2030 and up to 2,482,300 m^3/d by 2050.

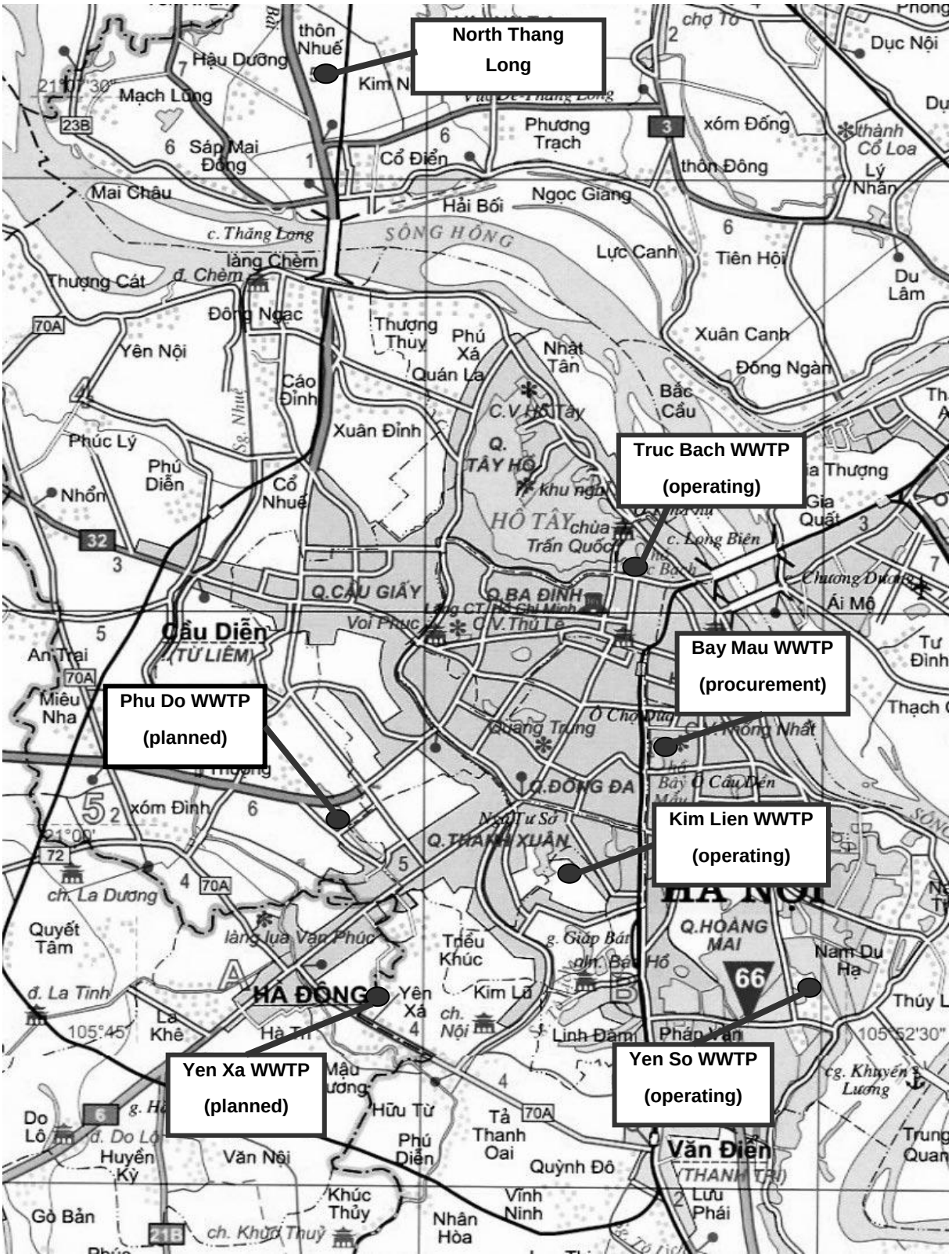

Figure 6: Existing and planned WWTPs in urban Hanoi.

Table 13: Existing and planned WWTPs in urban Hanoi.

Name of WWTP	Treatment capacity	Population serviced	Investment costs	Situation	O&M body
North Thang Long, Van Tri	42,000 m^3/d	150,000	-	Operating since 2009 with a capacity of 7,000 m^3/d	HSDC
Kim Lien	3,700 m^3/d	-	7.3 million USD for both	Operating since 2005	HSDC
Truc Bach, Ba Dinh	2,300 m^3/d	15,700			
Yen So, Hoang Mai	200,000 m^3/d	-	233.1 million USD	Operating since 2012 with a capacity of 125,000 m^3/d	Gamuda Berhard (for first 5 years), Built-Transfer model
Bay Mau, Hai Ba Trung	13,300 m^3/d	-	-	Procurement	-
Phu Do, Tu Liem	84,000 m^3/d	-	-	Planned	Built-Operate-Transfer model
Yen Xa, Thanh Tri	270,000 m^3/d	-	-	Planned	

8.3 Quality

Presented here is information on the process flows and technologies of Kiem Lien, Truc Bach and North Thang Long WWTPs. Information about the performance and quality of the effluent of the WWTP was gathered from the Hanoi Sewerage and Drainage Limited Company (HSDC) and the JICA [20]. Information was available for all treatment plants except for the Yen So treatment plant, as the research team did not get access to operational data.

8.3.1 Yen So wastewater treatment plant

As described above, the Yen So WWTP receives WW from two different river basins. The WW is pumped through the Kim Nguu canal to the treatment plant. After primary treatment with screens, sequencing batch reactor (SBR) is applied as the treatment technology. The effluent is treated with UV disinfection before it is diverted back into the river. Some of the wastewater is passing a ultrafiltration treatment step before it is reused as process water onsite. Overall, two anaerobic digester and two gas holder are installed, which produce and collect biogas. The WW sludge is treated by using settling-thickening tanks and anaerobic digestion, while a centrifuge is applied for further treatment of the solid fraction and another SBR is used for the treatment of the liquid effluent, including biological nutrient removal. The operation of the treatment plant was handed over to Phu Dien company, a local

private company that is now responsible for operation and maintenance. This was the first time in Hanoi that a private company took over the operation of a municipal WWTP.

8.3.2 Kim Lien and Truc Bach wastewater treatment plant

As described above, these two WWTPs were built for demonstration purposes. They both have the same design and applied technology: carrier-added activated sludge process with anaerobic-anoxic-oxic (A2O process) conditions. Figure 7 illustrates the process flow of the treatment plants. The

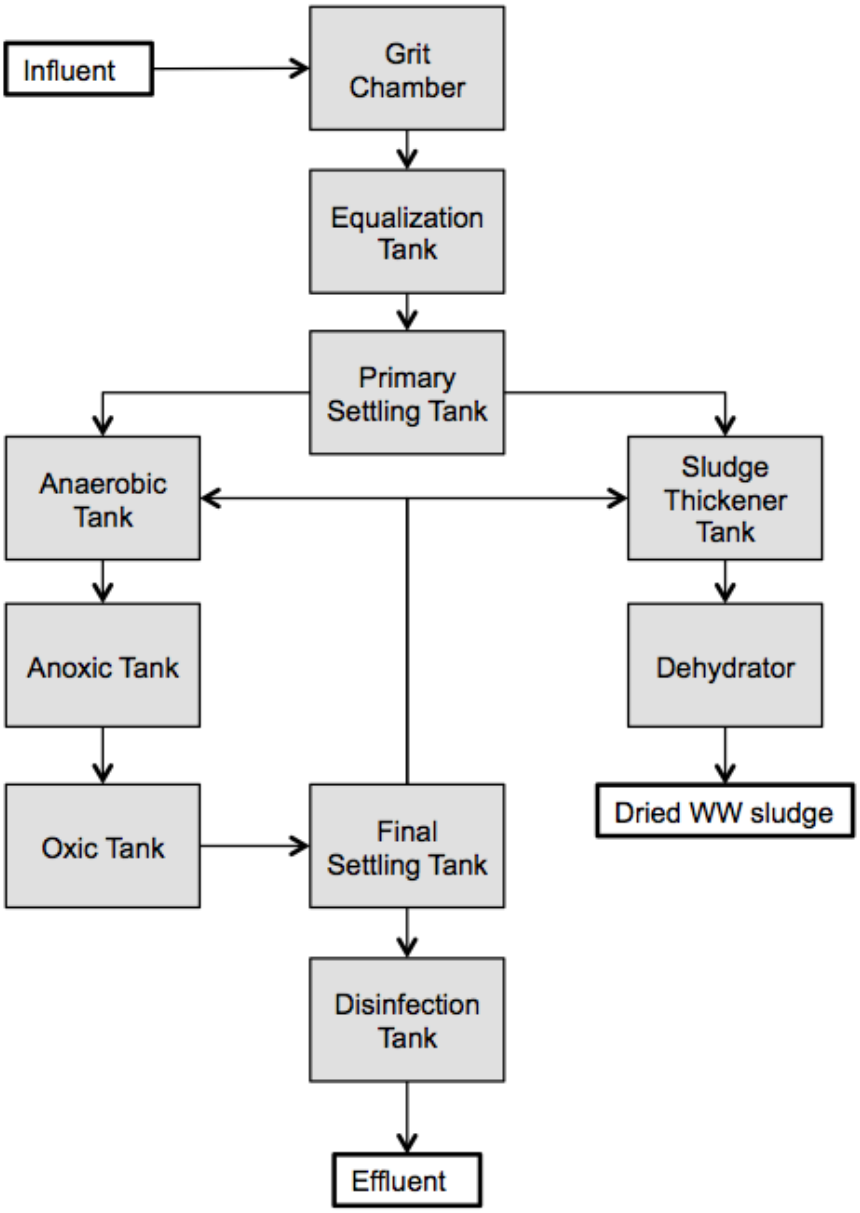

Figure 7: Process flow of Kim Lien and Truc Bach WWTP [20].

Table 14 and Table 15 present design values and average operating values for wastewater influent and effluent of Kiem Lien and Truc Bach WWTP. Comparing the design criteria with two different sampling campaigns shows that the treatment plants are within the discharge limits. However, the treatment processes are facing some difficulties due to the low organic content in the influent. Average BOD concentrations of the influent are 60% of the actual design capacity while average total nitrogen concentrations are above the design maximum. For the removal of nitrogen through nitrification and

denitrification activated sludge is needed whereas low concentrations of organic matter are the limiting factor. The treated wastewater is discharged into the Lu River.

Table 14: Water quality at influent and effluent of Kiem Lien WWTP [20]

Sampling point	Influent					Effluent				
Parameter	COD	BOD	SS	TN	TP	COD	BOD	SS	TN	TP
Authorized regulation value	-	-	-	-	-	48	30	60	18	3.6
Design Criteria	225	150	180	40	5.0	35	20	20	15	1.0
HSDC data average	189	94	86	44	6.2	22	11	6	16	1.4
JICA team data average	202	NA	73	41	6.1	35	NA	9	16	2.0

Table 15: Water quality at the influent and effluent of Truc Bach WWTP [20].

Sampling point	Influent					Effluent				
Parameter	COD	BOD	SS	T-N	T-P	COD	BOD	SS	T-N	T-P
Authorized regulation value	-	-	-	-	-	48	30	60	18	3.6
Design Criteria	225	150	180	40	5.0	35	20	20	15	1.0
HSDC data average	191	94	91	36	5.6	24	12	5	15	0.9
JICA team data average	181	NA	61	40	5.4	24	NA	2	14	1.9

8.3.3 North Thang Long WWTP

The applied technology and process flow of North Thang Long WWTP is the same as Kiem Lien and Truc Bach (refer to Section 8.3.2). The incoming wastewater is a mixture of industrial and domestic WW from North Thang Long Industrial Park, as the sewer lines that were planned for the connection of

150,000 people were not constructed. The treatment plant is only operating at one eigth of its total capacity. The influent and effluent water quality is presented in Table 16. Influent values show similar low concentrations as it is the case for the other two treatment plants while effluent values are well below the discharge limits.

Table 16: Water quality at the influent and effluent of North Thang Long WWTP [20]

Sampling point	Influent					Effluent				
Parameter	COD	BOD	SS	T-N	T-P	COD	BOD	SS	T-N	T-P
Water Quality Standards	-	-	-	-	-	50	20	50	30	4.0
Design Criteria	-	220	190	-	-	-	20	20	-	-
HSDC data average	115	60	57	44	5.2	17	9	5	13	1.0
JICA team data average	110	-	65	36	5.4	27	-	8	17	1.4

8.4 Water reclamation

WW reuse is a common practice in Asia and it was reported in 2008 that a total of 658,300 farmers are using WW informally and formally in the peri-urban areas of Hanoi [21]. Hanoi has a humid subtropical hot summer with heavy rainfalls up to 350 mm per month and average temperatures above 30°C. The winter in Hanoi is mild and dry with December and January being the driest and coldest months having an average monthly rainfall of 20 mm and average temperatures of around 15°C. Therefore, the interest in reusing WW lies on making use of the high nutrient load, rather than for the purpose of irrigation. Farmers directly divert water from the polluted rivers downstream of Hanoi. But, this also has negative impacts as the nutrient load cannot be controlled and rivers are highly polluted. Furthermore, it is most likely that the diverted water is contaminated with pathogens with causes a threat to the health of farmers and consumers of the agricultural products.

8.5 Conclusions

With the current configuration of treatment plants, water reclamation from treated WW is difficult to implement as the effluent is difficult to access. Ongoing and future projects should incorporate these elements there is interest to pipe treated WW to areas of agricultural activity. Since these activities are mainly in the rural districts of Greater Hanoi, the water would need to be piped long distances. As farmers are mainly interested in making use of the high nutrient load, the use for irrigation in agriculture would only be an option if WW would be partially treated, providing a safe product in terms of pathogen removal, but only partially remove the nutrients (e.g. Anaerobic Baffled Reactor).

9. Faecal sludge (FS)

As described in Section 8.1, 90% of Hanoi's population is connected to septic tanks. Within the urban boundaries of Hanoi, dry on-site sanitation technologies such as pit latrines are almost non-existent and are therefore not further elaborated within the scope of this report. Even though septic tanks are the most common sanitation type in urban areas in Vietnam, infrastructure to effectively manage the FS that derives from these systems does not exist. Sustainable FS management (FSM) will be the key activity that is required to improve the sanitation situation in Vietnam in the coming years [19].

9.1 Septic tank management

Technical specifications and standards for the size and design of septic tanks are set by the National Design Standard of Vietnam for Wastewater Systems. A manual for septic tank design, installation and O&M was issued by the Ministry of Health, while the Ministry of Construction is drafting a Design Code for septic tank design and construction [19]. Even though these regulations exist or are in process, the enforcement capacity to ensure compliance is lacking [22].

URENCO is responsible for providing environmental services, which includes septage management (FS collection and transport). However, 90 % of all septic tanks in Hanoi have never been desludged, as households only get their septic tank emptied when problems arise, such as blockages backing up into the home, or bad odour from anaerobic sludge flowing out into open drains [17]. The average desludging period for household septic tanks in Hanoi is estimated to be six to eight years [17, 23]. URENCO is assigned by the People's Committee to empty the septic tanks of public toilets in four of the nine urban districts of Historic Hanoi. Other than that, emptying is done by private emptying service companies who have entered the market with an estimated 112 trucks [18]. While URENCO has permission to discharge FS at the Cau Dien composting facility, there is absolutely no legal discharge location for private companies within all of Hanoi. This results in discharge directly into the urban environment, in open channels, lakes and rivers. Other than that, some small quantities of untreated FS are sold to farmers for direct application as a soil amendment and for use in fish ponds [18].

9.2 Quantity

For the quantification of FS, a wide range of methods exist that base their assessment on different factors, resulting in widely variable values. There is a difference in FS being (1) produced, (2) collected and transported, (3) delivered to official discharge sites. Not all produced FS is necessarily also being collected and transported, as septic tanks are not emptied on recommended desludging intervals. Furthermore, collected FS volumes are not necessarily being delivered to official discharge sites, as discharge fees and high transportation fees decrease the revenues of the emptying serviced provider. This greatly complicates the design of FS treatment plants, as quantities cannot accurately be determined.

Emptying services provided by private companies

It is difficult to estimate volumes of FS that are collected in Hanoi due to the lack of official discharge or treatment facilities, which results in pervasive illegal discharge. However, in 2012 Nguyen et al. conducted a study to assess quantities of FS that are produced and collected in Greater Hanoi [18]. The numbers are all estimates and the actual value of FS quantities being produced and collected

remain unknown, as the currently available methods are based on theoretical knowledge, interviews and literature.

Table 17 describes the four different methods that the study included to estimate FS that is produced and collected..

Table 17: Methods used for the calculation of FS quantities [18].

Q1) FS production (current desludging interval)	This method is based on the number of households in the city using septic tanks and pit latrines, multiplied with the average volume of septic tanks and pit latrines and divided by the actual desludging interval. Another 10% are added up for FS from offices, commercial and public places. It is assumed that only 90% of the tank volume actually gets emptied.
Q2) FS generation	This method is based on the accumulation rate of FS in septic tanks and pit latrines with 0.6 L/cap/yr for pit latrines and 0.3 L/cap/yr for septic tanks. 10% are added up for FS from offices, commercial and public places. It is assumed that only 90% of the tank volume actually gets emptied.
Q3) FS production (desludging interval: 1 year for pits, 2 years for septic tanks)	This method uses the same equation as Q1 but assuming a required desludging interval of one year for pit latrines and two years for septic tanks.
Q4) Current FS collected	This method uses data that was collected during a survey with emptying service providers using the number of trips by all trucks multiplied the volume of the vacuum tank. In the case of trucks emptying sludge at a centralized place, this method could be used in terms of a truck counting study to determine the quantity of FS that is collected and delivered.

Presented in Table 18 are the calculated quantities of FS based on these four methods. The results of method “Q2 - Faecal Sludge Generation” are that 1,573 m^3 FS per day are generated. This estimate is based on literature values for FS generation in latrines and septic tanks in general, the validity of these assumptions for Hanoi are not known. Values in the literature for FS generation vary widely and FS accumulation rates are not well understood. Whereas some methods calculate the amount of anaerobic sludge that accumulates in septic tanks, this is not necessarily the amount of FS to be emptied, as not only the anaerobic sludge gets emptied but also some of the liquid part.

"Q1 – Faecal Sludge Production", which seems more appropriate for the Hanoi context, estimated a total FS production of 768 m^3 FS per day. In this method the actual desludging interval was used together with the average size of the tank. In terms of FS quantities that actually get collected, this method is the one closest to reality, while method Q3 is based on the same equation but using a desludging interval that is recommended by literature and not based on actual values [17].

Method Q4 – Current Sludge Collected estimates the FS that actually gets collected, based on average number of trips and actual volume of 112 vacuum trucks. The result of 388 m^3/d shows that there is still a high potential for FS to be collected, while it should be kept in mind that the calculation method is based on very qualitative data. In result, it is very difficult to define the quantity of FS that is produced and collected. However, in reality it is to be expected that enough FS would be available if treatment technologies would be implemented. The challenge in this scenario is to dimension the treatment system in order to neither operate it over nor under capacity.

Table 18: FS quantities in Hanoi based on the calculation with different methods.

Quantification method	FS quantities [m^3/d]
Q1) FS production (current desludging interval)	768
Q2) FS generation	1,573
Q3) FS production (desludging interval: 1 year for pits, 2 years for septic tanks)	1,656
Q4) Current FS collected	388

Emptying services provided by public utilities

Public toilets of four out of nine urban districts are managed by URENCO 7. The daughter enterprise of the state-owned one member Co. Ltd. company URENCO has a fleet of four trucks and also manages the Cau Dien Composting Plant. FS from public toilets is collected and transported to the composting facility where it is first treated separately before some of the liquid part is used to keep the moisture content of the composting processes at the required level [18, 24]. Overall 230 fixed public toilets exist with an additional 85 mobile toilets. 190 of the fixed toilets are within the four districts that are managed by URENCO 7 and shown in Table 19 [25].

It is estimated that around 12.5 m^3 FS per day are collected from public toilets of the four central districts Hoan Kiem, Dong Da, Ba Dinh and Hai Ba Trung. The existing vacuum trucks have a capacity of 3.8 m^3, which results in each truck doing one trip per day on average [24]. Other sources report a total collected volume of 10 to 30 m^3/d [18]. The capacity for FS treatment at Cau Dien is 100 m^3, which shows that three to eight times more FS could be collected and treated by URENCO 7. During a field visit in June 2013, it was mentioned that a project is planning to implementing a new FS treatment plant with a capacity of 100 to 150 m^3/d. The location will be close to the Nam Son landfill, the biggest landfill of Hanoi, and is supposed to mainly receive sludge from the surrounding areas, including 50 m^3/d from the Noi Bai airport. Planned resource recovery from treatment products include irrigation in agriculture, but currently no other plans exist for the use of solids. By June 2013, the project was in the stage of getting final approval from the government.

Table 19: Number of public toilets in the four urban districts managed by URENCO 7 [25].

District	No. of public toilets
Ba Đình	30
Hoàn Kiếm	26
Đống Đa	53
Hai Bà trưng	81
Total	190

9.3 FS Characteristics

It is essential to know the characteristics of FS to design, plan and built adequate FS treatment facilities for appropriate resource recovery. The characteristics are highly variable and are influenced by a wide range of factors. Different from wastewater, there is no validated method or model, that can be used to calculate hypothetical values of FS quantities and characteristics for the influent of treatment facilities. Very little is known about the influence of different factors on FS characteristics. Therefore, a study was designed to evaluate the characteristics and quantities of FS in Hanoi. Spatial analysis of demographic data was used to design a sampling plan, based on potential indicators of FS characteristics, including single and multiple households (apartment building), public toilets, businesses and institutions. FS samples were taken from FS collection and transport trucks immediately following collection of the FS with a sampling device that was developed at the Laboratory for Environmental Biotechnology at École Polytechnique Fédérale de Lausanne (EPFL). A questionnaire was implemented at the household level during emptying to fully understand factors that contribute to the variability of FS. All analyses were performed at the Institute of Environmental Science and Engineering (IESE) at Hanoi University of Civil Engineering (HUCE) and conducted as described in (APHA,1997).

The results of the physico-chemical analysis are presented in Table 20, including the averages and standard deviations for ten parameters of 23 samples, which were taken between September and November 2013. 16 samples are from households, five from public toilets and two from office buildings.

Standard deviations for all parameters are high because of the high variability of FS. FS from households has higher concentrations of COD: 39,210 ± 23,978 mg/L, TN: 1,148 ± 640 mg/L and TP: 241 ± 161 mg/L TP, whereas FS from public toilets had higher concentrations of SCOD, NH_4-N and PO_4-P.

Characteristics of FS from public toilets in this study had similar values of TS, NH_4-N and TP as one carried out by URENCO (Table 21), however the COD values were 2.5 times higher in this study, while the number of samples analysed by URENCO is not known. Another study on FS from septic tanks in Da Nang, Vietnam observed similar characteristics for FS with cistern-flush toilets of 31,470 ±

24,081 mg/L COD [17]. This indicates a similar management and construction of septic tanks in both cities.

Studies characterizing FS from septic tanks in West Africa have observed much lower concentrations of TS, VS and COD than this study. For example 11,820 mg/L TS, 6,855 mg/L VS and 10,725 mg/L COD [26]. The organic load for FS in Hanoi would be almost four times as high, underlining the poorly managed septic tanks.

9.3.1 Conclusions for characterization and quantification

The implemented study has shown highly variable results for FS characteristics. A difference between FS characteristics of public toilets, households and office buildings could be observed. For the design of FS treatment infrastructure, it is important to determine the loads that are coming from the different sources. This can be determined by calculating how much FS is collected from the different sources. As figures for FS quantities vary widely, depending on the used method, further analysis are necessary. Currently collected FS accounts for 388 m^3/d, which seems to be very low compared to the production of around 1,600 m^3/d. Based on the high transport costs of FS, only decentralised to semi-centralized treatment facilities should be considered. Detailed spatial analysis for a defined neighbourhood would be necessary to accurately estimate the quantities that are produced and could potentially be collected. Together with the results of this characterization study, this would allow to design appropriate FS treatment infrastructure.

Table 20: Average concentration and standard deviation of FS characteristics of households, office buildings and public toilets in Hanoi

Parameter	Household (n=16)	Office Building (n=2)	Public Toilet (n=5)
Unit	**/g·L^{-1}**	**/g·L^{-1}**	**/g·L^{-1}**
Average TS	28.01	23.58	18.12
Std. Dev. TS	19.46	11.58	13.37
Average VS	20.73	18.01	14.64
Std. Dev. VS	13.53	8.81	11.44
Average TSS	26.08	21.07	15.91
Std. Dev. TSS	18.50	13.45	14.18
Average VSS	19.58	16.51	13.23
Std. Dev. VSS	12.90	9.94	11.96
Unit	**/mg·L^{-1}**	**/mg·L^{-1}**	**/mg·L^{-1}**
Average COD	39210	27667	26340
Std. Dev. COD	23978	7414	18493
Average SCOD	830	522	1231
Std. Dev. SCOD	617	291	878
Average NH4-N	562	236	714
Std. Dev. NH4-N	465	110	194
Average TN	1148	907	1061
Std. Dev. TN	640	423	476
Average PO4-P	59	79	124
Std. Dev. PO4-P	24	44	75
Average TP	241	164	189
Std. Dev. TP	161	138	123

Table 21: Characteristics of FS from public toilets in Hanoi [25].

Parameter	Concentration /mg·L^{-1}
pH	6,99
BOD_5	2.243
COD	10.800
TS	29.410
T-P	214,4
NH_4	697
TKN	770

9.4 Market of emptying services

The costs for emptying services by private companies in Hanoi varies depending on the size of the septic tank, and the household also pays based on the required number of trips for the truck to fully empty the tank. The average desludging fee is 34.3 USD/trip [18]. The survey of 401 households in Hanoi by Nguyen et al. (2012) has furthermore shown that higher income groups pay increased fees and also have an increased willingness to pay for the service compared to low income groups. Currently there is not one consistent fee structure or tariff policy for FSM services in Hanoi, resulting in the collection and transport companies charging as much as possible to maximize their profits. Additional water is also frequently added while emptying the septic tank, to liquefy compacted sludge, which also increases the emptying fee as it is based on volume. Nguyen et al. report an average septic tank size of 2.6 m^3 [18]. They showed in their analysis that the net profit of a private emptying service provider is 2,835 USD/truck/year, which is relatively high for Hanoi. Profits are maximized by no discharge fees and very low transportation costs, which will increase with the implementation of any FS management infrastructure. For example, the cost of transporting FS to the Cau Dien composting plant would result in no net profit. Furthermore, this would reduce the number of households that could be served per truck per day, which is currently 2.7. High costs for emptying contributes to the fact that households only have their septic tanks emptied every six to eight years, which greatly reduces the treatment performance and results in sludge overflow into drainage channels or sewers [17, 18].

Another strategy by households to reduce costs is using Bio-Additives in septic tanks (as shown in Figure 8). They claim to improve anaerobic digestion and reduce sludge if added regularly (e.g. every 6 months). Effectiveness of Bio-Additives has never been proven scientifically, and many studies have demonstrated no effect [27, 28]. As a result, this practise is also increasing costs to households, without a likely benefit. Examples of existing products are shown in Figure 8, they are on average 1.5 - 2 USD.

As an example of potential abuse of the system the research team observed that for the emptying of a septic tank of 3 m^3 a service provider made four trips with a 3.8 m^3 vacuum tank. As mentioned above the average emptying fee per trip is 34.3 USD, resulting in very high costs for the household.

Figure 8: Selection of Bio-Additives that were found in Hanoi

9.5 FS treatment

As mentioned in earlier sections, there are no legitimate places for FS discharge or treatment in Hanoi, other than the Cau Dien composting plant. Cau Dien has a treatment capacity of 100 m^3/d FS, but currently only receives 10 to 30 m^3/d. The process flow of the treatment plant is shown in Figure 9. FS is discharged and flows through a settling tank similar to an anaerobic baffled reactor for solid-liquid separation. More detailed information about the settling tank is not available. The liquid effluent from the settling tank flows into a small stabilization pond, of which some of it is used to control the moisture of the windrow compost piles. It appears that most of the liquid effluent of the pond is discharged into a nearby river, although no detailed information was provided.

The operational costs of the entire Cau Dien composting plant is 4.5 mio VND/ton (213 USD/ton) fertilizer. As explained above, the fertilizer often does not meet the requirements to be qualified as a branded fertilizer and therefore can only be sold for 1 mio VND/ton (47 USD/ton). Due to this financial loss, URENCO 7 has not shown any interest in expanding into combined market waste and faecal sludge treatment.

However, over the last ten years different approaches and solutions have been proposed for the improvement of FS treatment in Hanoi but none of these have come to a concrete investment into projects yet. IESE, as the leading institute for FS management, is working in close collaboration with the University of Darmstadt, Sandec/Eawag, Kyoto University and two Japanese companies (Kubota

and JSC) on putting research into practise and on the uptake of FS treatment in

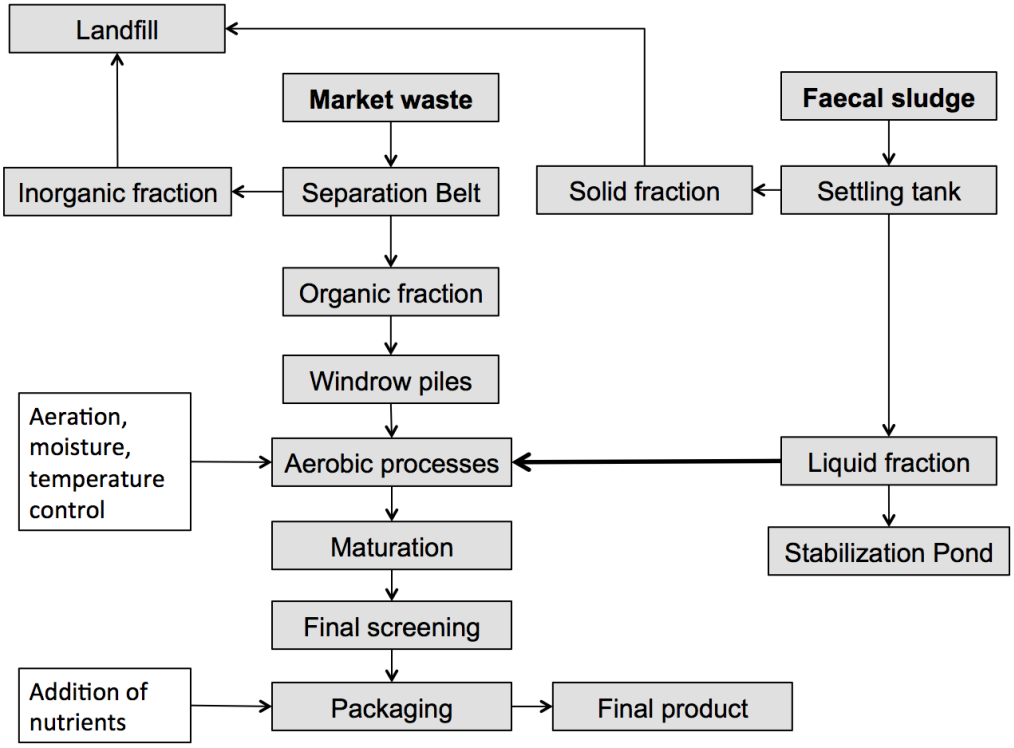

Figure 9: Process flow of the Cau Dien composting plant, including FS treatment.

9.6 End-use of FS

End-use of treated FS in Hanoi is very limited, with no reported end-use within the urban districts. In peri-urban areas some farmers are purchasing FS directly from emptying trucks and apply it raw in their fields. Other small businesses are often operated by one person, who manually empties latrines and septic tanks and transports the sludge on a bicycle. These businesses, on a small-scale, co-compost the FS with MSW or AIW and sell it as soil conditioner within the communities. These businesses are often operated by one person, who transports the sludge on a bicycle [18].

9.7 Conclusions

The FSM sector is very informal, with no legitimate discharge or treatment facilities other than the Cau Dien composting plant, transport costs is the largest cost for private emptying companies. Therefore, decentralised to semi-centralized treatment facilities should be considered for the context of Hanoi. If the transport distances are too large, illegally discharge to the environment will continue. Additionally, policies and regulatory frameworks are needed to develop a sustainable FSM chain, including regularly scheduled emptying of septic tanks at the household level.

10. Overall conclusions

This Waste Supply and Availability analysis has revealed the difficulties in drawing precise conclusions for the feasibility of implementing financially viable resource recovery from different waste streams. The size, complexity, and sprawling of Hanoi increased the complexity for estimating solid- and liquid waste generation. In addition, Hanoi is a very dynamic city and rapid changes in urban development are to be expected within the next decades, as existing master plans for the development of waste

treatment infrastructures are implemented. Nevertheless, potential exists to tap waste streams for resource recovery, but it is recommended that smaller, more defined areas are delineated for the assessment of feasible options for resource recovery. Based on this Waste Supply and Availability analysis, it is necessary that more regulations on collection, transport and treatment of FS need to be implemented that support options for the installation of FS treatment facilities. Within Historic Hanoi, MSW collection rates are very high, but this has yet to be expanded into peri-urban areas. Whereas AIW and AW is only produced in the rural areas of Greater Hanoi, which creates a completely different geographic context for implementation of business models. Upgrading of existing and planned organic SW treatment facilities seems like a viable option for creating valuable end-products, for which then markets would need to be created.

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13. Appendix

13.1 List of some FS emptying service companies

TT	Tên doanh nghiệp	Địa chỉ	Điện thoại	Số xe vận chuyển
1	Công ty TNHH Dịch vụ Môi trường HN	Số 24 ngõ 543 Đường Giải Phóng- Giáp Bát	36644858	2
2	Công ty công nghệ vệ sinh môi trường đô thị Hà Nội	73 Nguyễn Trãi	37649085	3
3	Công ty Môi trường Hà Nội	255 Cầu Giấy	39366260	3
4	Công ty Vệ sinh Môi trường Thanh Xuân	Số 10 ngõ 6 tổ 19 Cầu Diễn - Từ Liêm	37630464	3
5	Xí nghiệp Chế biến Phế thải Cầu diễn – URENCO7	60B Nhuệ Giang - Tây Mỗ - Từ Liêm	37646632	5
6	Công ty cổ phần vệ sinh môi trường đô thị Hà Nội	Số 38-ngõ 71-Hoàng Văn Thái - Thanh Xuân	35654244	3
7	Công ty vệ CP Môi trường Đô thị số 1	Số 26 ngõ 1B Long Biên – Ngọc Lâm - Quận Long Biên	38735421	4
8	Công ty CP Dịch vụ Môi trường Đô thị	Số 10 ngõ 85 Trung Kính – Trung Hòa – Cầu Giấy	37830836	2
9	Công ty CP Môi trường và Dịch vụ Đô thị Hà Nội	Nhà A3 Tập thể Bê tông Chèm – Từ Liêm	39900612	1
10	Công ty TNHH MTV Môi trường Đô thị - URENCO	18 Cao Bá Quát – Ba Đình		

13.2 Number of wards in urban districts (as of January, 2014)

#	District	Number and name of wards
1	Ba Dinh	14

		Cống Vị · Điện Biên · Đội Cấn · Giảng Võ · Kim Mã · Liễu Giai · Ngọc Hà · Ngọc Khánh · Nguyễn Trung Trực · Phúc Xá · Quán Thánh · Thành Công · Trúc Bạch · Vĩnh Phúc
2	Hoan Kiem	18 Chương Dương Độ · Cửa Đông · Cửa Nam · Đồng Xuân · Hàng Bạc · Hàng Bài · Hàng Bồ · Hàng Bông · Hàng Buồm · Hàng Đào · Hàng Gai · Hàng Mã · Hàng Trống · Lý Thái Tổ ·Phan Chu Trinh · Phúc Tân · Trần Hưng Đạo · Tràng Tiền
3	Tay Ho	8 Bưởi · Thụy Khuê · Yên Phu · Tứ Liên · Nhật Tân · Quảng An · Xuân La · Phú Thượng
4	Long Bien	14 Bồ Đề · Cự Khối · Đức Giang · Gia Thụy · Giang Biên · Long Biên · Ngọc Lâm · Ngọc Thụy · Phúc Đồng · Phúc Lợi · Sài Đồng · Thạch Bàn · Thượng Thanh · Việt Hưng ·
5	Cau Giay	8 Dịch Vọng · Dịch Vọng Hậu · Mai Dịch · Nghĩa Đô · Nghĩa Tân · Quan Hoa · Trung Hoà · Yên Hoà
6	Dong Da	21 Cát Linh · Hàng Bột · Khâm Thiên · Khương Thượng · Kim Liên · Láng Hạ · Láng Thượng · Nam Đồng · Ngã Tư Sở · Ô Chợ Dừa · Phương Liên · Phương Mai · Quang Trung ·Quốc Tử Giám · Thịnh Quang · Thổ Quan · Trung Liệt · Trung Phụng · Trung Tự · Văn Chương · Văn Miếu
7	Hai Ba Trung	20 Bạch Đằng · Bách Khoa · Bạch Mai · Bùi Thị Xuân · Cầu Dền · Đống Mác · Đồng Nhân · Đồng Tâm · Lê Đại Hành · Minh Khai Ngô Thì Nhậm · Nguyễn Du · Phạm Đình Hổ · Phố Huế · Quỳnh Lôi · Quỳnh Mai · Thanh Lương · Thanh Nhàn · Trương Định · Vĩnh Tuy
8	Hoang mai	14 Đại Kim · Đinh Công · Giáp Bát · Hoàng Liệt · Hoàng Văn Thụ · Lĩnh Nam · Mai Động · Tân Mai · Thanh Trì · Thịnh Liệt · Trần Phú · Tương Mai · Yên Sở · Vĩnh Hưng ·
9	Thanh Xuan	11 Hạ Đình · Khương Đình · Khương Mai · Khương Trung · Kim Giang · Nhân Chính · Phương Liệt · Thanh Xuân Bắc · Thanh Xuân Nam · Thanh Xuân Trung · Thượng Đình
10	Ha Dong	17 Quang Trung; Nguyễn Trãi; Hà Cầu; Vạn Phúc; Phúc La; Yết Kiêu; Mộ Lao; Văn Quán; La Khê; Phú La; Kiến Hưng; Yên Nghĩa; Phú Lương; Phú Lãm; Dương Nội; Biên Giang; Đồng Mai.
11	North Tu Liem	13 Cổ Nhuế 1, Cổ Nhuế 2, Đông Ngạc, Đức Thắng, Liên Mạc, Minh Khai, Phú Diễn,

		Phúc Diễn, Tây Tựu, Thượng Cát, Thụy Phương, Xuân Đỉnh, Xuân Tảo
12	South Tu Liem	10 Cầu Diễn, Đại Mỗ, Mễ Trì, Mỹ Đình 1, Mỹ Đình 2, Phú Đô, Phương Canh, Tây Mỗ, Trung Văn, Xuân Phương

13.3 List of markets

APPENDIX

(Attached to Decision No. 5058/QD-UBND dated 11.05.2012)

Appendix 1: List of priority investment projects

1. Regional integrated agricultural products wholesale market

No.	Project	Location	Area (ha)	Period of time	
				2010 - 2015	2016 - 2020
1	Regional integrated agricultural products wholesale market	Long Bien - Gia Lam urban area	30	x	
2	Regional integrated agricultural products wholesale market	Quoc Oai District	20	x	x
3	Regional integrated agricultural products wholesale market	Me Linh urban area	30	x	x
4	Regional integrated agricultural products wholesale market	Phu Xuyen urban	30	x	x
5	Regional integrated agricultural products wholesale market	Son Tay Town	30	x	x

2. Regional wholesale center

TT	Project	Location	Size (ha)	Period of Time	
				2010 - 2015	2016 - 2020
1	Regional wholesale center	Long Bien - Gia Lam urban area	20	x	
2	Regional wholesale center	Soc Son District	20	x	
3	Regional wholesale center	Chuc Son – Chuong My town	20	x	x
4	Regional wholesale	Hoa Lac urban	20	x	x

	center				

3. International and regional trade Center, international exhibition fair center

TT	Project	Location	Size (ha)	Period of Time	
				2010 - 2015	2016 - 2020
1	Regional trade center	Long Bien - Gia Lam urban area	20-30	x	
2	International exhibition fair Center	My Dinh - Tu Liem district	50	x	
3	International exhibition fair Center	Dong Anh	50	x	

4. The list of trade center

TT	District, Town	Project	Location	Scale (rank)
1	Ba Dinh District	Ba Dinh Trade Center	Lieu Giai ward	1
		Giang Vo Trade Center	Giang Vo Exhibition Area	1
2	Hoang Mai district	Trade Center	Southern urban area of Ring Road number 3	1
		Trade Center	Dai Kim – Dinh Cong urban area	1
		Yen So Trade Center	Lot C11 / CCKV3, Yen So ward	1
3	Ha Dong District	TSQ trade center	Mo Lao Ward	1
		Ha Dong stration trade center	Phu Luong Ward	1
		INPYUNG VINA trade center	Van Phu Urban Area	1
		SEOUL trade center	Van Phu Urban Area	1
		Gemstone Center	Duong Noi Commune	1
4	Long Bien - Gia Lam urban area	Trade center	Tien Duong Commune	1
		Trade center	Yen Thuong Commune	1
5	Hoai Duc district	An Khanh trade center	An Khanh urban area	1
6	Hoai Duc district	Trade center	Tram Troi Commune	1
		Kim Chung Trade center	Kim Chung Commune	1
7	Me Linh urban	Expansion Me	km 8, Thang Long - Noi Bai	1

	area	Linh Plaza	highway	
8	Quoc Oai Town	Metropole shopping center	Northern area of Quoc Oai	1

5. List of shopping centers

TT	District, Town	Project	Location	Scale (rank)
1	Ha Dong District	Ha Dong Market shopping center Da Lat shopping center	Nguyen Trai Ward	1 1
2	Urban belong to Tu Liem, Thanh Tri, Hoai Duc, Dan Phuong, Thanh Oai, Thuong Tin districts	shopping center shopping center shopping center shopping center		1 1 1 1
3	Me Linh urban area	Quang Minh shopping center		1
4	Dong Anh urban area	shopping center		1

6. Supermarket list

TT	District, Town	Project	Location	Scale (rank)
1	Hoan Kiem District	1 Hypermarket	41 Hai Ba Trung Street	1
2	Ba Dinh District	1 Hypermarket		1
3	Dong Da District	Hypermarket	Lang Thuong market	1
4	Cau Giay District	Hypermarket	Trung Hoa market	1
5	Hoang Mai District	Hypermarket		1
6	Thanh Xuan Distric	Hypermarket	Thanh Xuan Bac market	1
7	Ha Dong District	Hypermarket	Mai Linh market	1
8	Urbans belonging to Tu Liem, Thanh Tri, Hoai Duc, Dan Phuong, Thanh Oai, Thuong Tin districts	Hypermarket	Troi Giang market	1
		Hypermarket	Phung Khoang market	1
		Hypermarket		1
9	Me Linh urban area	Hypermarket	former Hai Boi wholesale market	1
		Hypermarket		1
10	Dong Anh urban area	Hypermarket	Dong Anh Town	1

			market	
		Hypermarket	To market, Uy No commune	1
11	Long Bien - Gia Lam urban area	Hypermarket	Ngoc Lam market	1
		Hypermarket	Da Ton market	1
		Hypermarket		1
12	Soc Son urban	Hypermarket		1
13	Hoa Lac urban	Hypermarket		1

7. Market List

TT	District, Town	Project	Location	Scale (rank)
I	Dong Da District			
1	Nga Tu So market	No. 46, Nguyen Trai road	1	Upgrade
II	Ha Dong District			
1	Ha Dong market	Nguyen Trai Road	1	Upgrade
III	Hai Ba Trung District			
1	Hom - Duc Vien market	Hue and Tran Xuan Soan streets	1	Upgrade
IV	Hoan Kiem Dist			
1	Dong Xuan Market	Dong Xuan Street	1	Upgrade
V	Hoang Mai district			
1	Southern Wholesale market	Den Lu Urban area	1	Upgrade
VI	Long Bien District			
1	Regional integrated agricultural products wholesale markets	Long Bien - Gia Lam urban area	1	New construction
2	CC1 market	Sai Dong new urban area	2	New construction
3	Lam Du market	Bo De Ward	3	New construction
4	Xom Moi Market	Ngoc Thuy Ward	3	New construction
VII	Tay Ho District			
1	Buoi Market	Buoi and Hoang Hoa Tham Roads	1	Upgrade
VIII	Ba Vi district			
1	Dong Tam market	Phu Dong Commune	1	New construction

2	Nhong market (new)	Phu Son commune	1	New construction
IX	Chuong My district			
1	Xuan Mai Market	Xuan Mai town	1	Upgrade
2	Dong Phuong Yen Agricultural products wholesale market	Dong Phuong Yen commune	1	New construction
X	Gia Lam district			
1	Nanh Market	Ninh Hiep commune	1	Upgrade
2	Regional integrated Agricultural products wholesale market	Long Bien - Gia Lam urban area	1	New construction
XI	Me Linh district			
1	Regional integrated Agricultural products wholesale market		1	New construction
XII	Phu Xuyen district			
1	Regional integrated Agricultural products wholesale market		1	New construction
XIII	Quoc Oai district			
1	Regional integrated Agricultural products wholesale market		1	New construction
XIV	Thanh Oai district			
1	Agricultural products and foodstuffs Wholesale markets	Dong Gum area, Bich Hoa commune	1	New construction
XV	Thuong Tin district			
1	Voi market	Ha Hoi commune	1	Upgrade
XVII	Tu Liem district			
1	Minh Khai wholesale market	Minh Khai Commune	1	Upgrade
2	Thuong Cat Forest Products Market	Thuong Cat commune	1	New construction
XVIII	Ung Hoa district			
1	Agricultural products market	Van Dinh town	1	Upgrade
XIX	Son Tay Town			
1	Nghe Market	Quang Trung Ward	1	Upgrade

2	Regional integrated Agricultural products wholesale market		1	New construction

Note: *Location, scale, land use, total investment and capital investment of the projects are detail calculate, selected and specified in the stage of formulation and submit investment project.*