Domestic private fecal sludge emptying services in Cambodia: between market efficiency and regulation needs for sustainable management

Clément Frenoux and Alicia Tsitsikalis

ABSTRACT

Over the past decades, in developing countries, several urban sanitation management models have been promoted, showing various results, often poor, as regards reducing negative environmental, public health impacts and in reaching access to sanitation for all. Many studies and reports highlight that solutions should be found by promotion of on-site and decentralized sanitation approaches including fecal sludge management (FSM). However, few papers have either offered a comprehensive analysis of FSM services, regarding both demand from households and services provision from public and/or private operators. Based on field research in Cambodia, this paper aims to fill this gap. It is built on a large survey conducted in three cities in 2011. Results showed that the Cambodian FSM sector is dominated by private mechanical extraction and transportation operators (ETO). The FSM market looks economically efficient with reasonable fees. It also offers a reasonably high level of service quality including profitability of businesses, although the FSM market is also characterized by strong negative environmental externalities that are not considered. Consequently, this paper advocates an integrated urban sanitation approach that aims at exploring in more detail how to integrate gradually and complementarily private mechanical ETOs and households practices into a more complex sanitation urban model raising the key issue of financing the externalities' costs.

Key words | externalities, fecal sludge management, market-oriented approach, regulation, urban sanitation

Clément Frenoux (corresponding author)
LEREPS/GRET, Université de Toulouse 1 Capitole,
Manufacture des tabacs, 21 allée de Brienne,
31 042, Toulouse,
France
E-mail: *frenoux@gret.org*

Alicia Tsitsikalis
GRET, Campus du Jardin Tropical,
45 bis avenue de la Belle Gabrielle,
94 736 Nogent sur Marnes cedex,
France

INTRODUCTION

In developing countries, over the past decades, several urban sanitation management and governance models have been promoted showing various results, often poor, in reducing environmental pollution and negative public health impacts as well as in reaching access to sanitation for all. Most of them were focused on combined sewerage infrastructural approaches using particularly public-managed arrangements linked or not with water supply utilities. Internationally recognized, failures of this model have many faces. They are mostly due to the high up-front investment costs, the specific urban growth of developing cities characterized by urban sprawl, the singular increase in world urban population particularly in developing countries. Failures are also linked to inappropriate financing incentives' modalities (subsidies, grants, etc.), the maladaptation of governance models to encompass the heterogeneous nature of household demand and particularly regarding the poor. Concerning this, an international consensus has arisen among most researchers, international donors and non-governmental organizations (NGOs). It advocates that solutions to these problems should be found by the promotion of on-site and/or decentralized sanitation using a market-based approach, notably encouraging fecal sludge management (FSM) services, as conventional/combined sewerage systems investment costs remain far too expensive.

doi: 10.2166/washdev.2014.219

www.manaraa.com

However, few papers have either offered a comprehensive analysis on an in-depth assessment of FSM practices, both concerning demand from households and on FSM service provision from public and private operators. Moreover, although FSM has progressively gained interest, most attention remains focused on the 'quantity of sanitation systems built' (how to increase the rate of access to sanitation) rather than raising the crucial question about the 'quality of sanitation system' (how to improve the urban sanitation system management). Using an in-depth field research commissioned and funded by the Bill and Melinda Gates Foundation, this paper aims first to fill this gap. It is based on a large survey conducted in three Cambodian cities in 2011: Kampot (a small city), Siem Reap (a medium-sized city), and Phnom Penh (the capital).

In Cambodia, the urban sanitation management model is based on a common combined sewerage approach linking drainage, wastewater collection, transport, and off-site treatment. In spite of this being the main scenario, a large range of sanitation systems are in fact used at the household level. In the center of cities, most urban sanitation systems (when they exist) contain a pre-treatment stage, largely variable, built on rural technical 'standard' (pits), before discharging settled effluent into the sewerage systems. For households (HH) located outside the 'sewer' coverage area, on-site systems are most common and also based on a rural technical 'standard'. The investment costs of these systems remains quite low ranging from 40 to 200 USD. Recently, with the increase in urban densification, the FSM practice at the household stage has increased significantly. However, without public institution response, the FSM market is dominated by numerous 'informal' private operators. Small in size, these operators are mostly mechanical. They use complex truck facilities to desludge household sanitation systems. The Cambodian FSM market is also characterized by high competition among private mechanical extraction and transportation operators (ETOs), lower barrier entry (12,000 USD for a locally assembled truck), and strong market-oriented approaches. Most of them are finally profitable and efficient. They provide, at a quite cheap tariff to households (capacities ranging from 20 to 50 USD), good quality FSM services. This is thanks to an adapted business model based on low investment, operation and maintenance costs. Following this figure, the Cambodian urban sanitation paradigm appears economically efficient.

Nevertheless, in Cambodia, from the upstream of the sanitation value-chain, affordable but low quality sanitation technologies are also predominant (pits are rarely watertight). Most fecal sludge is finally directly discharged into the environment at the household stage (into sewers and open canals). Institutionally, there is no technical standard available and no processes to certify and control the quality of sanitation facilities built. The proportion of households having their feces tank emptied is consequently very low, on average 20% of the total urban population, even though tariffs are quite affordable compared to household willingness to pay. Then, most fecal sludge collected by private mechanical ETOs is also directly discharged into the environment. Unregulated, unformalized, there is no systematic control from public authorities either to enter into the sanitation business or deal with FS dumping. Consequently, we adopt a critical stance discussing the real performance of a market-based approach to urban sanitation management arguing that although a market-based approach to sanitation involving private mechanical ETOs sounds promising, the attention of researchers and NGOs needs to be more focused on how to regulate them. Using the externality concepts (Pigou 1920; Coase 1960; Buchanan & Stubblebine 1962) as a framework of analysis (an externality is a cost or benefit that results from an activity or transaction and that affects an otherwise uninvolved party who did not choose to incur that cost or benefit), we demonstrate that despite, non-networked approach, affordable and profitable private sanitation businesses, without any government and policy involvement, these approaches do not attain public health and environmental impact reduction. We advocate an integrated urban sanitation approach that aims at exploring in more detail how to integrate gradually and complementarily private mechanical ETOs and HH practices into a more complex sanitation urban model including current practices both regarding FSM and conventional systems, raising also the key issue on financing the externalities' costs.

METHODS

Results presented come from a large study conducted in Cambodia from June to November 2011. It aimed at gathering and rigorously analyzing data to better understand

www.manaraa.com

FSM in Cambodia and particularly its extraction and transportation components. The first challenge was to identify and select a range of cities, representative of all those existing in Cambodia. Excluding Phnom Penh with its 1.24 million of inhabitants, urban areas can be divided into small and medium cities. Indeed, the second city of the country (Siem Reap) has only 170,000 inhabitants and most of the other cities have fewer than 50,000 inhabitants. Consequently, the following criteria were applied: (1) total population, the 'size': the capital of Cambodia, one medium-sized city, and one small-sized city; (2) geographical location: one city in the center of the country, one city in the north, and one city in the south; (3) environment specificity: one city along the Mekong River, one city in the Mekong basin, and one city close to the sea. Three cities have thus been selected: Phnom Penh, a large city (1.24 million inhabitants), Siem Reap, a medium one (168,700 inhabitants), and Kampot, a small city (38,800 inhabitants). The data comes from three kinds of assessment: an in-depth desk review of legal and policy documents, a large household survey, and a detailed investigation of private mechanical and manual ETOs with sanitation supply chain stakeholders. The legal and regulatory survey contained a review of laws and policies regarding administrative (decentralization), environmental (pollution control), land management, and urban sanitation issues. The household survey sampling was based on the number of population and a transect approach in each city. The transect approach was considered as the most appropriate due to the specificity case of Cambodian cities with their strong geographical heterogeneity versus a high socio-economic homogeneity and its impact on sanitation practices. HH interviews were done from June to September 2011. A total sample of 1,320 households for Phnom Penh, 428 households for Siem Reap, and 308 households for Kampot were surveyed using a closed-question questionnaire. Different criteria were tested to identify the demand determinants: type of equipment, socio-economic status, and specific location on the city (Table 1).

The analysis of ETOs combined two steps (Table 2). A prescreen survey was conducted in order to identify all the private mechanical and manual ETOs in each city (that was an unknown). Twenty-three private mechanical operators and 25 manual ones (24 in Phnom Penh, one in Kampot, and none in Siem Reap) were found. A total of 22 operators were interviewed in detail. The following typology of operators (the categories were proposed by the Bill and Melinda Gates Foundation to compare data given from a ten-country study and explains the absence of large operators in Cambodia) was used: (1) public ETOs; (2) private ETOs: small (only one truck), medium (from two to four trucks), large (more than four trucks); (3) manual ETOs. Following the data collected directly from the ETOs, the authors also conducted cross-check analysis in order to confirm or refute field-collected information such as: price of fuel, taxes paid at the dumping site, real investment cost from the truck assembler and fees charged from the HH survey. The financial analysis is also based on a cross-check between the data given by the operators and hypothetic calculations. Other relevant stakeholders along the supply-chain (truck assemblers, latrine builders) were also interviewed. Moreover, technical field visits were done to collect data on the dumping sites.

Table 1 | 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	428	3.96
Kampot	38,819	7,612	5,137	308	5.90

Source: (NIS 2008) and authors.

Table 2 | Survey distribution of ETO survey per city

Type of ETO	Name of the city	Category	Estimated total number of ETO	Number of ETO surveyed	%
Manual ETO	Phnom Penh		24	5	21
	Kampot		1	1	100
Mechanical ETO	Phnom Penh	Small	12	5	42
		Medium	4	6	86
	Siem Reap	Small	5	4	80
		Medium	1	0	0
	Kampot	Small	1	1	100

www.manaraa.com

RESULTS: THE QUITE HIGH ECONOMIC EFFICIENCY OF CAMBODIAN FSM SECTOR

Urban sanitation in Cambodia: flood control, high access to sanitation, large range of technologies used and a legal ignorance on FSM

In Cambodia, several ministries are involved in urban sanitation management but four of them are predominant: (1) 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; (2) the Ministry of Environment (MoE) is in charge of water pollution control and environmental protection; (3) the Ministry of Land Management and Urban Planning is responsible for construction standard control and issuing construction permits; (4) the Ministry of Rural Development (MRD) is responsible for rural sanitation. At the provincial level, a local department of each ministry exists and is involved with the provincial authorities in urban sanitation management. In 2003, the Cambodian government issued the National Policy on Water Supply and Sanitation (RGC 2003), a 'key crucial factor for setting up an institution that can maintain and expand the services'. It is the only document that frames urban 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 discharged 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'. However, guidelines do not consider non-sewer solutions (that often exist in urban areas), and only look for financing mechanisms, including 'target subsidies in exceptional circumstances' (Kopitopoulos 2005). Although the institutional framework (national strategy and policies) is rather clear, there remain some overlaps among ministries, especially responsibilities between MPWT and MIME on household sanitation and between MPWT and MRD on who is in charge of sanitation in peri-urban areas. The MPWT is responsible for sanitation service delivery, but it has shown low investment capacity and weak skills in managing utilities. Investments are still mostly funded by ODA. Moreover, few laws and decrees were voted and enforcement is particularly complicated resulting in a lack of coordinated responses to urban sanitation issues. If extraction and transport practices are known by public authorities, the treatment of sludge is not managed or controlled by them. There are no mentions of FSM control and regulation in any document reviewed except the rural water and sanitation strategy recently issued (Okelford 2010). Only the MoE undertakes some controls on FSM operators when they desludge at the authorized dumping site.

Regarding access to sanitation, the current situation also remains unclear as studies (Levisay & Sameth 2006; Kov *et al.* 2008) show: coverage rates vary from 56.1 to 61.1%. What is certain is that there are large gaps between rural areas, where access to improved sanitation is low, and urban areas, where access to sanitation is higher than 80% (Table 3). 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

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[a]	5.5	43.1	3.1	51.7	–	0.2	43	4.9	48.1
Kampot[b]	7.7	33.3	0.8	41.8	–	1.2	49.7	7.3	58.2

[a]Based on the Tonle Sap region average data and not on Siem Reap specifically.
[b]Based on the coastal region average data and not on Kampot specifically.
Source: (NIS 2005).

www.manaraa.com

small cities like Siem Reap and Kampot used septic tank and other on-site sanitation systems more. The term 'septic tank' is used widely in Cambodia. Commonly used in old buildings built by the French, classic septic tanks can be found in the center of cities. Behind these standardized data there are a large range of technological options that are commonly used in Cambodia. No technical standards are provided in urban areas and rural technologies are often used in urban contexts. However, some 'standard designs' can be identified: (1) multi-storey buildings which are connected directly to combined sewerage systems or to septic tanks (on-site) [the sewerage systems installed in Cambodia are combined systems that collect both wastewater and rainwater and usually comprise: (i) a secondary sewer system; (ii) a primary open-channel system; (iii) pumping stations; (iii) wetlands that treat the effluent]; (2) middle standard households which sometimes use 'classic septic tanks' but more often interconnected pit systems either discharging directly into combined sewerage systems (sewerage or open-air channel) or infiltrating; (3) urban poor or other HH which have no sewage system and use traditional pour-flush latrines with pits. The private sector is largely involved in sanitation system construction. An estimated 80% of household latrines are purchased at market prices from private sector providers (Robinson 2007; Roberts *et al.* 2007). However, this private sector is characterized by a fragmented network of business including importers, local manufacturers, wholesalers and retailers, and masons (Salter 2008).

Historically, Cambodian cities used a combined sewerage system that collects both rain water and wastewater. Due to intense rainy season and high flooding risks, most of the urban sanitation investments in cities are made for flood control (open channel that drain rain water out of the city) and less for sewage collection and treatment. In Phnom Penh, 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 open channel networks of about 160 km in all. Seven pumping stations annually lift 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). After transportation, the wastewaters are then transferred into three wetlands which provide natural removal of biological contamination (Boeung Trabek, Steung Mean Chey, Boeung Tumphum). Only 56% of suspended solids are settled in wetland before entering the river; the content of the metal elements such as Cd, Pb, Cu, and Zn significantly exceeds the WHO standard (Tomonori *et al.* 2005). In Phnom Penh, household sanitation fees are charged on the water bill (10%) representing about 2 million USD per year. In Siem Reap, there is an old conventional sewerage system, upgraded and extended (using separated approach and lift station) by recent projects funded by international donors (Agence Française de Développement and Asian Development Bank). A wastewater treatment plant was also built and run efficiently. The system is also operated by the MPWT. Household sanitation fees are paid directly by the household with a separated bill from water and electricity. Finally, in Kampot, there is only a combined sewer in the city center, built by the French in the early 1950s without a wastewater treatment plant. Existing wastewater collection and treatment follow the Cambodian urban sanitation scheme with combined sewer working as a drainage system and as a settled sewer. Cambodian urban sanitation system combines finally an on-site part (the pit or tank) and an off-site one (the sewer and drainage network) where fecal sludge is normally and theoretically intercepted by pits or tanks. Based on the three cities case studies, the high urban sanitation coverage is confirmed with various types of latrine for a total coverage of at least 90% in each town; a variable access to sewerage systems (86% for Phnom Penh against 32% in Siem Reap and 40% in Kampot) (there are some slight differences between these data collected from the HH survey (2011) and the NIS data (2005) due to different administrative borders of the cities considered) and a large variety of sludge pre-treatment facilities (pits, tanks, septic tanks, etc.). Considering only the pre-treatment facilities, most systems are constituted of infiltration pits (as in rural areas). In Phnom Penh, few HH (26%) have no pre-treatment facilities (only 24% are connected to the sewer directly while 2% discharge in the

www.manaraa.com

environment) whereas in Siem Reap and in Kampot, every HH has pre-treatment assets on their land. The living conditions in the three towns present similarities (number of people per household) and differences (smaller housing and more of it in shared buildings in Phnom Penh, lower proportion of well-off households in small and medium towns) but none is clearly correlated to sanitation practices.

Household FSM: informal private ETOs, lack of regulation, low entry costs and technical innovation

When the pits or septic tanks are full, the household has few possibilities to desludge. The Public Administration indeed has pit empting trucks (Phnom Penh and Siem Reap have ten trucks and one truck, respectively), but they are dedicated to operating and maintaining the combined sanitation systems of the cities. They do not desludge at the household level even when many pre-treatment facilities exist. The deficiency of service is filled by small private 'informal' ETOs who have been investing in the sector for the past 20 years without any incentives from the government. Following study results, private ETOs appear to be the main pit emptying providers for households and small businesses in Cambodia. Moreover, it is not the manual ones that are mostly represented, but the mechanical ones. Public institutions have little control over them. The MPWT delivers only road permits for the trucks but no contracts or licenses to operate FSM services and the MoE also has little control.

In Phnom Penh, the current FSM market is covered 79% by private mechanical ETOs, 14% by HH themselves, and 7% by manual operators (Figure 1). In medium-sized cities, the same trends are observed where the current market is over-dominated by private mechanical ETOs at 87%. Few HH empty their sanitation system themselves (14%). In small cities the situation is changing. Indeed, manual operators have a larger market share in contributing to FSM services than in other kinds of cities. The field research shows that these private mechanical ETOs can be characterized as family-scale companies with only one to four trucks ensuring a service for HH and a few businesses. They are mostly small-sized enterprises owning only one truck with two to three staff. There are no large-sized businesses in Cambodia concentrating capital and in a

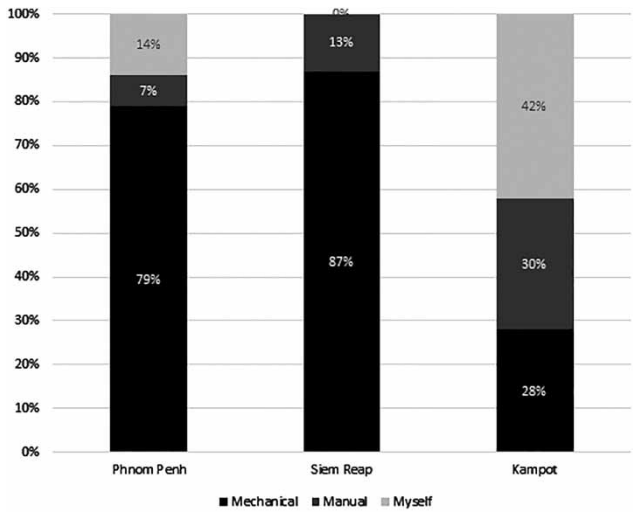

Figure 1 | FSM market structure.

monopoly situation. In Phnom Penh, 69% of the operators own only one truck, 23% have two or three trucks, and only 8% have four trucks. This results in a proportion of 69% of small operators and only 31% medium-sized businesses. In total, they represent around 13,400 trips per year. In Siem Reap, the entire market is covered by small operators which represents around 1,100 trips per year. Interestingly in Kampot, 71% of the market is covered by manual operators and 29% by small operators which represent only 170 trips per year. From the market efficiency framework perspectives, Cambodian private mechanical ETOs also demonstrate low entry costs, technical innovation, profitable and sustainable business and efficiency gains due to competition among them.

The specificity of the Cambodian case is the low entry costs and technical innovation. Low entry costs are mainly due to second-hand locally assembled trucks that are particularly efficient. A common system (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$ depending on the purchase date and purpose the truck was initially used for. The market barriers to entry are consequently low compared to, for example, trucks used in the African region. Moreover, the maintenance can be done locally. The tank size can also be chosen, and it can be changed without changing the engine. Interestingly, the tanks have different sizes depending on the kind and size of the city: from 3 m^3 in Siem

www.manaraa.com

Reap, 5 to 8 m^3 in Phnom Penh and Kampot. The smaller trucks are cheaper on average, their cost varying from 12,000 US$ to 15,000 US$ and also depending on the quality of the truck. One of the most crucial arguments for the service quality is based on the capacity of the truck to empty all the sanitation systems (pits) in one trip. Therefore, many mechanical private ETOs consider that they need a big truck in Phnom Penh because the demand is high and the distances greater. None of the operators in Phnom Penh said that they had exceptional volumes or had to do two trips for a single HH. They also never have mixed sludge from two different HH in the same trip. Consequently, the trucks appear technically and economically adapted to the site of the work in order to promote efficiency.

Low tariff and aggressive commercial-oriented approaches

Technically adapted, their service delivery model also seems commercially adapted. In Phnom Penh, fees appear quite homogeneous for private mechanical ETOs and the average tariff is estimated at 36 US$/trip or 7.2 US$/m^3. All ETOs surveyed said that the emptying service tariff has a variable structure depending on the number of trips needed according to the size of work and the distance of the trip, rather than the volume itself; that is why we use the average fee per trip and not per m^3. It can vary from 30 to 50 US$ for a trip, not far from the manual ETOs that have a tariff fee varying from 25 US$ to 30 US$ (but the household said that they generally pay more – 45 US$). In Siem Reap, the average fees are about 20 US$/trip (6.6 US$/m^3) on average but can reach 150 US$ as a maximum. The average tariff is lower than in Phnom Penh, due to the lower distance from the emptying location to the dumping site (5 km). In Kampot, due to the low number of clients, the mechanical ETO is constrained to have a high tariff to cover expenses – about 50 US$ per two rings (12.5 US$/$m^3$). The manual operator has a tariff depending on the size of the work and on the number of rings of the pit. It is around 12 US$ per ring emptied (6 US$). Fees charged are globally competitive and do not seem to exclude poor HH. In Phnom Penh, the fees represent less than 0.2% of the annual household expenses. Results also show that they represent 0.35% of annual HH expenses for the poor HH and 0.12% of the annual HH expenses for the well-off HH. No correlation was found between poverty and emptying modality both in Phnom Penh and Siem Reap. To conclude, fees charged seem quite cheap and in line with household capacity to pay and as the willingness to pay is around 7 US$/$m^3$ it does not exclude anyone from the FSM service.

According to the household survey, service satisfaction appears also very high, ranging from 96% in Phnom Penh to 98% in Siem Reap. For mechanical ETOs services, the reasons of satisfaction are that the service is clean (first response), the operator is quick to come (second response), and fast to operate (third response). Concerning the manual pumper in Kampot, the satisfaction comes also from the clean service and the cheaper tariff. Despite the fact that households are satisfied, households who emptied will not call the same operator next time. It seems that there is no 'fidelity' in this sector and every service given is in a competitive way for one time only. In Phnom Penh and in Siem Reap, the ratio of repeat clients, those who will call the same operator for a future emptying, is very low, close to 24%. Consequently, private mechanical ETOs have developed an aggressive commercially oriented approach. About 180 leaflets per client per truck are disseminated throughout Phnom Penh, and telephone numbers are painted on poles and sign boards. Almost 7.4 million of leaflets were distributed in Phnom Penh for 31 trucks in one year, which represents about 15 leaflets per client. Except for two operators, there are at least two marketing staff, normally permanent, confirming the commercially oriented strategy of these structures. Moreover, the expenses in marketing are strongly correlated to the profit and to the number of clients (Figure 2). The success of an operator seems to be based on their ability to have an aggressive marketing strategy by posting leaflets in the city.

Profitable business, dynamism, innovation, and efficiency gains

Private mechanical ETO activity is characterized by high operational costs (gasoline and human resources are the main ones). Transport and operation costs represent from 47% (Phnom Penh) to 66% (Siem Reap) of the total costs. The analysis shows that the average cost per trip can vary

www.manaraa.com

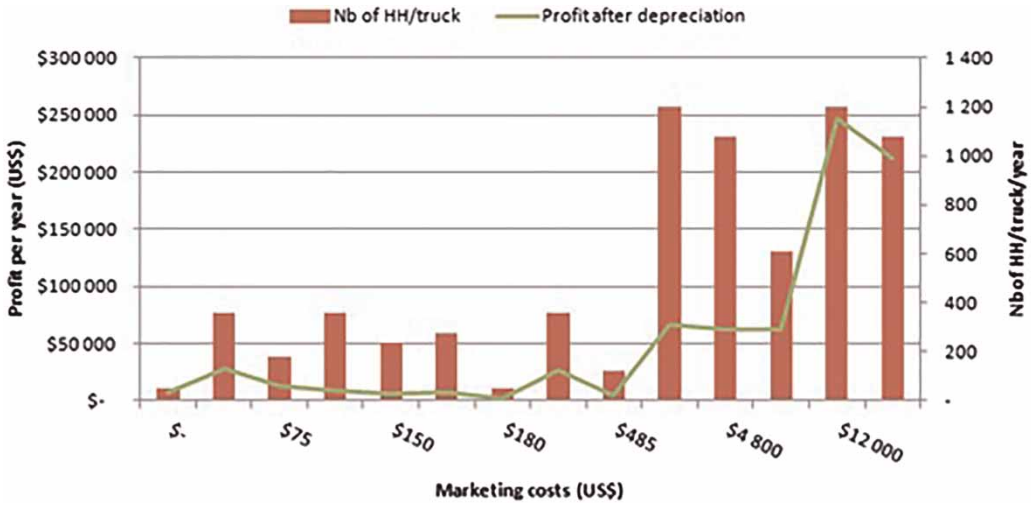

Figure 2 | Direct correlation between marketing and profit.

a lot among ETOs. Some of them are very productive with a cost of around 18 US$ while others are less productive with an average cost per trip of 33.9 US$. Only one was unprofitable. Not surprisingly, gasoline consumption is largely variable depending on the distance and in which city: in Phnom Penh customers are far from the dumping site and in Siem Reap closer to it. The business model is therefore very sensitive to an increase in gasoline price. There is an average of three staff per truck: one is responsible for work evaluation, driving the truck and/or price negotiation and the other two do the emptying work. Fifty-six percent of operators give a variable share, from 20 to 25% of the tariff as wages. Concerning the return to investment, most private mechanical ETOs have had their investment quickly 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 projection 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. The most important difference between small and medium size operators is the depreciation costs for trucks and the high income in return per truck (which investment has been already returned). Having more trucks increases proportionally the costs and does not generate scale economies. In Phnom Penh, on average, there are 431 customers per year per truck or 36 HH/month. However, there is a wide range of differences among the ETOs from 48 HH per year per truck to 1,212 HH per year per truck. In Siem Reap, on average, there are 264 customers served per year per truck (22 HH/month in average). The business structure is more homogeneous than Phnom Penh ranging from 156 to 276 HH/year. In Kampot, due to the different structure of the market, the only mechanical ETO that appeared recently has, on average, 48 customers per year (4 HH/month on average). Mechanical private ETOs present a high diversity of profile and results; some of them are more dynamic, efficient, and profitable. Their performances are mainly based on their productivity, measured by the number of clients per truck per year, which can vary a great deal: Type 1, 'Survivors' (from 1 to 150 customers per year) that make on average 2,400 US$ per year profit; Type 2, 'Competitors' (from 150 to 350 customers) whose profit can be from less than 1,000 to 1,800 US$ per year per truck. Their profit is less important than Type 1 because of truck depreciation taken into account and fixed charge; Type 3, 'Performers' dealing with more than 350 customers and earning from 4,000 to 20,000 US$ per year and per truck profit. Type 3 includes the most dynamic operators and may be the only ones who will subsist from this competitive market in the long term. A strong competition exists that leads to an efficient and profitable business model. Demand is satisfied with this service that is at a quite affordable tariff. Financial constraints for investment do not appear as a major constraint due to low market

www.manaraa.com

entry costs. The main constraints applying to operators seems to be business ones due to important competition between operators and a rather low demand in Cambodian cities.

DISCUSSION: SANITATION AS A MARKET DOES NOT CREATE SUSTAINABLE MANAGEMENT

Low demand, saturated market, unsuitable technologies and direct discharging of fecal sludge into the environment

The proportion of HHs in the total sample having already emptied their feces tank is very low in each city, only 21.9% in Phnom Penh, 14% in Siem Reap, and 19% in Kampot. Low demand is a strong specificity of the Cambodian FSM sector (Figure 3). The frequency of emptying is also quite low. On average, in Phnom Penh, the frequency is 0.31 emptying per year (the assets are emptied every three years), which is quite similar to 0.25 (median) of the sample (once every four years). In Siem Reap, it is closer to 0.56 (once every two years). The average volume is also quite different per type of treatment assets. There is no real correlation between the date of construction, the volume of tank, the water consumption, and whether the HH is connected to the sewer or not. The demand is also not correlated to the socio-economic profile. Poor households have almost the same desludging practices and the same nature of facilities. For example, 17% of the poor who emptied their pits did it manually themselves whilst 18% of medium HH did this.

Another surprising fact is that most of the HH surveyed that had already 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 to the sewer most sanitation systems in Cambodia need to be emptied. There is no link between the type of sanitation assets and the emptying frequency. Indeed, in Phnom Penh, the HH that are connected to the sewer empty their assets more than the others, confirming the paradoxical 'on-site/off-site' nature of Cambodian urban sanitation. In Phnom Penh, the center of the city is more represented, certainly due to the date of installation. Possibly flooding in the city also has an impact as most empting is done during the rainy season (74%). Analyzing the fecal sludge production/collection at the household level, in most cases little fecal sludge is finally collected. (The market and sludge production

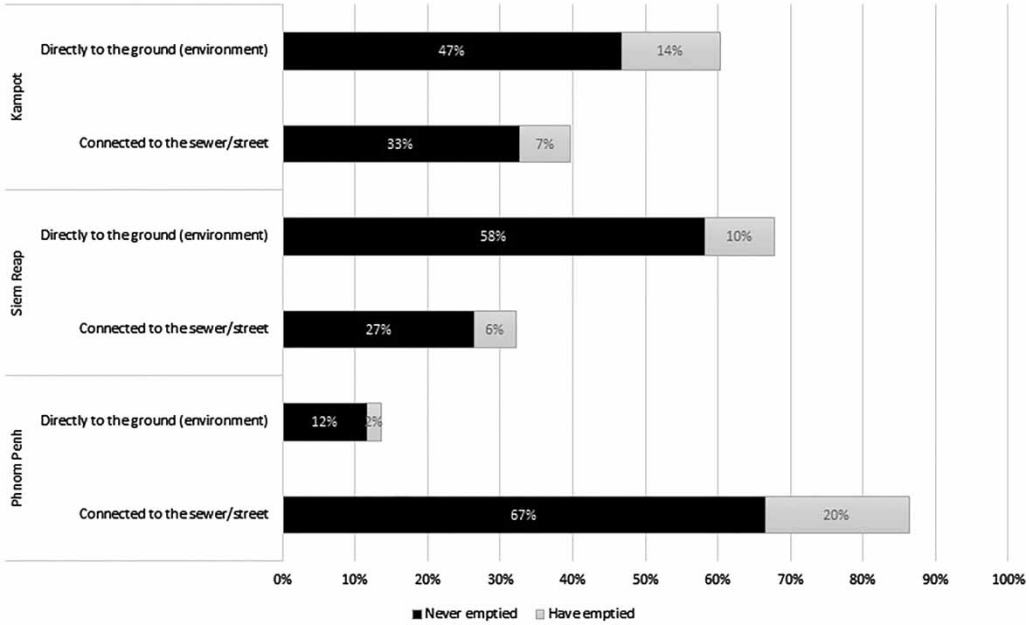

Figure 3 | Who emptied their pit?

www.manaraa.com

estimate was based on a cross-check of different parameters. The aim was to articulate data relative to: (i) the frequency of emptying services; (ii) the volume of fecal sludge produced per type of system; (iii) the nature of equipment (septic tank, infiltration pits, etc.); (iv) the discharge modality (to the sewer or directly to the environment). The main bias in the nature of the study was its ambition to look at prospective trends on demand without looking at past ones. To estimate future demand, according to our survey, the following hypotheses were made: we expected that the frequency of emptying would not change in the future and that the people who have the same assets and technological profile would empty at a same proportion to those who already emptied once.) One way to explain the low frequency can be related to the number of people living in the house. On average, there are six people in the houses that never emptied their pit or septic tank while there are 8.4 people in the houses that have emptied. However, one can find that, upstream of the sanitation value-chain, low quality sanitation technologies are predominant (pits are rarely watertight) and most of FS is directly discharged into the environment at the household level, which could have a strong impact on public health and the environment in the future. Indeed, a theoretical approach based on the average volume of production of sludge estimated at 0.06 m^3/pers/year (0.17 L/capita/day) was used to calculate the theoretical production of the city. It appears that 92,941 m^3 of sludge is produced in Phnom Penh, 25,662 m^3 in Siem Reap, and 489 m^3 in Kampot. However, 29% of the sludge produced in Phnom Penh is actually collected through operators, only 9% in Siem Reap, and 53% in Kampot.

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. 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. This represents globally: (1) a current market of 42,391 HH, 8% of the urban population of Cambodia; (2) almost 320 jobs in the country; (3) 1,271,720 US$ per year of incomes (with an average tariff of 30 US$). The potential market represents 38% of the urban population and is located in proportion in medium-sized cities rather than in big cities or small ones. However, when estimating the actual capacity of pumping and the number of trucks, results show that the market coverage is already very high, 77% in Phnom Penh, 57% in Siem Reap, 122% in Kampot. Due to a low demand, the actual capacity of the market to absorb future demand appears very high. Finally, it is not surprising that competition is high in Cambodia and particularly in Phnom Penh and Siem Reap. In Phnom Penh, private mechanical ETOs pay 1.5 US$/dumping/trip and must theoretically discharge into official dumping sites far from the center. However, public ETOs do not 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 a wetland recently built by international donors. Operators pay 1.5 US$/dumping/trip. In Kampot, there is no dumping site. However, in Phnom Penh if most ETOs said that they dump at the dumping site, the survey shows that only one really goes there. Finally, only 16% of the operators are discharging in the authorized sites. The authors conducted two field surveys in order to check the actual number of trucks that dump at the official site and only 5 out of 31 existing trucks in Phnom Penh do so. The survey was done at the official sites during 1 day. Thus, many unofficial dumping sites exist throughout the city mainly due to the cost of transportation and a lack of control.

Negatives externalities, regulation needs and the promotion of an original essential services regulatory framework

Despite a competitive market, demand remains particularly low and environmental and public health issues are raised. It entirely justifies the role and the intervention of both national and local authorities to regulate the sector. Indeed, using the externalities framework of analysis, the current Cambodian FSM market does not take into account the costs of environmental and public health impacts. Regarding these issues, the Cambodian urban sanitation sector is, moreover, truly unproductive. At the household level, the current population density in Cambodian urban areas is a high source of pollution mainly due to the poor design and quality of sanitation system in towns. Most fecal sludge in urban areas is directly discharged to the environment without any treatment. ('There is a problem of quality. By definition, an improved latrine can be a simple construction. However,

www.manaraa.com

factors such as the latrine design and construction quality, and the latrine placement in relationship to water sources or food storage and preparation areas can seriously affect consumer benefits in terms of health and environment or simply value for money' (Salter 2008: 5). From the service provision, suppliers (latrine builders) and providers (desludgers) provide quite affordable products and services, but seem totally independent from public regulation, excluding externalities, that lead to non-environmental and unsafe practices. There is no systematic control for entering into the sanitation business, to define technical standards both on sanitation facilities and FSM systems, and few controls are undertaken to control fecal sludge dumping. Nevertheless, these issues appear quite complex and a simple response cannot be formulated. Two questions are particularly raised. The first focuses on the kind of regulation modalities that could be implemented, including informal private mechanical and manual FSM operators into the conventional sanitation system. The second is directly linked with the previous and questions how to include of externalities costs (who will pay, who will collect, who will redistribute, etc.).

On the first question, FSM services present particular economic attributes compared to other essential urban services like water supply and electricity. As a non-networked industry, FSM is characterized by non-fixed assets (truck), low up-front investment (only one truck), low assets specificity (the truck can be resold without sunk costs) and an absence of economy of scale (trucks are limited by their storage capacity). These factors consequently require specific regulation frameworks and are probably significantly different from those coming from other essential service sectors. Certainly, tariff regulation through a licensing model seems complex to implement and control because of the number of private mechanical ETOs and the diversity of services provided (in terms of volume pumped, transportation length, difficulties of operators). Controlling each FSM operator could also be too costly. A contract-based approach like a public-private partnership giving to one operator a monopoly situation on a particular geographical area (or a part of the city for each operator) could also fail. It could lead to losing the interesting competition effects that can be observed in Cambodia and could potentially create conflicts and additional costs between operators and public institutions to ensure that control for each geographical area is respected. From the users' perspective, it could also create difficulties in reaching the 'right' operators responsible for each area, involving time and cost as FSM providers operate throughout the entire city. While the market is working quite well at the household level, the measures and recommendations should be adapted and not disturb practices but orient them to more sustainable options. On the second question, a regulatory model also needs to be designed to allow the sufficient financing of effluent collection, transport, and treatment both on combined sewerage system and FSM services. A key idea could be based on how to force FSM providers to move to the right location to dump and also how to constrain households to desludge more frequently. Potential sources of financing are already available. Indeed, most of Cambodia's urban population is used to paying sanitation taxes, for instance in the water bill in Phnom Penh or directly to the sanitation operators in Siem Reap. However, FSM services and particularly the treatment stage do not currently gain any support. To force private mechanical ETOs to move purely via control from public institutions also appears inefficient considering the enforcement of law in developing countries, particularly Cambodia. Consequently, an original innovative approach needs to be promoted; aiming at not giving bias to the market forces but promoting performance and reaching minimal standards to mitigate environmental risks. Solutions have to be implemented in relation to the current market and the trends observed in each city, not destroying but creating incentives for better practices.

RECOMMENDATIONS

Based on this brief overview and analysis, five main recommendations are proposed in order to improve and optimize service quality, efficiency, and effectiveness on the FSM sector in Cambodia.

1. At the national level, public authorities should be helped to implement policy dialogue and sector regulation in two ways: (i) land management could promote pre-treatment technologies at the household scale with standards of construction thus evacuation could be controlled by public administration; (ii) MoE and MPWT

www.manaraa.com

should work closely during the licensing process of operators not to establish the tariff, but simply just to supervise the number of trucks in each city.

2. To incentivize private ETOs in large and medium cities, decentralized sludge treatment systems could be developed. The treatment of the sludge collected is an obvious priority and the implementation of decentralized treatment would reduce the negative impact to the environment, as well as possibly helping to reduce transportation costs. A strict zoning approach within PPP contracts is not adapted by Cambodian cities and the existent developed market. However, investing in decentralized fecal sludge treatment plants could push operators to reallocate their trucks to strategic places. It could help optimize the transportation costs and reduce the final cost for customers, while also protecting the environment. Payment from public institutions could also be one an another source of incentive coming from the taxes paid in water bills.
3. Increase demand and develop 'pre-treatment' technologies for households: the development and promotion of high quality pre-treatment assets would be an efficient complementary solution of limiting the impact on the environment with only pre-treated wastewater discharging into the drainage system and fecal sludge being collected by the ETOs.
4. In small cities, authorities and donors could support manual operators in adopting semi-mechanized technologies. The case of Kampot shows that the FSM market is very low and does not yet allow the running of a mechanical service, as in Phnom Penh or Siem Reap. Manual operators can play a significant role as they already cover a large part of the market, but their working conditions must be improved to increase their efficiency as well as to control the health risks. Burying sludge, a practice adopted a long time ago in Malaysia, could be an efficient solution for small cities and should be developed to avoid any future problems in towns. They also could be encouraged and subsidized to provide semi-mechanized systems that could allow them to transport the sludge greater distances than they currently do.
5. Promote public awareness and environmental protection during urban sanitation campaign: access to sanitation in urban areas is quite high, however systems are often of low environmental quality and encounter problems. Raising the population's awareness could support the increase of demand for quality sanitation equipment and services. However, this has to be supported in parallel with the development of simple and affordable technologies.

CONCLUSION

It is commonly accepted and criticized that 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 & The World Bank 2002). Does this mean that nobody is acting in this field? On the contrary, this study demonstrates that the market for ETOs is almost saturated due to a great deal of competition and a limited demand. In fact, private mechanical operators dominate the market for households and small producers whilst public operators are offering sewerage cleaning services. In addition, even if the operators are small, even having one to three trucks, their business models is quite profitable. They offer an affordable tariff and a satisfactory emptying service. They have adapted their offer technically and commercially due to a risk mitigation strategy and low entry costs. However, this market neither stimulates demand, nor is it sufficiently controlled. It produces strong negative environmental externalities that are not included in the tariff. The study was focused on this part of the value chain but raises issues that are more global. Indeed, most of the fecal sludge is directly discharged both by households and private operators into the environment. This situation raises the issue of public control and regulation over this competitive and relatively efficient market. Also, this paper highlights difficulties in regulating this specific service, the importance of adapted institutional arrangements, following a city's characteristics (size of market, treatment and transport technologies) and proves that an integrated value-chain approach is the key method to assessing the sector.

DISCLAIMER

This article is based on research funded by the Bill & Melinda Gates Foundation. The findings and conclusions contained

www.manaraa.com

within are those of the authors and do not necessarily reflect positions or policies of the Bill & Melinda Gates Foundation.

ACKNOWLEDGMENTS

We would like to address special acknowledgement to our survey team which carried out excellent work during the field study, and particularly: Mr Benjamin Clouet, Mr Pheaktra Thlang, Mr By Virak, Mr Hy Thy, and Mr Yi Sokkol and to the reviewer of the report Ms Antoinette Kome (SNV) and Sangeeta Chowrly (BMGF).

REFERENCES

Buchanan, J. M. & Stubblebine, W. C. 1962 Externality. *Economica* **29** (116), 371–384.

Coase, R. 1960 The problem of social cost. *J. Law Econ.* **3**, 1–44.

Kopitopoulos, D. 2005 *A Strategy for Enhancing Urban Sanitation in Cambodia*. The World Bank, Washington, DC.

Kov, P., Sok, H., Roth, S., Chhoeun, K. & Hutton, G. 2008 *Economic impacts of sanitation in Cambodia. Water and Sanitation Program*. The World Bank, Phnom Penh.

Levisay, M. & Sameth, C. 2006 *Measuring Rural Water Supply Access: Findings from a Comparative Analysis of Cambodian National Surveys*. Water and Santiation Program, The World Bank, Phnom Penh.

NIS 2005 *Cambodia Demographic and Health Survey*. Ministry of Planning, Phnom Penh. http://www.nis.gov.kh/index.php/en/national-statistical-systems/statistical-master-plan/88-cdhs.html

NIS 2008 General Population Census of Cambodia 2008, National Report on Final Census Results. http://www.nis.gov.kh/index.php/en/find-statistic/site-administrator/cips-2004/final-pop-cen-2008.html#

Okelford, J. 2010 *Rural Water Supply Sanitation and Hygiene Strategy 2010–2015*. Ministry of Rural Development, Phnom Penh.

Pigou, A. C. 1920 *The Economics of Welfare*. McMillan & Co, London.

PPIAF and The World Bank. 2002 *Private Solution for Infrastructure in Cambodia: a country framework report*. Public-Private Infrastructure Advisory Facility and the World Bank, Washington, DC.

RGC 2003 *National Policy on Water Supply and Sanitation*. The Royal Government of Cambodia, Phnom Penh.

Roberts, M., Tanner, A. & McNaughton, A. 2007 *Supply Chain Assessment for Sanitary Latrines in Rural and Peri-Urban Areas of Cambodia*. Édité par The Water and Sanitation Program (WSP) The World Bank, Washington, DC.

Robinson, A. 2007 *Rural Sanitation and Hygiene in Cambodia: The Way forward?* Water and Sanitation Program, Phnom Penh.

Salter, D. 2008 *Sanitation Demand and Supply in Cambodia. Identifying Constraints to Increasing Sanitation Coverage. Field Note*. Water and Sanitation Program, Phnom Penh.

Tomonori, T., Yukio, T. & Chea, S. 2005 Sewage water quality of Phnom Penh City. *J. Water Environ. Technol* **2**, 133–143.

First received 8 October 2012; accepted in revised form 9 May 2014. Available online 7 August 2014

www.manaraa.com

Reproduced with permission of copyright owner.
Further reproduction prohibited without permission.

www.manaraa.com