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FINAL REPORT

Landscape Analysis and Business Model Assessment in Fecal Sludge Management: Extraction & Transportation Models – Cambodia

Final Report

Volume 1 – Main Report

GRET/CAMBODIA

This study have been funded and supervised by:

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ACRONYMS AND ABBREVIATIONS

ACRONYMS

ADB	Asian Development Bank
AFD	French Development Agency
AIMF	International Association of French-speaking Mayors
AIRF	International Association for Regional French-speaking Mayors
Apsara	Authority for protection and coordination of Angkor Temple Site
AusAID	Australian Agency for International Development
COMPED	Cambodian Education and Waste Management Organization
CfD	Cambodians for Development
ETO	Extraction & Transportation Operators
PDPWT	Provincial Department of Public Works and Transport
PDIME	Provincial Department of Industry Mines and Energy
PDE	Provincial Department of Environment
PPWSA	Phnom Penh Water Supply Authority
JICA	Japanese International Cooperation Agency
KOICA	Korean International Cooperation Agency
KWS	Kampot Water Supply
SRWS	Siem Reap Water Supply
MEO	MEchanical extraction & transportation Operators
MAO	MAnual extraction & transportation Operators
FS	Fecal Sludge
FSM	Fecal Sludge Management
HH	Household
MIME	Ministry of Industry Mines and Energy
MPWT	Ministry of Public Works and Transport
FSTP	Fecal Sludge Treatment Plant
FSDS	Fecal Sludge Dumping Site

ABBREVIATIONS

Riels	Riels
USD	United State Dollars

ER	Exchange Rate 4,000 Riels = 1 US$
m^3	Cubic Meter
l	Liter
COD	Chemical Oxygen Demand
BOD	Biological Oxygen Demand

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CHAPTER. I – BACKGROUND AND SURVEY METHODOLOGY

I. BACKGROUND

■ Brief overview

The Kingdom of Cambodia is located in South-East Asia having a western border with Thailand (http://www.wssinfo.org/data-estimates/table/ 2008), a northern one with Lao PDR and an eastern one with Vietnam. According to the last national census conducted in 2008, the country population is about 13.8 Million (NIS 2008). Over the past 10 years, Cambodia has experienced high economic growth and an improvement of living conditions thanks to the development of the global and sub-regional market particularly expressed through the progress of tourism and the increase of textile manufactories in the capital Phnom Penh.

Total Population	13.8 millions
Rural Population (%)	80%
Urban Population (%)	20%
Annual Population growth	1.9%
GDP per capita (US$)	447
GDP per capita (PPP)	2929

However, Cambodia remains characterized by economic activities focused on agricultural production and small business activities. Few industries exist and they generally are concentrated in Phnom Penh. Furthermore, over 80% of the population live in rural areas only the remaining 20% live in urban areas. Other than Phnom Penh with its 1.3 million inhabitants, cities in Cambodia can be considered small cities. The second city of the country (Siem Reap) has only 170,000 inhabitants and most of them have fewer than 50,000 inhabitants. Since the early 1990s, Cambodia has managed to make impressive improvements in reducing poverty, rebuilding the water and sanitation sector, and extending water supply to an increasing number of its population.

■ Urban sanitation: high coverage

Albeit the significant effort made, there are still a high number of people that have no access to improved sanitation. The latest figures from the Joint Monitoring Programme (JMP) (http://www.wssinfo.org/data-estimates/table/ 2008) for Cambodia continue to show low coverage rates for rural sanitation. Indeed in 2008, only about 29% of the total Cambodian population had access to improved sanitation. The Royal Government of Cambodia (RGC) has taken steps to address this issue and has recently started to implement a clear strategy to support and develop access to sanitation in rural areas.

On the contrary, surprisingly, the access to improved sanitation coverage rate is quite high in urban and peri-urban areas[1] (67% in Cambodia in 2008). Other, more detailed sources, such as the Cambodia Demographic and Health Survey (NIS 2005) show that in urban areas the average number of households (HH) connected to sewers is about 28.9%, to a septic tank 25.8%, to a pit latrine 1.4%.

[1] According to the Cambodian general census 2009, the sanitation coverage rate in urban areas is 80%: 56% through sewer connections, 40% through septic tanks, 3% through latrines and 1% others.

Table 1 - Comparison of sanitation types and coverage values (Kov P. 2008)

	Improved sanitation (%)				Unimproved sanitation (%)				
	House connection	Septic Tank	Pit latrine	Total	Public toilet	Pit latrine	Open	Other	Total
Rural	1.1 %	12.6 %	2.0 %	15.7	-	0.9	78.1	5.2	84.2
Urban	28.9 %	25.8 %	1.4 %	56.1	-	0.7	32.3	10.8	43.8
Total	**5.2 %**	**14.5 %**	**1.9 %**	**21.6**	**-**	**0.9**	**71.4**	**5.9**	**78.2**

However, following the Economic Impacts of Sanitation study (Kov P. 2008) there is an unclear vision of the sector situation. Indeed, it appears that the improved sanitation coverage varies from 56.1% to 61.1 % following the data available.

- Urban sanitation: but low quality systems

In Cambodia, most of urban sanitation systems, in the core of major cities, when they exist, are based on centralized approaches linking drainage and wastewater collection and treatment. Pre-treatment is very common both in the core and peri-urban areas before discharging wastewater in sewerage systems composed of unstructured sewers and open canals.

For HH located outside the service coverage area, on-site systems are most common. However, in urban areas, the Cambodian water and sanitation sector is characterized by systems that provide water supply services to the population without providing sewerage and sanitation services (PPIAF and WB 2002).

Regarding more specifically the sanitation sector, there are only a few sanitation projects in urban and peri-urban areas. The MPWT is responsible for sanitation service delivery, but it has shown a low capacity for investment and weak skills in managing utilities. Consequently, actual urban sanitation conditions are very poor due to poorly designed sanitation systems with often no or limited treatment or pre-treatment of effluent. Fecal sludge is generally dumped in the environment without any safe-treatment. There are no technical references. Institutional framework also is either unclear or non-existent without a clear definition of responsibilities and boundaries between public health issues, drainage and sanitation managements. Indeed, there is a growing concern for urban pollution of groundwater, serious environmental damage and public health issues.

- An ignorance of Fecal Sludge Management in Cambodia

If many stakeholders have paid attention to the access to sanitation growth rate, fewer organizations have offered a comprehensive analysis of the extraction and transportation of fecal sludge in Cambodia.

Few in-depth and global surveys and analysis have yet been conducted. Though, many SMEs, extraction & transportation operators, either manual or mechanical, latrine builders and other "informal" stakeholders are active in this sector. They are working day to day to build and disseminate sanitation products and services. They play a great role which is not recognized yet:

- they provide a complementary service to households who cannot afford being connected to a piped sewage system;
- these systems are flexible, adaptable and affordable to the demand and they are providing employment and incomes to an unskilled population;

Within this framework, the Bill and Melinda Gates foundation intended to start an in-depth survey of Fecal Sludge Management in Cambodia in order to provide a comprehensive analysis of the sector and to identify key recommendations and potential steps to move forward.

II. OBJECTIVES AND METHODOLOGY

1. KEY OBJECTIVES

The "Landscape Analysis and Business Model Assessment in Fecal Sludge Management: Extraction and Transportation Models in Asia" aims to gather and rigorously analyze data based on a representative range of criteria to better understand fecal sludge management in Cambodia and especially its extraction & transportation. It aims to better understand the living conditions of these operators, their technical, financial and economic situation, and the market size through a household survey. At a secondary level, it aims to provide key data and recommendations about the opportunities, constraints, conditions and potentiality of development of these markets in a prospective analysis. Consequently, the main objectives of this study are to:

- to conduct an in-depth survey and analysis of the current and potential market of fecal sludge extraction and transportation;
- to develop a better understanding of this area of sanitation service delivery in three cities of Cambodia;
- to disseminate the results for discussion and debate at the local level among urban sanitation policymakers and practitioners;
- to inform with in-depth empirical research investment by governments, donors and other development partners.

2. MATERIALS AND METHODS

2.1 Survey methodology

- Desk review: few documents are available

The desk review was achieved largely including country documents and experiences. First of all, it is interesting to notice that very few documents have been issued on fecal sludge management, but an important number over the past years on access to sanitation. Most of the legal documents were enacted in the early 2000 and are under revision. Besides, there are many more documents available about environmental topics in general. The number of those studies and documents has increased especially in the last three years. A detailed list of the documents reviewed is available in the bibliography at the end of the document.

- Sampling and selection of target cities

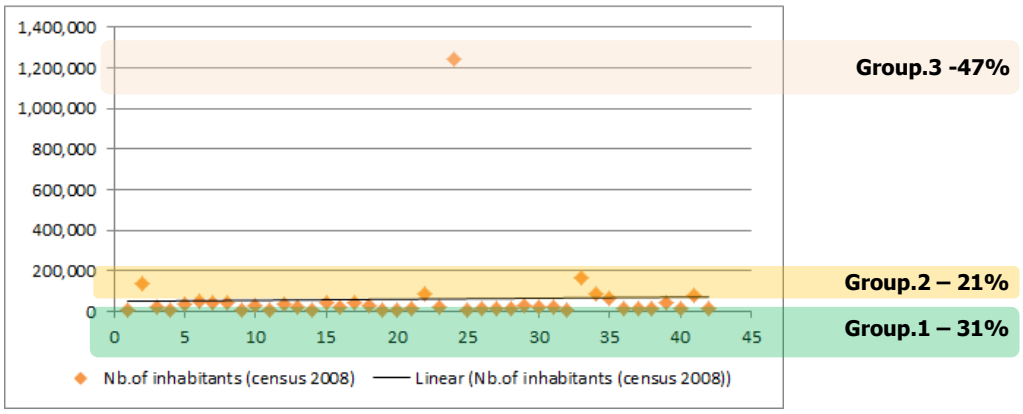
The first challenge was to identify and select a range of cities, representative of cities in Cambodia. Three categories of urban areas were considered: i) large cities; ii) medium-sized cities; iii) small-sized cities. Regarding the urban area definition from the 2008, Cambodian national census considers as urban 42 cities. Table 1 and figure 1 below show the distribution of cities following their number of inhabitants. A detailed table has been placed in the Volume.2 - Appendix.1- Detailed table of cities in Cambodia.

Following table 1 below and figure 1, a basic analysis shows clearly those three main types of cities that need to be considered regarding fecal sludge management practices: i) the city which contains over one million inhabitants that represents 48% of the population living in urban areas; ii) cities which contain from 60,000 to 200,000 inhabitants that represent 21% of the total population living in urban areas; and iii) cities which contains from 5,000 to 50,000 inhabitants that represent 31% of the total number of cities.

Table 1 – Type of Cities in Cambodia

Type of Cities	Num.	Total inhabitants	% of Urban population
Group – 1. Small-sized	36	802,703	31%
Group – 2. Medium-sized	5	568,332	22%
Group – 3. Large	1	1,327,615	48%
Grand Total	**42**	**2,614,027**	**100.00%**

Figure 1 – Cities distribution in Cambodia with linear trendline



In order to select the three cities, the following criteria were applied: i) total population, the "size": the capital of Cambodia, one medium-sized city and one small-sized city; ii) geographical location: one city in the center of the country; one city in the north and one city in the south; iii) environment specificity: one city along the Mekong River; one city in the Mekong basin and one city close to the sea. These criteria aim to select different types of physical, environmental, socio-economical characteristics.

Following these criteria, we assume that one city per group needs to be selected: i) in group 1, 36 cities can be selected containing from 5,000 to 60,000, Kampot city was designated due to an average population size; ii) in group 2, 5 cities can be selected but Siem Reap was targeted due to its high population growth over the past 10 years (42%) compared to Battambang (2%); iii) in group 3, Phnom Penh is the only large city of the country so it was selected. Table 2 below shows the general characteristics of the population trend for each city. As show the table below, Phnom Penh and Siem Reap experienced a high increase of their population (72% and 42%) when Kampot experienced a smaller increase (7%).

Table 2 – Trend of population on targeted cities

Name of city	Name of province	Nb. of inhabitants (census 1998)	Nb.of inhabitants (census 2008)	Growth (%)
Phnom Penh	Phnom Penh	950,373	1,327,615	72%
Siem Reap	Siem Reap	97,105	168,662	42%
Kampot	Kampot	36,036	38,819	7%

- Customer survey methodology

The household survey sampling was based on the number of population and a transect approach in each city. There are several ways to sample households: i) random choice; ii) spot survey; iii) transect survey, etc. However, the transect approach is most appropriate in the specific case of Cambodian cities due to the strong geographical heterogeneities of socio-economical and sanitation data of these cities.

Indeed, this approach if it is well-managed can represent a slice of a city which includes the variety of situations along one transect and consequently can reduce the normal bias of socio-economic analysis. The total number of household survey was defined following the table below using an average number of inhabitants per household of 5.1 based on the General Population Census 2008 (NIS 2008).

Table 3 – Survey Distribution per cities

Name of the city	Number of population	Number of HH	HH in transect selected	Number of survey	% per transec
Phnom Penh	1,242,992	243,724	65,974	1,320	**2.00%**
Siem Reap	168,662	33,071	10,768	426	**3.96%**
Kampot	38,819	7,612	5,137	303	**5.90%**

The number of HH survey to be conducted was based on the population density in each commune (with the same surface area on average) along transect. In Phnom Penh, two transects were defined and only one in Siem Reap and Kampot. Figure 2 below shows an example of the calculation modalities used in the case of Phnom Penh transects. The Transect mapping has been placed in Volume.3-Mapping-Surveying transect in Phnom Penh, Siem Reap and Kampot. An example for Phnom Penh is in Figure 3.

Figure 2 – Transect calculation in Phnom Penh

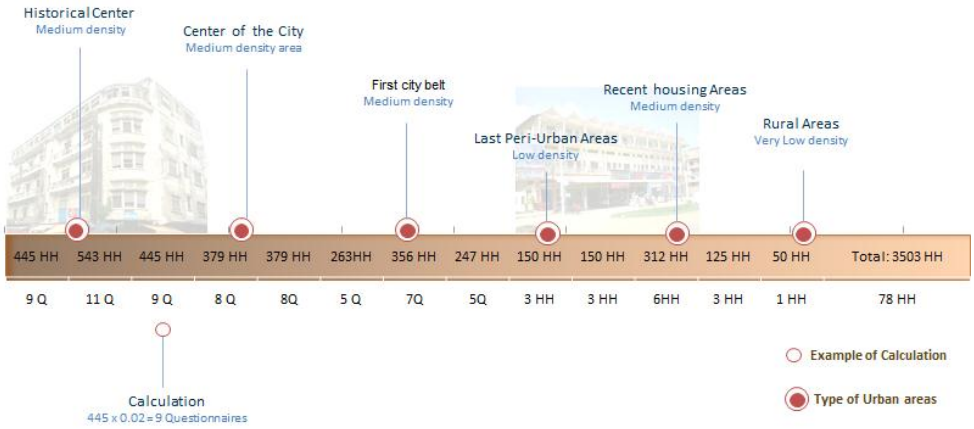
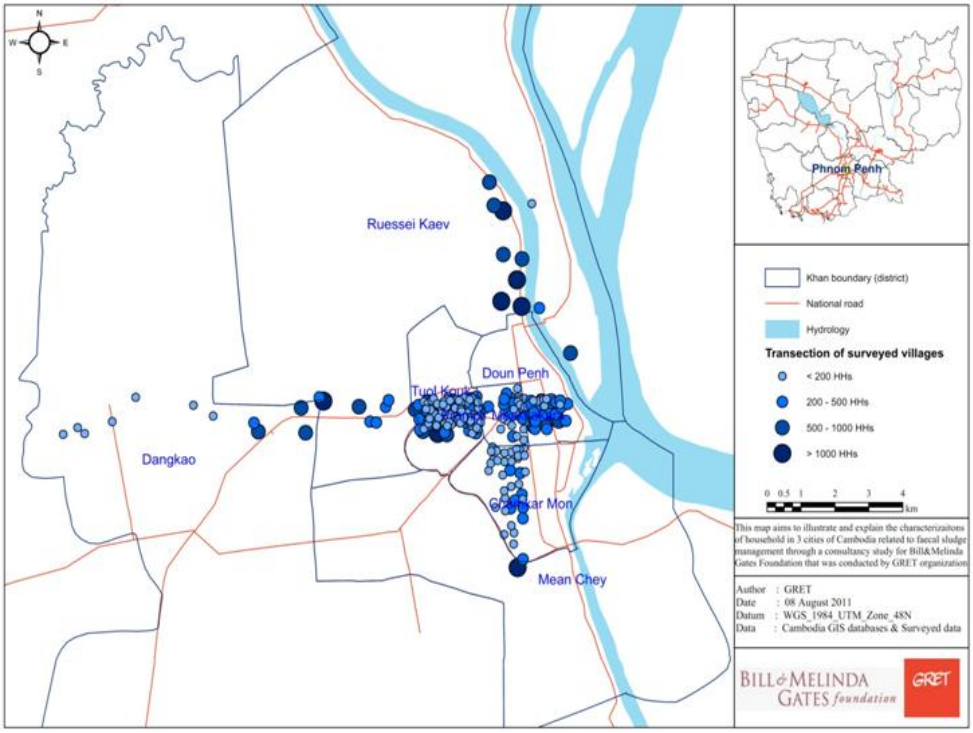


Figure 3 – Example of surveying transect in Phnom Penh



- E&T operators survey methodology

The survey and sampling of extraction & transportation (E&T) operators was done in two steps: i) pre-screen survey in order to identify all E&T operators both manual and mechanical; ii) a sampling of operator type identified during the pre-screen survey; iii) an in-depth analysis of each type of E&T operators based on a sampling from the pre-screen survey. The following typology of operators has been used: i) public E&T operators; ii) private E&T operators: small E&T operators, medium E&T operators, large E&T operators; iii) manual E&T operators. The sampling of the operators is given in the table below:

Table 4 – Pre-screen sampling of E&T operators in Cambodia

		Type	# of operators	# of operators surveyed	%
Manual E&T operator	Phnom Penh		24	5	21%
	Kampot		1	1	100%
Mechanical E&T operator	Phnom Penh	Small	12	5	42%
		Medium	7	6	86%
	Siem Reap	Small	5	4	80%
		Medium	1	0	0%
	Kampot	Small	1	1	100%

- Stakeholder consultation

The main stakeholders in FSM in Cambodia were met in each city to collect general data and better understand the content of certain documents. A first meeting was organized to provide general information on: i) roles and responsibilities of each institution at the national and local level; ii) collection of texts and documents for the desk review at the local level; identify general approach and strategy for the future. A detailed review of stakeholders met is available in Appendix.2-Stakeholders-reviewed.

2.2 Data analysis

- Household survey

In order to determine the socio-economic status of the households, many criteria were checked at the beginning: i) the detailed expenses, ii) the incomes of the first and the second worker in the house; iii) the qualitative perception of the evaluator, iv) the income per day per capita calculated and v) the detention of some specific assets. Every criterion was tested and compared to evaluate the poverty of the HH. The last one, the detention of assets gave us a close cross of each criterion and was the one we kept for the analysis.

An indicial number was created per points according the assets that the HH owned: i) means of transport (number of bicycle, motorcycle, car per HH), ii) number of phones per HH; iii) number of computers per HH and; iv) type of energy used for cooking. Following these criteria, points were attributed to each HH. Gret assumes that from 0 to 10 points, the HH can be considered as a poor, from 15 to 30 points as a medium and more than 30 points for the HH considered as well-off.

- Business and financial analysis

For the business and financial analysis, the methodology takes into account different parameters: i) the data collected in the pre-screen survey were used to determine the number of clients and global incomes and expenses and ii) the data collected during the in-depth survey were used for the detailed analysis of the expenses and the incomes. Following the data gained directly from the E&T operators Gret conducted cross-check analysis in order to confirm or refute some data such as: price of fuel, taxes paid at the dumping site (we conducted two analysis to check the real number of trucks that dump at the official site and finally only 5 out of 31 do so), real investment cost from the truck maker, fees charging from the HH survey.

CHAPTER II – CURRENT STATUS OF FECAL SLUDGE MANAGEMENT IN CAMBODIA

I. FECAL SLUDGE MANAGEMENT OVERVIEW

1. INSTITUTIONAL ENVIRONMENT

1.1 Institutional structure

- Sanitation Sector vision

The sector vision is based on: "Every person in rural communities has sustained access to safe water supply and sanitation services and lives in a hygienic environment by 2025" (CMDG).The main principles promoted are: 1) The sustainability of improved sanitation facilities and hygiene behavior; 2) Community-based management; 3) Demand responsive approach; 4) Sanitation financing without hardware subsidies (Okelford J. 2010).

Actually, the first priority for the Ministry of Public Work and Transport of wastewater and Sanitation development are Phnom Penh, Siem Reap, Sihanoukville and in second, Kampot, Koh Khong, Battambang and Kratie (Pisith 2008).

- National level

Urban sanitation is an issue that involves many stakeholders and in which the responsibilities are shared between many ministries, agencies or local authorities. Urban sanitation is related to environmental issues as well as health, land planning or water resource protection issues. In Cambodia, several ministries are involved in urban sanitation but four ministries are predominant:

i) the Ministry of Public Works and Transport (MPWT) is responsible for urban drainage and sanitation in urban areas of Cambodia including the Phnom Penh Municipality;

ii) the Ministry of Environment (MoE) is in charge of water pollution control and environmental protection: the MoE was established in 1993 with the mandate to protect and upgrade environmental quality and public health through prevention, reduction and pollution control measures. It inspects pollution sources in collaboration with concerned institutions, issues fines, and/or compiles information for authorized institutions;

iii) the Ministry of Land Management and Urban Planning (MoLMUP) is responsible for construction standard control and issuing construction permits;

iv) the Ministry of Industry Mines and Energy (MIME) is in theory responsible for urban sanitation at the household level;

v) Ministry of Water Resources and Meteorology (MoWRAM) was established in 1999 to define the policies for strategic development of water resources. It currently has a limited role in the water sector and focuses mainly on granting water abstraction rights;

vi) the Ministry of Rural Development (MRD) is responsible for rural sanitation (latrine construction and standards) conforming to the national strategy for water and sanitation adopted in 2003.

The figure below aims to show the main responsibilities and tasks regarding water supply, urban and rural sanitation and on FSM point of view.

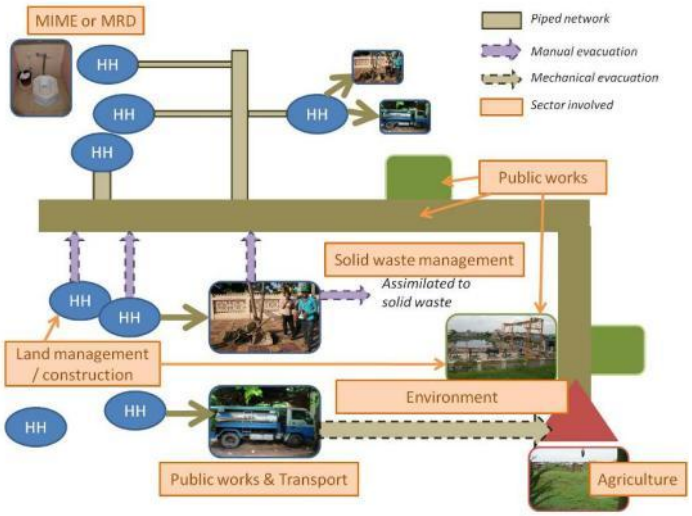
Figure 4 – Main tasks and responsibilities in Water Supply and Sanitation Sectors

TASKS		INSTITUTIONS AND ACTORS							
		MPWT	MoE	MOWRAM	MIME	MoPLU	MRD	HH	Private
POLICY AND LAW	GENERAL	Urban sanitation	Water pollution control and Environmental protection	Water ressorces management	Urban Water supply and Sanitation	Urban planning and Construction	Rural Sanitation	NA	NA
	FSM	Transport				Type of sanitation facilities	Septage Management in the RWSS	NA	NA
INFRASTRUCTURE	GENERAL	OFF-SITE Sanitation system		Irrigation System	Water Supply Utilities			ON-SITE Sanitation system	
	FSM	Truck emptying							Truck emptying
FINANCE	GENERAL	OFF-SYSTEM such as: Primarlty sewerage and drainage system, Wastewater Treatment Plant SEWER CLEANING: management of sewer cleaning			WATER UTILITIES: Several models State Owned Enterprises, State Agencies, Private Compagy			ON-SITE Sanitation system such as: Secondary Drainage System and On-site (Pit, Septic Tank) FSM: Domectic HH emptying (Fees)	
	FSM								Truck emptying
MANAGEMENT	GENERAL								Collection of fees from the HH
	FSM								
REGULATION	GENERAL		Water pollution control	Water ressources protection	Water Tariff Policies	Control of Sanitation Facilities			
	FSM	Control of Private E&T operators on vehicule and on	Control of E&T operators if unauthorities						Fees to MoE and MPWT
PUBLIC AWARANESS	GENERAL		Environmental protection				Promotion of Sanitation Marketing		
	FSM	No	No	No	No	No	No	No	No

- Provincial level

In each city targeted by the action, a local department of each ministry exists and is involved with the provincial authorities in urban sanitation management. For that purpose, municipal authorities and the departments representing each ministry need to be involved in the action implementation. These are: 1) the Provincial Department of Public Works and Transport (PDPWT) that is responsible for building and managing infrastructures (treatment plants, pumping stations, primary networks); depending on the equipment and capacity, the DPWT can clean sewers and collect fees; 2) the Provincial Department of Environment (PDoE); 3) the Provincial Department of Land Management and Urban Planning (PDoLMUP); 4) the Provincial Department of Industry, Mines and Energy (PDIME). Through the D&D (Deconcentration and Decentralisation) process voted in 2001, local authorities such as districts and communes have responsibilities in planning and public service provision. Indeed, municipalities are responsible to plan the construction, installation of the networks and their extension; they own the infrastructure and are responsible for their maintenance.

Figure 5 – Framework of responsibilities



According to law fecal sludge E&T operators should apply to three different permits or license regarding different ministries:

i) the MoE shall deliver a license for the discharge or transportation of effluent when the amount of their effluent exceeds ten cubic meters per day not including the amount of water used to cool the engine;

ii) the MPWT is in charge of delivering a license for vehicles and control the "use of the vehicle"; the MPWT is also in charge of urban sanitation (and sometimes in direct competition with private operators);

iii) the MIME delivers licenses in the water sector but could deliver also licenses in the sanitation sector; the definition of sanitation services appears clearly in article 35 "The right to provide sanitation service in this law is the right of ownership, operation and managing facilities to collect, discharge and treat sewerage for insure of the safe, reliable, and economic efficient operation". In article 31, licenses can be delivered for "4- Sanitation Service License, 5- Wastewater Discharge Collection License and finally 6- Sewerage Treatment License."

1.2 Legal framework

The main legal documents that frame urban sanitation are: the Environmental Protection Law (1996), the Sub-decree on Construction Permits (1997), the Sub-decree on Water Pollution Control (1999), the National Water and Sanitation Policy (2003) and recently the Rural Water Supply, Sanitation and Hygiene Strategy: 2010-2025 (2010). On the solid waste management sector, a specific note is in Volume 2 – Appendix.3-Solidwaste management note.

- National Policy on water supply and sanitation 2003

In 2003, the Cambodian government issued a National Policy on Water Supply and Sanitation, a "key crucial factor for setting up an institution that can maintain and expand the services" that is the only document that frames urban sanitation. However, there is not yet a strategic plan, political agenda and law in order to enforce and detail this policy.

The National Policy on Water Supply and Sanitation consists in three parts: urban water supply, urban sanitation and rural water supply and sanitation. The policy promotes the construction of "community sanitation systems, [where] all residents share in financing the systems, whether they use them or not". The scale of application of these criteria is the "neighborhood sanitation block" (household conglomerates). These "community sanitation systems" are then supposed to be

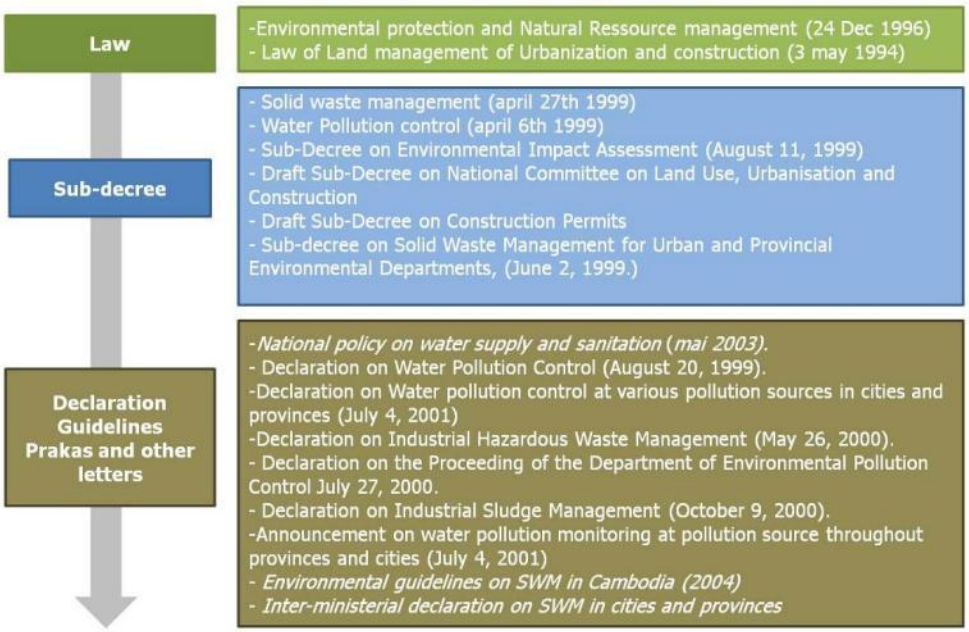
discharging into either a decentralized treatment facility or into "zonal sanitation systems" (public sewerage), where "the use of separate sewerage and drainage systems should be promoted and encouraged, particularly in new installation areas."

The document identifies the need of "separate responsibilities" (operation, regulation) among "the Ministry, other responsible ministries and local authorities", without naming any of them. However, "Municipal and Provincial authorities are responsible for urban sanitation". The last chapter of the document is explicitly focused on "expanding service to the poor". However, guidelines do not consider non-sewer solutions, and only look for financing mechanisms, including "target subsidies in exceptional circumstances". (Kopitopoulos 2005).

- Water pollution control

The MoE should control the effluents which are discharged and their conformity with the standards enacted (1999). In terms of regulatory framework, some legislative texts complete this national policy, there exists at the national level some laws and sub-decrees on water pollution control or on solid waste management. These texts give clues about sector principles: i) effluent standards and norms of pollution enacted follow international standards; ii) the polluter is the payer: the source of pollution is responsible for the treatment of effluent; iii) the approach is centralized with the willingness to install combined sewers in all the urban areas and connect all the HH, not taking into account the specificity of the cities or even the feasibility of those networks, their maintenance and operation.

Figure 6 – Urban sanitation, enviromental protection and solidwaste management laws



Source : **Cambodia Environmental Health Country Profile, World Health Organization, As of December 3, 2004**

1.3 Aid and business actors

- Largest program in sanitation

Most of NGOs and Donors are working in Cambodia in order to enhance access to sanitation in rural areas. The largest projects implemented are:

i) Plan International, Unicef, MRD have introduced the CLTS approach in 2003. Currently, 258 villages have been covered in over 9 provinces. Results show that a significant number of latrines have been built without external assistance. However, the level of usage is quite low (64%) while 23% of the HH abandoned their sanitation facilities and the remaining ones still have no latrine (35%).

ii) Different sanitation marketing approaches have been piloted with success in Cambodia by several NGOs such as: IDE, WTO, Lienaid and Gret. All are based on a no-hardware subsidy approach, adapted CLTS mixed with marketing, low-cost latrine dissemination and support to local producers.

iii) The Tonle Sap Rural Water Supply and Sanitation project (TS-RWSSP), funded by ADB, is the largest rural sanitation program in Cambodia, with an estimated US$ 5.1 million for sanitation. It aims to improve the sanitation situation of 25% of the Cambodian population.

iv) The National Biodigester Programme (NBP) is a joint programme between the Ministry of Agriculture, Forestry and Fisheries (MAFF) and the Netherlands Development Organisation (SNV), which aims to develop quality biodigester systems with an enabling framework for sustainable operation and management. The pilot phase ran from 2005 till December 2009 and the program is extending till 2012 and scaled up to 12 provinces.

In urban areas surveyed, the JICA and AFD have funded the definition of master plans (respectively in PP and SR) on wastewater collection and drainage systems. The Korean Cooperation Agency is acting through Korean private actors (bank and consulting firms) to install some piped networks through important loans (one approved in SR and another in Kampot but has been postponed). Moreover, very few NGOs are active in the sector. Indeed, only one CfD is focused on urban sanitation. The following projects were implemented in order to upgrade the wastewater management in these cities:

Table 2 – Past large projects in urban Sanitation

No. Project Name Funding	Agency	Location	Year
Emergency Rehabilitation Project for Water Supply and Sanitation in Battambang	EU ECHO-ASIA Pro II.	East Part of Town Center about 200 ha.	1994
Provincial Towns Improvement Project Wastewater Management System, Sihanoukville	ADB 11.19 million USD	Covers an area of 221.5 ha with 3,368 service connections	2006
Mekong Tourism Development Project, Wastewater Management System in Siem Reap.	ADB - 10.8 Million USD	About 530 ha 7 February	2009
MEK-WATSAN program	UN-Habitat	three towns in Cambodia have been identified for participation in the Mekong Water and Sanitation Initiative	In-progress

- Financing institution

The banking sector in Cambodia is characterized by a lack of involvement in financing SMEs, especially in the sanitation sector. There are several MFIs such as: Amret, Ank, Vision Fund, and several commercial banks: Acleda, ANZ, CamKo, etc. However, the banking sector in Cambodia is unfortunately extremely conservative in its attitude to risk. Many SMEs mentioned that they could not access finance to expand or improve their operations or to invest in capital investment. From the household and business side, MFIs are conformist and do not want to propose micro-credit for "unproductive investments".

- The private sector in sanitation

In Cambodia, there are many SMEs who are active in the urban sanitation sector. Along the urban sanitation value-chain, SMEs are: sanitation systems designers, producers, importer, retailers, constructors and masons, pit and tank emptiers, re-users and recyclers, etc.). Studies show that the SMEs are already delivering most of sanitation systems in Cambodia (Roberts, Tanner et McNaughton, Supply Chain Assessment for Sanitary Latrines in Rural and Peri-Urban Areas of Cambodia 2007) and (Roberts et Long, Demand Assessment for Sanitary Latrines in Rural and Urban Areas of Cambodia 2007).

Few are dedicated to sanitation (mechanical emptiers for instance), most are occasionally involved in the chain (architects, masons, small construction companies, real estate developers). However, the upstream part of the sanitation value-chain is characterized by low quality products (combined sewers, septic tanks and latrines) neither coherent nor designed using a holistic approach. Downstream of the sanitation value-chain, SMEs (emptying systems, sludge re-use for farming) remain mainly unstructured and informal.

2. OVERVIEW OF SANITATION ASSETS AND FECAL SLUDGE QUALITY PRODUCED

2.1 Overview over cities

Following the Cambodia Demographic and Health Survey (NIS 2005), Phnom Penh has a high rate of HH connected to the sewer when the medium-sized and small cities used more septic tank and other on-site sanitation systems.

Table 3 – Sanitation coverage by region (urban area) (NIS 2005)

	Improved sanitation (%)				**Unimproved sanitation (%)**				
	Sewer connection	Septic Tank	Pit latrine	Total	Public toilet	Pit latrine	Open	Other	Total
Phnom Penh	90%	3.9%	0.6%	94.4%	-	0%	2.8%	2.8%	5.6%
Siem Reap*	5.5%	43.1%	3.1%	51.7%	-	0.2%	43%	4.9%	48.1%
Kampot**	7.7%	33.3%	0.8%	41.8%	-	1.2%	49.7%	7.3%	58.2%

*based on the Tonle Sap region average data and not on Siem Reap specific, **based on the Coastal region average data and not on Kampot specific.

However, behind these standard data there is a large range of technological type that are used commonly in Cambodia. The part below aims to present an overview of each type that will be used after for HH survey and technical assets description.

Moreover, the sewerage systems installed in Cambodia are combined systems that collect wastewater and rainwater. They are often composed of: i) a secondary sewer system; ii) a primary open-channel system; iii) pumping stations; iii) wetlands that treat the effluent.

- Secondary sewer system

In the street, HH sanitation systems are connected to a closed sewer that collects both rainwater and wastewater. These sewers are often blocked due solid waste and other materials that move in the sewer during the rainy season. This causes flooding problems for the inhabitants living in urban areas.

- Open-channel and lift station

After the secondary sewer discharge the wastewater and rainwater into big open canals that drain the cities to several points. They transport the wastewater to lift stations located close to wetlands or lagoons that can treat the wastewater.

In Cambodia there is no technical specification on sanitation collection, transport and treatment assets. Nevertheless, some "standard designs" are often used by latrine installers such as: i) multi-storey buildings are connected directly to combined sewerage systems or to septic-tanks if they are far from the network; ii) certain middle standard households use "septic tanks" but most use pit systems either discharging directly into the drainage system (sewerage or open-air channel) or infiltrating to the ground through sump holes; iii) urban poor or HH which have no sewage system use traditional pour-flush latrines.

The sanitation systems connected to the sewer often discharge pretreated wastewater without solids. The sullage (gray water) is often discharged directly into the channel or combined sewage system.

- Type 1 – One pit connected to the sewer or not connected to the sewer

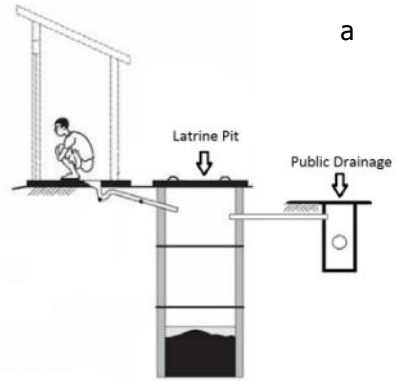
The first type of sanitation system that can be found very often in cities is the standard one pit latrine system that is connected to a sewer or that discharges directly into the street (Fig. a) or into the environment or infiltrates (Fig.b). Sometimes there is a connection-box or interceptor tank (volume 100l) between the pit and the sewer.

The pit is rarely sealed at the bottom so that can permit the infiltration of wastewater into the ground.

This first stage can be named "pre-treatment" tank. Consequently, only supernatant is discharged into the secondary sewer system or into the environment. The absence of a deflector can, in some cases, reduce the pre-treatment undergone by the sludge before discharge.

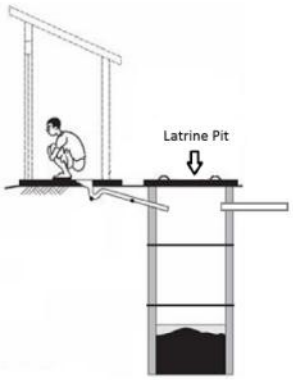
The pit is composed by three concrete rings with a diameter of 0.90 meters. The total average volume is estimated from **0.75 cubic meters to 1.5 cubic meters.**

a



Option 01: Latrine with single pit

b



Option 01: Latrine with single pit

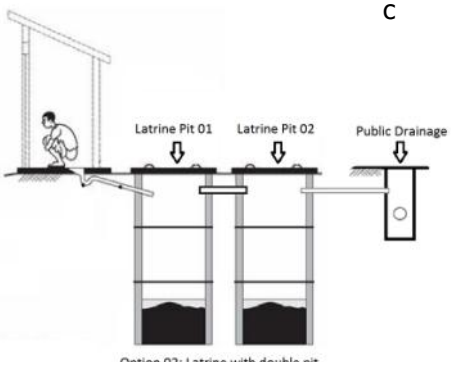
- Type 2 - Pits in series connected to the sewer or infiltrating

The second type of sanitation system is composed by a series of pits that are linked by pipe. They can have from 2 to 4 pits at the maximum. As the first pit system these systems can be connected to the sewer or discharge directly into the street (Fig. c) or the environment or infiltrate (Fig.d).

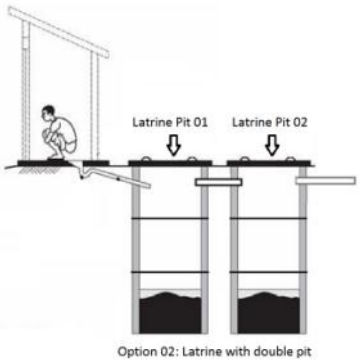
As the first pit system, the pit in series system is not sealed at the bottom so that allow infiltration of wastewater into the ground. This first stage can be named "pre-treatment" tank. The system presents the same problem on discharging fecal sludge into the environment or in the secondary sewer. The pit is composed from 2 to 4 pits by three concrete rings with diameter of 0.90 meters.

The total average volume is estimated from **1.5 cubic meters to 3 cubic meters.**

c



d



Option 02: Latrine with double pit

e

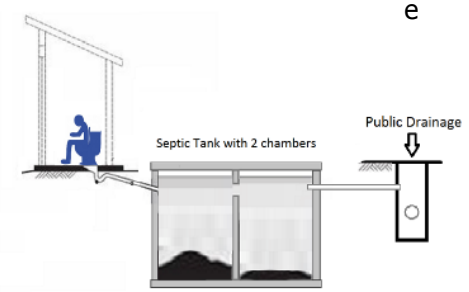
- Type 3 - Septic tank/stock tank connected to the sewer or infiltrating

The third type of sanitation system is real septic tank because of a seal at the bottom that avoids infiltration into the environment. Most of them were built under the French colony during the 50s. News ones made of plastic have recently been introduced in Cambodia but these kind of system are anecdotic. As the other sanitation systems two main ways of wastewater evacuation are: connection to the sewer or discharge directly into the street (fig.e), the environment or infiltration (fig.f).

As, the other systems if the technical specification are not respected (no deflector), feces can be discharged by an overflow into the sewer or in the environment. Generally only the treated supernatant can be discharged.

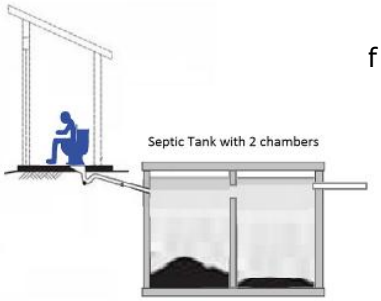
This system is composed by two chambers as a real septic tank with two stages of pretreatment. The average volume is estimated from **2 to 3 cubic meters.**

e



Option 05: Latrine with Septic Tank of 2 or more chamber

f



Option 05: Latrine with Septic Tank of 2 or more chamber

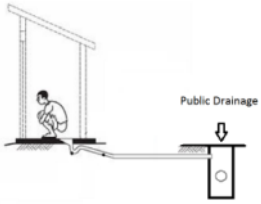
- Type 4 - Direct connection to the sewer or no storage assets

Few households have a direct connection to the sewer (fig.g) without any pretreatment/storage stage like an off-site system.

In theory these systems do not required any Extraction and Transportation services but sludge accumulates at the bottom of manholes. These systems often exist in the core of Cambodian cities.

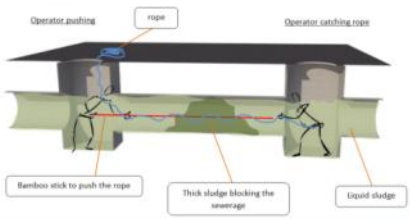
Finally, these system need to be emptied sometimes when the manhole (fig.h) are block with too much fecal sludge or by solid waste and others solid materials.

g



Option 06: Direction connection to Public Drainage

h



2.2 Fecal sludge quality

Few chemical and biological analyses are available in Cambodia to determine sludge quality. In the region we are working in, the origin of fecal sludge is either from septic tanks (biochemically more stable due to long storage periods) or from individual sanitation facilities, commonly called simple pit latrines. Chemically, the particularity of Fecal Sludge is that they are biochemically unstable: i) High BOD_5 concentrations; ii) High NH_4^+-N concentrations (from urine); iii) High content of water (TS < to 20%).

The chemical and biological analyses made in Phnom Penh in April 2010 (Clouet and Frenoux 2010) on both pit latrine tank and fecal sludge extraction from truck shows:

Table 5 – Septage quality in Phnom Penh

Type	Value
pH	8.1
Turbidity	1,563 NTU
Total solids	73 g/l
BOD	574 mg/l
COD	9,685 mg/l
Oil and grease	9.95 mg/l
Total coliform	1.5×10^8

3. OVERVIEW OF FECAL SLUDGE MANAGEMENT VALUE-CHAIN DESCRIPTION

3.1 Fecal Sludge Management value-chain

FS value-chain starts with demand from households for different types of works required: emptying their treatment assets which are overflowing or just full or cleaning the sewer lines on tertiary roads. They are several kinds of stakeholders that are involved in the value-chain: i) truck assemblers; ii) public mechanical E&T operators; private E&T operators that can be small (only one truck), medium (from 2 to 4 trucks) or large (more than 4 truck); manual E & T operators; fecal sludge re-users; authorized fecal sludge dumping site operators; "un-authorized" fecal sludge dumping site operators. A detailed analysis is in Volume 2 – Appendix 4.

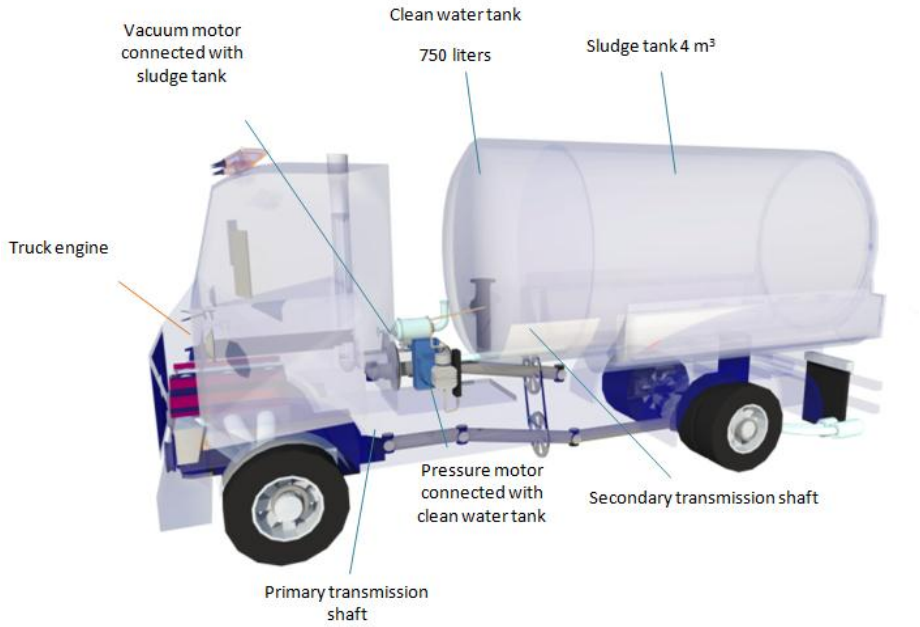
- Truck assemblers

There are two truck assemblers in Phnom Penh and one in Siem Reap.

It seems that they have built most of the emptying systems existing in Cambodia. We estimate that 50 trucks have thus been built in Phnom Penh in the past 15 years. In general, the truck equipment is home-made with second-hand materials built by the operators described above. A wide range of types of truck is used.

The advantage of local assemblers is their flexibility: the maintenance can be done locally, the tank size can be chosen, and the tank can be changed without changing the engine. The trucks are equipped with two different types of pipes, one for water and one for pumping. They have to be changed every two or three years. The second hand trucks come from Korea or China.

Figure 7 – Standard truck design in Phnom Penh



- Public Extraction & Transportation Operators

Public E&T mechanical operators are managed in general by the DPWT or by municipalities in order to operate and maintain the primary sanitation systems of the cities. There are public E&T operators in Phnom Penh and in Siem Reap which have respectively 10 trucks and 1 truck. The trucks are imported and come from Europe, Russia or Japan.

These trucks are in charge of the maintenance of the sewerage system in Phnom Penh and in Siem Reap. They do not desludge at the household level. When a district (Sangkat) has a problem in their area, they call the MPWT who will then establish a proposal for the Phnom Penh authorities. Most of the time this proposal is accepted and they can start the work of deblocking sewerage pipes, or changing the pipe if necessary. This truck is operated ideally by 4 people, 2 people are enough.

- Mechanical private E&T operators

Mechanical private desludgers dominate the HH emptying market. They run trucks that empty septic tanks, latrines or clean sewers. They are both informal and formal. They generally run from 1 to 4 trucks but small operators are predominant.

The private sector can be characterized as a family-scale company with one to four trucks insuring a service for HH and few businesses. They discharge the sludge directly to the environment or in authorized sites but without treatment of the sludge.

The tanks have different sizes depending on the city: from 3 m^3 in Siem Reap, 5 m^3 to 8 m^3 in Phnom Penh and Kampot. According one truck assembler, a common system without the truck (5 m^3 sludge tank and 1 m^3 clean water tank, two pumps) is usually sold from 15,000 US$ to 20,000 US$. Then the total cost depends on the quality of the truck.

The smaller trucks used in Siem Reap are cheaper on average, their cost varies from 12,000 US$ to 15,000 US$ also depending on the quality of the truck.

- Manual Private E&T Operators

Manual emptiers are mostly "informal" actors that work for a day to deslugde manually sewers or latrines. 50 manual emptiers were identified in Phnom Penh and 2 in Kampot but none were found in Siem Reap.

Private manual pumpers are usually work in the construction sector with many activities including installing piped networks, cleaning the sewers, emptier of tanks and even plumbing repairs;

The manual pumpers of Phnom Penh can be divided into two categories. First the multitask workers waiting in dedicated places of the city (Stung Mean Chey/Tual Kork) who are ready for whatever work they are asked for, and on the other hand the Ek Chai, solid waste collectors of the city who offer their services in a more dynamic way, advertising their presence. In Kampot, the manual emptier works mainly in this domain.

However, it is important to notice that all of them have different stories, different backgrounds and habits. The emptying activity is sometimes not their regular income source and sometimes is only part of their income.

- Re-users

Along the value chain, some small farmers use sludge as fertilizer. These practices are however very informal and difficult to measure. Many E&T operators say that they occasionally resell the sludge in the countryside (for farmers to use as fertilizer for rice crop) through contact and relationships, but no clear practices where found. They also say they do not dump sludge in the same place every time.

- Dumping site

In Phnom Penh, there are three authorized dumping sites that are wetlands. Private E&T operators pay 1.5 USD/dumping/trip. Public E&T operators don't have to pay and can discharge the liquid part of their load in the open canals across the city. In Siem Reap, there is a dedicated place to dump fecal sludge at wetland recently built by international donors. Operators pay 1.5 USD/dumping/trip. In Kampot, there is no dumping site. However, in Phnom Penh if most of E&T said that they dump at the wetland the survey shows that only one really goes there. So, many unofficial dumping sites exist throughout the city.

3.2 Fecal sludge extraction

- The phone call and the negotiation

When someone calls a E&T Mechanical Operator (several

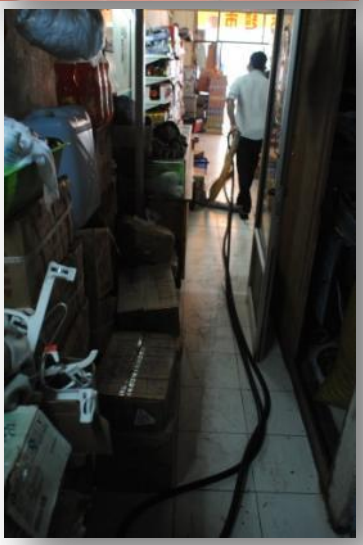
operators have one or two people full time placing stickers everywhere in town every day of the week, even if they have only one truck). He or one of his staff goes by motorbike to negotiate the price considering volume, distance, access and future opportunities, etc.

- Arrival and setting up

The two staff that operate the truck arrive and install the flexible pipes together with if necessary strong PVC ones. Then they use tape to make sure every connection between pipes is water and air tight, even on the back of the truck.

Once this is done, the lever which put in contact the secondary transmission shaft and the pump is activated from the back of the truck and the pumping starts. In all cases the truck was empty at the start of operation but they told us there is almost no flow variation between the tank being already full or empty. The flow of sludge being vacuumed was around 40 m^3 per hour.

- Cleaning and payment



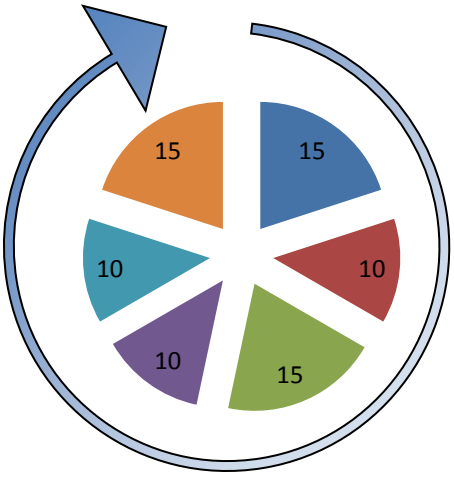
In all cases the E&T Mechanical Operators were actively pumping for less than 15 minutes, the pipe is then raised up and the lever to start the under pressure water in the truck is activated. Clean water arrives and allows the operator to clean the pipe whilst pulling it out of the hole (it is dirty on the outside). Once the pipe is clean, it's lifted a little bit so the remaining sludge inside is vacuumed too. Once the pipe is emptied, on operator cleans the ground while the others are placing the pipes on the truck. This takes 5 minutes. The operator is paid then and they can move on after they roll back the clean water pipe on the revolving stand at the back of the truck.

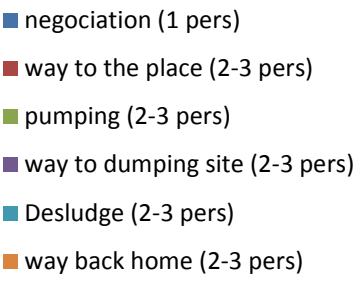
- Dumping

The truck will then move to the dumping site in order to dump the sludge. All but the operator that empties at the official dumping site have their own un-official dumping site where they dump.

These figures can vary a lot so they should be taken as estimates of the repartition of the time pumper spend in the several phases of their work.

Figure 8 – Operation schedule for Fecal Sludge Extraction

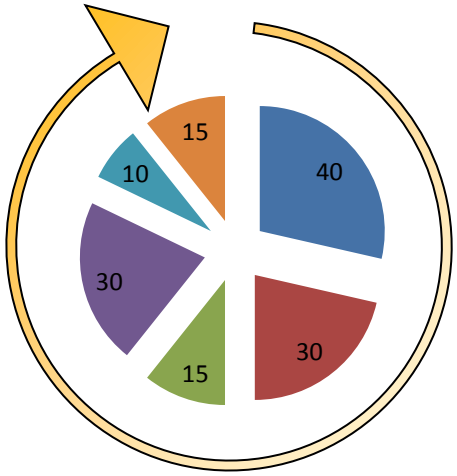


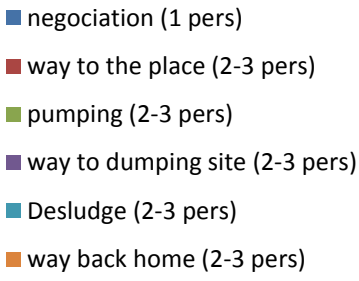


Short cycle of 75 minutes

(data displayed in min)

Total transport = **65 % time** spent (50 min average, including negotiation)





Long cycle of 140 minutes

(data displayed in min)

Total transport = **85 % time** spent (115 min average, including negotiation)

CHAPTER III. THREE STUDY CASES OF FSM IN CAMBODIA

I. OVERVIEW

Overview			
Population data:	**Phnom Penh**	**Siem Reap**	**Kampot**
Population	1,327,615	168,662	38819
Number of HH in city	270,942	34,421	7,922
Consultant HH survey data:			
HH survey sample size	1,320	428	308
Data Analysis tool (eg SPSS etc)	Sphinx	Sphinx	Sphinx
Survey method used	Transect selection		
Access to Drinking water			
	Phnom Penh	**Siem Reap**	**Kampot**
% HH with home connection through Public water utilities	85%	12%	57%
% HH using Piped systems to public taps	0%	0%	0%
% HH using wells or drilled wells	0%	84%	4%
% HH using home connection through Private utilities	14%	2%	24%
% using Other sources	0%	0%	15%
Types of Sanitation facilities			
	Phnom Penh	**Siem Reap**	**Kampot**
Type of sanitation collection facility			
% HH with one pit connected to the sewer/street	45%	14%	14%
% HH with one pit to the ground or environment	6%	37%	21%
% HH with > one pit connected to the sewer/street	13%	11%	20%
% HH with > one pit to the ground or environment	5%	19%	31%
% HH with septic tank connected to the sewer/street	3%	4%	1%
% HH with septic/stock tank to the ground or environment	1%	4%	0%
% HH with direct connection to the sewer /street	24%	0%	0%
% HH with direct discharging into the ground or environment	2%	0%	0%
% of HH with no Latrine	3%	12%	12%
Usage of the sanitation facility from survey			
Household size	**4.9**	**4.9**	**4.9**
average users per toilet	**6.3**	**5.4**	**5.6**
% Pits/tanks that receive grey water			
HH Survey Data m: emptying frequency/method			

	Phnom Penh	Siem Reap	Kampot
Emptying Frequency			
% HH that have Emptied at least once	**22%**	**15%**	**21%**
% Never emptied	**78%**	**85%**	**79%**
Frequency:			
Average Frequency of emptying per Year:	**0.31**	**0.56**	**0.47**
More than 2 times per Year	0%	1%	0%
Twice per year	0%	0%	1%
Once per year	1%	2%	3%
Once every 2 years	2%	4%	4%
Once every 3 years	3%	2%	2%
Once every 4 years	3%	2%	4%
Once every 5 years	3%	2%	1%
Between 5 - 10 years	4%	1%	4%
More than 10 years	6%	1%	3%
Method of emptying			
% HH that use manual emptiers	6%	0%	30%
% HH that use mechanical emptiers	80%	86%	30%
% HH that emptied themselves	13%	14%	41%
HH Survey Data : HH expenses			
	Phnom Penh	**Siem Reap**	**Kampot**
HH Income/month			
Average income (USD/HH/month)	550	496	530
Cost of other services			
Average water bill (USD/month)	8.03 US$	2.25 US$	6.77 US$
Average phone bill (USD/month)	15.50 US$	12.62 US$	11.36 US$
Average electricity bill (USD/month)	26.67 US$	17.24 US$	14.29 US$
Average solid waste collection bill (USD/month)	Na	Na	Na
Cost of emptying*			
Avg manual emptying Fees per city per service	25 US$		36 US$
Avg. mechanical emptying Fees per household per service	36 US$	20 US$	75 US$
Avg ANNUAL manual emptying cost per household	7.75 US$		17 US$
Avg. ANNUAL mechanical emptying cost per household per service	11 US$	11 US$	35 US$

Mechanical emptying business information			
	Phnom Penh	**Siem Reap**	**Kampot**
# of private mechanical businesses in city	19	6	1
# of trucks run by private businesses	31	8	1
# of trucks owned by utilities	5	1	0
What are utility trucks used for	Private trucks for pit emptying and sewer cleaning of HH; Utility trucks only	Private trucks for pit emptying of HH; Utility trucks only for pit	Private trucks for pit emptying and sewer cleaning

	for main sewer cleaning	emptying and sewer cleaning	
# of private businesses that are small (1 truck)	13	5	1
# of pvt businesses that are medium (2-5 trucks)	6	1	0
# of pvt businesses that are large (>5 trucks)	0	0	0
What are the capacities of private trucks (m^3)	5	3	5
What are capacities of Utility trucks (m^3)	7	7	0
Price for new truck (mention for what m^3 capacity)	20,000 US$	15,000 US$	20,000 US$
Price for USED truck (mention for what m^3 capacity)	15,000 US$	12,000 US$	15,000 US$
Are most trucks 2nd hand or new at time of purchase	Yes	Yes	Yes
Typical age of trucks in city?	8 years	8 years	8 years
What is typical number of trips per day for the trucks?	1.6	0.6	0.1
Avg distance per trip	15 km	5 km	15 Km
Avg time per trip (hr)	2 hours	1.5 hours	2 Hours
Cost of fuel for truck? (USD/liter)	1.4	1.4	1.4
Financial access for private owners			
What % of the private truck owners take loans?		17%	
What are bank interest rate and years for repayment?		18% and 3 years	
Are the rest self-financing?		Yes	
Do they run any other business from which they get this self finance money?		Yes	
What % of the FS emptying owners does this as their main business?	79%	40%	
What are the other sources of funding for these operators besides bank and personal money?	personal fund and family	personal fund and family	personal fund and family
Who is the Owner?	Large variety	Large variety	Large variety
Treatment/dumping site			
	Phnom Penh	**Siem Reap**	**Kampot**
What is the official dumping site for city?	wetlands	WWTP	Nothing
What is the m^3 capacity of this treatment facility? Max flow/day during the rainy season	1,000,000	3,000	-
Where is it located?	edge of city	outside city	-
What is the dumping fee truckers have to pay? (USD)	1.5	1.5	-
Is this payment per trip or per month or m^3?	per trip	per trip	-

II. LARGE CITY: PHNOM PENH

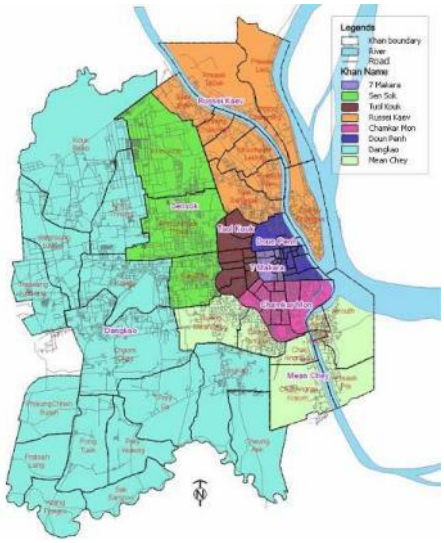
1. BACKGROUND: PHNOM PENH STUDY CASE

1.1 General information

■ Physical and economical description

Located along the Mekong River Bank and the Tonle Sap, Phnom Penh, has a population of 1,327,615 inhabitants living on 678.46 km^2 which contains 8 districts (Khan) and 96 communes (Sangkat). This shows a high density of population.

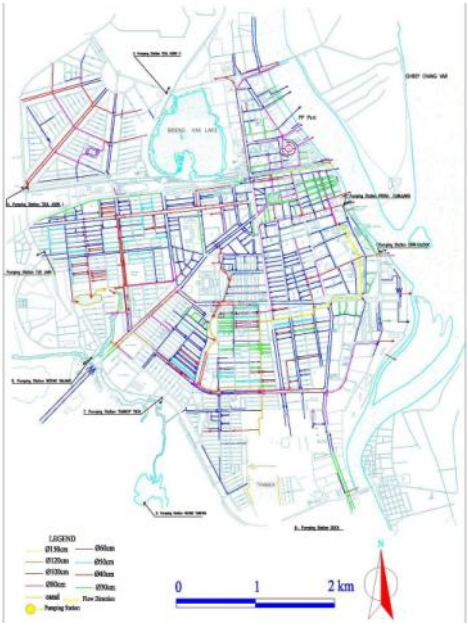
Four of the districts are in the central areas and four more in peri-urban areas. In terms of housing, there is an important diversity of housing. However each housing type doesn't really reflect the socio-economic status of the HH and social mixity of the city is predominant, especially in the center (Saighi and Tsitsikalis, 2010).



Source: http://www.phnompenh.gov.kh

■ Urban water supply

Water Supply in Phnom Penh is ensured by the Phnom Penh Water Supply Authority, a State-Owned Enterprise (SOE). The PPWSA has made great strides in bringing water to 85% of the population (compared to 47% in 1998).The utility performances is impressive : more than 110,000 home-connection were installed; production capacity has increased from 26,881 to 300,000 m^3/day in 12 years and technical losses reduced from 72% to 10%. The quality of service delivery is close to international standards supplying 192,092 customers with an average daily consumption on 128 l/day/capita. However, PPWSA has no mandate to handle sanitation.



■ Urban sanitation system

Urban sanitation in Phnom Penh is largely ignored and several systems exist. In the center of the city commercial and residential users are connected to a French-designed combined sewerage system (with tertiary and secondary sewers leading to open-air canals) that serves the central area including both sewage (gray and black water) and drainage water (storm water collection). It has both pipe and canal networks of about 160 km in all. 7 pumping stations are to lift annually 30 million and 6 million cubic meters, respectively, of domestic and industrial wastewater. The sewage network is old and poorly maintained. The MPWT is in charge of the operation and maintenance of the system. The system is unable to deal with peak flows, contributing to flooding in many districts during the rainy season (Kopitopoulos 2005).

The Japanese International Cooperation Agency (JICA) has extended this network in the present years and established a master plan for the next 10 years.

- Wastewater treatment system

After transportation, wastewater is transferred to three wetlands which provide natural removal of biological contamination (Boeung Trabek, Steung Mean Chey, Boeung Tumphum) see Volume 2 – Appendix 11 - Analysis of Authorized Dumping site in Phnom Penh. However, the natural wetlands and water courses have a very low capacity of treatment. Only 56% of suspended solids are settled in wetland before entering to the river; the content of the metal elements such as Cd, Pb, Cu and Zn significantly exceeds the WHO standard (Takeuchi Tomonori, 2005). Furthermore, (Nareth et al., 2008) indicated that 10% of waste effluents are directly evacuated into Tonle Sap and Mekong Rivers. Commercially, to ensure maintenance work, the sanitation tariff is integrated into a 10% tax on the PPWSA bill that is transferred to Municipality of Phnom Penh at the end of each month.

2. DEMOGRAPHIC AND SOCIO-ECONOMIC INFORMATION

2.1 Population characteristic

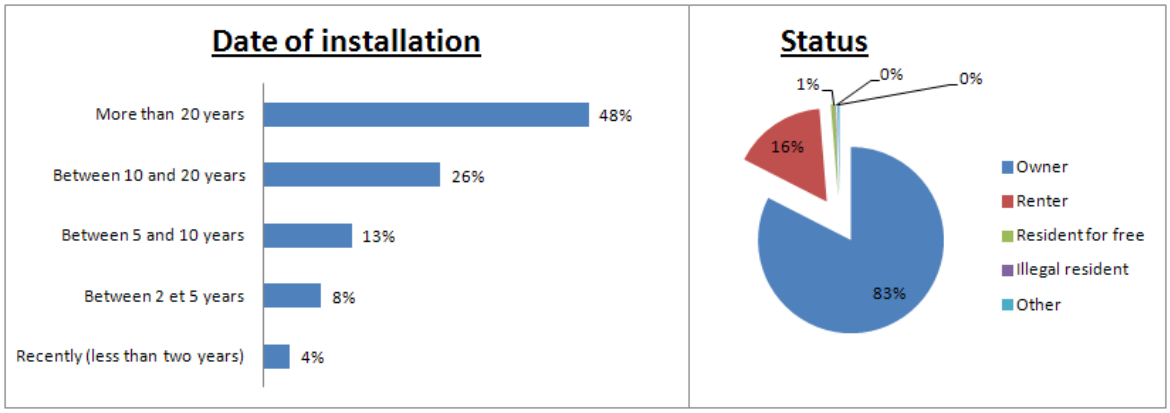
- Household

The average size of a HH in Phnom Penh is estimated at 5.1 persons per HH following the general census of population when the average number of people in a house is 6.3 persons (the discrepancy in household size and house population is due to the limit of the HH, some old people live in their family and are not counted as part of the HH). The size of houses varies relating to the construction material: around 70 m^2 on average for the concrete house, 65 m^2 for the wood house and only 12 m^2 for the palm/bamboo house. On average, there is 1 inhabitant per 8 m^2.

- Type of housing

60% of households surveyed have been living in their current houses for less than 20 years, while 40% have been there for more than 20 years. It shows that people started to move to Phnom Penh only after the political stability of the country which was the first legislative election in 1993. Likewise, the proportion of houses constructed before and after 20 years doesn't show a significant difference. This means that the old houses were partially occupied by new inhabitants. On the other hand, the recent habitats (less than 10 years) represent only 25% of the total surveys. 83% of the HH own their apartments.

Figure 9 – Date of installation and status of housing in Phnom Penh



2.2 Incomes and budget

Generally, two people in a household ensure the income. The average income is around 671 USD per month per household. According to our methodology; 24% of the HH are poor, 55% are "medium" and 21% are well-off.

People are earning on average an income estimated per capita per day of 4,5 USD. The ratio between poor HH income and well-off HH income is 363%.

30% of the expenses are represented by food and the allocation is remarkably similar for the poor, the medium and the well-off HH as seen in the table below:

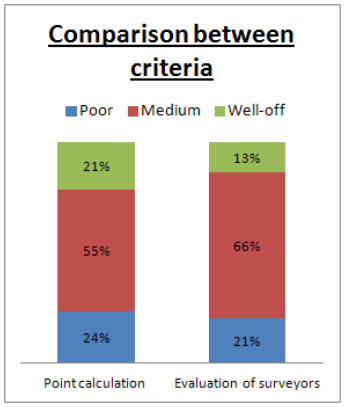
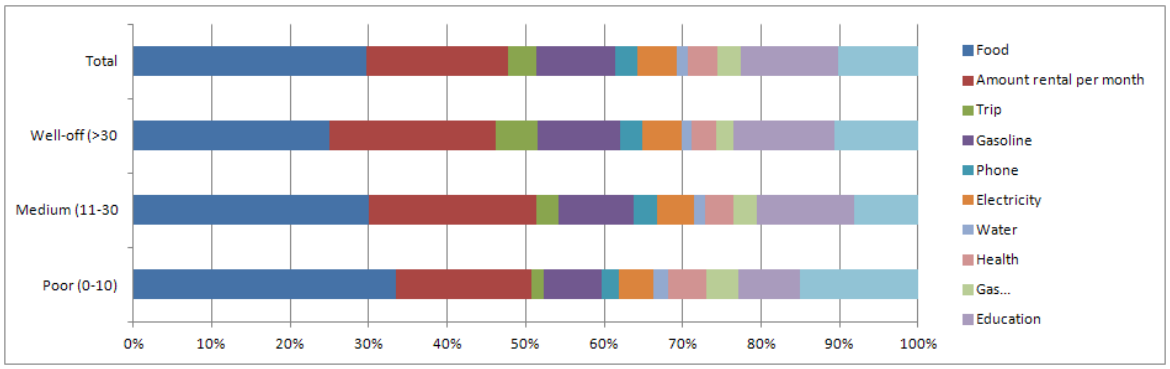


Figure 10 – Socio-economic incomes and expenses of HH in Phnom Penh

	Poor (0-10)	Medium (11-30)	Well-off (>30)	Total
Income (dec)/capita/day	1,7	3,1	5,4	3,3
Income (est)/capita/day	2,4	4,2	7,2	4,5
Total monthly income declared	241	522	963	548
Monthly income est	319	634	1 158	671
Monthly savings declared	17	49	174	67
Savings estimated	114	306	536	320

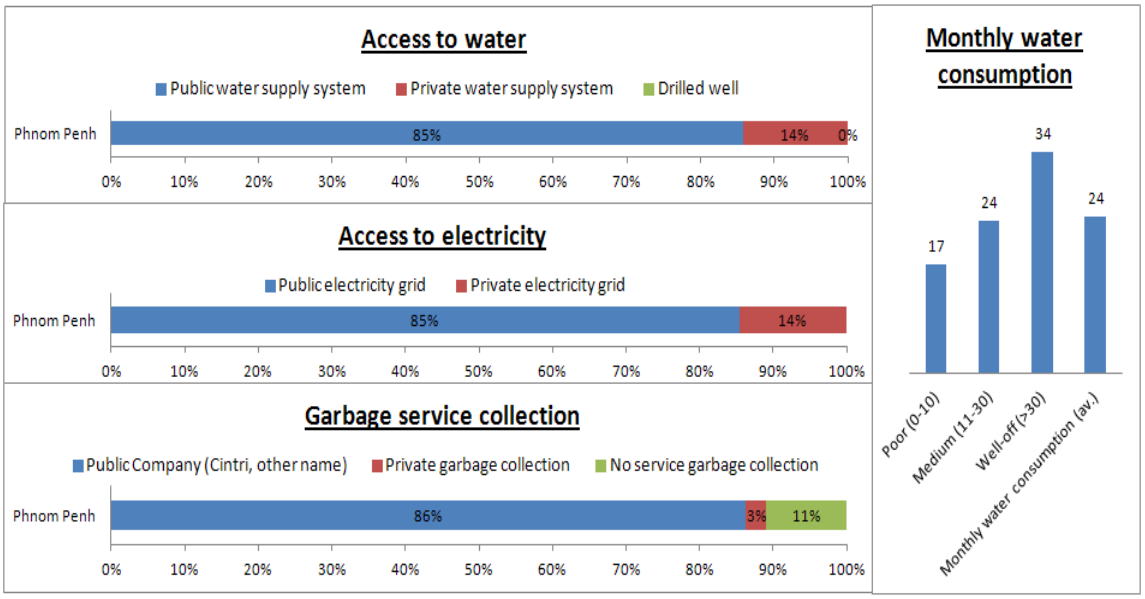


2.3 Access to water and services

The area covered by the study is wider than the PPWSAs service area, thus only 85% are covered in the area surveyed. The quality of water supply meets WHO standards.

According to the survey, the monthly water consumption is almost 24 m^3 which represents 127 L/capita/day. Almost 85% of the population is covered by CINTRI garbage collection system. In the same way as the water supply, the electricity coverage is high and close to 85%.

Figure 11 – Access to service in Phnom Penh



*Public means the official providers

**Private means the unofficial actors who provide a service to the population.

3. HOUSEHOLD SANITATION PRACTICES

3.1 Type of sanitation assets: collection and storage

Within the total households surveyed (1,320 HHs), **98.5% have sanitation assets**, while other 1.5% doesn't have any: they normally defecate in the open or use their neighbor's assets. For the households having sanitation assets, 75% of them have pour flush traditional latrine, 877 HHs (66%) have showers, 772 HHs (58%) have sinks and 374 HHs (28%) having WC with pour flush. For dry pit latrines, we could see only 3 cases in periurban area. The table put below show the detailed sanitation systems that are used in Phnom Penh.

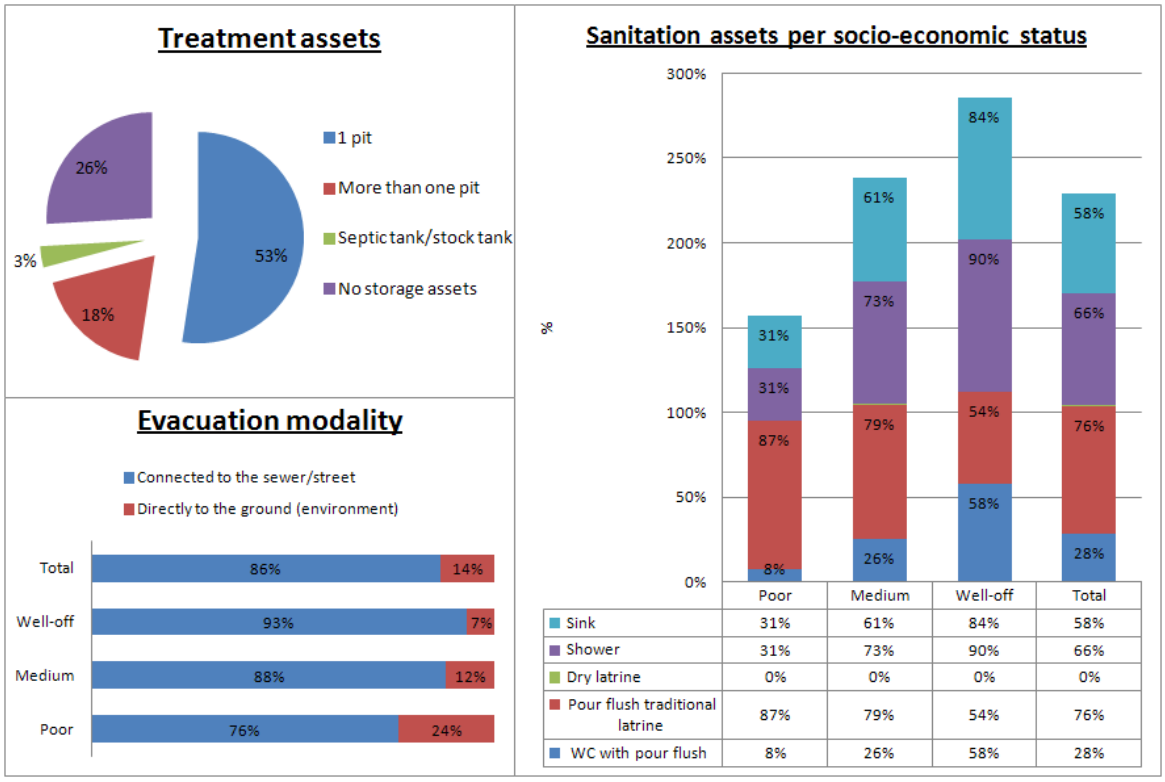
Table 4 – breakdowns of sanitation systems that are in Phnom Penh

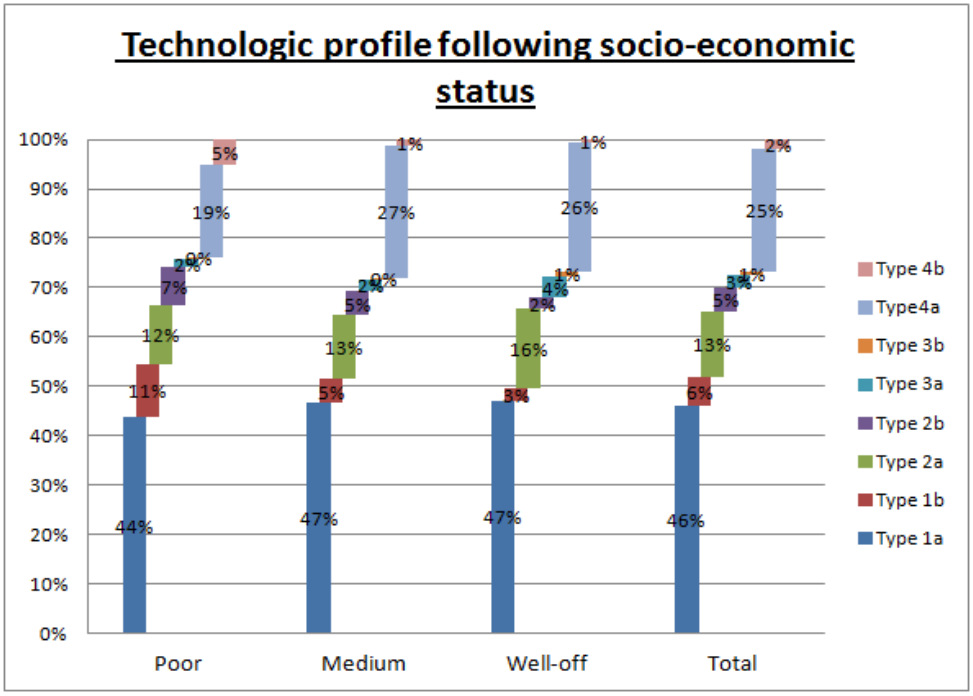
% HH with one pit connected to the sewer/street	45%
% HH with one pit to the ground or environment	6%
% HH with>one pit connected to the sewer/street	13%
% HH with> one pit to the ground or environment	5%
% HH with septic tank connected to the sewer/street	3%
% HH with septic/stock tank to the ground or environment	1%
% HH with direct connection to the sewer /street	24%
% HH with direct discharging into the ground or environment	2%
% of HH with no Latrine	3%

In a comparison per socio-economic status, we can notice that the differences are important, 31% of poor HH have sinks and showers when they are respectively 84% and 90% in the well-off HH. 49% of the HH declared that the grey water is going in the same asset than the washing water. Surprisingly enough, **if the latrine technology is quite different per economic status, on**

the contrary, the systems for storage are quite similar. Indeed, almost 86% of the HH are connected to the sewer/street (and after goes to the open-canal).

Figure 12 – Typology of sanitation systems in Phnom Penh





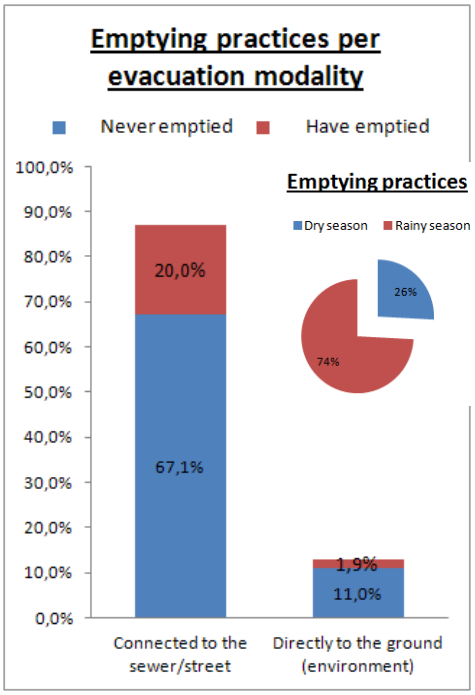
4. FECAL SLUDGE EMPTYING PRACTICES

4.1 Who emptied their latrine?

Only 21.9% of people in Phnom Penh have at least once emptied their feces tank. This proportion is quite low and it opens many questions about emptying practices.

Most of the HH surveyed that emptied their latrine are connected to the sewer (20% when 1.9% is not connected to the sewer). Indeed, due to the pre-treatment stage before discharging in the sewer most sanitation systems in Cambodia need to be emptied.

The center is more represented due to certainly the date of installation. Possibly flooding in the city has an impact as the figure on the right shows most of empting is done during the rainy season (74%).



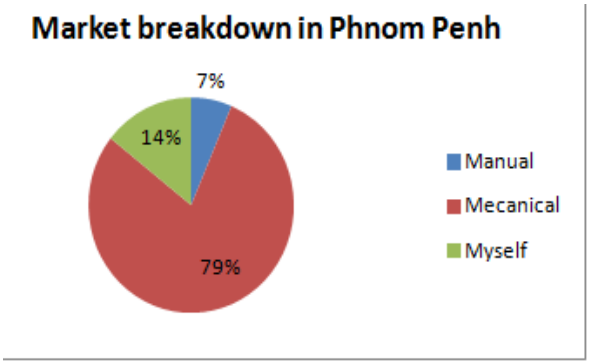
4.2 How do they do it?

- Type and size of market

A high majority of households interviewed who want to have a sludge extraction service call a mechanical pumper (79%) when manual emptiers represent 7% and 14% empty their assets themselves.

For mechanical and manual, there are two type of emptying: i) domestic emptying; ii) sewer cleaning.

The sewer cleaning represents a big part of the market, 40% of households say they pay for sewer cleaning when only 21% do so for domestic emptying.



There are no clear differences between the socio-economic status and the type of emptying methods that HH use. Poor HH use less mechanical operators (69%) than the well-off (85%) but in general the profile of type of emptying practices is similar.

- Fees

The average fee declared by the HH for manual emptying is about 30 USD when it is **47 USD** for mechanical emptying. The tariff deviates around ± 20 USD for both activities according to the negotiation and the size of work.

- Demand

The households that have not-yet-emptied said that they will call for the mechanical emptying services when their pits get full. On average, the price they prefer is around 35 USD, showing that the actual set price and the willingness to pay are linked.

Figure 13 – Fecal sludge emptying HH practices in Phnom Penh

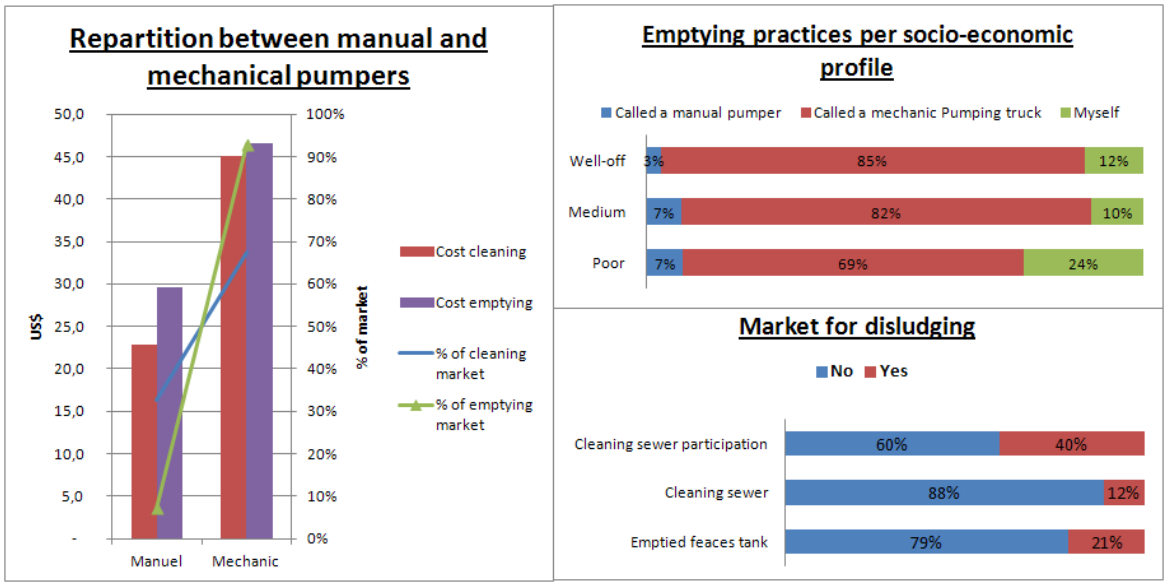
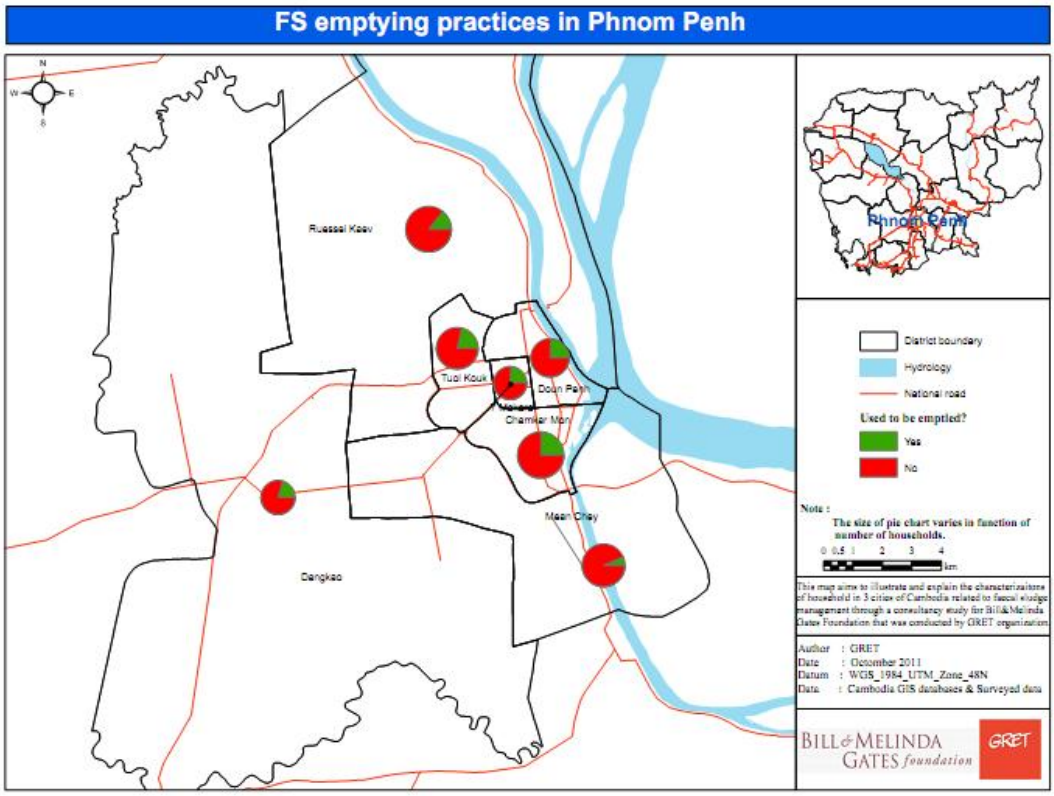


Figure 14 – Fecal Sludge emptying practices in Phnom Penh



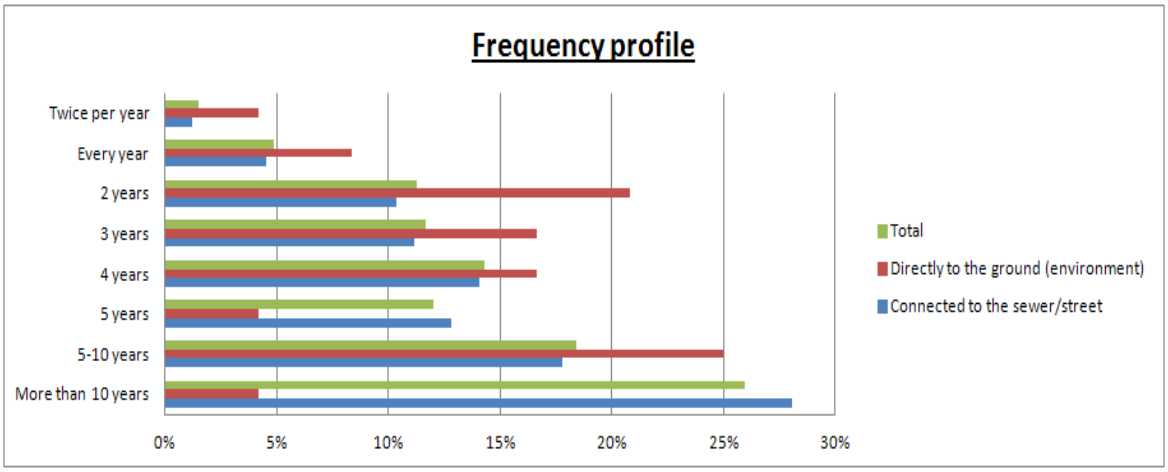
4.3 Frequency of emptying: When?

The frequency profile of emptying shows that it varies a lot according the technological profile (type of asset and type of evacuation modality) but that it's quite high in general. The average is 0.31 emptied per year (the assets are emptied every 3 years), which is quite similar to 0.25 (median) of the sample.

The average volume is quite different per type of treatment assets. As well as the frequency, we will take into account this diversity (cf. p. 18): i) Type 1 – one pit: 1.21 m^3; ii) Type 2: more than one pit: 3.32 m^3; iii) Type 3 - Septic tank: 2.50 m^3. There is no real correlation between the date of construction, the volume of tank, the water consumption, and if the HH is connected to the sewer or not.

One of the best reasons to explain the frequency is related to the number of people which are living in the house. In average, there are 6 people in the houses that never emptied their pit or septic tank whilst there are 8.4 persons in the houses that have emptied.

Figure 15 – Frequency of emptying in Phnom Penh



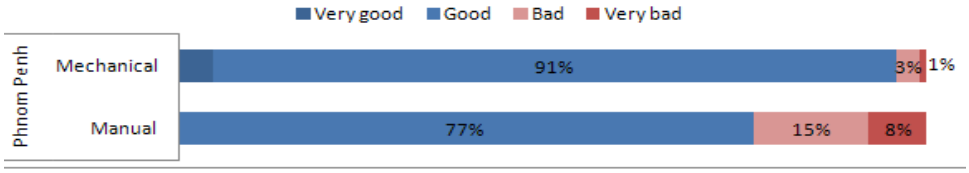
4.4 Service satisfaction

Globally, the households are satisfied with both E&T services. Mechanical E&T services are considered as better (96% are satisfied) than the manual (77% are satisfied).

For mechanical service, the reasons of satisfaction are that the service is clean (fist quotation), the operator is quick to come (second quotation) and fast to operate (third quotation). Concerning the manual pumper, the satisfaction comes from the clean service and the cheaper tariff. As a consequence, the dissatisfaction for mechanical E&T operator comes from the tariff considered too expensive and for the manual E&T operator, from the service considered too long.

Despite the fact that households are satisfied, 58% of the households who emptied won't call the same pumper next time. It seems that there is no "fidelity" in this sector and every service given is on a competitive way for one time only.

Figure 16 – Satisfaction of the service in Phnom Penh

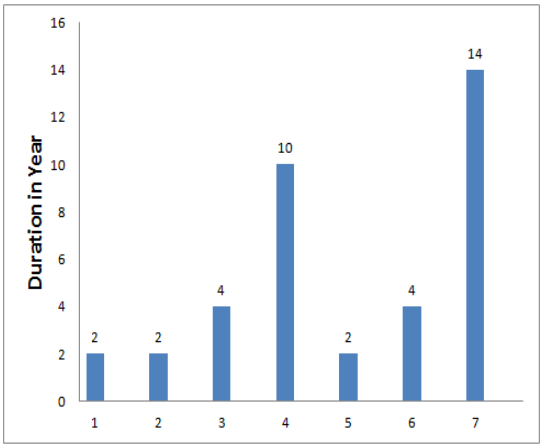


5. FECAL SLUDGE SERVICE DELIVERY PRACTICES

5.1 General overview

- Business history

Historically, the mechanical emptying operators in Phnom Penh came from a same origin, the oldest operator. 20 years ago, there was only 1 E&T Mechanical Operator with 1 vacuum truck. He had been working for wastewater unit of Phnom Penh. His work was to follow 2 emptying trucks that were donated by French Embassy. Anticipating a potential market, he started to run his own business by manufacturing his own vacuum truck whose systems were copied from French trucks. He optimized the operation system by adding the clean water system. At that time, the market was totally covered by him. Due to the unlicensed business and the profitability perspective, his workers started to run their own businesses, too. This action has continued to the next operator generations.



Finally, fecal sludge management services in Phnom Penh are not recent businesses but have increased recently in important proportions. Indeed, one of the third of E&T Mechanical operators began their business less than one year ago, entering in the competition with the other older E&T Mechanical operators. Phnom Penh is also the only town where the three kinds of E&T Mechanical operators exist (small, medium and large).

- Typology of E&T Operators

Most of the market of FSM is dominated by private operators but the MPWT has around ten trucks donated by public or private donors that are in charge of sewer cleaning. They empty very few households but are in charge of emptying the sanitation assets of public institutions. Private operators do finally most of household fecal sludge extraction and transportation as well as sometimes sewer cleaning when the MPWT trucks are not available.

According to our pre-screen review, there are 24 manual E&T operators and 19 mechanical E&T operators in Phnom Penh having in total 31 trucks. Manual E&T operators are difficult to identify and seem to be insignificant competitors regarding mechanical E&T operators due to the strong availability (and cheap capital cost) of vacuum trucks. Finally, manual E&T operators are more involved for sewer cleaning and construction works than for emptying domestic HH. The table below shows the specificity per type of business:

Table 6 – Typology of E&T Operators in Phnom Penh

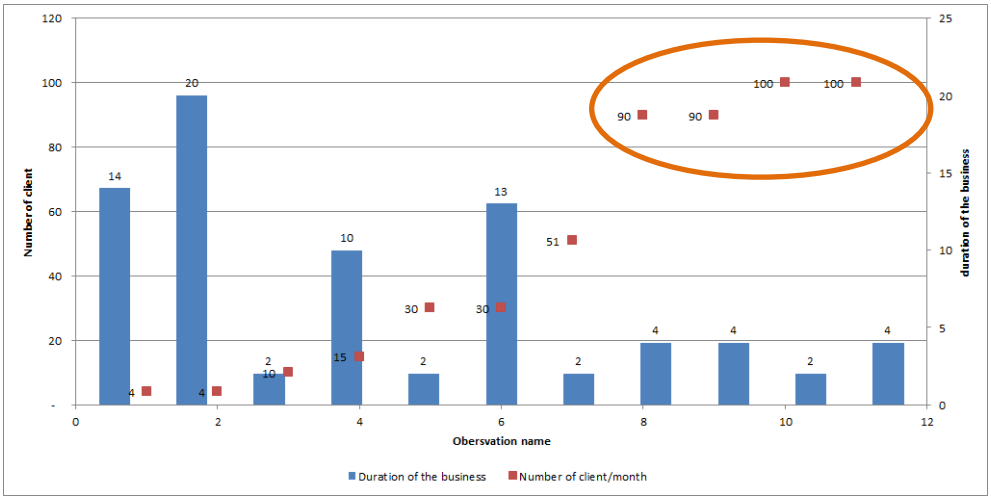
Profil	Unit	Manual	Mechanical		Total Mechanical	Total
			Small	Medium		
Number of operators	Num.	24	12	7	19	43
Number of truck	Num.	0	12	19	31	31
Average staff number	Num.	1	3	9	6	6
Total Investment	US$	100	13,224	49,673	26,873	26,893

5.2 Service delivery assessment

■ A heterogeneous size of market

In Phnom Penh, for 79% of the mechanical E&T operators the emptying activity is their main activity. Following the business, the number of customer varies significantly among operators: 73% of the operators have less than 30 clients per month when some of them have more than 100 HH per month and per truck. As shown in figure 11 below, it is important to notice that the recent Mechanical E&T operators, thanks to an aggressive marketing strategy, have gained a significant market proportion.

Figure 17 – Number of customers and duration of the business in Phnom Penh



Not only sludge emptying, but also sewer cleaning service is provided by mechanical E&T operators but it is important to notice that they clean only sewers at the household level, except an operator who is the oldest and knows some public institutions. The "Domestic" sewer cleaning costs is about 20 US$ per households (for 4 meter long and one manhole) but depending on the size of work to do. However, sewer cleaning represents only 5% of whole emptying activities in Phnom Penh.

■ Tariff fees and size of the business

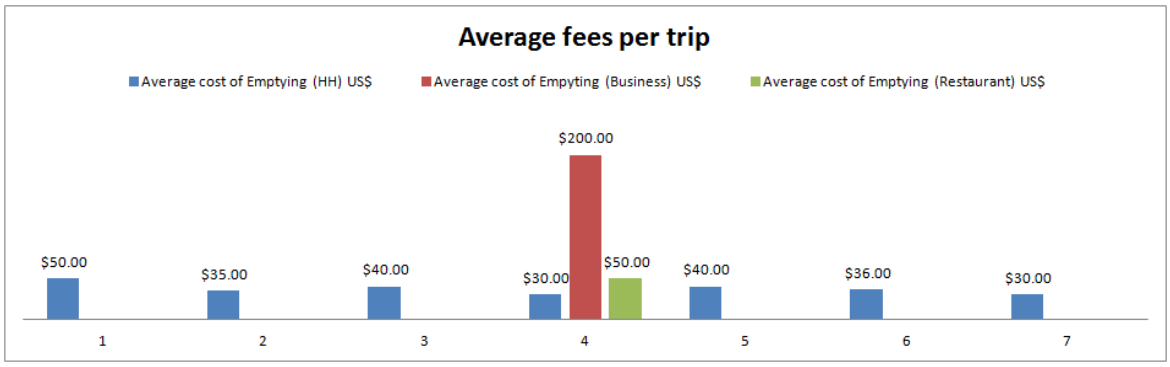
The fees appear quite homogeneous for mechanical E&T operators. The average cost is about 36 USD/trip. The E&T Manual operators have a tariff fee varying from 25 US$ to 30US$ but the household said that they pay more in general 45 US$.

Moreover, all E&T operators surveyed said that the tariff of emptying service has a variable structure depending on the volume to be emptied and the distance of the trip. As an example, the tariff can varies from 30 to 50 USD for a trip. Few operators have a special tariff for businesses and restaurants. But they charge following the volume pump and the number of trip done. On average, there are 431 customers per year per truck so to say 36 HH/month. However, there is a wide range of differences among the E&T operators from 48 HH per year per truck to 1,212 HH per year per truck.

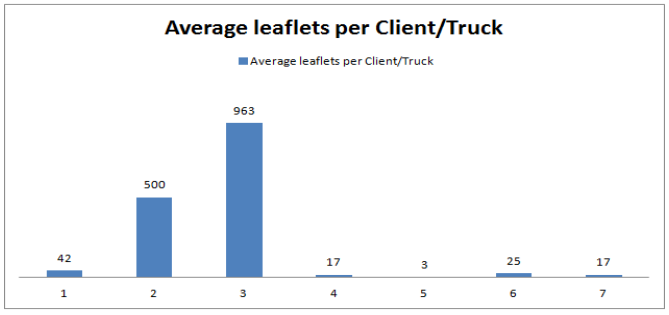
Surprisingly, most of the operators surveyed have only domestic clients expect for medium operators. On average, there are 7.5% of clients who are businesses and restaurants. It takes in general 3 trips to empty a restaurant and takes half a day.

Figure 18 – Tariffs in Phnom Penh

	Unit	Manual	Mechanic		Total Mechanic	Total
			Small	Medium		
Tariff fees (USD)	USD	25	39	33	36	
Market size	HH/truck or pers/year	156	317	503	431	431
% of incomes coming from disludging the businesses			12%	5%	9%	
Volume/HH disludging declared	m3	-	4,0	5,1	4,5	3,5
Volume per hotel/business disludging	m3	-	10,7	16,3	13,7	10,1



- Marketing strategy and mapping



According to the survey, no determined market area is distinguished, meaning that all E&T operators can operate everywhere in or outside Phnom Penh. Sometimes, they work in other provinces (in the peri-urban area of Phnom Penh) at a competitive tariff.

The marketing approaches are leaflet distribution, telephone numbers painted on poles and sign boards. About 180 leaflets per client per truck are disseminated throughout Phnom Penh. If we estimate this amount per all the trucks in Phnom Penh, it has been a number of almost 7.4 million of leaflet distributed in Phnom Penh for 31 trucks, which represents around 15 leaflets per client. It's interesting to underline that that the "old" operators have lost their clients. This can be explained by their marketing strategy. Indeed, when they were alone on the market, the operators had a high price (35$ to 50$) without competition and they continue to do so. New E&T operator's market strategy is rather different with an "aggressive" marketing strategy through a high number of leaflets disseminated per year. However, the service quality needs to be maintained in order to keep their clients.

Table 7 – Average and total leaflets per truck in Phnom Penh

		Small	Medium	Total
Average leaflets per Client/Truck	Unit/HH/truck	304,8	70,1	176,7
Average leaflet per truck operating	Unit/truck	331 660	160 400	238 245

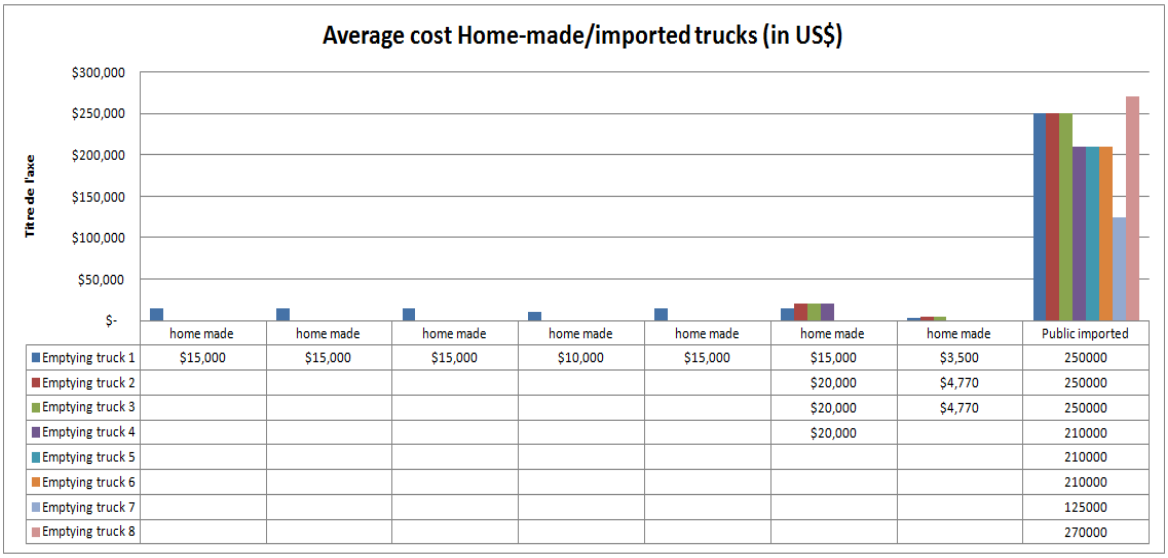
5.3 Technical assets and operation & maintenance

- Type of truck

The truck average volume of truck in Phnom Penh is about 5 cubic meters. It normally costs from 12,000 to 20,000 US$ depending on the price of the truck used (quality of the second hand). On average, the investment cost per truck is 13,390 USD. For an imported truck that is used by the public utilities the cost is closed to 200,000 USD in average.

Most operators had their own investment capital. A detailed field note is in the Volume 2 – Appendix 4. The low cost 3,500 US$ were bought a long time ago in 1990. Moreover, the public truck imported from Europe or Asian countries cost really a lot more than the locally adapted trucks.

Figure 19 – Capital cost of truck home-made versus imported



	home made	home made	home made	home made	home made	home made	home made	Public imported
Emptying truck 1	$15,000	$15,000	$15,000	$10,000	$15,000	$15,000	$3,500	250000
Emptying truck 2						$20,000	$4,770	250000
Emptying truck 3						$20,000	$4,770	250000
Emptying truck 4						$20,000		210000
Emptying truck 5								210000
Emptying truck 6								210000
Emptying truck 7								125000
Emptying truck 8								270000

The design of trucks seems to be determined by the quality of service perceived and not by the real needs of HH. One of the most crucial arguments for the service quality stands on the capacity of the truck to empty all the systems. Therefore, many E&T mechanical operators consider that they need a big truck in Phnom Penh because the demand is high and the distances bigger. None of the operators in Phnom Penh said that he had exceptional volumes or had to do 2 trips for a single HH. They also never have mixed sludge from 2 different HH in the same trip.

- Number of staff

For operation, there are on average 3 staff per truck: one is responsible for work evaluation, driving the truck and/or price negotiation; other two do the emptying work. It appears that some operators also have marketing staff (when they are bigger, with three to four trucks). Sometimes, the negotiation part is done by the one who owns the truck. He goes himself to negotiate with the clients, evaluate the work before sending the truck. The staff are usually their relatives or friends.

56% of the operators give a variable part from 20% to 25% of tariff as wage. Except for 2 operators, there are at least 2 marketing staff that are normally permanent and earn around 70 USD/month. They are responsible for posting the phone number leaflets and for rechecking the places used to be posted. They do these sorts of activities as routine.

5.4 Incomes and expenses

- Incomes and expenses

On average, manual operators spend 120 USD for operation and maintenance when small mechanical E&T operators spend 641 USD and medium 2,348 USD. It represents 37% of the incomes for the manual operators when it is respectively 47% and 68% for the mechanical operators.

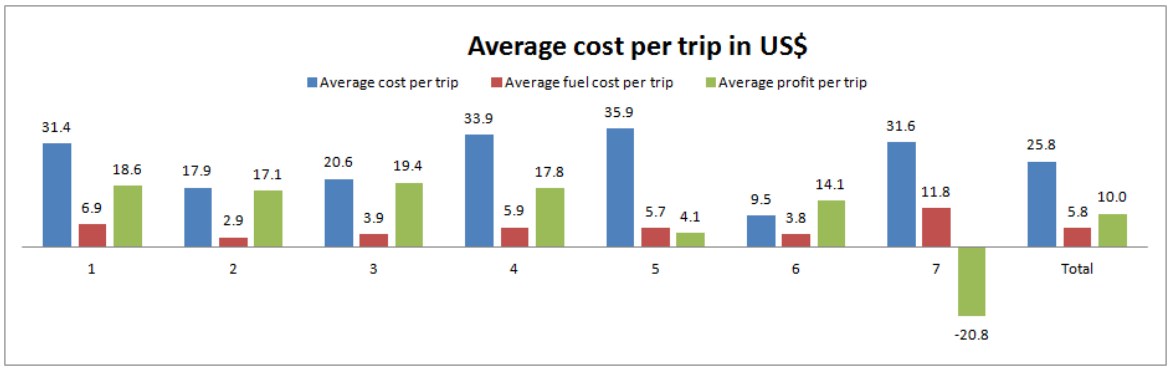
Figure 20 – Simplify incomes statement in Phnom Penh

		Small	Medium	Total
Income/HH/truck	US$	43,3	38,6	40,8
Cost/HH/truck	US$	26,2	31,6	29,2
Capital reimbursement duration	years	2,5	2,9	2,7
Average of Truck depreciation	US$	1 400,0	1 383,3	1 390,9
Energy/trip	$/trip	5,2	10,3	8,6
Average fuel consumption per trip	L/trip	4,4	5,1	4,8

- Average cost and profit per trip

The analysis shows that the average cost per trip can vary a lot among the E&T operators. Some of them are very productive with a cost around 18 US$ when others are less productive with an average cost per trip from 33.9 US$. Only one is unprofitable. Surprisingly the average cost of fuel per trip is widely large from 2.9 to 7.9 US$ per trip.

Figure 21 – Average total cost, fuel cost and profit per trip



5.5 Dumping sites and reusing practices

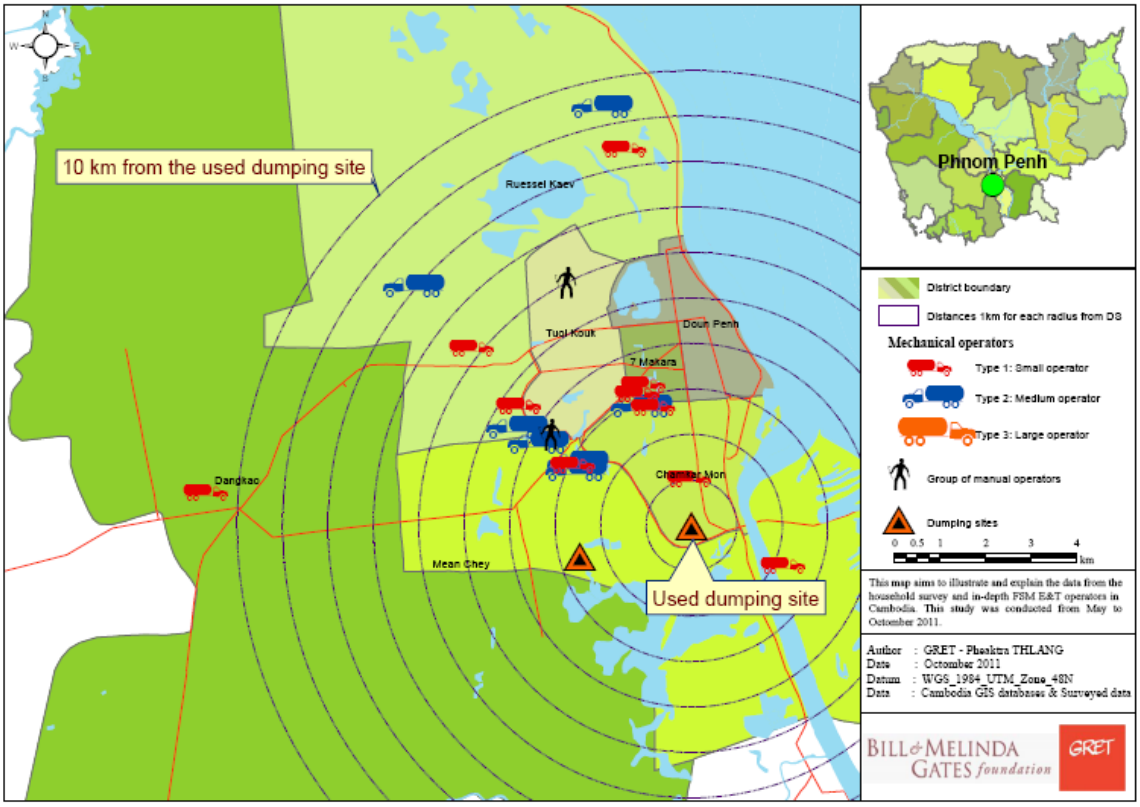
The fecal sludge is sometimes discharged directly to the wetlands considered as "authorized dumping" sites but without any pre-treatment. The municipality of Phnom Penh has begun alerting operators to dispose fecal sludge at the available wetland in the past few years. Before, the E&T operators could discharge directly in rice fields or gardens whose owners allowed it.

The sites for disposing sludge are mainly the authorized ones and in fewer cases rice fields. In

Phnom Penh, Boeung Trabaek pumping station is the most used; then Boeung Tumpun; and finally Chamchar Dong is the least used.

In 80% of the city, the transport from the extraction site to the authorized dumping place will represent a cost higher than 2.5 US$, we also have to count that the operator needs to pay 1.5 USD at the authorized dumping site. The average money saved by going to an official authorized close site would be between 16 USD and 30 USD per day, this value being very variable, but could represent a save of up to 10% of their income.

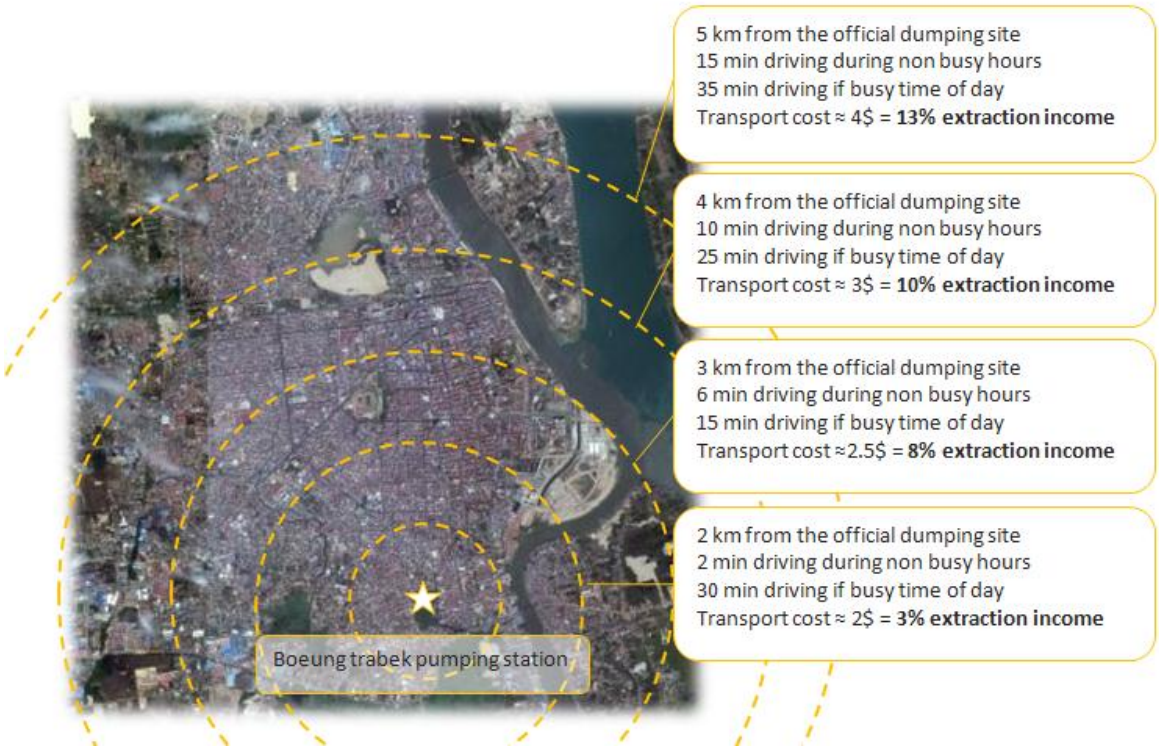
Figure 22 – Mapping of E&T operators in Phnom Penh



The authorized dumping site at Boeung Trabaek is simply a pumping station. The emptyier has to pay a fee to the pumping plant operator and they can then connect their pipe to a connector installed by the commune on the station pipes, the sludge thus ends up in Choeung Ek lake without treatment.

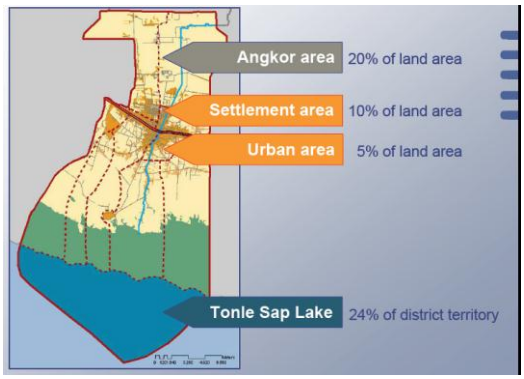
In order to fully understand the problem of the authorized/unauthorized dumping sites in Phnom Penh we need to look at them from a mapping perspective. The values presented further are mean values collected through our experiences with the pumpers. Once we understand this issue properly, we can understand easily that when a driver is pumping in the outside areas or close to the peri-urban zones, he is extremely tempted to empty his truck in a very close site.

Figure 23 – Mapping Cost of Dumping site



III. MEDIUM CITIES

1. BACKGROUND: SIEM REAP STUDY CASE



1.1 General information

- Physical and economical description

Located in the north-west of Cambodia, Siem Reap is a medium town that has become an increasingly popular tourist destination. Siem Reap is Cambodia's second largest city, with a domestic population of over 200,000 people. The annual population growth rate is estimated at 2.2%. The city welcomes over two million visitors each year – in 2008. 1.2 million Cambodians and 1.1 million foreigners visited Siem Reap. The town has more than "11,000 rooms in its hotels and guesthouses, with more being built to meet growing demand" (USAID, 2010). National and international tourists visit the Angkor heritage park which highlights the history, culture, customs and traditions of Cambodia. Their presence also generates sanitation needs.

- Urban sanitation issues

Due to the important touristic development, sanitation, solid waste management and drainage systems are considered as crucial issues for the city. Development of activities in various sectors and especially in tourism can cause significant local and national impacts (and in some instances international issues). In that case, development activities need to comply with environmentally sound technologies and practices and the provincial Department of Environment has identified three major environmental issues in Siem Reap (2008): i) water quality / sanitation issues; ii) solid waste management issues; iii) air and noise pollution (due to new constructions activities, to the use of diesel generators, to traffic, etc.)

On the first point, the Deparment of the Environment (DoE) criticizes the gradual contamination of water sources resulting from the discharge of wastewater into the environment with little or no treatment from households, factories, hotels, restaurants, guesthouse, and hospitals,. Moreover, Siem Reap faces many other environmental issues: i) the disposal of solid waste into water sources (rivers, canals, ponds, lakes) often causes flooding and shortens the life of roads; ii) the impact on public health of excreta disposal in anarchic settlements, floating houses, floating restaurants, etc.

- Wastewater system management

In terms of sanitation and drainage issues, as in Phnom Penh, there is an old conventional sewerage system, completed by recent works funded by AFD (2009-2011) and ADB (2007-2011).

It was constructed between the 1930s and 1950s and is in a poor condition due to lack of maintenance, deterioration and vandalism. The system functions as a rudimentary combined sewer system and receives septic tank effluent water and conveys these flows to open main canals. Virtually all the existing sewers will therefore need to be replaced under future storm water and wastewater management programs.

The province is now discussing with the MPWT for a Korean loan to extend the service to the entire city and build a wastewater treatment plant. The main stakeholders and projects (2008) are the following: i) JICA financed a study (2004-2006) on an integrated Master Plan for Sustainable Development of Siem Reap (2020) and Water supply system; ii) ADB has two projects: West Siem Reap Sewerage & Drainage Development project and Chong Kneas Environmental Improvement

project (3.53 million US$ for 17,000 inhabitants); iii) Apsara Authority has a project to introduce ISO 14001 to Angkor and another project funded by AFD on East Siem Reap Sewerage & Drainage Development (rehabilitation and improvement of 34 km of sewer – instead of building a separate treatment plant, the policy is to transfer the collected wastewater to the west treatment plant).

2. DEMOGRAPHIC AND SOCIO-ECONOMIC INFORMATION

2.1 Population characteristics

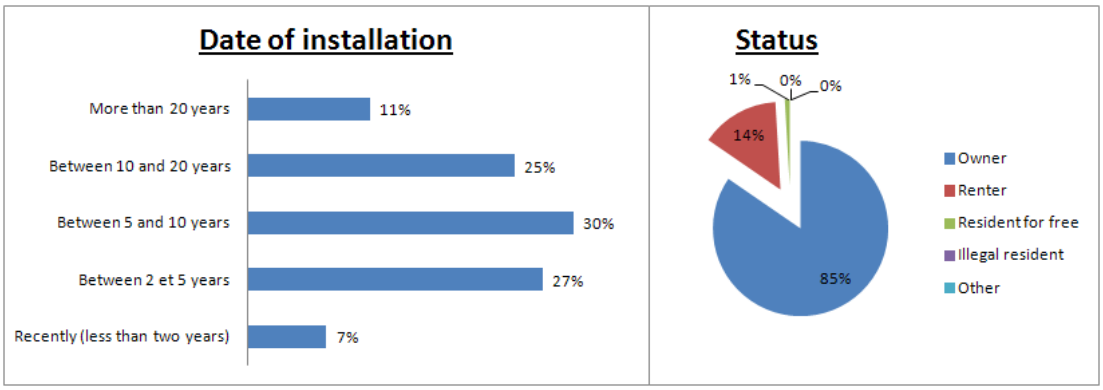
- Households

The average size of the HH in Siem Reap is estimated at 5.1 persons when the average size of a house is estimated at 6.1 inhabitants (as in Phnom Penh the discrepancy in household size and house population is due to the limit of the HH, some old people live in their family and are not counted as part of the HH).

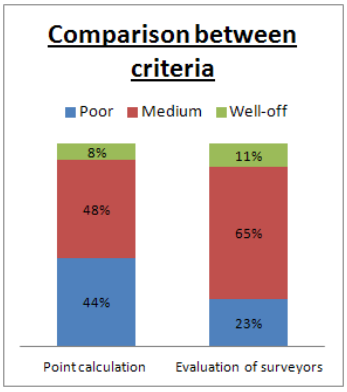
- Type of housing

89% of the houses are individual houses lived in by one family. On average, the surface per capita is 12 m^2. There are almost no differences between areas in the town. Most of the houses surveyed are located on tertiary roads (60%) or dead-end (27%). 64% of the houses are of recent construction – built less than 10 years ago. Almost 60% are made of concrete, build directly on the ground. 85% of the families declare that they own their house. The survey shows that there were two phases of installation: i) one from 1980 to 1984, after the Khmer Rouge period; ii) one from 2000 explained by the touristic boom.

Figure 24 – Date of installation and status of housing in Siem Reap



2.2 Incomes & budget



In Siem Reap, two people in one household ensure the sources of income. The average income about 360 USD per month per household surveyed and 497 USD estimated following the expenses analysis. The actual dynamism of the city is revealed in the structure of the employment in Siem Reap, more than 74% of the HH work in the service sector.

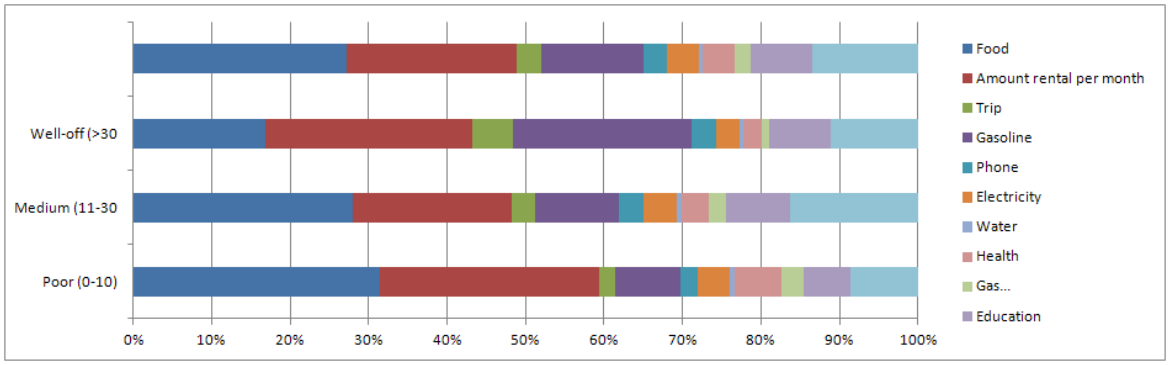
According to our methodology per points, 44% of the HH are poor, 48% are "medium" and 8% are well-off. People are earning in average an income estimated at 3.3 USD per capita per day.

The ratio between poor HH income and well-off HH income is 503%. In opposition to the situation observed in Phnom Penh, the allocation of the budget is quite different between socio-economic profiles.

Indeed, well-off HH have more expenses in gasoline and trips than the poor HH. For water and electricity, the allocation is the same, but on health, poor HH spend almost three times more than the well-off HH (6% of their budget against 2%).

Figure 25 – Incomes and Expenses in Siem Reap

	Poor (0-10)	Medium (11-30)	Well-off (>30)	Total
Income (dec)/capita/day	1,5	2,2	5,2	2,2
Income (est)/capita/day	2,1	3,2	8,4	3,3
Total monthly income declared	218	388	927	360
Monthly income est	290	522	1 457	497
Monthly savings declared	18	43	222	47
Savings estimated	130	181	624	203

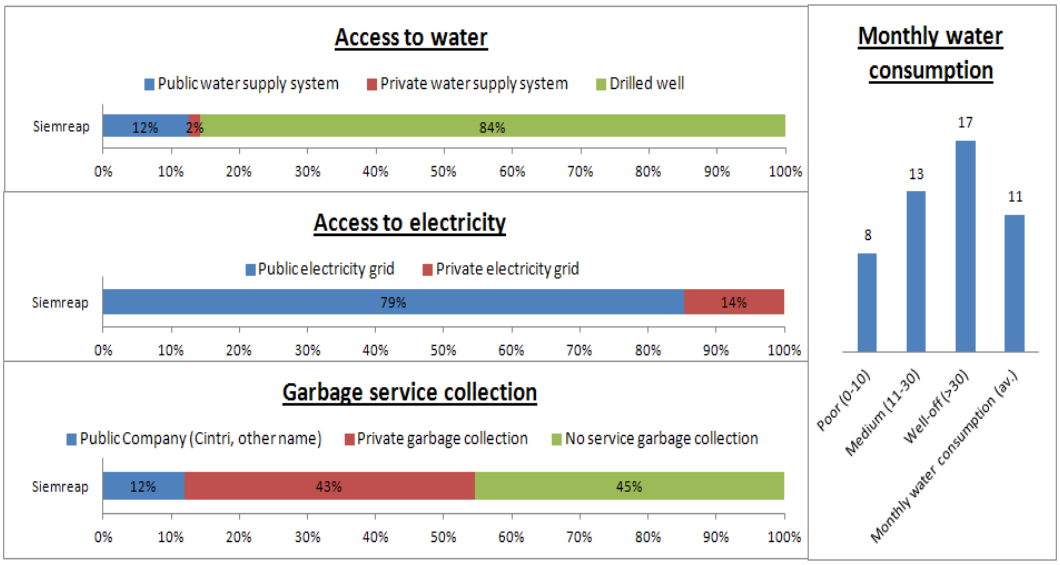


2.3 Access to services

The survey shows that in Siem Reap, only 12% of population is supplied by Siem Reap Water Supply (SRWS), the public utility in charge of water distribution, mainly in the eastern area. It is possible the question was misunderstood by the HH surveyed as another analysis shows a water coverage close to 70%. However, we also notice that there is an unequal access to services in terms of localization.

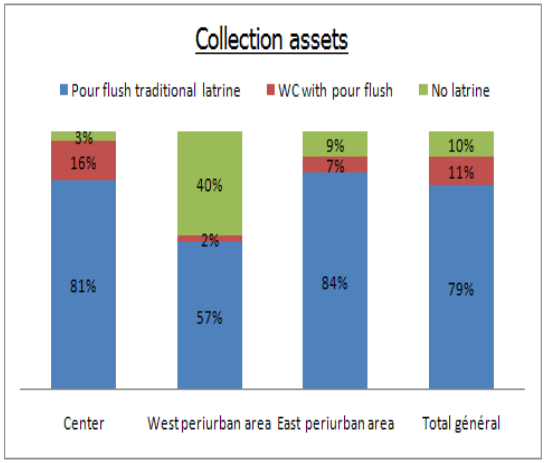
In the west peri-urban area, there is no garbage collection service, no access to a water supply service and less access to electricity than in the other areas. The monthly water consumption is quite low, around 11 m^3 which represents 61,4 l/capita/day. Almost 79% of the population is connected to the electricity network and only 12% is covered by GAIA garbage collection system (which is quite recent). Some other private services also seem to exist, locally represented. Almost 45% of HH don't have any access to a proper and regular service of garbage collection.

Figure 26 – Access to service in Siem Reap



3. HOUSEHOLDS SANITATION PRACTICES

3.1 Type of sanitation assets: collection and storage



In terms of sanitation equipment, 10% of the HH surveyed have no latrine, 79% have with a traditional pour flush latrine, and 11% have a modern WC. Of the 10% of the HH who don't have latrine, only 2% of them are using public latrine. Others are using neighbor's latrine for free.

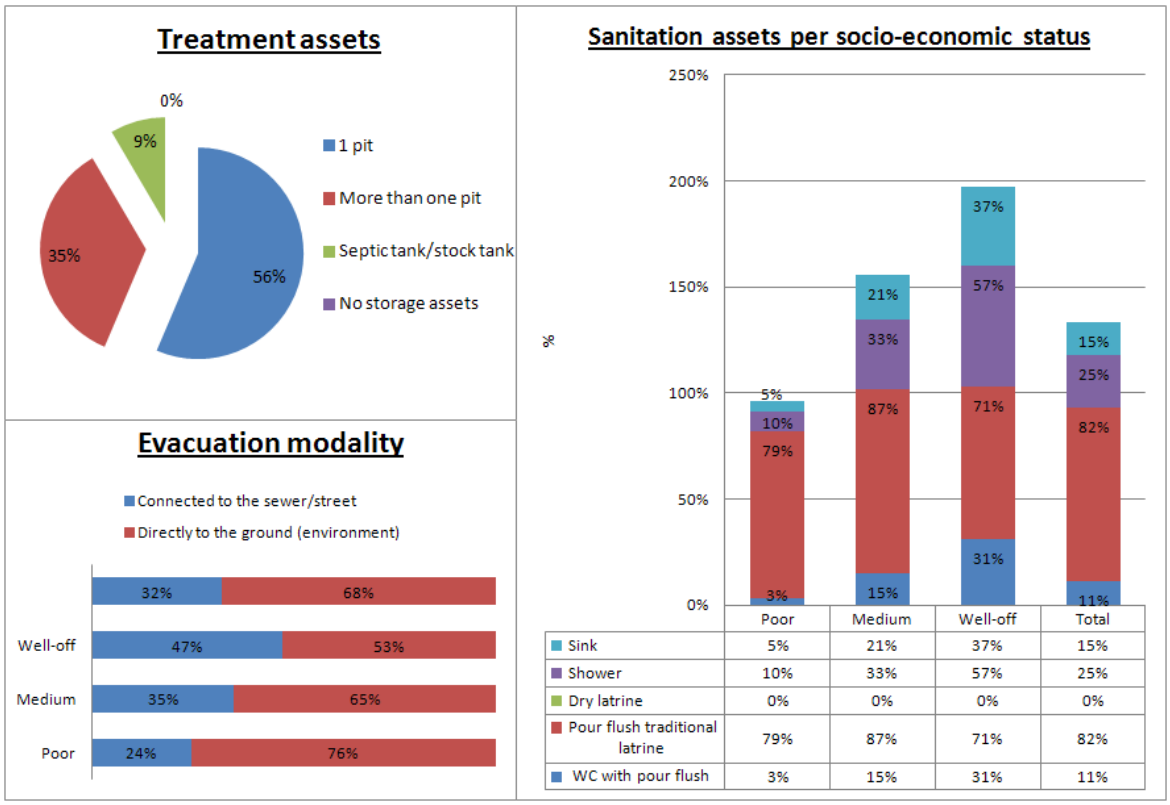
In a comparison per socio-economic status, we can notice that the differences are quite important, 5% of poor HH have sinks and 10% have a shower when they are 57% in the well-off category.

The HH surveyed who don't have any sanitation equipment for defecation are the poorest households. It's interesting to notice that 71% of the well-off HH still have a traditional latrine when they are equipped with a sink and a shower.

Two thirds of the collection assets discharge their wastewater directly to the environment. Only 32% are connected to the sewer or discharge wastewater to the street. 92% of the HH who have a latrine (80% of the HH surveyed) have infiltration pits into the ground for evacuation. Only 8.3% have a septic tank. The evacuation modality slightly differs regarding the socio-economic status, the well-off discharge more often into a sewer or the street whereas the poor use more infiltration pits.

Based on the survey, the average volume is quite different than Phnom Penh per type of treatment assets used: Type 1 – one pit is estimated at 1.6 m^3; Type 2 – More than one pit is estimated at 4.0 m^3 and Type 3 – 3.4 m^3. Interestingly, there are no direct connections to the sewer in Siem Reap.

Figure 27 – Sanitation assets in Siem Reap



4. FECAL SLUDGE EMPTYING PRACTICES

4.1 Who emptied their latrine?

Only 15% have at least once emptied their latrine or sanitation system. According the HH surveyed, there is no difference between dry and rainy season (48% of people emptied in the rainy season and 52% in dry season) but 15.3% of HH surveyed who have a latrine declared that it is flooded or unusable in the rainy season.

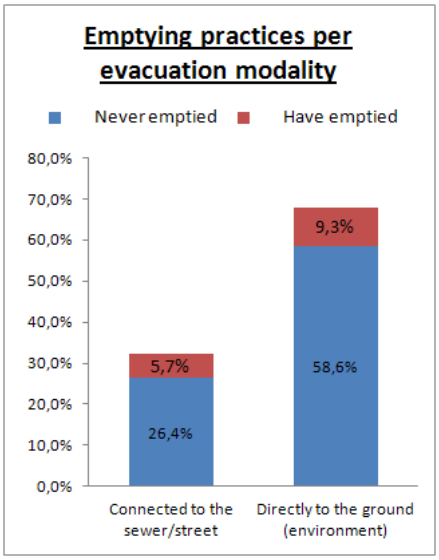
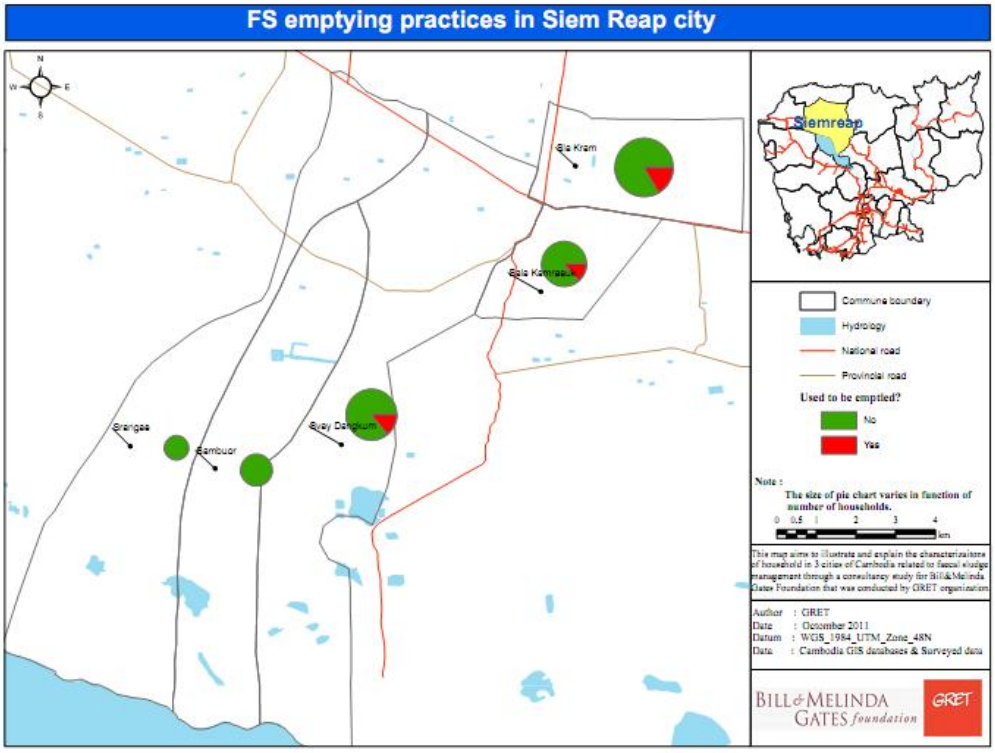


Figure 28 – Fecal Sludge Emptying practices in Siem Reap

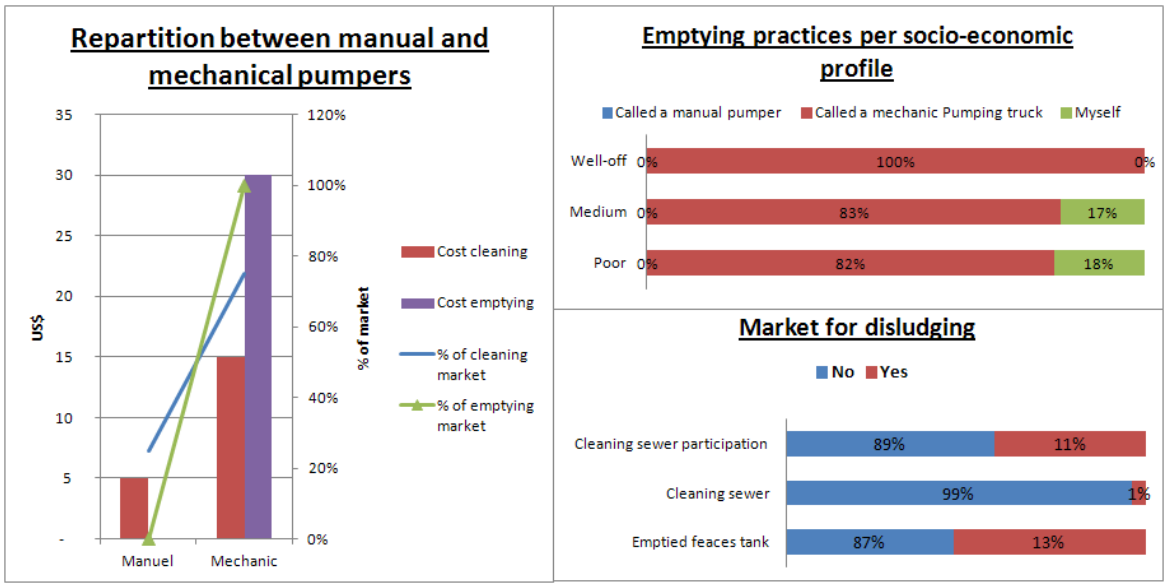


4.2 How do they do it?

Most of the households surveyed who used a sludge extraction service of called a mechanical pumper but few of them emptied their latrine themselves. Respectively 17% and 18% of medium and poor HH did this. They did it with mostly with a bucket and 25% of them with an irrigation pump. Sludge is then either buried or dumped behind the house.

Sewer cleaning is less represented than in Phnom Penh: only 1% of the HH surveyed have paid to clean their sewer. It seems that some manual operators have cleaned sewers but it has been impossible to identify them. The market for manual operators is thus considered insignificant.

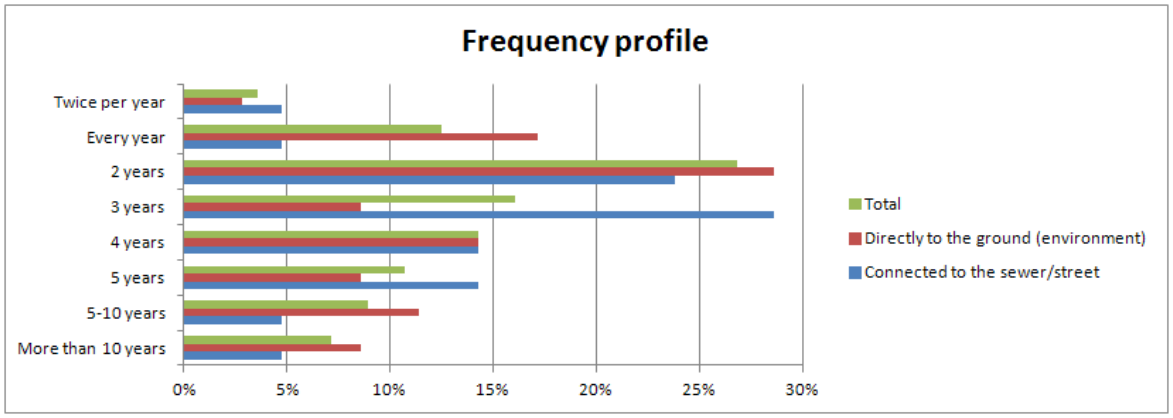
Figure 29 – Fecal sludge emptying HH practices in Siem Reap



4.3 Frequency of emptying: when?

The analysis of the frequency of emptying below shows that it varies a lot following the technology profile (type of asset and type of evacuation modality that is used). The HH emptied their latrine 0.56 times per year or every 2 years.

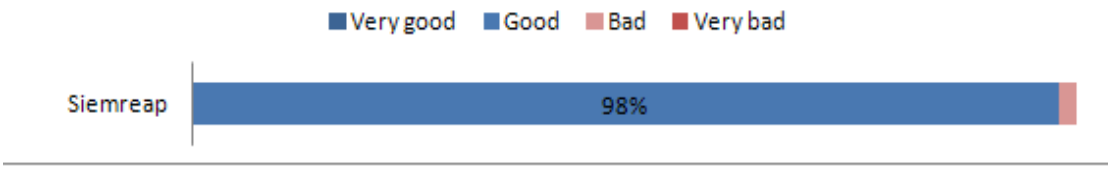
Figure 30 – Frequency of emptying in Siem Reap



4.4 Satisfaction of the service

Globally, the households are satisfied with the emptyiers' service. The main arguments, in Siem Reap, are that the tariff fee is cheap, that the service is clean and the operators are fast.

Figure 31 – Satisfaction of the service in Siem Reap



As in Phnom Penh, the ratio of faithful clients, those who will call the same operator for a future emptying is very low close to 24%.

5. FECAL SLUDGE SERVICE DELIVERY PRACTICES

5.1 General overview

- Typology of E&T operators

There are six mechanical operators. Five are small and began their activity less than four years ago. One is medium sized, *Sokha Pumping* (4 trucks) but he is operating a concession contract with the Apsara authority, exclusively for the Temple area. He's not authorized to service households. Apparently, there are no manual E&T operators in the city of Siem Reap.

By opposition with Phnom Penh, all E&T operators can be considered as formal due to the fact that they paid the patent at the beginning of their activity. Less than 40% of the mechanical E&T operators run this activity as a primary activity. As they don't separate their income per activity, it is possible they underestimate the income received from this activity. The market appeared recently, two of the E&T operators surveyed started 4 years ago and two others less than a year ago.

Table 8 – Typology of E&T Operators in Siem Reap

Profil	Unit	Small	Medium	Total
Number of operators	Num.	5	1	6
Start of the business	Year	2	-	2
Number of truck	Num.	5	3	9
Average staff number	Num.	2	51	10
Total investment (average)	US$	12,375		12,375

5.2 Service delivery assessment

- Customers profile

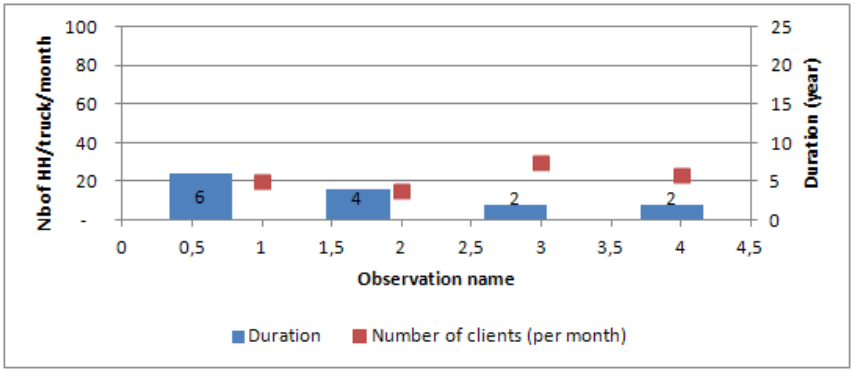
In Siem Reap, there are many more clients that are restaurants and businesses than in Phnom Penh. For them, almost three trips are needed to empty their systems. Some operators have then some business customers that always call the same operators. It is common that the restaurants and businesses empty three times per year, which represents a large part of the emptying market. In Siem Reap, mechanical E&T operators are less involved in cleaning the sewer.

The only medium-sized mechanical E&T operators does not take part in the local market and rarely empties other areas as it is a highly controlled structure, due the presence of Apsara managing the urban planning in the temple zone.

In Siem Reap, we completed the analysis with a small survey (20) on the businesses to understand their practices and their constraints and to compare the data with what the

mechanical E&T operators said. There is no ambition to be representative but it appears that they are an important clientele. 88% have already called a pumper to empty their tank and/or clean the sewer. They called mechanical E&T operators. Almost 50% are calling operators less than once every 2 years (a similar frequency to that of HH).

Figure 32 – Number of customers and duration of the business in Siem Reap



- Tariffs and size of businesses

The average tariffs is about 20 USD but can be close to 150 USD as a maximum. The tariff is lower than in Phnom Penh, due to the lower distance from emptying location to the dumping site (5 km).

In average there are 264 customers per year per truck (22 HH/month in average). The business homogeneity is important in Siem Reap, clientele ranging from 156 to 276 HH/year.

Two operators declared very low incomes so that the average hides the profitability of others. The average fuel consumption appears also very high. We can guess that they have over-estimated their fuel consumption, showing by this that it's one of their main constraints.

- Marketing strategy and mapping

As in Phnom Penh, there is no separation of customer catchment areas between them. The competition appears to be based on marketing efforts. The marketing approaches are leaflet distribution, telephone numbers painted on poles and sign boards. There are 3,100 leaflets per truck on average distributed in Siem Reap per year which represents 11 leaflets/HH.

As in Phnom Penh, the service quality depends, according to them, on the efficiency of cleaning and on operation speed (fast but clean). They can't guarantee the efficiency and durability of the emptying which depends on external constraints.

5.3 Technical assets and operation & maintenance

- An adapted truck technology

The empting activity in Siem Reap has been very interesting to survey because the trucks are special, small and adapted to the bumpy dirt roads of the city. The trucks all follow the same pattern. They are quite different from the Phnom Penh ones because they are using a motor already providing a side transmission whereas in Phnom Penh a secondary transmission was created. The final result is impressive as it has been in use for two years now without any problems. For instance a Korean Hyundai dumper truck from 1992 bought second hand for 8,000 USD, is upgraded for 4,000 USD to a vacuum truck. The prices are similar for the adaptation of a gasoline tanker truck. The Korean / Japanese models of trucks used for emptying activity in Siem Reap have all been changed from either tanker trucks or dumper truck.

Sokha Pumping, the company in charge of emptying all the toilets in Siem Reap temple zone has a 5 m^3 locally adapted truck with clean water tank. Two other new Hyundai 7 m^3 ones were purchased in 2003.

Concerning public trucks, the waste water unit received as part of the sewerage network maintenance tools, a 7 m^3 IVECO truck with a clean water compressor. Unfortunately, they don't have any technician to operate or repair the truck in case it breaks.

- Less staff than Phnom Penh

For operation, there is one to two staff per truck: one is responsible for work evaluation, driving the truck and/or price negotiation; the other does the emptying work. None have dedicated marketing staff except Sokha Pumping who has administrative staff due to its bigger size.

5.4 Incomes and Expenses

On average, small mechanical E&T operators are earning 5,971 USD profit per year (after depreciation). The average duration of return on investment is 1.8 year. They spend around 503 USD per month expenses. The average energy cost is around 7 USD/trip.

5.5 Dumping sites

The situation in Siem Reap is different from that of the other cities because a proper integrated project has been developed and is in progress.

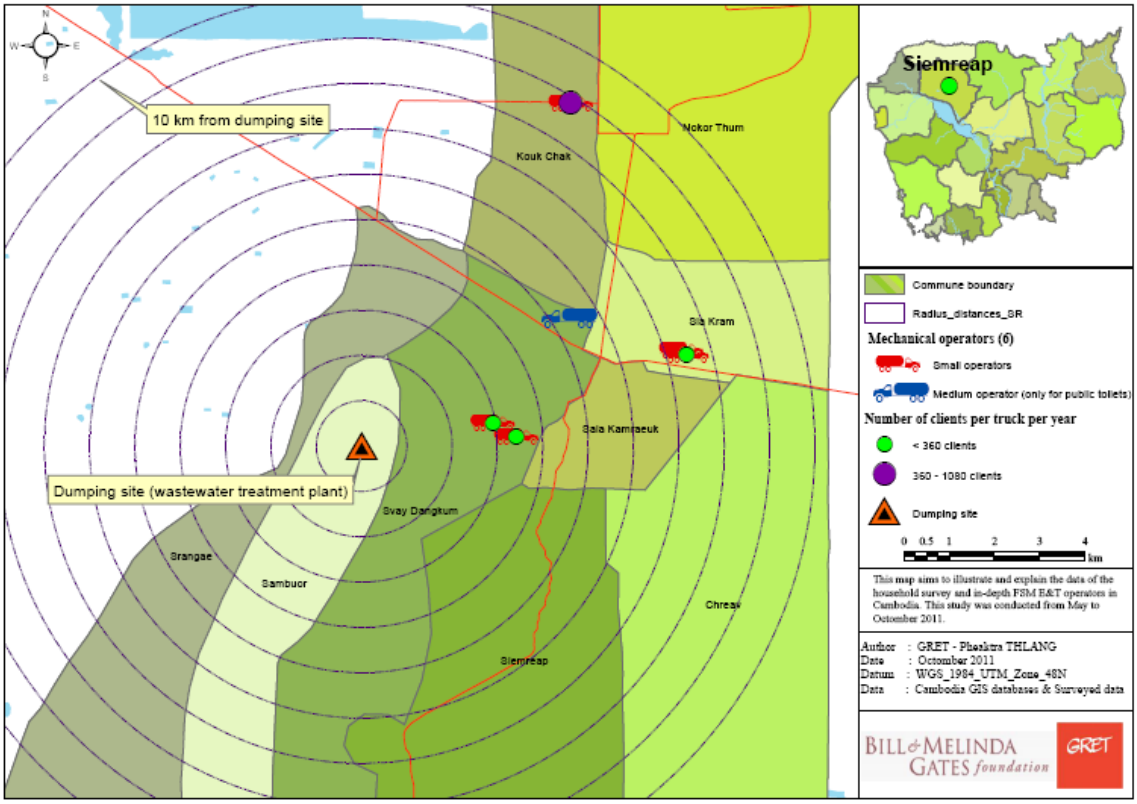
The Asia Development Bank (ADB) and the Government of the Kingdom of Cambodia have agreed to implement the Greater Mekong Sub-Region (GMS) Mekong Delta Tourism Development Project (MTDP), which will be financed by a project loan from the ADB. Within Cambodia, the MTDP is being implemented through the Ministry of Tourism (MoT).

The new project planned : i) the construction of an interceptor sewer to collect sewage flows from the reticulated network and transferring them to a new WWTP ii) the construction of interceptor chambers and iii) the clearing and rehabilitation of existing combined sewers. Later, a pump station will be built at a site along Wat Chork Street 600 m southwest of the intersection with the Ring Road to transfer flows to the WWTP. The construction of a forced main sewer 2.9 km in length to the WWTP site will bring all sludge to the new WWTP in the west of the town about 2.5 km from the Wat Chork Street and Ring Road intersection.

As mentioned earlier, the operators will go to the WWTP that will open all day. There is an arranged place for them to empty their truck in either of the two anaerobic ponds as shown above. It takes the operators 10 to 15 minutes to empty the 3 m^3 trucks into one of the two ponds and 20 minutes to reach the plant. Rarely, the operators discharge into the clients field when they ask.

The estimated (no data collected) number of trucks desludging in the plant every day is 10, which would represent 5 operators coming once or twice a day, plus the three Sokha trucks emptying every day the sludge collected on the sites of Angkor Wat. The total volume of sludge discharge in these anaerobic ponds can be estimated at 30 m^3/day.

Figure 33 – Wastewater treatment plant in Siem reap



IV. SMALL CITIES

1. BACKGROUND KAMPOT CITY

1.1 General overview

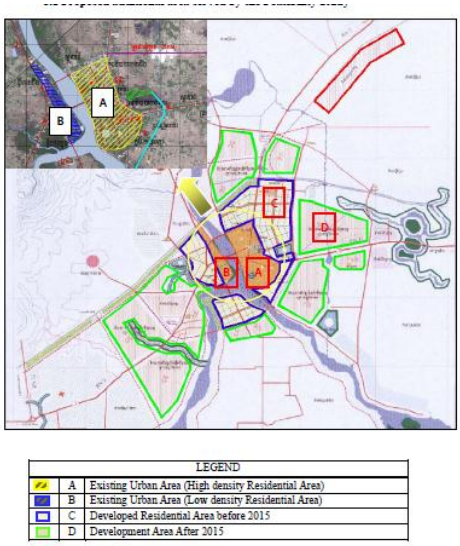
- Physical and economical description

Kampot city is located in the south-east of the Kingdom of Cambodia near the Vietnamese border. According to the last national census conducted in 2008, Kampot has around 48,310 inhabitants in the center and there may be over 115,000 inhabitants in the peri-urban area. This secondary town is characterized by economic activities focused on rice production and commercial activities. However, they are turning gradually to tourism because of the general development of the country. Indeed, many tourism activities have been developed in recent years (hostels, guesthouses, restaurants ...).

- Urban water supply

As in 13 of 24 provincial capitals of the country, water supply in the town of Kampot is ensured by a state agency depending of the MIME, the Kampot Water Supply (KWS). Commissioned in 1953, the infrastructure has recently benefited from several renovations on loan. The total length of the network is 46.7 km composed of 42% of old pipe installed in 1953 and 43% of new pipe installed by ADB project in 2006.

Figure 34 – Map of sewerage system



- Urban sanitation issues

Kampot Municipality does have an urban plan which is prepared by Provincial Department of Land Management, Urban Planning, Cadastral and Construction in cooperation with GIZ. This urban plan has not yet been approved by the Provincial Governor (UN-Habitat, 2010). The urban plan shows the extension areas of the town, industrial zones, roads, sewage system, waste water treatment plant and dumping site. Besides this urban plan, it also has many sectoral plans which are prepared separately by different institutions in Kampot province. In terms of sanitation and drainage, there is a combined sewer, built by the French in the early 1950's, covering the center. Some of the old buildings and houses have also septic tanks but most of the HH are not connected to it.

A study was conducted by the Korean cooperation (KOICA) in order to improve the sanitation system by upgrading the sewer system and the construction of a wastewater treatment plant but the project is currently postponed. For solid waste management, a new contract has been signed with GAIA for 12 years, (2010-2022) and a new dumping site has been identified (19 ha – 11 km from the city center).

2. DEMOGRAPHICS AND SOCIO-ECONOMIC INFORMATION

2.1 Population characteristics

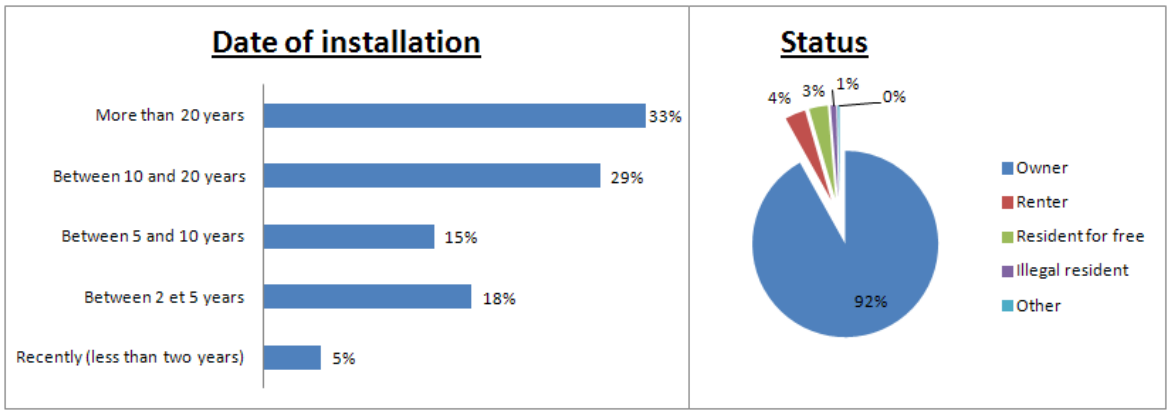
- Households

The average size of a HH in Kampot is 4.9 persons when the average size of a house is 5.4 inhabitants, the same explanation holds for Kampot as for Siem Reap and Phnom Penh regarding this difference.

- Type of housing

By opposition with Siem Reap, most of the houses have been built more than 10 years ago (62%). 92% of the families declare that they own their house. Almost 71% of the houses are individual houses composed by one family. On average, the surface per capita is 12 m^2. More than half of the population is living either in a dead end (18%) or on tertiary roads (42%). The installation is quite old. One third of the HH have been installed more than 20 years ago.

Figure 35 – Housing practices in Kampot



2.2 Incomes & budget

The average income is declared to be around 374 USD per month per household and estimated at 524 USD.

According to our scoring methodology, 40% of the HH are poor, 50% are "medium" and 10% are well-off.

People are earning on average an income estimated at 3.6 USD per capita per day. The ratio between poor HH income and well-off HH income is of 259%.

As in Siem Reap, the allocation of the budget is quite different between socio-economic profiles. Indeed, well-off HH have much more expenses in gasoline and education than the poor HH.

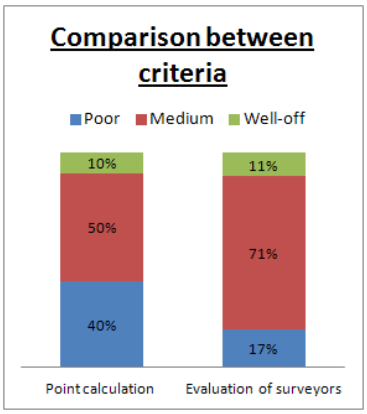
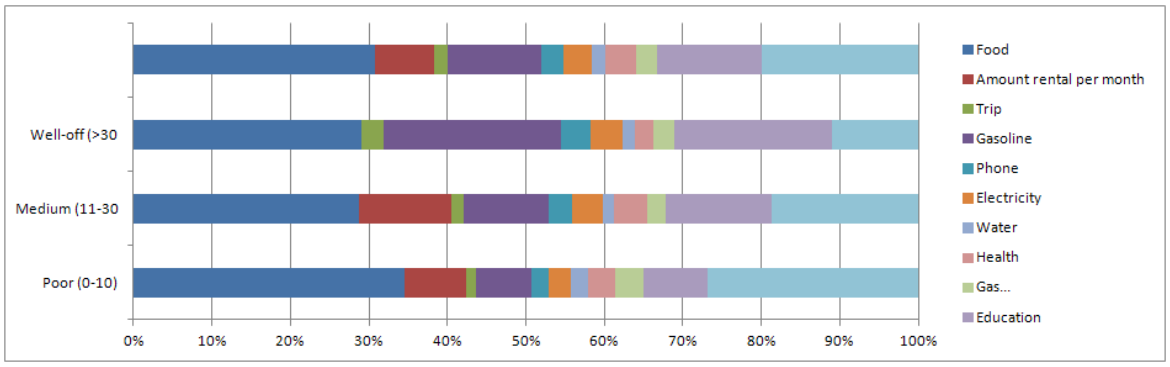


Figure 36 – Incomes and expenses of HH in Kampot

	Poor (0-10)	Medium (11-30)	Well-off (>30)	Total
Income (dec)/capita/day	1,6	2,4	5,7	2,4
Income (est)/capita/day	2,9	3,5	6,3	3,6
Total monthly income declared	219	394	892	374
Monthly income est	380	551	985	524
Monthly savings declared	20	39	128	41
Savings estimated	182	219	421	224

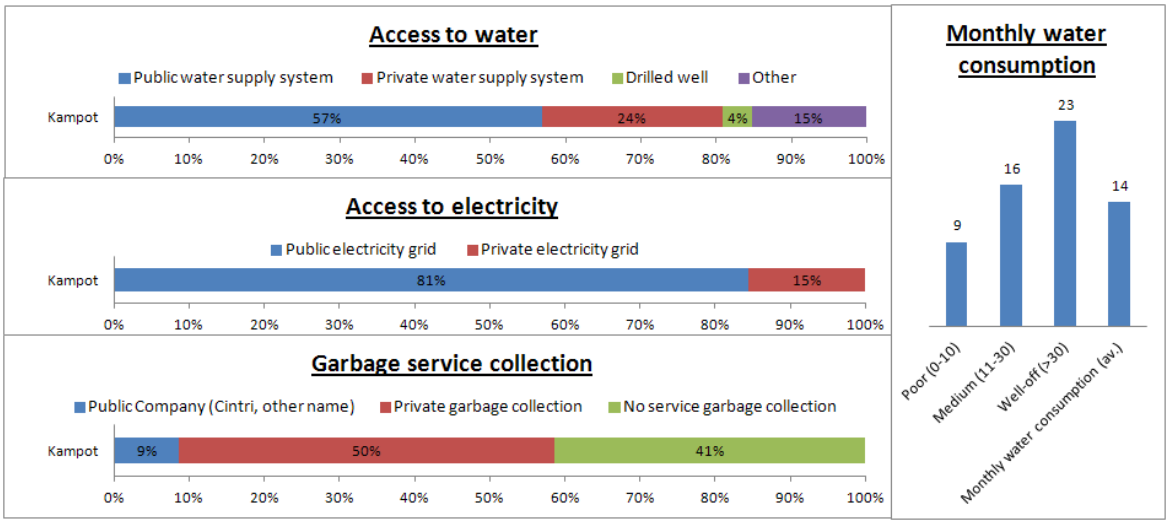


2.3 Access to services

In Kampot, 57% of population is directly covered by KWS but, according to study produced in 2010, almost all the private water providers are connected to the KWS and resell water to households through less expensive connections (GRET, 2010).

The monthly water consumption per HH is around 14 m^3 which represents 85.4 l/capita/day. Almost 81% of the population is connected to the electricity network and only 9% is covered by GAIA garbage collection system (which is quite recent). Almost 41% of HH don't have any access to a proper and regular service of garbage collection.

Figure 37 – Access to service in Kampot



3. HOUSEHOLD SANITATION PRACTICES

3.1 Type of sanitation assets: collection and treatment

89% of HH have assets in the house for defecation. 11% have no sanitation assets. The town is less equipped in other sanitation assets than the others and inequalities are high between poor HH and well-off ones. It's interesting to notice that as in PP and in opposition with Siem Reap, treatment assets are similar and evacuation modality are quite different according to the socio-economic status. 39% are connected to the sewer or to the street.

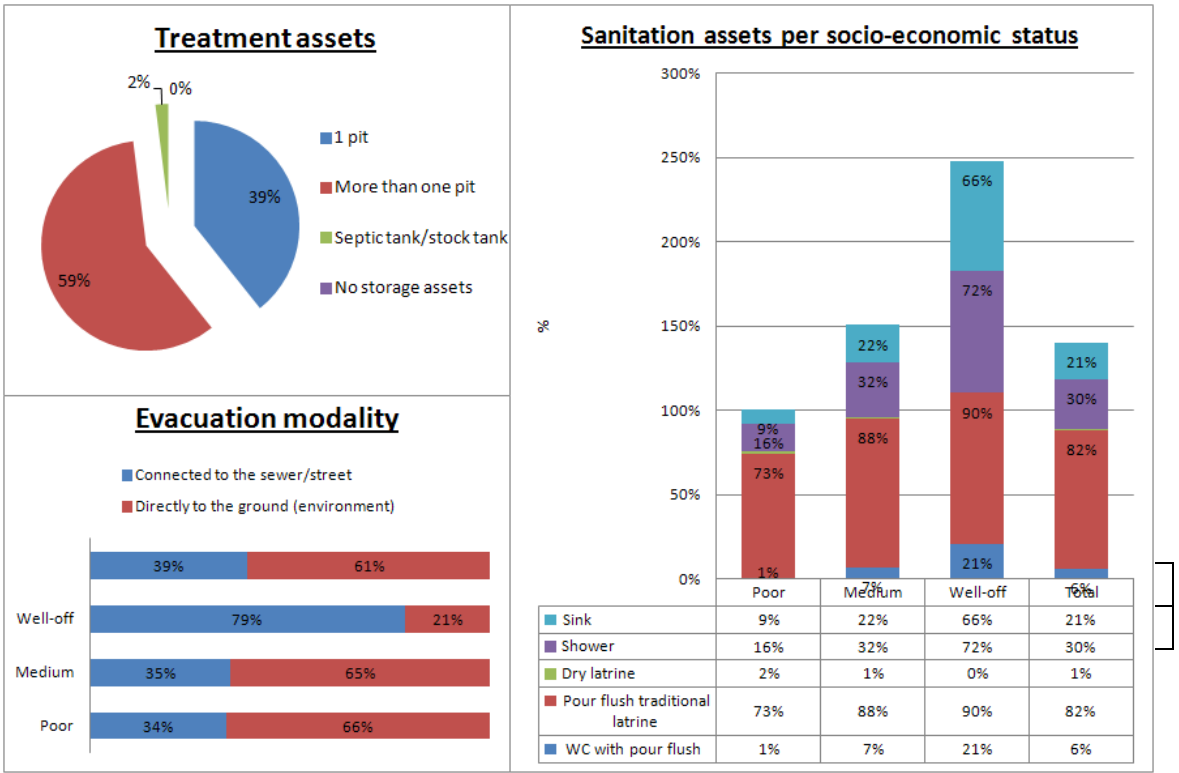
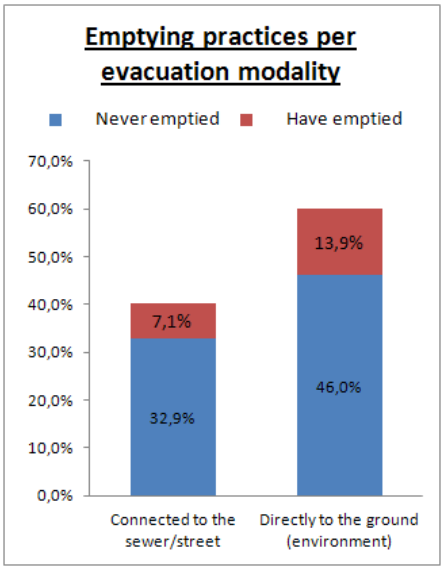


Figure 38 – Household sanitation systems in Kampot



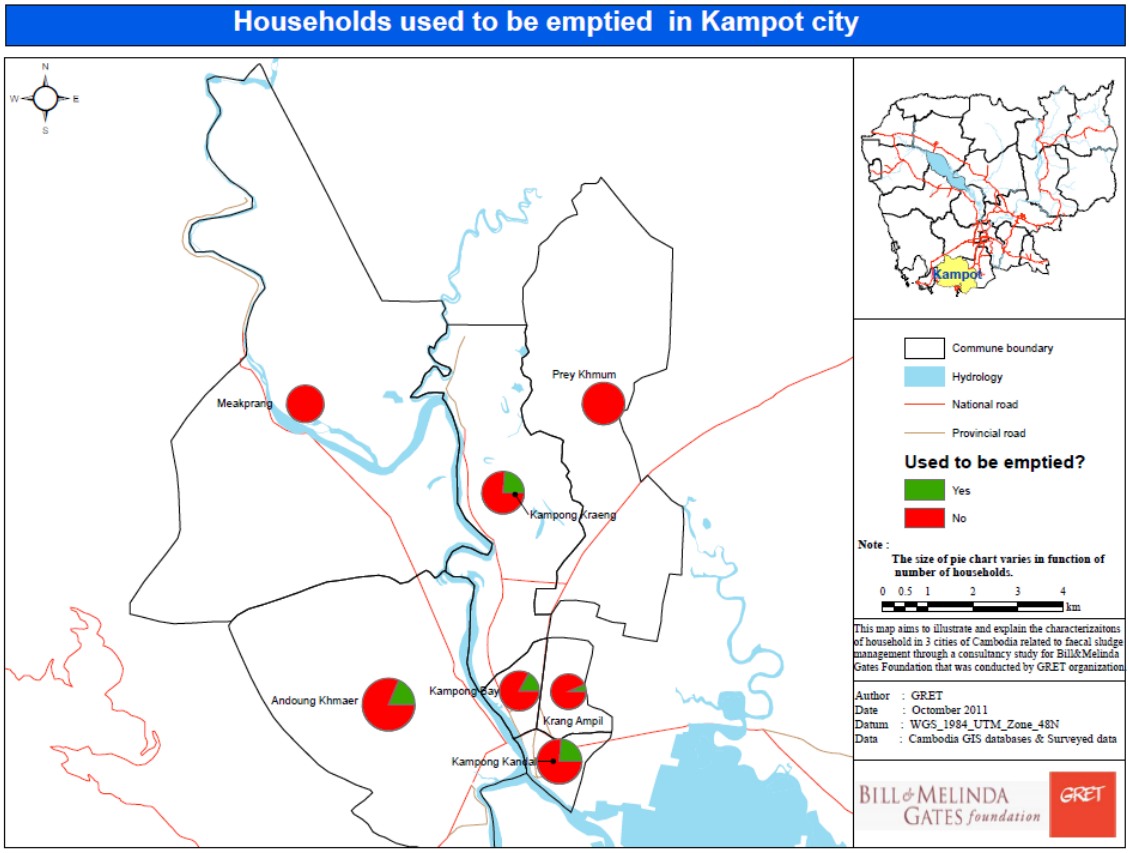
4. FECAL SLUDGE EMPTYING PRACTICES

4.1 Who emptied their latrine?

On the total of HH, 21% have at least once emptied their feces tank. A small difference exists between dry and rainy season but on the contrary to PP, it's in dry season that most of the HH are empty their feces tank. Most of the people who have at least once emptied are not connected to the sewer. It seems that their off-site system works apparently better than in Phnom Penh.

Only 13% of the HH declared that the washing and bath water are going into the same assets.

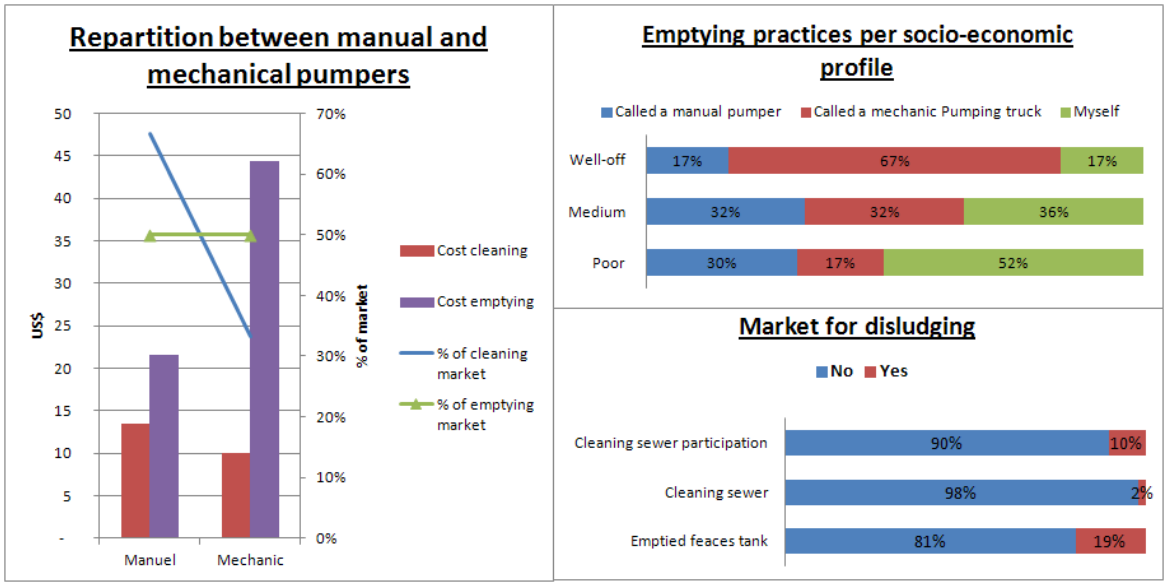
Figure 39 – Fecal Sludge emptying practices in Kampot



4.2 How do they do it?

The market for emptying is much more competitive in Kampot between manual and mechanical operators and correlated to the socio-economic status of the HH. In fact, the general repartition is for 30% manual, 30% mechanical and 40% per personal means.
The emptying method is highly correlated to the socio-economic situation. Almost 52% of the poor HH are emptying themselves their latrine. The fee for manual emptying is 20 USD per manual operators and around 45 USD declared for mechanical.

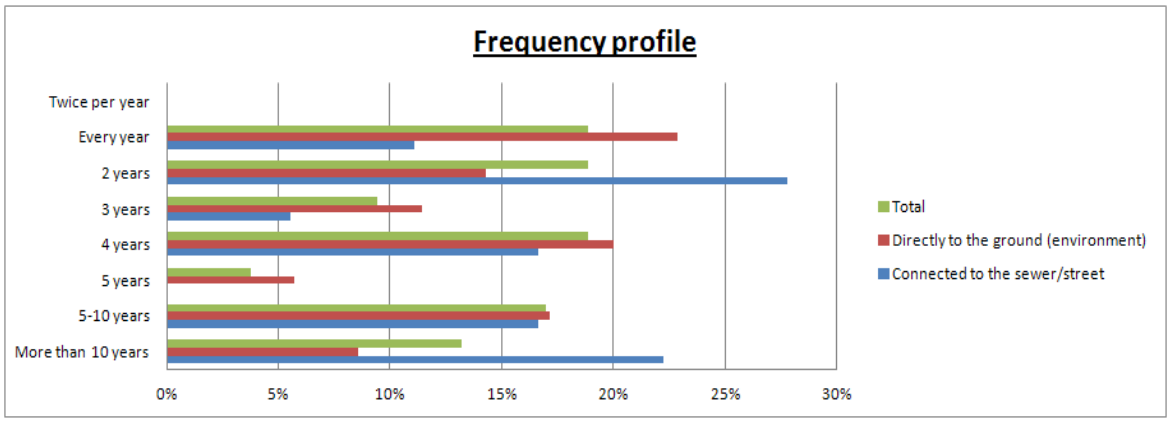
Figure 40 – Emptying practices in Kampot



4.3 Frequency of emptying: when?

The frequency profile of emptying shows that it varies a lot according the technologic profile (type of asset and type of evacuation modality). The average is 0.48 disludge per year (i.e. the HH are emptying every 2 years).

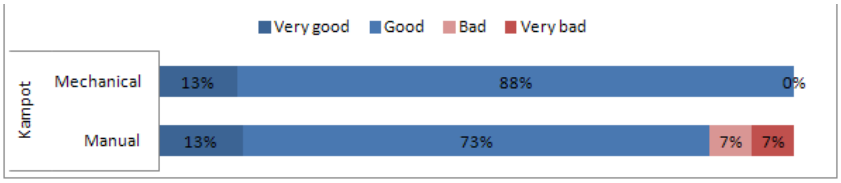
Figure 41 – Frequency profile in Kampot



4.4 Satisfaction of the service

Households are globally satisfied with the service and especially by the fact that it's clean after operation for both manual and mechanical operators. The people who were not satisfied with the manual E&T operator didn't give any reason for that feeling. In general, due to a oligopolistic market (two competitors), the fidelity rate is higher than in Phnom Penh or Siem Reap. 69% of the households declared that they will call the same operator (both manual and mechanical) for emptying their latrine next time.

Figure 42 – Satisfaction of the service in Kampot



5. FECAL SLUDGE DELIVERY PRACTICE

5.1 General overview

- Typology of E&T operators

In Kampot, there are two manual operators but just one has had this activity for six years and considers it as his main activity. The other one is helping him for large jobs. A new mechanical E&T operator appeared on the market recently, less than a year ago, but he has other activities. He owns a company in construction works and is earning much more revenue from that activity. He has only one truck. Before his arrival, people used to call mechanical operators from Phnom Penh. Both manual and mechanical are unofficial; they have not been registered to the Ministry of Commerce. There is no mechanical E&T public operator, nor a medium operator in the city.

5.2 Service delivery assessment

- Customer profile

Most of them are households living in Kampot center. Sometimes the mechanical operator go to Kep, but he is confident of the development of the market. He noticed that construction around the new market (2000) are under the level of market so in the rainy season, all the tanks are flooded. Besides, water from the market enters in the HH tanks; but for the moment, he doesn't have any customers from that area. In Kampot, there are many systems with 3 ring pits combined to 2 ring pits – he usually empties only the first pit.

The manual operator is more competitive. He has an average of five clients per month but it seems very variable. Most of the time, his clients are HH. Hotels have tanks that are too large and take two to three days to empty; he has three to seven clients per month on average. Out of 10 clients, six are well-off, three are medium to poor, and one is very poor (he gives some delay for paying). He seems to have more clients in rainy season.

His primary activity is to be a "cyclo-pousse" (but he earns less money than as pit-emptyer – 60 $ per month income). He considers it's an occupation which enables good incomes; the market exists and is increasing.

Both manual and mechanical E&T operators used to have domestic clients more than businesses. For the moment, the mechanical one has on average 48 customers/year (4 HH/month in average).

- Tariff and size of the business

Due to the low number of clients, the mechanical E&T operator is obliged to have an important tariff to cover his charges. It's 50 USD per 2 rings (2 m^3) in Kampot (25 USD per ring) and an increase of 30 USD in Kep. The manual operator has a tariff depending on the size of the work and on the number of rings. It is around 12 USD per ring emptied. Consequently, he can earn from 20 USD per operation to 100 USD.

5.3 Technical assets and operation & maintenance

- Type of equipment

The mechanical E&T operator bought his truck in Phnom Penh. It's similar to the trucks described in the previous part. The volume of the trucks (5 m^3) seems to be over-sized for city demand (2,5 m^3/HH). In terms of equipment, the manual operator has: i) a support plank, wooden rod, (he changes it 4 to 5 times per year); ii) a Bucket (he changed once in 6 years – 7,500 R); iii) a 200 l barrel (10 $ per year); iv) gloves; v) mask and boots.

- Number of staff

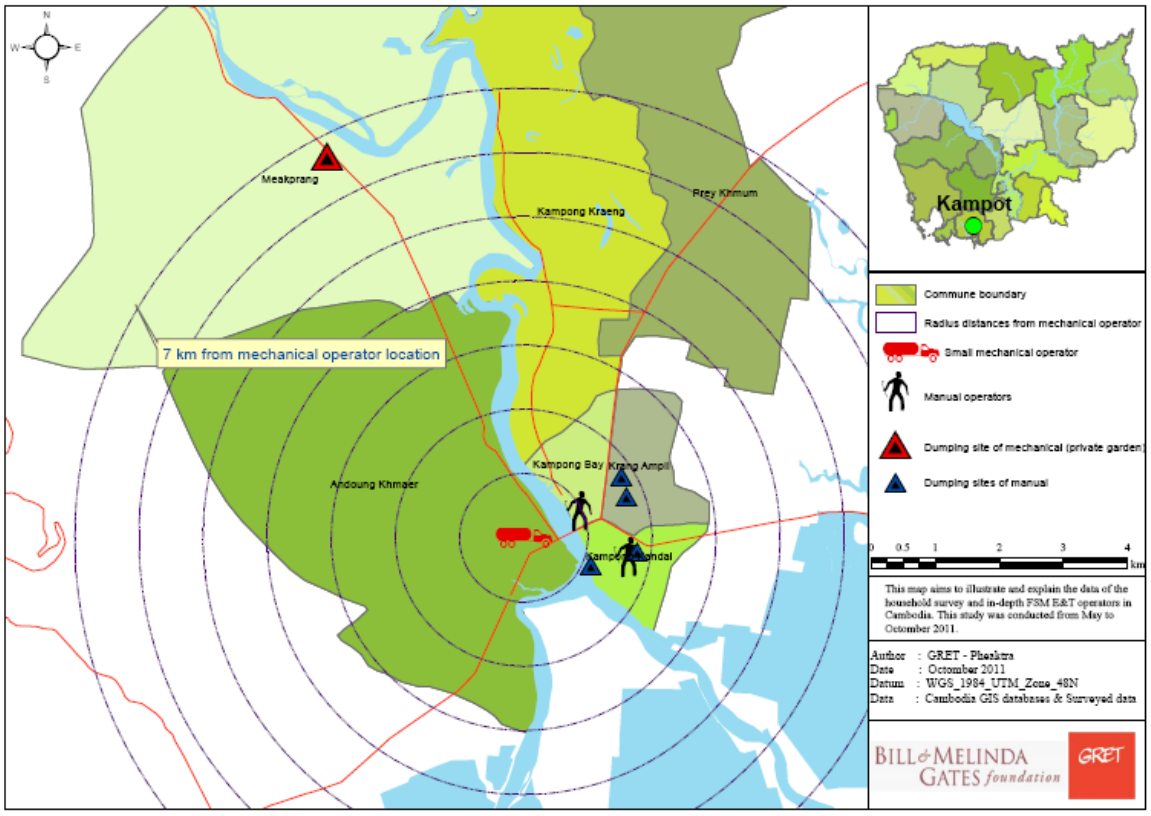
The mechanical operator has 3 staff to run the truck but they are initially construction workers. The teams can change depending on the availability of the workers. They are not experienced in this activity. Only the driver has been trained in Phnom Penh to operate the truck.

A manual emptying lasts around 4 hours for 3 rings (around 3 m^3). Another person needed, so he works with a close friend or a family member and the money is divided into two equal parts.

5.4 Dumping sites

There are no authorized sites in Kampot. Both mechanical and manual E&T operators discharge directly into the environment. The manual operator told us that one of his main constraints is transportation of the sludge. He uses the owner's field, after asking for authorization. However, he wants to buy a small 500 l truck (2,000-3,000 USD) to desludge and sell the sludge (30 l for 2,000 R) to farmers.

Figure 43 – Dumping site and Operators in Kampot



CHAPTER. IV - FECAL SLUDGE MANAGEMENT: MARKET AND BUSINESS ANALYSIS

I. KEY FINDINGS

Based on the assessment of each city, a cross-check analysis was undertaken following the main information collected. Primarily, some key findings can be easily identified.

Similar urban configuration and socio-economic organization: the number of persons per family is around **5**. The number of persons per house is almost the same, about **6**. In terms of housing and socio-economic profile, small and medium towns are also similar: these are mostly constituted by individual houses rather than by buildings. The poor and medium categories represent more than 90% of the entire sample, higher than the 79% in Phnom Penh. However, this conclusion masks many differences as the inequalities seem less important in Phnom Penh than in Siem Reap.

The Cambodian urban sanitation paradigm: sanitation coverage is quite high in all cities of Cambodia, often close to 90%. The urban sanitation management model is not based on a difference between on-site and off-site sanitation. This division is not relevant. The Cambodian urban sanitation paradigm aims first at flood control, using in part open air drainage systems and then to collect wastewater. De facto, existing sewer systems follow this paradigm and function as settled sewers, the solid phase intercepted in pits or tanks with a form of pretreatment. Thus a typical urban sanitation system in Cambodia combines an on-site part (the pit or tank) and an off-site one (the sewer and drainage network).

- On-site versus off-site sanitation: an irrelevant approach in Cambodia

Considering only the treatment assets, most of the systems are constituted by infiltration pits (like in rural areas). In Phnom Penh, the connection rate to the sewer is very high, up to 86%, whereas in small and medium towns, the rate is around 35% (32 % in SR and 40% in Kampot). Moreover, in Phnom Penh, almost 26% of the HH have no treatment asset and are connected to the sewer directly (24%) whereas in Siem Reap or in Kampot, every HH has pretreatment assets on their land, this is linked both to the greater density of the Phnom Penh sewer and drainage network and to due to the availability of more space to install them in these towns.

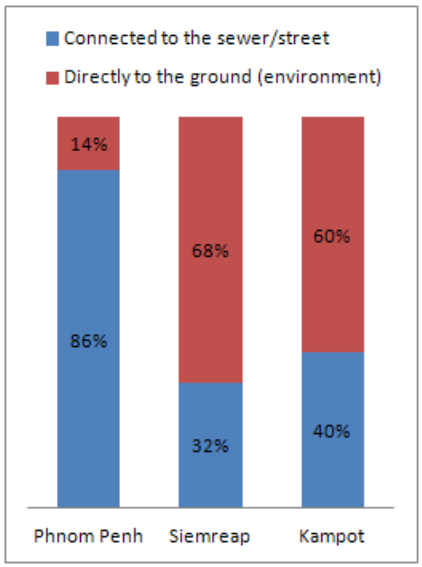
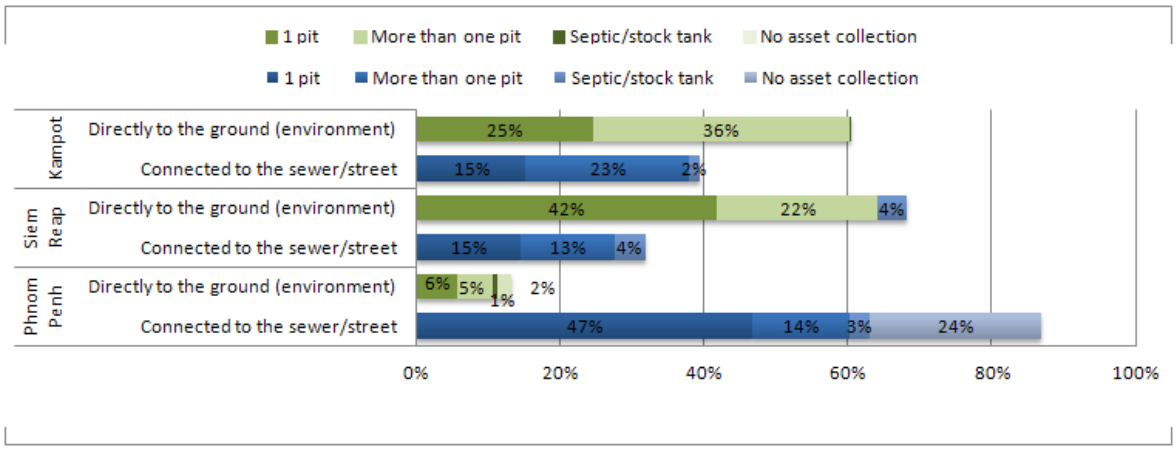


Figure 44 – Evacuation modality and assets comparison

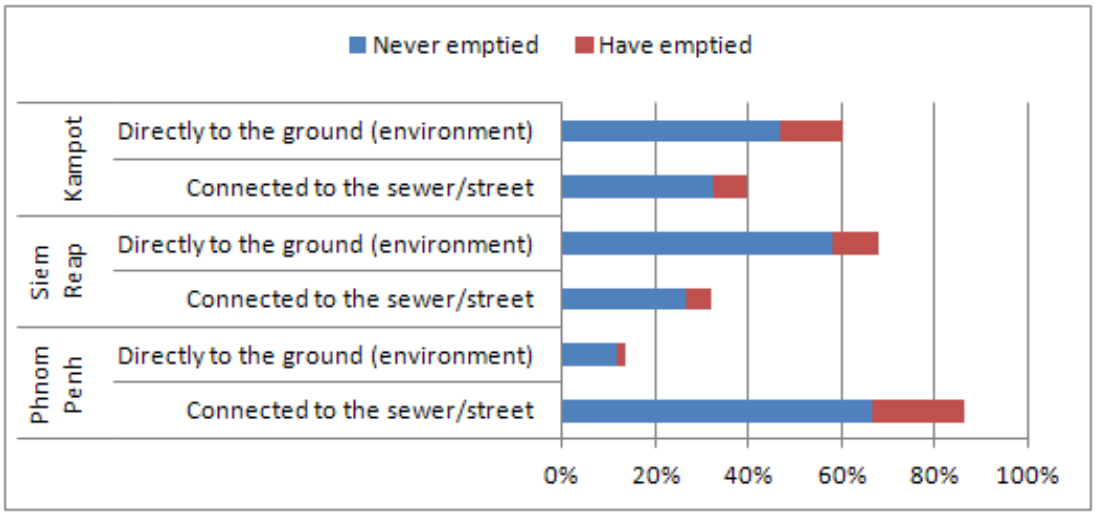


- Low emptying practices and more emptying on off-site sanitation than on-site sanitation…

What are the influences of technological assets on the emptying practices? Emptying practices are low and homogeneous in the three cities: only 15% in Siem Reap, 21% in Kampot and 22% in Phnom Penh.

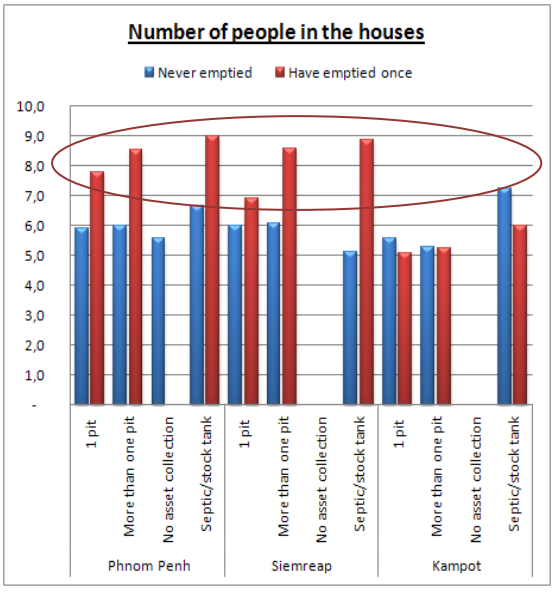
Surprisingly, there is no link between the type of sanitation assets and the emptying frequency. Indeed, in Phnom Penh, the HH who are connected to the sewer empty their assets more than the others, confirming the paradoxical "on-site / off-site" nature of Cambodian urban sanitation.

Figure 45 – Emptying practices and evacuation modality



- A high correlation between emptying practices and the number of people using the assets

Finally, the main criterion to determine the reasons for emptying is related to the number of people in the houses. Indeed, the number of HH who have emptied is highly correlated to the number of persons into the house.



As show the table below, when the number is high we observed a higher amount of the HH who have emptied their sanitation systems. It is particularly significant in Phnom Penh and Siem Reap, the HHs who have emptied have an average number of 8.1 in Phnom Penh and 7.9 in Siem Reap.

	Phnom Penh	Siemreap	Kampot	Total général
Never emptied	5,8	5,9	5,4	5,8
Have emptied	8,1	7,9	5,2	7,6
Total	6,3	6,1	5,4	6,1

II. MARKET AND BUSINESS MODEL ANALYSIS

1. METHODOLOGY

- Fecal sludge production

In order to calculate the fecal sludge production, two methodologies have been tested: i) firstly, frequency and volume declared in the survey were applied to each kind of assets; ii) secondly, a theoretical approach by fixing the production of sludge per capita per year produced. To fix this parameter and determine this production, we calculated the ratio for each asset of those who emptied. It gives us a theoretical number of sludge produced per asset per capita. This number gives us an average of 0.06 m^3/year/capita produced. We applied this criterion then to calculate the fecal sludge production in each city.

Table 9 – Fecal sludge production calculation

Determination of the accumulation rate per type of asset	(I) = total volume /nb of persons using this asset		(II)= I x av. frequency		(III) = II x 1000/365 day	
Total	0,20	m3/capita	0,06	m3/capita/year	0,17	L/capita/day
1 pit	0,12	m3/capita	0,04	m3/capita/year	0,10	L/capita/day
More than one pit	0,41	m3/capita	0,13	m3/capita/year	0,35	L/capita/day
Septic/stock tank	0,25	m3/capita	0,08	m3/capita/year	0,21	L/capita/day

- Methodology

To estimate future demand, according to our survey, the following hypotheses were made: i) we supposed that the frequency of emptying will not change in the future and that the people who have the same assets and technological profile will empty at a same proportion than those who already emptied once.

We have to notice that there are important biases in the calculation of the future market. It's coming from the fact that we don't really know why an individual HH decides to empty or not.

2. LARGE CITIES BUSINESS MODEL

2.1 Fecal Sludge production and demand for emptying

- Fecal sludge Production Calculation

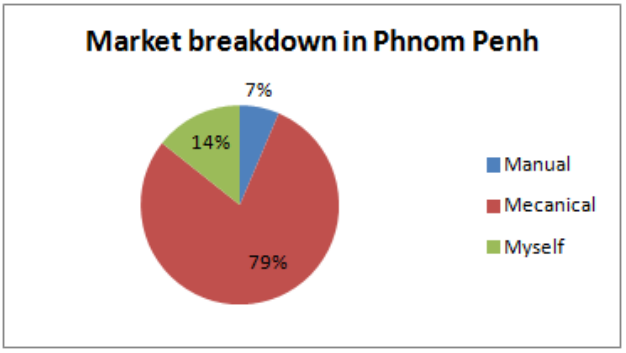
According our methodology, we estimated the actual market crossing the data from the household survey and from the operator's interviews. In Phnom Penh, there is an important difference

between each volume estimated considering that the E&T operators overestimated the average volume of emptying, from 4 m^3 to 5 m^3 when HH estimate that the average is closer to 1.5 m^3.

Table 10 – Calculation sheet for fecal sludge production

	Type of sanitation system	Emptied	% - Technologic profile	%	# of system	Volume m3	Number of Sanitation System following the Frequency									
							No answer	> 10 years	5-10 years	5y	4y	3y	2y	Every year	Twice /year	>2times/year
								0.1	0.1	0.2	0.3	0.4	0.6	1.0	1.7	2.5
Phnom Penh Market	Type 1	No	Connected	33%	403	1.2	33%	0%	0%	0%	0%	0%	0%	0%	0%	0%
			Directly to the ground	4%	55	1.2	4%	0%	0%	0%	0%	0%	0%	0%	0%	0%
		Yes	Connected	14%	173	1.2	0%	28%	17%	13%	13%	10%	10%	5%	1%	1%
			Directly to the ground	1%	13	1.2	0%	8%	23%	0%	23%	15%	23%	8%	0%	0%
	Type 2	No	Connected	9%	111	3.3	9%	0%	0%	0%	0%	0%	0%	0%	0%	0%
			Directly to the ground	4%	51	3.3	4%	0%	0%	0%	0%	0%	0%	0%	0%	0%
		Yes	Connected	5%	56	3.3	0%	23%	14%	14%	11%	20%	13%	4%	2%	0%
			Directly to the ground	1%	8	3.3	0%	0%	38%	13%	0%	25%	13%	0%	0%	13%
	Type 3	No	Connected	1%	16	2.5	1%	0%	0%	0%	0%	0%	0%	0%	0%	0%
			Directly to the ground	0%	5	2.5	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
		Yes	Connected	1%	17	2.5	0%	35%	35%	0%	18%	12%	0%	0%	0%	0%
			Directly to the ground	0%	2	2.5	0%	0%	0%	0%	0%	50%	0%	50%	0%	0%
	Type 4	No	Connected	24%	294		24%	0%	0%	0%	0%	0%	0%	0%	0%	0%
			Directly to the ground	2%	24		2%	0%	0%	0%	0%	0%	0%	0%	0%	0%
	Total			100%	1228	2.3	78%	6%	4%	3%	3%	3%	2%	1%	0%	0%

- Analysis of actual market



In Phnom Penh, the market is covered at 74% by private, at 14% by HH and 7% by manual operators. It means that there is not a great potential for growth as only the 14% of new client that emptied themselves could be a target in the future. The actual volume of fecal sludge collected is estimated at through the survey **25,764 m^3/year** and the potential market is estimated at **92,941 m^3/year**. The theoretical sludge collected is 26,979 m^3/year. This is greater than the real fecal sludge production due to the fact that E&T operators cover a larger part than the administrative area of the city.

Table 11 – Actual and Future market in Phnom Penh

Estimation of the role of FSM operators in Fecal Sludge Collected in Phnom Penh							
		Actual market (volume m3)			Future market (volume m3)		
		Manual	Mecanical	Myself	Manual	Mecanical	Myself
Type 1	Connected	1,269	12,492	2,830	4,577	45,063	10,209
	Directly to the ground	98	976	195	352	3,521	704
Type 2	Connected	293	4,489	488	1,056	16,194	1,760
	Directly to the ground	-	781	-	-	2,816	-
Type 3	Connected	-	878	98	-	3,168	352
	Directly to the ground	-	878	98	-	3,168	352
Total		**1,659**	**20,494**	**3,709**	**5,985**	**73,931**	**13,378**

- Potential market

The table put below aims to analyze the future market in Phnom Penh. Based on the capacity of the trucks the market is already covered at 77%.

Table 5 – Potential market in Phnom Penh

GRET METHOD	Phnom Penh
PRODUCTION per YEAR	
Based on survey data = **P1**	**25,764 m^3**
Theoretical calc = **P2**	**92,941 m^3**
Theoretical FS collected per year = C	**26,979 m^3**
Based on survey average number of clients of mechanical op. per year	**574**
Based on survey average number of clients of manual op. per year	**48**
Theoretical capacity of trucks m^3 (sludge part)	**4 m^3**
Theoretical volume pumped m^3 = C1	**71,176 m^3**
Potential volume to be collected = C2	**21,765 m^3**
Market coverage C2/P2	**77%**

2.2 Financial and Business analysis

- Incomes statements: small

Income statement - City of Phnom Penh

Mechanical Small E&T Operator (Proposed model)

1 trucks (5 m3/truck capacity), 50 trips per month

Item	Annual Amount		Monthly	Per trip	Percentage
	USD	Riels	USD	USD	%
Personnel Costs					
Wages paid: *1 Unit Manager*		-	-	-	
1 Driver	1,500	6,150,000	125	2.50	**10%**
2 Operators	4,320	17,712,000	360	7.20	**29%**
Social Contribution to permanent staff *(10%)*		-	-	-	
Medical expenses *(10%)*		-	-	-	
Overtime		-	-	-	
Subtotal	**5,820**	**23,862,000**	**485**	**10**	**39%**
Operating and dumping costs					
Registration fees of company	122	500,000	10	0.20	
Licensing fees for truck *(incl. fitness, etc)*	63	260,000	5	0.11	
Office building rent *(for office (partial) & garrage))*	420	1,722,000	35	0.70	
Telephone	180	738,000	15	0.30	
Electricity		-	-	-	
Water	60	246,000	5	0.10	
Offices supplies, computer	21	85,280	2	0.03	
Trucks Maintenance and repair	214	878,835	18	0.36	
Safety Equipment *(hand tools and spares)*		-	-	-	
Fuel *(pumping & transport)*	2,476	10,152,000	206	5.16	
Sludge dumping/tipping Fees	720	2,952,000	60	1.20	
If sold for re-use: Transportation costs to buyer		-	-	-	
Others : marketing	1,752	7,183,200	146	2.92	
Subtotal	**6,029**	**24,717,315**	**502**	**11**	**45%**
Equipment Capital costs					
Loan Interest paid to Bank		-	-	-	
Insurance costs for trucks, vehicles	87	356,700	7	0.15	
If used, costs to refurbish truck (one time- upfront)	-	-	-	-	
Truck Depreciation Cost *(15% per year)*	1,857	7,614,286	155	3.10	
Tyres annual replacement Cost	250	1,025,000	21	0.42	
Suction pipes replacement Cost	120	492,000	10	0.20	
Vehical rental cost	-	-	-	-	
Subtotal	**2,314**	**9,487,986**	**193**	**4**	**1634%**
Total recurring cost	**14,163**	**58,067,301**	**1,180**	**25**	**10000%**
Revenue Sources					
Emptying (Households only) - *97%*	20,952	85,903,200	1,746	34.92	
Emptying business - 3%	900	3,690,000	75	1.50	
Other uses** of the trucks (specify each)	-	-	-	-	
If sold for re-use: Income from sale to buyer	-	-	-	-	
Total revenue	**21,852**	**89,593,200**	**1,821**	**36**	
Profit /Loss					
Profit before Tax	**7,689**	**31,525,899**	**641**	**12**	
Tax	**1,538**	**6,305,180**	**128**	-	
Profit (loss) after Tax	**6,151**	**25,220,719**	**513**	**12**	

- Incomes statement medium

Income statement - City of Phnom Penh

Mechanical Medium E&T Operator (Proposed model)

3 trucks (5 m3/truck capacity), 150 trips per month

Item	Annual Amount		Monthly	Per trip	Percentage
	USD	Riels	USD	USD	%
Personnel Costs					
Wages paid: *1 Unit Manager*		-	-	-	
3 Driver	4,500	18,450,000	375	2.50	**8%**
6 Operators	12,960	53,136,000	1,080	7.20	**23%**
Social Contribution to permanent staff *(10%)*		-	-	-	
Medical expenses *(10%)*		-	-	-	
Overtime		-	-	-	
Subtotal	**17,460**	**71,586,000**	**1,455**	**10**	**31%**
Operating and dumping costs					
Registration fees of company	122	500,000	10	0.07	*0%*
Licensing fees for truck *(incl. fitness, etc)*	190	780,000	16	0.11	*0%*
Office building rent *(for office (partial) & garrage))*	975	3,997,500	81	0.54	*2%*
Telephone	240	984,000	20	0.13	*0%*
Electricity		-	-	-	*0%*
Water	120	492,000	10	0.07	*0%*
Offices supplies, computer		-	-	-	*0%*
Trucks Maintenance and repair	227	930,700	19	0.13	*0%*
Safety Equipment *(hand tools and spares)*		-	-	-	*0%*
Fuel *(pumping & transport)*	9,285	38,070,000	774	5.16	*16%*
Sludge dumping/tipping Fees	2,700	11,070,000	225	1.50	*5%*
If sold for re-use: Transportation costs to buyer		-	-	-	*0%*
Others : marketing	2,720	11,152,000	227	1.51	*5%*
Subtotal	**16,580**	**67,976,200**	**1,382**	**9**	**29%**
Equipment Capital costs					
Loan Interest paid to Bank		-	-	-	
Insurance costs for trucks, vehicles			-		
If used, costs to refurbish truck (one time- upfront)	-	-	-	-	
Truck Depreciation Cost *(15% per year)*	5,571	22,842,857	464	9.29	
Tyres annual replacement Cost	750	3,075,000	63	1.25	
Suction pipes replacement Cost	1,125	4,612,500	94	1.88	
Vehical rental cost	-	-	-	-	
Subtotal	**7,446**	**30,530,357**	**621**	**12**	**40%**
Total recurring cost	**41,486**	**170,092,557**	**3,457**	**31**	**100%**
Revenue Sources					
Emptying (Households only) - 97%	62,856	257,709,600	5,238		
Emptying business - 3%	2,700	11,070,000	225		
Other uses** of the trucks (specify each)	-	-	-	-	
If sold for re-use: Income from sale to buyer	-	-	-	-	
Total revenue	**65,556**	**268,779,600**	**5,463**	-	
Profit /Loss					
Profit before Tax	**24,070**	**98,687,043**	**2,006**	**(31)**	
Tax	**4,814**	**19,737,409**	**401**	-	
Profit (loss) after Tax	**19,256**	**78,949,634**	**1,605**	**(31)**	

- Profit estimates

As we saw before and it's especially true for Phnom Penh, the average number of customers per truck and per month is highly variable from one operator to another. On average, the operators with one truck have 32 clients per month when the operators with four trucks have 80 customers per truck and per month. This average hides many differences between each small operator in terms of profit.

The E&T operators who recently entered in the market have on average more clients than the "historic" operators.

In the small type, the number of HH/truck/year can be from 120 to 1,200, so to say a 10 times ratio. In the medium type, the difference can be even more, up to 25 times (48 against 1200 HH/truck/year).

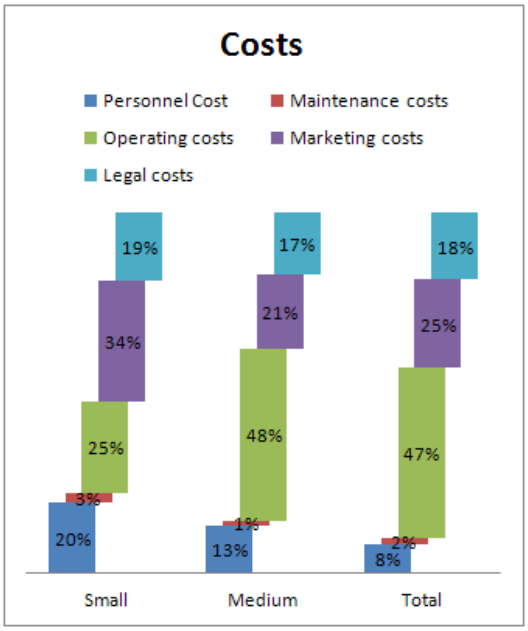
Small & medium E&T operators earn on average from 5 USD to 24 USD per customer (12,7 USD on average). In Phnom Penh, it's interesting to underline that the earnings of medium E&T operators are less than those of small ones.

This can be explained as we saw that there are some medium sized who have a very low number of customers per truck.

- Costs analysis

The table 42 below shows the structure of expenses declared in the in-depth survey by small and medium operators in Phnom Penh. The expenses are divided into 5 parts: (1) for operating & costs ≈ 47%, (2) for marketing costs ≈ 25%, (3) for staff ≈ 8%, (4) for legal costs ≈ 8% & (5) for maintenance cost ≈ 2%. The operational expenses are mainly on energy consumption (≈ 60%), marketing (leaflet printing ≈ 20%), dumping charge (≈ 7%) and the rests for other expenses such as maintenance, consumables, etc. On staff expenses, 80% are for operating staffs and 20% for marketing staffs. However, these results vary slightly between *"strong marketing operators"* and *"non-marketing operators"* who have limited marketing expense.

Figure 46 – Costs analysis



3. MARKET AND BUSINESS MODEL ANALYSIS IN MEDIUM CITIES

3.1 Fecal sludge production and demand for emptying

- Fecal sludge production calculation

The calculation sheet is similar to the one developed for Phnom Penh and aims to show the method of calculation that we use.

Table 12 – Calculation sheet for fecal sludge production

	Type of sanitation system	Emptied	% - Technologic profile	%	# of system	Volume m3	Number of Sanitation System following the Frequency									
							No answer	More than 10 years	5-10 years	5y	4y	3y	2y	Every year	Twice /year	>2times/year
Siem Reap Market	Type 1	No	Connected	12%	45	1.6	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%
			Directly to the ground	38%	138	1.6	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%
		Yes	Connected	2%	9	1.6	0%	0%	0%	11%	11%	44%	33%	0%	0%	0%
			Directly to the ground	4%	15	1.6	0%	0%	13%	0%	13%	13%	27%	27%	7%	0%
	Type 2	No	Connected	11%	41	1.8	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%
			Directly to the ground	18%	65	1.8	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%
		Yes	Connected	2%	7	1.8	0%	14%	0%	14%	14%	14%	14%	14%	0%	14%
			Directly to the ground	4%	16	1.8	0%	19%	13%	13%	13%	6%	25%	6%	0%	6%
	Type 3	No	Connected	3%	11	2.00	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%
			Directly to the ground	3%	12	2.0	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%
		Yes	Connected	1%	5	2.0	0%	0%	20%	20%	20%	20%	20%	0%	0%	0%
			Directly to the ground	1%	3	2.0	0%	0%	0%	33%	33%	0%	33%	0%	0%	0%
	Total			100%	367	2.7	85%	1%	1%	2%	2%	2%	4%	2%	0%	1%

- Actual market in Siem Reap

The market in Siem Reap is drastically dominated by private E&T operators at 87%. Few HH empty their sanitation system themselves (14%). Based on our calculation, the actual volume of fecal sludge collected is estimated at **3,684 m^3**/year. The potential market is estimated at 25,662 m^3/year.

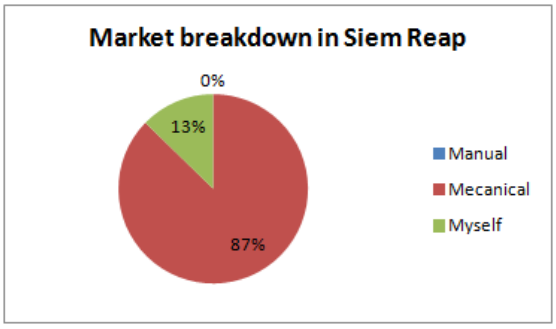


Table 13 – Actual market in Siem Reap

Estimation of the role of FSM operators in Fecal Sludge Collected in Siem Reap							
		Actual market (volume m3)			Future market (volume m3)		
		Manual	Mecanical	Myself	Manual	Mecanical	Myself
Type 1	Connected	-	536	67	-	3,733	467
	Directly to the ground	-	938	67	-	6,532	467
Type 2	Connected	-	402	67	-	2,800	467
	Directly to the ground	-	737	335	-	5,132	2,333
Type 3	Connected	-	536	-	-	3,733	-
	Directly to the ground	-	536	-	-	3,733	-
Total		**-**	**3,684**	**536**	**-**	**25,662**	**3,733**

- Potential market

The table below shows that the FSM market potential is more important in Siem Reap .Only 57% of the market is already covered and 11,015 m^3/year cannot currently be collected when the sanitation system will be full.

GRET METHOD	Siem Reap
PRODUCTION per YEAR	
Based on survey data = **P1**	**3,684 m^3**
Theoretical calc = **P2**	**25,662 m^3**
Theoretical FS collected per year =C	**2,520 m^3**
Based on survey average number of clients of mechanical op. per year	**210**
Based on survey average number of client manual op. per year	**0**
Theoretical capacity of truck m^3 (sludge part)	**2.25**
Theoretical volume pumped m^3 = C1	**14,648 m^3**
Potential Volume to be collected = C2	**11,015 m^3**
Market Coveraqe C2/P2	**57%**

3.2 Financial and business analysis

- Incomes statement Small

Income statement - City of Siem Reap

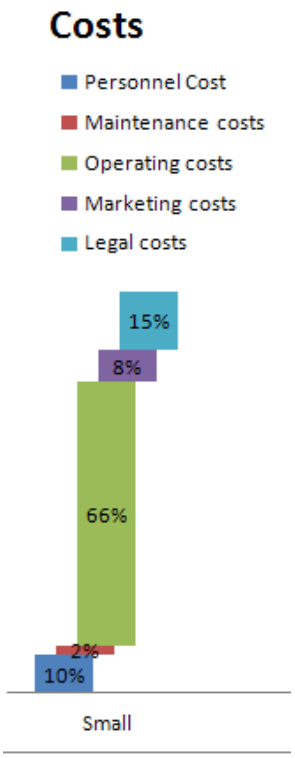
Mechanical Small E&T Operator (Proposed model)

1 trucks (3 m3/truck capacity),26 trips per month

Item	Annual Amount		Monthly	Per trip	Percentage
	USD	Riels	USD	USD	%
Personnel Costs					
Wages paid: *1 Unit Manager*		-	-	-	
1 Driver		-	-	-	0%
2 Operators	1,373	5,628,480	114	4.40	20%
Social Contribution to permanent staff *(10%)*		-	-	-	
Medical expenses *(10%)*		-	-	-	
Overtime		-	-	-	
Subtotal	**1,373**	**5,628,480**	**114**	**4**	**20%**
Operating and dumping costs					
Registration fees of company	30	123,000	3	0.10	
Licensing fees for truck *(incl. fitness, etc)*	63	260,000	5	0.20	
Office building rent *(for office (partial) & garrage))*	420	1,722,000	35	1.35	
Telephone	90	369,000	8	0.29	
Electricity		-	-	-	
Water		-	-	-	
Offices supplies, computer		-	-	-	
Trucks Maintenance and repair	165	676,500	14	0.53	
Safety Equipment *(hand tools and spares)*		-	-	-	
Fuel *(pumping & transport)*	1,609	6,598,800	134	5.16	
Sludge dumping/tipping Fees	720	2,952,000	60	2.31	
If sold for re-use: Transportation costs to buyer		-	-	-	
Others : marketing	100	410,000	8	0.32	
Subtotal	**3,198**	**13,111,300**	**266**	**10**	**47%**
Equipment Capital costs					
Loan Interest paid to Bank		-	-	-	
Insurance costs for trucks, vehicles		-	-	-	
If used, costs to refurbish truck (one time- upfront)	-	-	-	-	
Truck Depreciation Cost *(15% per year)*	1,929	7,907,143	161	6.18	
Tyres annual replacement Cost	250	1,025,000	21	0.80	
Suction pipes replacement Cost	120	492,000	10	0.38	
Vehical rental cost	-	-	-	-	
Subtotal	**2,299**	**9,424,143**	**192**	**7**	**3346%**
Total recurring cost	**6,869**	**28,163,923**	**572**	**22**	**10000%**
Revenue Sources					
Emptying (Households only) - *97%*	6,178	25,328,160	515	19.80	
Emptying business - 3%	1,560	6,396,000	130	5.00	
Other uses** of the trucks (specify each)	-	-	-	-	
If sold for re-use: Income from sale to buyer	-	-	-	-	
Total revenue	**7,738**	**31,724,160**	**645**	**25**	
Profit /Loss					
Profit before Tax	**868**	**3,560,237**	**72**	**3**	
Tax	**174**	**712,047**	**14**	-	
Profit (loss) after Tax	**695**	**2,848,190**	**58**	**3**	

- Profit

The businesses appear fragile having 5% to 11% of profit per year if we consider that they have provisions for their equipment calculated.



- Costs analysis : more fixed expenses

The expenses are divided into 5 parts: (1) for operating costs ≈ 66%, (2) for marketing costs ≈ 8%, (3) for staff ≈ 10%, (4) for legal costs ≈ 15% and (5) for maintenance cost ≈ 2%. Some comments can be made on this business:

On the contrary of PP, most of the charges are fixed (58%) if we consider that personal costs are then fixed wages for most of the Siem Reap operators. It's mainly due to the small number of clients per month.

The legal costs can be important representing 15% of the charges declared due to all E&Ts go to the wastewater treatment and are more formalized than in Phnom Penh.

4. MARKET IN SMALL CITIES

4.1 Fecal sludge production

- Fecal sludge production

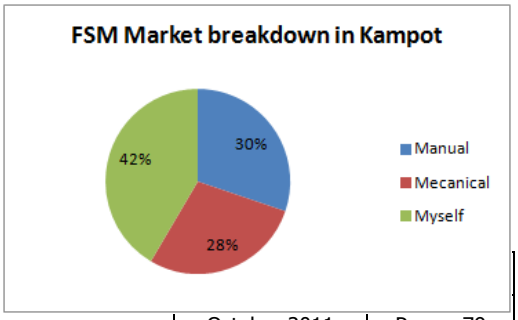
The calculation sheet is similar than Phnom Penh and is based on the same method of calculation.

Table 14 – Calculation sheet for fecal sludge production

	Type of sanitation system	Emptied	% - Technologic profile	%	# of system	Volume m3	Number of Sanitation System following the Frequency: No answer on frequency	More than 10 years	5-10 years	5y	4y	3y	2y	Every year	Twice /year	>2 times/year
Kampot market	Type 1	No	Connected	32	13%	1.4	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%
			Directly to the ground	43	17%	1.4	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%
		Yes	Connected	7	3%	1.4	0%	29%	0%	0%	14%	0%	43%	14%	0%	0%
			Directly to the ground	17	7%	1.4	0%	12%	0%	6%	29%	29%	6%	12%	6%	0%
	Type 2	No	Connected	47	19%	1.8	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%
			Directly to the ground	73	29%	1.8	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%
		Yes	Connected	11	4%	1.8	0%	18%	27%	0%	18%	9%	18%	9%	0%	0%
			Directly to the ground	17	7%	1.8	0%	6%	29%	6%	6%	0%	24%	18%	12%	0%
	Type 3	No	Connected	4	2%	1.9	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%
			Directly to the ground			1.9	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
		Yes	Connected			1.9	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
			Directly to the ground	1	0%	1.9	0%	0%	100%	0%	0%	0%	0%	0%	0%	0%
	Total			252	100%	3.0	79%	3%	4%	1%	4%	2%	4%	3%	1%	

- Actual market

The market structure in Kampot is also different from the ones observed in Phnom Penh and Siem Reap. Mechanical E&T operators represent only 28% while 30% are manual. Most of the household empty themselves their sanitation systems. Based on our calculation, the actual volume of fecal sludge



collected is estimated at **1,013 m³/year**. The potential market is estimated at 4,890 m³/year. The table shown below presents the detailed results of the calculation.

Table 13 – Actual and Potential Market

Estimation of the role of FSM operators in Fecal Sludge Collected in Kampot							
		Actual market (volume m3)			Future market (volume m3)		
		Manual	Mecanical	Myself	Manual	Mecanical	Myself
Type 1	Connected	58	39	39	282	188	188
	Directly to the ground	97	58	175	470	282	846
Type 2	Connected	78	117	19	376	564	94
	Directly to the ground	78	78	156	376	376	752
Type 3	Connected	-	-	19	-	-	94
	Directly to the ground	-	-	19	-	-	94
Total		**312**	**292**	**429**	**1,504**	**1,410**	**2,069**

- Potential market

The market is already covered at 122% in Kampot due to the presence of one mechanical operator. However, this system seems to be inappropriate to Kampot context that does not generate a sufficient demand for a mechanical E&T and certainly not for a 5 m³ tank. The Siem Reap tank size would be better.

GRET METHOD	Kampot
PRODUCTION per YEAR	
Based on survey data = **P1**	**1,013**
Theoretical calc = **P2**	**4,890**
Theoretical FS collected per year =C	**260**
Based on survey average number of clients of mechanical op. per year	**48**
Based on survey average number of client manual op. per year	**60**
Theoretical capacity of truck m³ (sludge part)	**4**
Theoretical volume pumped m³ = C1	**5,952**
Potential Volume to be collected = C2	**(1,062)**
Market Coveraqe C2/P2	**122%**

4.2 Business model in Kampot

- Manual operators

Income statement (Manual emptying)

Study area: Kampot

Item	Annual amount		Monthly amount	per emptying	% /emptying
	USD	Riels	Riels	Riels	
Capital Costs					
Wages for all employees	-		-	-	
Small equipment (wheelbarrows, shovels, buckets, etc.).	20.00	82,000	6,833	1,367	6%
Safety equipment (gloves, boots, etc.).	25.85	106,000	8,833	1,767	8%
Others (specify)	-		-	-	
Subtotal	**45.85**	**188,000**	**15,667**	**3,133**	**14%**
Operating Costs					0%
Fees paid for emptying support	-		-	-	
Transport support fees paid	240.00	984,000	82,000	16,400	74%
Disinfectants	36.59	150,000	12,500	2,500	11%
Medicine used	-		-	-	
Material renting	-		-	-	
"baksheesh" for Harassment	-		-	-	
If sold for re-use: Transportation costs to buyer	-		-	-	
Subtotal	**276.59**	**1,134,000**	**94,500**	**18,900**	**86%**
Total Cost	**322.44**	**1,322,000**	**110,167**	**22,033**	**100%**
Revenue					
Emptying (HH)	1,440.00	5,904,000	492,000	98,400	19,680
If sold for re-use: Income from sale to buyer	-		-	-	-
* Other uses of the equipment (specify)	-		-	-	-
Total Revenue	**1,440.00**	**5,904,000**	**492,000**	**98,400**	**19,680**
Profit/ Loss					
Profit / Loss	**1,117.56**	**4,582,000**	**381,833**	**76,367**	**19,679**

- Profit

The analysis shows that the profit of the manual operator is quite high considering that the fixed charges are quite low in this kind of business. On average, the manual pumper won 100 USD per month that is considered as a quite good salary in secondary town of Cambodia for a non-primarily activities.

5. COMPARATIVE ANALYSIS OF SERVICE DELIVERY

5.1 Market breakdown among small, medium and manual

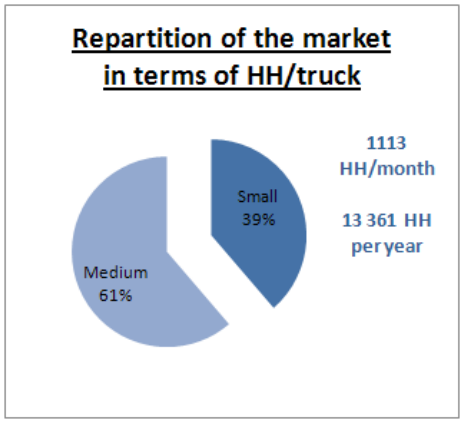
- Manual versus Mechanical?

In terms of market size, one third is covered by small operators when two thirds is covered by medium ones which represent around 13,400 trips per year.

The analysis below is based on an average calculation per truck operating not depending on the category it belongs to. In Phnom Penh, 431 HH/year was considered as an average number of clients per truck. The global market repartition is shown in the table 15.

In Siem Reap, In terms of market size, the integrality of the market is covered by small operators which represent around 1,100 trips per year. The medium sized business, Sokha Pumping shouldn't be providing services to households.

Interestingly in Kampot, 71% of the market is covered by manual operators and 29% by the small operator which represents around 170 trips per year.



	# HH/year	% HH/month	#trucks
Small	5 172	39%	12
Medium	8 189	61%	19
	13 361		*31*

- A predominance of "small" private mechanical E&T operators

Despite the different contexts, we can see that there is a predominance of mechanical private E&T operators on the fecal sludge management market. Manual operators and public trucks are often used for cleaning the sewer more than servicing households. Indeed, there are no large size businesses in Phnom Penh or in Cambodia. Moreover, 69% of the operators have one truck, 23% have two or three trucks and 8% have four trucks. It gives a proportion of 69% of small operators and only 31% of medium size businesses.

However, in Phnom Penh and Siem Reap, an in-depth analysis of the E&T mechanical operators shows that the number of trucks is not a determining parameter of the size and type of operators. Indeed, in each category (small and medium), there are some operators having less than 30 clients per month and other having more than 100 customers each month.

5.2 Business Profile of Operators among survivors, competitors and performers

- Productivity per truck is the key indicators to compare the E&T Mechanical Operators

The in-depth analysis of the E&T operators in the three towns shows that taking into account the number of trucks is not enough to understand the business delivery model. Indeed, there is a wide range of operators. Despite the fact that they have only one truck, some mechanical E&T operators are more dynamic, efficient and profitable than some medium operators. Profit doesn't depend on the number of emptying systems nor on the number of customers in general. It clearly depends on the number of customers per year and per truck, the productivity, but surprisingly, it is not correlated.

Table 15 – Productivity of E&T Mechanical Operators

	Phnom Penh			Siem Reap		Kampot	
	Small	Medium	Total	Small	Total	Small	Total
<360 clients/y							
Nb of HH/truck	150	48	99	232	232	48	48
Number of truck	2	6	8	3	3	1	1
360-1000/y							
Nb of HH/truck	360	486	444	360	360		
Number of truck	1	4	5	1	1		
>1000/y							
Nb of HH/truck	1 140	1 140	1 140				
Number of trucks	2	8	10				
Total Nb of HH/truck	**588**	**558**	**572**	**264**	**264**	**48**	**48**
Total Number of truck	**5**	**18**	**23**	**4**	**4**	**1**	**1**

The table 16 shows that the small operators (less than 150 clients per year or one to three clients per week) are generating higher profit per customers than the one who have around one client per day (150 to 300 clients per year) because of the truck depreciation. Finally, there can be three kinds of profiles:

- Type 1 - small operators **"Survivors"** (from 1 to 150 customers) that make on average 2,400 USD per year profit;
- Type 2 - middle operators **"Competitors"** (from 150 to 350 customers) whose profit can be from less than 1,000 to 1,800 USD per year;
- Type 3 - "big" operators **"Performers"** dealing with more than 350 customers and earning from 4,000 to 20,000 USD per year and per truck profit.

Table 16 – Diversity of businesses profiles

Type	Nb of customers	Profit per customer	Nb of operators	Nb of customers per year / per truck in average	Nb of trucks	Staff average	Profit per year / per truck
Type 1	Less than 150	19,3	6	85	10	5	1 682
Type 2	From 150 et 350	4,6	6	244	6	3	1 239
Type 3	More than 300	13,3	7	863	13	7	11 678
Total		15,0	19		29	7	5 909

We have to be careful then analyzing the profile per city between small and medium operators

■ A marginal market for manual E&T operators

In general, it's difficult to compare the cities due to a low number of manual operators in general. In Siem Reap, their absence is also surprising. However, it appears that there are important differences between the manual operator profiles between each city: i) in Phnom Penh, manual operators don't really have this activity as their primary one. They are used to working in construction works and don't consider the emptying activity as a specific one. In Kampot, on the contrary, it seems to be an important activity. We can assume that in small and medium cities, where the market for mechanical emptying is emerging and the rate of those emptying themselves is important, manual emptiers are quite important for insuring a kind of transition between "self-emptying" and mechanical services.

■ No scaling economy

The most important difference between small and medium operators is the depreciation costs for trucks and the high income in return per truck (whose investment has been already returned back).

But in general, we can consider that small operators are more dynamic and profitable than medium ones.

There is finally no economy done by scaling the business. Having more trucks increases proportionally the costs and does not generate scale economies as fixed costs constitute an important proportion of the expenses.

- Breakeven point

A simulation of the business plan for those operators shows that the breakeven point is around 19 clients / per month in Phnom penh and 22 clients per month in Siem Reap.

Concerning the investment return, most of the mechanical E&T operators have their investment returned. The average duration of the return is in 2.5 years but some operators could have their investment back in 1.5 years.

- A safe risk mitigation strategy

The high variability of the expenses suggests that the E&T operators are in a strategy to secure their investment in priority. When they returned their investment and become stabilized in the market, they can increase their fixed charges to recover more benefits. We can also notice that this model is highly adapted in terms of equipment and commercial service delivery to the cities and to the demand. The volume capacity is adapted to provide service the maximum volume of an HH.

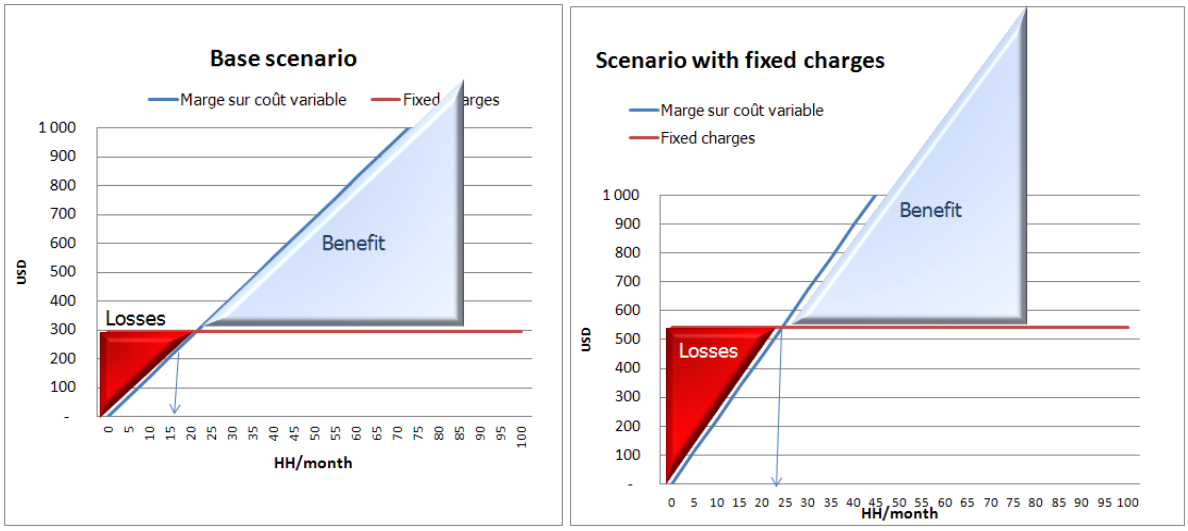


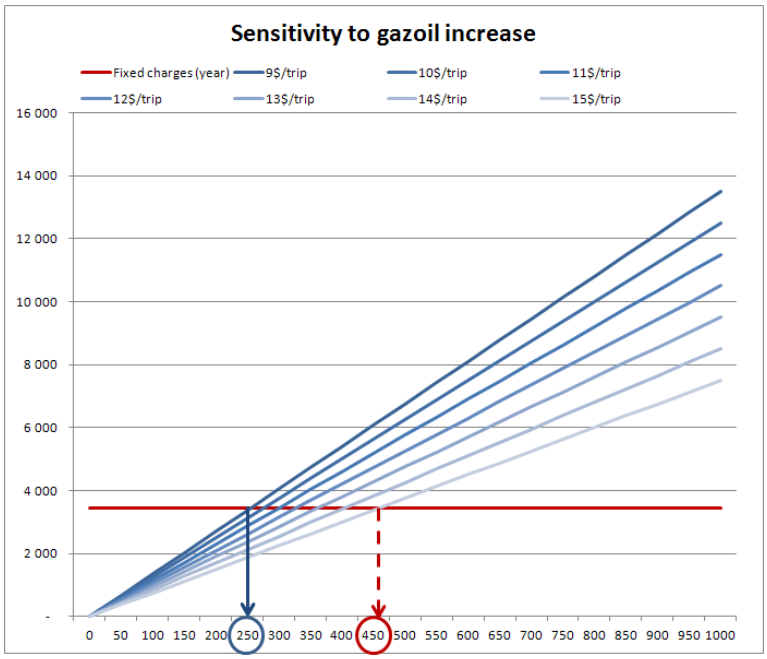
Figure 47 – Base scenario and scenario with fixed charges

- A high sensitivity to risk of gasoil increase

Transport and energy expenses are important representing almost 40% of the total. These external factors have an important impact on the business model and explain the differences of the tariffs between each city. The consumption of gasoil is very variable depending on the distance and in each city: in Phnom Penh customers are far from the dumping site and in Siem Reap closer to it.

This appears to be one of the main constraints. The figure below shows a fall of profitability with increasing energy costs. On this point, the business model is very sensitive and an increase of gasoil price has a strong impact on the number of clients needed to be profitable. As example, 1 USD increase per trip needs to have 30 customers more per month.

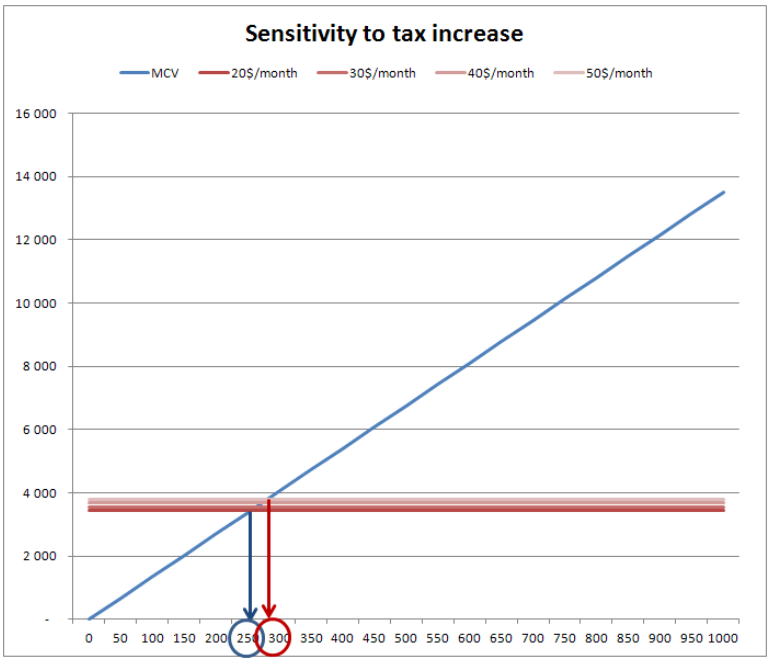
Figure 48 – Sensitivity regarding energy cost increasing



- A low sensitivity to tax increase

At the inverse, taxes cost are the only part which is less variable between cities. It can represent a quite important expense, especially for small operators (it can be over 18% of the expenses). Moreover, we noted that some fines have been delivered this year at unauthorized disposal sites and more controls seem to be done. It represents another risk for the operators (a fine can reach 500 USD). However, the sensitivity is quite less important on the business model as the table below shows:

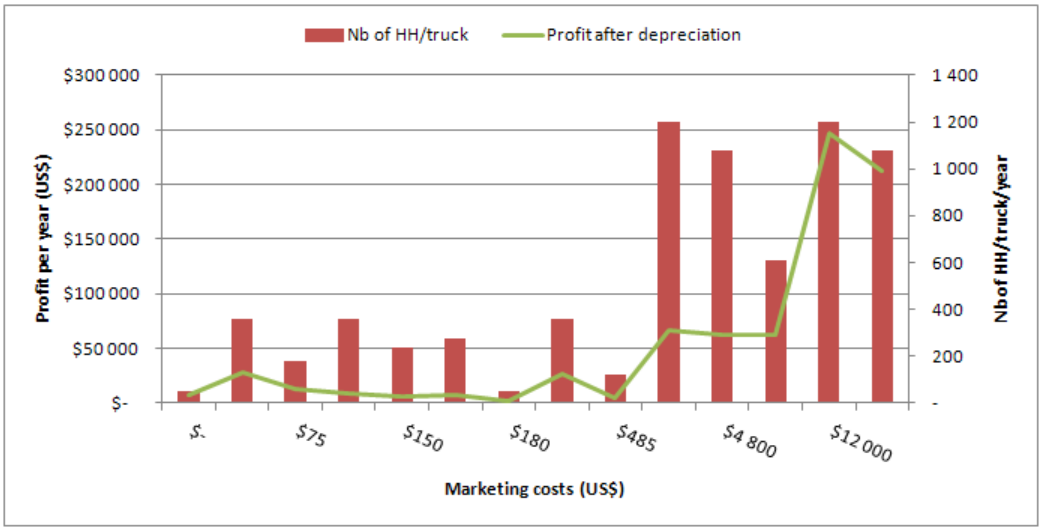
Figure 49 – Sensitivity regarding the tax increasing



- A high importance of marketing costs to be profitable

As we see in the figure below, the expenses done in marketing are correlated to the profit done and to the number of clients. The success of an operator seems to stand on his ability to do an aggressive marketing strategy by posting leaflets in the city.

Figure 50 – Marketing costs and profit



6. CONCLUSION

In Kampot and in Siem Reap, the business model appears very sensitive and fragile. The high amount of operating costs compared to their low market (143 HH/year so that 11 clients per month in average is on the limit of profitability) explains that difference.

In general, considering the main criteria of HH/truck, we can see that there is a development dynamic from a certain type of operators and that they are generally interested to continue and develop their businesses; the low amounts of investments are not a check for those operators.

Considering all the specific data for the three cities, we applied a theoretical approach to calculate the market size and the overview of demand and offer across cities. We have taken into account: 1) an average of persons in HH; 2) an average of HH per truck operating each year; 3) an average frequency per city; 4) an average volume; 5) the proportion of houses having emptied in each city; 6) the repartition of the market between mechanical and manual E&T operators.

Besides, we have considered that in medium cities, despite the fact that we didn't find any manual operator in Siem Reap, the proportion should be the same as in Phnom Penh. Then, we applied those parameters according to the census data to each city.

6.1 Results

The results show that there are 81 trucks in all the country, close to the 80 to 90 constructed by the truck manufacturer in Phnom Penh and 74 manual operators in all the country.

CLASSIFICATION OF CITY	NUMBER OF CITY	POPULATION	# trucks	%	# manual	%
Up to 1,000,000 Inhabitants	1	1 242 992	39	48%	24	30%
From 50,000 to 200,000 inhabitants	6	629 963	23	28%	14	17%
From 5,000 to 50,000 inhabitants	35	426 019	19	23%	36	44%
Total	**42**	**2 298 974**	**81**		**74**	

It represents globally: i) a current market of 42,391 HH, 8% of the urban population of Cambodia; ii) almost 320 jobs in the country; iii) 1,271,720 USD per year of incomes (with an average tariff of 30 USD). The potential market represents 38% of the urban population and is located in proportion in medium sized cities rather than in big cities or medium ones.

III. CONCLUSION AND RECOMMENDATIONS

1. CONCLUSION

1.1 Institutional constraints: some overlapping

Even if the national strategies, policies and responsibilities of ministries have limited overlap and are quite clear with legal documents, their application appears controversial and they are often not applied by the government due to a lack of regulatory procedures. Indeed, in most cities, these texts are not locally implemented. The financial and technical means are not allocated to implement those texts (especially on the control side but also on operation and maintenance).

1.2 Commercial constraints: the lack of demand and market competition

- Market competition, lack of demand in a limited market

At this step, the main constraint which appear clearly is a commercial one: 74% of the operators who say there are problems quote "commercial constraints" as the main one (14/19 operators). However, the reasons are not the same, it depends on the city. Clearly, in Siem Reap and Kampot, all the operators are saying that there is a lack of demand. In Phnom Penh city, they said there was a lot of competition (58% of those who responded that it was their main constraint) and, on a second hand a lack of demand (42%). A third constraint is quoted four times: the price negotiation with the HH.

The market seems to increase but is already saturated. No more operators seem to be needed. The offer is too large for the existing market.

- Tariff and demand

Tariffs differ a lot from a city to another. It can be explained by competition but not only. There is an adjustment of tariffs to cover the charges which are quite similar in each city for the operators in the same range of clients.

However, the tariff cannot be increased too much if new requirement will be needed. The demand and the willingness to pay are limited to 35 US$ per emptying.

	Phnom Penh			Siem Reap		Kampot		Total
	Small	Medium	Total	Small	Total	Small	Total	
Average cost of Emptying (HH)	39	33	36	20	20	75	75	42
Income/HH/truck	43	39	41	22	22	75	75	45
Cost/HH/truck	26	32	29	23	23	83	83	43
Profit/HH/Truck	17	7	12	(1)	(1)	(8)	(8)	3

1.3 Technical constraints: very effective and adapted trucks

- Effective technology

Technical constraints were not quoted much (20% or 4/19 operators). The technical problems are related to: pumping (three quotes) and opening the pit cover (one quote); emptying (1 quote).

In the in-depth analysis, the pumpers were saying that there are some houses difficult to access where it takes more time to reach the pit. It is also sometimes difficult to access the house. Finally, financial constraints are quoted twice: the energy cost for transportation and the lack of capital to invest, but it appears very specific and not generally shared by all the operators.

The technical analysis of the trucks show that they are very adapted to the Cambodian context and few constraints can be identified.

- But the maximum productivity is not yet reached

In each city (except Kampot), they have adapted the technical equipment to the needs. The average maximum capacity of operators (100HH/truck) is not yet reached.

Capacity/year	Phnom Penh		Siem Reap		Kampot	
	# HH	Volume	# HH	Volume	# HH	Volume
Actual Capacity	15 547	69 962	852	2 982	48	120
Potential capacity	37 200	167 400	6 000	21 000	1 200	3 000
Market development potential	42%	42%	14%	14%	4%	4%

1.4 Financial constraints: no constraint…apparently

According to the survey, nobody is interested in loans because, without a clear business plan, they are afraid of taking risks with the bank instead of with their relatives. They are not used to taking loans for this kind of amount.

Due to the low capital cost of truck and their quite good efficiency there is not so much barrier to investment.

1.5 Impact on environment and health: downstream of the value-chain

Finally, the main general concern which is less considered by the operators is the disposal site and the treatment part of their work. Very few sanitation systems are emptied every day but there is fecal sludge produced. They are not used to reuse the sludge and seem to disapprove the control done by the authorities. None of them have paid any patent or license for desludging. Many different constraints and contextual specificities in each city explain the repartition of the market, the type of assets emptyed and the nature of the market (competition or monopole, structure, tariffs). It must be taken into account for defining a strategy for the country.

Finally, the impact of poor sanitation on public health, living conditions and economic development are little known by the authorities. Moreover, there is a lack of thinking and commitment of treatment infrastructure at local level that can treat wastewater and sludge.

2. RECOMMENDATION TO MOVE FORWARD IN FECAL SLUDGE MANAGEMENT

RECOMMENDATION N° 1: SUPPORT THE NATIONAL AUTHORITIES TO IMPLEMENT POLICY DIALOGUE AND SECTOR REGULATION

Key constraints: a lose-lose situation

Even if the national strategies, policies and responsibilities of ministries have limited overlap and are quite clear in the legal documents, their application appears controversial and they are often not applied by the government due to a lack of regulatory procedures and particularly in the fecal sludge management sector. An overlap of responsibilities exists among the MPWT and the MoE and urban planning on the regulation of urban sanitation. The situation can highlighted as a lose-lose action. There is no control from the authority and that allows the easy creation of business but with too many business creations the market might turn down.

Key recommendations

Clarify the role and understanding on FSM issues: responsibilities need to be clarified and reinforced in environmental protection and urban sanitation sectors at the national level. Moreover, information on the reality and the issues of fecal sludge management needs to be disseminated throughout the country.

Create a framework for licensing: there is no framework for licensing FSM businesses in Cambodia. But a simple authorization can drastically improve the situation. Indeed, a limited number of licenses can be issued relating to the number of HH per cities and can ensure for the E&T operators that they have a long term view of the market.

RECOMMENDATION N°2: PROTECT THE ENVIRONMENT PROMOTE FRIENDLY "PRE-TREATMENT" TECHNOLOGIES

Key conclusions and constraints: bad quality sanitation systems

Most of the fecal sludge is directly discharged into the environment but the pre-treatment paradigm needs to be kept: The current population concentration in towns is source of a concentration of pollution due to poor sanitation and most fecal sludge in urban areas is directly discharged into the environment without any treatment. The present situation of sewerage and drainage is alarming and requires urgent intervention to address the issues. The current situation raises an alarming problem for public health and environmental protection.

Solutions to this problem must be searched within the home "pre-treatment" sanitation family of technologies as "separative" sewerage systems remain far too expensive[2]. Flooding risks are far higher and immediate than risks strictly linked to sanitation in the urban management of the Cambodian cities. It would be unproductive and ineffective to invest twice: i) a drainage system; ii) a sewerage system when the public financing face international funding challenges.

Many private actors build every day low quality sanitation systems that will reinforce the problem in the future: many studies show that the private actors are already delivering most sanitation systems in Cambodia. However, these actors do not know much about technical specifications, as they cannot find technical or financial assistance allowing them to develop the urban sanitation sector. Finally, the quality of systems that they built is low and particularly from the environmental protection point of view. This situation will reinforce the sanitation problem in the future. Most of the pits built continue to not be sealed at the bottom.

Key recommendations: supporting the supply chain is an investment for the future

The sanitation supply chain actors face: i) a lack of technical and management skills; ii) unavailable friendly sanitation products adapted to the Cambodian context; ii) a lack of access to finance. The sanitation market remains unstructured, making it difficult to bridge supply and demand. To change that, the following recommendations can be identified:

Improve sanitation products: sanitation supply chain actors have no access to technically standard products. There is a strong need to develop or standardise a large range of environmental products such as: prefabricated latrines and septic tanks, adapted sludge collection and treatment systems.

Improve production processes: sanitation supply chain actors need to have improved technical processes in order to ensure the environmental and technical quality of sanitation systems and a good management of resource efficiency (less water and cement for latrine production).

[2] The total capital cost of a sewer system is estimated at 1,000 USD per household.

Facilitate access to finance and business management skills: supply chain actors need to improve their skills in commercial, business planning and financial management. Advocacy aimed at finance institutions needs to be undertaken to allow them to better understand the sector.

There is space for a sanitation business development service centre whose aim would be to provide technical and managerial support to sanitation businesses and to help them bridge the gap that exists with the financial sector.

RECOMMENDATION N°3: IN LARGE CITIES AND MEDIUM CITIES PROMOTE A DECENTRALIZED TREATMENT SYSTEM

Key constraints: no market and strong competition

In Phnom Penh city, the study shows that there is a lot of competition. The market seems to increase but is already saturated. No more operators seem to be needed. The first constraint is linked with their unofficial status. The offer is too large for the existing market. The analysis of the market shows that presently private E&T operators dominate the market. However, a big market is not reached by them: sewer cleaning due to technological problems.

The market structures show that there are no clear coverage areas that are dedicated to E&T operators that can imply higher cost of energy due to a long transportation. Finally, distance and speed is the highest part of the cost of emptying. The willingness to pay is around 35 USD when private E&T operators charge 45 US$. Finally, three mains challenges for mechanical E&T operators: i) reach the sewer cleaning market with an improvement of technologies (high-pressure truck); ii) promote decentralized treatment system managed by private operators or public utilities in order to reduce transportation costs; iii) decrease the cost of the fees in order to reach more clients.

In medium cities, the market of FSM is more limited than large cities. The case of Siem Reap shows that no manual operators exist and the market is totally dominated by mechanical operators. The size of truck 3 m^3 is sufficient to have a good level of service. The challenge is related on the number of operators that enter into the market that create an "unprofitable" one.

Key recommendations: Market relocation with small decentralized sludge treatment plants

Improve truck technology for sewer cleaning: as shown in the survey domestic sewer cleaning represents a big part of the market but private E&T operators cannot reach it. An adaptation of the truck can be easily achieved in order to enter in this market.

Promote and develop low-cost sludge treatment plant for E&T operators: currently, there is no real sludge treatment plants implemented. One of issues is to promote treatment to E&T operators showing them they can reduce their transportation costs. The Malaysian solution (ground trench) can be applied as a minimum, more sophisticated technology could be introduced to produce compost and energy.

Define official market areas if there is investment in sludge treatment solutions: a big challenge is how to control dumping at the official site. To convince them, a market area can be defined if the private E&T operators invest in small sludge treatment plant near their location. Another approach would be to have these plants managed by public authorities with more regulation.

In medium-size cities push to concentration: the only way to reduce the number of E&T operators is to push a "forbid new operators" regulation using a licensing procedure or to push current operators to concentration as professional operators. Indeed, because the market is small in medium-cities, FSM remains a secondary activity.

RECOMMENDATION N°4: IN SMALL CITIES MOVE MANUAL TO SEMI-MECHNANIZED TECHNOLOGIES

Key constraints: limited market and competitive manual operators

The case of Kampot shows that the FSM market is very low and does not permit to run a mechanical E&T service like in Phnom Penh or Siem Reap. However, manual operators can play a strong role as they already cover a big part of the market. Moreover, small towns face strong problems on treatment of wastewater and sludge.

Key recommendations: support manual to switch to semi-mechanized

Improve the quality of manual operators: a semi-mechanized "very small truck" consisting of a 2.5 cubic meter tank that could be pulled by a motorbike.

Promote simple sludge treatment technology: with more land, the trench approach developed and tested in Malaysia could be interesting due to the low volume of sludge produced per year.

RECOMMENDATION N°5: PROMOTE PUBLIC AWARENESS AND ENVIRONMENTAL PROTECTION

Key constraints

On the demand side of the sanitation market in Cambodia, access to sanitation in urban area is quite high but generally the system used encounter problems and some of households are willing to invest in improved sanitation systems. Interestingly, the capacity and willingness to pay for improved sanitation are quite high (50 to 200 USD/household), even though households are not aware of the consequences of poor sanitation on health and the environment and they lack information regarding existing sustainable solutions.

Key recommendations

Inform about sanitation supply chain actors: providing information on who can build and manage high quality sanitation systems and what are the tariffs charged for each system;

Promote safe urban sanitation: in order to reduce the lack of promotion and advertising to stimulate the demand for sanitation products and services;

Develop access to credit for equipment: access to micro-credit in order to finance the sanitation systems;

Public awareness in order to reduce the lack of awareness on environmental and health issues linked to sanitation: public health, living conditions, economic and social impacts.

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