Business Analysis of Fecal Sludge Management: Emptying and Transportation Services in Africa and Asia

Draft Final Report

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ACRONYMS

AAWASA	Addis Ababa Water and Sewerage Authority
AEPB	Abuja Environmental Protection Board
CPHEEO	Central Public Health & Environment Engineering Organization
DOE	Department of Environment
EPA	Environmental Protection Authority
EPB	Environmental Protection Bureau
ESH	National Environmental Sanitation and Hygiene
FCF	Free Cash Flow
FS	Fecal Sludge
FSM	Fecal Sludge Management
GDP	Gross Domestic Product
HH	Household
IWK	Indah Water Konsortium
JMP	Joint Monitoring Programme
LGA	Local Government Agencies
NEMA	National Environment Management Authority
NPV	Net Present Value
ONAS	Office National de l'Assainissement du Sénégal
ONEA	Office National de l'Eau et de l'Assainissement
OPEX	Operating Expense
FSTP	Fecal Sludge Treatment Plant
ROI	Return on Investment
SDB	Sludge Drying Bed
SPAN	National Water Services Commission
URENCO	Urban Environment Company
VEPF	Vietnam Environmental Protection Fund
WHO	World Health Organization
WASA	Water and Sewerage Authority
WWTP	Waste Water Treatment Plant

EXECUTIVE SUMMARY

This study was initiated and funded by the Bill & Melinda Gates Foundation to map the urban sanitation situation and assess business and operating models for fecal sludge management in 30 cities across 10 countries in Africa and Asia, specifically focussing on the extraction and transportation market segments. The available information about fecal sludge emptying and transportation service delivery is both limited and weak. In a majority of cities, fecal sludge management (FSM), as a service to households, is largely ignored by local and national governments. Decision makers, entrepreneurs and investors in social businesses lack the necessary information – on market size, business opportunities, and profitability – to make FSM a functional component of the sanitation value chain. In many cases the entrepreneurs also lack recognition from the public utilities that they are providing these services to households that are not connected to the centralized sewers – which is the case for the majority of households in the surveyed cities.

The study was carried out in Burkina Faso, Ethiopia, Kenya, Nigeria and Senegal in Africa and Bangladesh, Cambodia, India, Malaysia and Vietnam in South/Southeast Asia. Three cities of varying population sizes in each country (under 100,000 to over 5 million) were selected to provide a view of a range of urban fecal sludge emptying and transportation situations and services. The study was conducted by a team of local consultants in each country and managed by a global coordinator. The approach used was to gather users' perspectives through household surveys and to collect data on the financial and business models of the emptying service providers. For consistency of execution and data gathering by all ten-country teams, a common analytical framework was created outlining the survey questions for the households and business owners.

The study generated vast amounts of data from over 13,000 household surveys and 150 detailed financial surveys of fecal sludge emptying and transportation service providers. This report presents the comparative analysis based on these data from those surveys in the 30 cities. Details of each country study are also available in the final reports submitted by the country teams. Findings in this report refer only to the cities surveyed in the 10 countries and not to African or Asian countries in general and the analysis based on the information and data from the ten country reports.

A majority of households in the 30 cities surveyed are off-the sewer network and use on-site sanitation facilities. In Africa, only Nairobi has household-sewer connectivity that is close to 50%. In Asia, households in Cambodia and Vietnam that are connected to the sewer pipeline still use pits and septic tanks as pre-treatment sites, and are thus still in need of emptying services. Pit latrines are the most common on-site sanitation technology in Bangladesh, Burkina Faso, Cambodia, Ethiopia and Kenya, while septic tanks are dominant in the other five countries.

Households spend only a small percentage of their income on on-site sanitation. The average monthly income per household with on-site sanitation ranges from $170 to about $600 (with the exception of Malaysia where it was $2204). Of this, less than 4% is spent on emptying services, whose frequency ranged from once every year (Senegal), to once every 3 – 5 years (Cambodia, Vietnam), with the most common frequency across the countries being once every two years.

Emptying the on-site facilities is done both manually and mechanically, with 34.3% of the surveyed households using manual services. With approximately 5.6 million households in the 30 cities using on-site sanitation, this data implies that almost two million households today rely on manual emptying for sludge management. The remaining households use mechanical emptying services that are provided, for the most part, by private operators in every city.

Using the data of household emptying frequency, size of the pits and septic tanks and the fee charged for emptying, the total available market for emptying service across the 30 cities is estimated to be $134 million. In the ten capital cities, the market size ranges from $200,000 in Phnom Penh to over $40million in Nairobi. This is the market that is being targeted by the private mechanical operators, although not always as formal operations within the regulatory framework of the local authorities.

The private business owners that run these emptying services usually do so as an additional business, rather than as their focus, to supplement their incomes and they purchase the vacuum emptying trucks from personal savings or loans from family and friends. Only 20% of the 119 mechanical emptying businesses surveyed had taken out a commercial loan for the purchase of a truck. The cost and sourcing of trucks is the single biggest challenge for these entrepreneurs. In Asia (with the exception of Malaysia), the trucks are assembled locally using second hand transport trucks modified for the purpose of extraction by the addition of old vacuum pumps, hoses and container tanks. Typical cost for such a locally assembled truck in Asia is about $13,000 (other than in Malaysia where new parts are used). In Africa on the other hand, the trend is to purchase very old second-hand vacuum trucks from Europe (Mercedes or Renault are popular models) that are repaired and put back on the road. Some of the trucks in cities in Africa are at least 30 years old and had been purchased by the entrepreneur at an average cost of $34,000.

Some regional trends were seen in the business operations between Africa and Asia:

- Average truck capacity in Asia is just over $3m^3$ and in Africa around $10m^3$ – tracking the differing average pit volumes;
- Pits in Asia average $2m^3$ vs. $7m^3$ in Africa;
- Age of emptying trucks in Africa is 15 to over 30 years and in Asia between 5 to 10 years;

- Local assembly of trucks in done in Asia, while businesses in Africa import second hand trucks; and
- The cost of the trucks is three times higher in Africa than in Asia.

The choice of trucks used has a significant impact on business profitability. Looking at the unit economics of operations, it costs about $11,000 in operating expenses for a truck in Asia and three times that much in Africa. The breakdown of costs too are strikingly different, with African businesses spending 76% of their expenses on variable charges such as fuel and maintenance, while their Asian counterparts spend most of their expenses (62%) on fixed costs – mainly staff salaries. The single largest component of operating costs in Africa is fuel, making up 40% of expenses. This fact is attributed to the large capacity trucks used that consume more fuel, old trucks that are fuel inefficient and the long distance travelled to dumping sites located outside the cities.

In spite of the high upfront capital costs for trucks and high operating costs, the annual profit per truck in Africa is $12,000 and is twice that seen in Asia. The reasons for this are the higher empting fee charged ($60 vs. $28 in Asia) and the larger number of trips per day per truck made in Africa.

A comparative analysis was done to determine trends in business profitability within the countries and regions, and the only factor that had a clear and strong correlation to profitability of the business, was the size of the fleet. Across all countries, having a single truck business meant profitability levels were unstable and near loss – especially when depreciation costs of the trucks were included. Having operations with two or more trucks provided the business with greater efficiency, less downtime and an opportunity to capture commercial emptying contracts. The support systems necessary to creating sustainable and profitable businesses are lacking in the areas of finance, accessible, efficient and safe dumping sites and affordable and efficient truck maintenance services.

To capture the full potential of the very large $134million market, this report presents several recommendations for consideration, including ways to support the scaling of the single truck operators to become mid to large sized operations. Access to finance is an area that will need to be addressed, as self-financing is very limiting and a very slow road to business growth. To save on fuel costs and increase truck efficiency, transfer stations must be introduced – either as permanent structures or in the form of innovative ideas such as the geo-tubes being tested in Malaysia. Furthermore, the experience in Malaysia has shown that regulating scheduled desludging is needed to enforce the correct operations of the septic tanks and maintaining predictable and steady income for the operators. Truck sourcing options need to be considered – especially local manufacturing or assembly – without which the capital outlay on poor quality vehicles in Africa would continue to adversely impact return on investment. A more effective

supply chain is also needed with an inventory of spare parts to reduce the downtime of these expensive trucks.

Lastly, evaluating the financial viability of the businesses and affordability of their services to households addresses one piece of the ecosystem needed to create financially and environmentally sustainable business models. Without a safe place to dump the collected sludge, merely collecting and transporting it away from the households is effectively only relocating the sludge. Sludge treatment plants and sludge reuse are needed to complete this cycle to ensure a complete and effective sanitation value chain.

CHAPTER 1: INTRODUCTION

Lack of access to safe sanitation globally has a profound effect. The consequences of almost 2.6 billion people in the world using unsafe toilets or practicing open defecation are devastating to their health and to their financial and personal well being. According to the World Health Organization (WHO), diseases transmitted through human waste contaminated water include diarrhea, cholera, dysentery, typhoid and hepatitis and cause 115 deaths every hour in Africa anone. Of the roughly 2 million people that die every year from diarrheal diseases, most of them are children under the age of five. Progress on improving sanitation has been woefully inadequate and the world is far from reaching the Millennium Development Goal (MDG) target for sanitation.

Among the reasons for this poor performance in sanitation service provision are an ongoing failure to prioritize the sector and inadequate financing thereof. In a recent report published by the WHO (Hutton, G. 2012), the capital costs of achieving the MDG target for sanitation are estimated at $23 billion a year from 2010 to 2015, or a total of approximately $115 billion. Going beyond MDG goals, achieving universal sanitation coverage would require incremental capital costs of $217 billion over the five-year period. The provision of urban sanitation dominates funding requirements, making up almost 60% of the need.

The economic benefits of addressing this issue are, however, equally significant – estimated as being $54billion a year globally. A study commissioned by the World Health Organization points out that every US$1 invested in water and sanitation, would yield an economic return of between US$3 and US$34 depending on the region (Hutton G. & Haller L., 2004) Groundbreaking studies by the World Bank's Economics of Sanitation Initiative, found that the economic costs of poor sanitation and hygiene amount to billions of dollars a year. Specifically for the countries covered in this study, Table 1 shows the economic loses due to poor sanitation.

Table 1: Economic loses per year due to inadequate sanitation

	Bangladesh	Burkina Faso	Cambodia	India	Kenya	Nigeria	Vietnam
Losses	US$ 4.2 billion 6.3% GDP (2007)	US$ 171 million 2% OF GDP (2010)	US$ 448 million 7.2% GDP (2005)	US$ 53.8 billion 6.4% GDP (2006)	US$ 324 million 0.9% GDP (2010)	US$ 3 billion 1.3% of GDP (2010)	US$780 million 1.3% of GDP (2005)
Spending on Sanitation	0.1% GDP WASH budget in 2008*	0.1% GDP	0.5% GDP WASH budget in 2007*	0.6% GDP WASH budget in 2008*	0.1%-0.5 GDP	0.1% GDP	

*Data for these countries was obtained from WASHwatch.org

Clearly, the spending on improving sanitation in these countries is far below the economic costs of not doing so. For these countries, the study found that the annual economic losses due to poor sanitation made up from 0.9% to 7.2% of GDP with spending on sanitation lagging considerably behind that figure and at only between 0.1% to 0..6% of the GDP.

1.1 Background And Rationale For The Study

To the extent that the development world focuses on increasing access to improved sanitation for all, the approaches taken have seen a move from subsidies for toilet construction to supporting demand generation from within the communities concerned. However, access to improved toilets is not an end in itself. Building open-defecation free communities will require sustained use of these latrines, and, as a result, the need for provision of sustainable services of pit emptying and transportation for safe disposal or treatment of waste.

Only 13% of the households in Africa and 18% in Asia are connected to the piped sewerage network, while 47% in Africa and 30% in Asia rely on non-piped sanitation systems, with the remaining households not having any access to sanitation facilities (WHO/UNICEF 2000). The majority of cities in developing countries rely on informal services for excreta disposal. These services include mechanical as well as manual emptying of the latrines. While latrines may be "improved" per WHO/UNICEF Joint Monitoring Programme (JMP) definitions of "hygienic separation of human excreta from human contact", the inevitable need for emptying creates the potential for a significant risk to public health. Not only is contact with human excreta unavoidable during manual emptying, the fecal sludge itself is often disposed – even in the case of mechanical service providers – directly into the environment without treatment. This can result in communities that have made progress in increasing access to improved sanitation seeing the benefits of this progress negated by the fact of living in and around fecal sludge that has merely moved from their toilets to their immediate environment.

Despite the significance of the issue, research about fecal sludge emptying and transportation service delivery is both limited and weak. There are considerable knowledge gaps about fecal sludge emptying as a service, and its effectiveness as a component or an integrated part of cities sanitation service provision. Indeed, most studies have focused on either household latrine acquisition or on treatment/reuse options. Existing data and knowledge about the market drivers and constraints on non-piped sanitation services, from the time the pit is emptied to when the contents of the pit are disposed of (whether at a treatment site, or directly into the environment), is extremely limited or non-existent.

It is acknowledged that governments play a limited role in the extraction-transportation market segments. Most of the work is conducted by private individuals and organizations, often on an informal basis, with limited involvement and oversight from government / utilities. Further, while there is some individual knowledge of pit emptiers and truckers, and some high level rapid assessments of septage management (AECOM 2010), there is extremely limited data on the business models of these private emptying businesses. This data is needed to provide the necessary information on market needs and challenges, that would then enable targeted funding by governments, donors, or development partners.

This 30-city study in African and Asia aims to build the knowledge base in this area and, in particular, to narrow the information gap on management, business and operating models for fecal sludge management within the extraction and transportation market segments. It includes primary data on the market size, business models and profitability of emptying service provision obtained through conducting in-depth surveys of service providers, individual households, government agencies, treatment/disposal site operators, and other commercial lending institutions.

1.2 Objectives And Scope Of The Study

The purpose of this research was to provide detailed data of sanitation emptying businesses and challenges and opportunities to sector stakeholders engaged in this sector, for the purpose of informing more in-depth empirical research and investments by governments, donors and other development partners. In the countries and cities where the study was conducted, results will be structured to feed into discussion and debate at the local level among urban sanitation policymakers and practitioners, in order to develop a better understanding of this area of sanitation service delivery.

The main objectives of this study were to:

1. Document the existing business models in sludge extraction and transportation, in order to inform subsequent grant making by the Foundation and other donors;
2. Widely disseminate the findings in order to share the learnings with potential entrepreneurs, investors and other donors, implementers and practitioners in the sector to help build sustainable service provision in sanitation stewardship;
3. Help build local capacity of sanitation practitioners in each country; and
4. Formulate policy recommendations to support sustainable businesses in fecal sludge management (FSM). Each country team will receive additional funding to host national workshops with policymakers and other stakeholders.

The study was carried out in ten countries across Asia and Africa by local teams with experience in fecal sludge management. In each country, three cities of varying population sizes were

selected to order provide a comprehensive view of the urban sanitation emptying services. The study sought to gather information at a city level in each country, of the demand for and supply of sanitation extraction and transportation services, the unmet gaps, its reasons and recommended solutions. Direct field observations, household surveys, interviews with fecal sludge management stakeholders and quantitative analysis of the business models of entrepreneurs formed the basis of rigorous case studies within each country. Each country team analyzed the operations, revenues and expenditures of existing private enterprises in fecal sludge management.

Among the questions and data gathered in the 30 cities were the following:

- What types and sizes of on-site sanitation facilities do these cities have?
- What is the percentage of mechanical versus manual emptying services used?
- What is the household emptying frequency?
- What is the household emptying fee?
- Number of private and public trucks in the city
- Are utility trucks used for household emptying?
- Number of private businesses that are small (1 truck), medium size (2-5 trucks) and large (>5 trucks)
- What is the range of capacities of private trucks (in m3)?
- What is the price of a new truck vs. second-hand one?
- Are most trucks second-hand or new at time of purchase?
- What is the typical age of trucks in city?
- What is typical number of trips per day for the trucks?
- What is the profitability level of the emptying companies?
- What constitutes the main expenses in running this business?
- Where is the sludge dumped and is there any re-use of it?
- What is the market size of the emptying business in these cities?

Specific study outputs were to conduct at least 10,000 household surveys and 150 emptying service provider interviews in gathering this data and documenting the financial models of existing businesses. This data was used in estimating the fecal sludge emptying market size and providing recommendations for optimizing the business models.

CHAPTER 2: METHODOLOGY

2.1 Selected Countries And Cities

This study was carried out in ten countries in parallel: Burkina Faso, Ethiopia, Kenya, Nigeria and Senegal in Africa and Bangladesh, Cambodia, India, Malaysia and Vietnam in South/Southeast Asia. These countries were selected based on the diversity of approaches and models in the geographically dispersed regions, including best performing countries in Africa and Asia. Some of these are countries of strategic interest for the Foundation or have existing engagement that could be built upon. Within each of these countries, in-depth case studies were conducted in three cities in order to better understand the full spectrum of urban sanitation service delivery models for different market sizes.

The cities selected in each country included the capital city, a secondary large city and a mid-sized city as shown in Table 2:

Table 2: List of selected cities

	Capital city	City 2	City 3
Burkina Faso	Ouagadougou	Bobo Dioulasso	Fada N'Gourma
Ethiopia	Addis Ababa	Dire Dawa	Hosaena
Kenya	Nairobi	Kisumu	Mombasa
Nigeria	Abuja	Ibadan	Yenagoa
Senegal	Dakar	Touba	Thies
Bangladesh	Dhaka	Khulna	Faridpur
Cambodia	Phnom Penh	Siem Reap	Kampot
India	Delhi	Jaipur	Madurai
Malaysia	Kuala Lumpur	Melaka	Kuala Terengganu
Vietnam	Hanoi	Ho Chi Minh City	Hai Phong

The selection criteria used by the consultants in each country for choosing the three cities were based on the different sizes of the cities, their geographic spread in the country and diversity of business models for emptying and transportation of fecal sludge. In India, the consultant team additionally used results from a World Bank study that ranked states with access to sewerage facilities, and picked a state from the top, middle and low performing tiers. In India, the official sanitation figures report only authorized settlements. The survey for this study did not, however, make this distinction and also reported the on-site sanitation figures for residents of un-recognized neighbourhoods within the selected cities, as these areas have a particularly high incidence of dependence on on-site sanitation systems.

The selected cities, based in western and eastern Africa, South Asia and Southeast Asia, have population sizes that range from just over 38,000 in Kampot, Cambodia to 15 million in Dhaka, Bangladesh (Figure 1). More specifically, the population distribution of these cities is:

- 4 cities with populations over 5 million
- 12 cities between 1 million to 5 million
- 2 cities between 500,000 to 1 million
- 9 cities between 100,000 to 500,000
- 3 cities under 100,000

Collectively they represent over 67 million people and provide a valuable insight into urban FSM practices across these ten countries. The country teams gathered the population size data through available official documents, the sources of which are noted below in Figure 1.

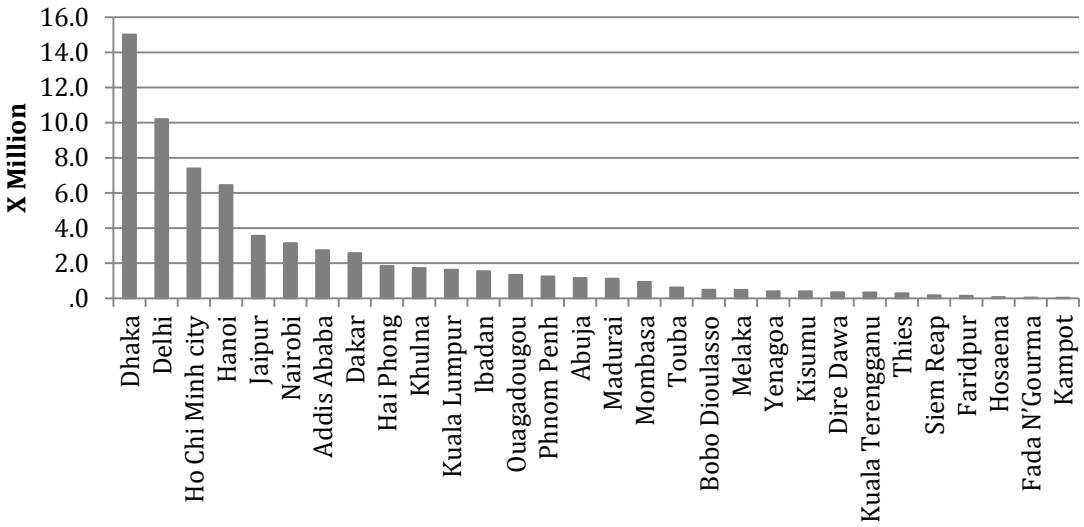


Figure 1: Population of cities surveyed[1]

2.2 Project Approach And Execution

A very deliberate decision was made to have this study executed by local teams of consultants based in each country. Their experience and stake in developing local urban sanitation solutions gave these teams a distinct advantage. Another advantage of engaging national teams for this study was that they could then build on the findings beyond the end of this project – whether

[1] *Source:* Ethiopia- Census 2007; Nigeria-2006 population census projected to 2010 using the UNFPA growth rates; Kenya- Census 2009; Senegal- Agence Nationale de Statistique et de la Démographie (ANSD); Bangladesh- UN Population Division: World Urbanization Prospects: the 2009 Revised Population Database & 2010 Faridpur Municipality Situation Analysis Report; Cambodia- General Population Census 2008 ; India- Census of India 2001, City Development Plan, 2006;Malaysia- 2010 Population & Housing Census ; Vietnam- General Statistics Office 2009

through subsequent funding from the Foundation or other donors or by influencing and partnering with the local government sanitation officials and policymakers.

Country-teams were selected based on their deep knowledge of the sanitation sector, strong understanding of small-scale sanitation service providers and good local networks to conduct the research. Recognizing that it may not be possible to have one organization have the breadth of expertise needed for this project, the lead consultant was encouraged to find the relevant experts based in each country to form the highest calibre overall team for this study. Each team was required to include experts in socio-economics, finance and fecal sludge management, to lead the formulation of the methodology and analysis of the data. The teams selected for each country were typically made up of experts from different organizations – academic institutions, public utilities, NGOs, country-based consulting firms and independent sanitation consultants – and accountable to the lead consultant.

Overall project management and coordination was conducted by a global coordinator. Consultants based in the regions were also added to the team to provide support in regional coordination. A research team was later brought into the project once all surveys had been completed, to conduct statistical analysis of the data and consolidate all household and operator survey results into a master database. A short summary of the project teams' composition is provided in Appendix A.

A common analytical framework was created and shared with all country teams at the start of the study to enable a consistent platform for enquiry and output. Detailed questionnaires for household surveys, an income statement format for financial information from service providers and interview questions with other FSM stakeholders were also included in the common framework. Further details on this framework and the manner in which the survey was conducted are provided in the following section. All teams were provided the framework and training on the contents and use of the framework prior to the kick-off workshops.

Two kick-off workshops were held in Asia and Africa to launch the study with shared understanding of objectives and expectations of outcome. Mid-point workshops were held (in each region) to share findings, lessons learnt and challenges faced, and to provide an opportunity for country teams to learn from each other and re-adjust plans for the rest of the project if needed. Guidance and targeted training on financial analysis of the service providers income statements, was provided throughout the project and formally during the workshops. Deep project management needs of this study were met by formalized bi-weekly data and progress reviews between each country team and the global coordinator, and discussion, guidance and feedback to the teams by the global coordinator on their Interim and Final reports and analysis.

To encourage the country teams to share the results and findings with larger audiences, financial incentives were built into the team contracts, with additional funding provided for presenting the

results of the work at international conferences, publication in peer-reviewed journals and for presenting to local governments and policymakers.

The project timeframe was April 2011 through October 2011 for nine of the teams and July 2011 through January 2012 for the Kenya team that only joined the project in June 2011. The project timeline for Africa is shown in Figure 2 below. The Asian study and deliverables were staggered by two weeks from the African one to allow for separate workshops.

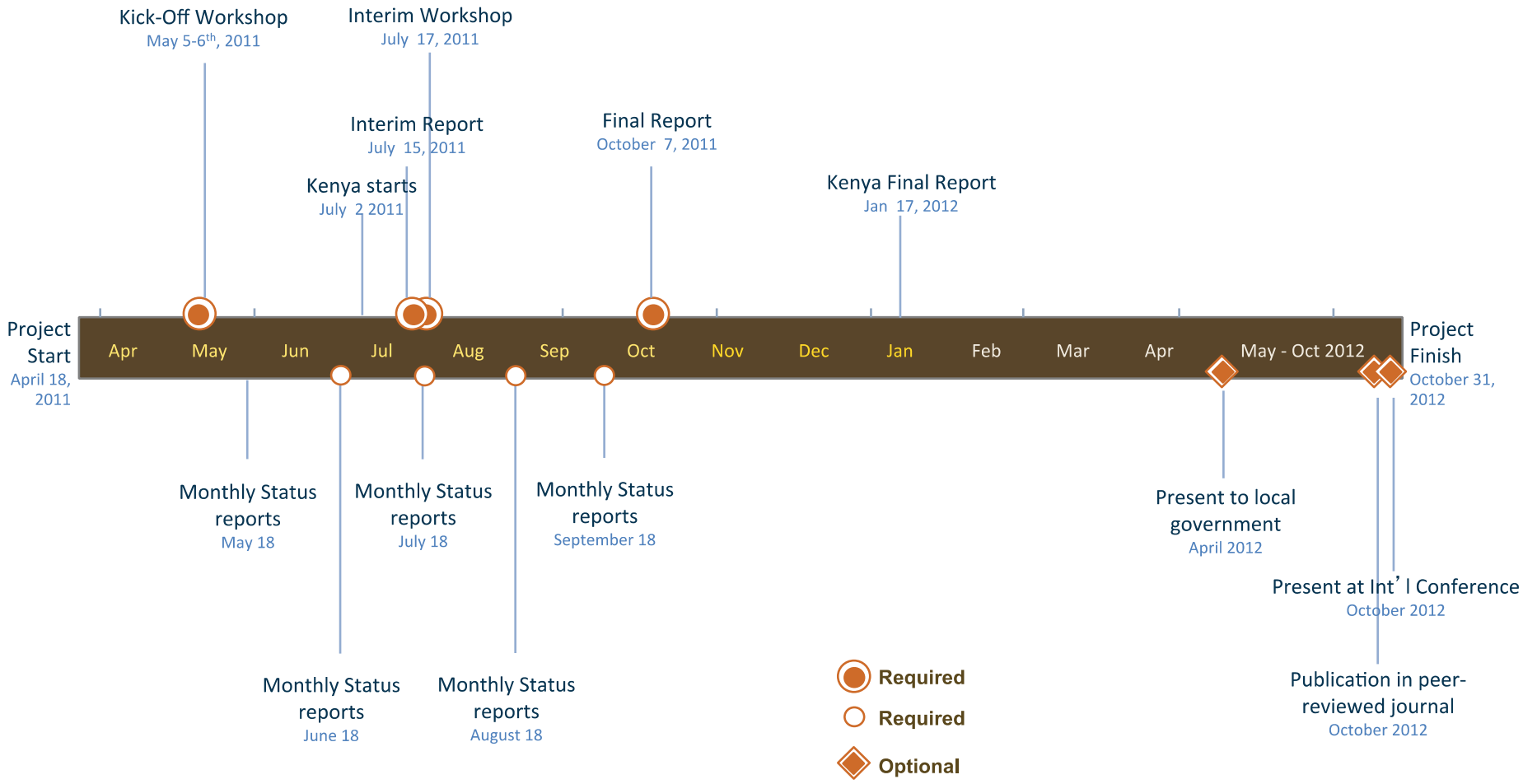


Figure 2: Project Timeline and Deliverables for Africa

2.3 Data Collection

2.3.1 Secondary data

A desk review was conducted by all country teams at the start of the study to develop background information on the selected cities. Research of existing literature and governmental documents on sanitation was Information was gathered on the size of the population, urban water and sanitation coverage, wastewater and fecal sludge treatment facilities (if any) and institutional framework for fecal sludge management.

2.3.2 Household survey

Data was gathered via desk research of exiting literature and governmental documents on sanitation and FSM by all teams. Primary data were collected through household surveys, direct observation of the household facilities and via interviews with other stakeholders, including extraction and transportation operators, fecal sludge (FS) treatment site operators, municipal authorities, national sanitation utility, research institutes and sludge re-users.

The common analytical framework provided a baseline questionnaire for the household surveys for consistency and comparative analysis. Some country teams translated the questionnaire into the local language and reformulated specific questions to be relevant within the cultural context. The various elements of the common framework document included:

- Household Survey Questionnaire
- Interview guidance for FS extraction and transportation operators, FS re-users, municipal authorities, and governmental agencies in charge of water supply, sanitation and environment protection
- Forms to describe sanitation facilities, process of FS extraction, dumping sites or treatment plants, and activities of reuse
- Models of Income Statement for manual and mechanized service providers

The sampling methodology for the household surveys selected by the teams varied across countries based on the nature of on-site sanitation systems determined during the desk review. The on-site sanitation systems' distribution across the cities and among the demographics varies significantly from city to city and across the countries. This was especially the case in Asia where the distribution of on-site sanitation depended on the city's urban planning and sewage network, location of new settlements by new low-income immigrants to the city and technologies of the on-site system itself. Phnom Penh and Hanoi have most of the households connected to the sewer pipeline, but also have the connections passing through either pits or septic tanks. Transect or random sampling in these cities can capture a representative picture of the situation. But in cities like Delhi, where the new low-income immigrants reside in unrecognized settlements at the fringes of the city with predominant reliance on on-site systems, or in Dhaka, where there are pockets of habitations which rely on on-site latrines (with the rest of the city

linked to sewage network or to open drains), it became necessary to use targeted sampling methods. The customized sampling techniques chosen by the consultants, varied across the ten countries based on the patterns of their cities, and were designed to capture typical households living with on-site sanitation. Country-specific details of household sampling methods are highlighted below.

Asia

As documented and updated information and maps on on-site sanitation sites were available from government sources, in Malaysia the team conducted random sampling of the households with on-site sanitation facilities. Commercial premises with on-site sanitation were also included.

The Cambodian team used a transect method to represent a slice of the city encompassing the diversity of socio-economical and sanitation data in Cambodia. Number of households to be surveyed was then selected based on the population density in each commune along the transect. Two transects were defined for the capital city and one each for the two smaller cities.

In order to capture households that have emptied at least once before, the Vietnam team selected households that had lived in the house for over 10 years from 251 wards in the three cities (out of a total of 687). Sampling was done from wards located in the inner city as well as households from peri-urban communes.

After consultations with local municipal authorities and field visits, the team in India found all three cities had sizeable portions in the center that were connected to the piped sewage network. On-site sanitation was predominantly seen in areas that were either newly developed habitations on the periphery of the city or in unauthorized settlements. For this reason and the size of the cities in India, the team thus selected a purposive sampling methodology[2] to target specific areas in the city with high incidence of on-site sanitation facilities. Within these clusters, random sampling was used to select the sample households.

Bangladesh also had a unique situation in that, for the capital city Dhaka of over 14 million inhabitants, most households do not require emptying services for their on-site facilities as they are linked to canals of storm drainage systems. As such, a purposive sampling method was selected for nine pockets of the city which had a greater probability of households not linked to sewerage or drain water networks. For the other two smaller cities, Bangladesh team was able to select households from each of the city wards using random sampling.

[2] Purposive sampling is a type of selective sampling technique where the units that are investigated are based on the judgment of the researcher.

Africa

A multi-stage stratified sampling technique was adopted by Nigeria to cover all the wards in each of the administrative areas of the municipality. Communities were eventually stratified into residential densities: high density (low-income), medium density (middle income), and low density (high-income) to ensure that all types of toilet facilities in the cities were captured.

Sampling methods in Senegal were chosen in light of the uniqueness of the three cities. To accommodate the array of sanitation practices in Dakar, the Senegal team used a three-level stratification method. In Dakar, areas were first selected with homogeneous characteristics with regards to urbanization, sanitation and water consumption. Random selection of districts within the homogeneous areas was followed by a determination of number of households to survey based on population density. In the smaller two cities, randomized sampling was undertaken of households across various administrative districts.

In Ethiopia, cities are divided administratively into sub-cities (Kifle Ketemas) that are sometime further divided into the smallest administration area called Kebeles. The team employed a clustered stratified random sampling technique, with all sub-cities or Kebeles used as the clusters. From each cluster, households were randomly selected and interviewed based on a sampling frame that considered income levels, accessibility and multi purpose households.

The Burkina Faso team used random sampling within all city districts while the Kenya team chose households from each "sub-location" i.e. smallest administrative unit the cities. Within the sub-location, the surveyed areas were selected where the households were not connected to the network, and had a distribution of socio-economic levels. Sample size within each sub-location was selected proportionate to the population densities.

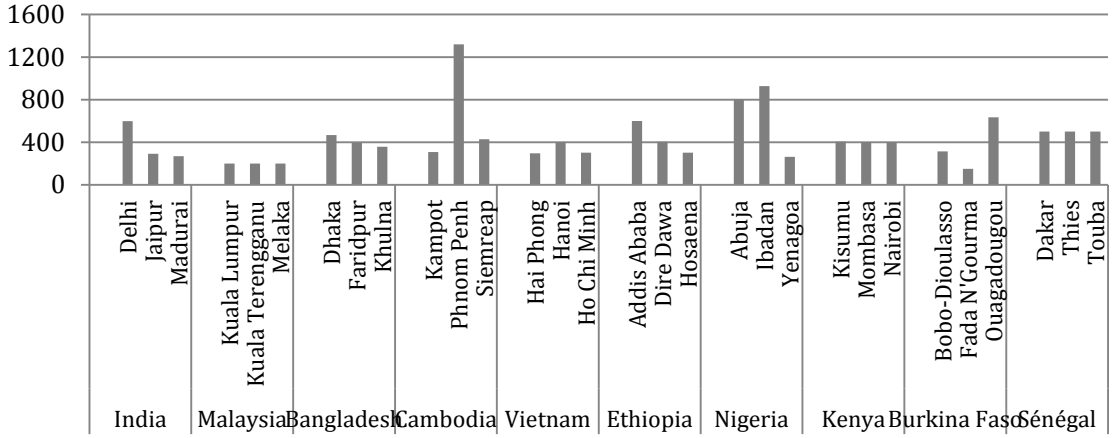


Figure 3: Number of households surveyed per city

The number of households surveyed by city in shown in Figure 3 which provided a high accuracy level with confidence levels between 90% - 99%. The determination of sample size

can influence the accuracy and quality of the research. A standard calculation of the sample size per city can be achieved based on the following formula commonly used in socio-economic surveys[3]:

$$N = \frac{t^2 \text{ x } p\ (1-p)}{m^2}$$

N= size of sample t = level of confidence (e.g. 95% (1.96) p = estimated prevalence of on-site sanitation, m = error margin at 5%

As mentioned above, the countries used different methods to build the sample of survey. So by choosing p=0.5 for city wide survey and p=0.9 for purposive survey, it was possible to determine if the data from these surveyed areas reflected the situation for the city at large. Overall, most of the data are accurate with a 90% – 99% confidence levels, except Fada N' Gourma in Burkina Faso which had 75% and Yenagoa in Nigeria had a 89% level of confidence. Details of the level of confidence of each city are shown in Appendix B. By the end of the study, a total of 13,144 household surveys had been completed in the 30 cities.

2.4 Financial Data

Rigorous data collection and analysis of current services supply and demand, the size of the market and the technical, financial, and economical situation of the operators and their businesses was gathered by the interviews with the various stakeholders. Consultants conducted detailed interviews with fecal sludge emptying and transportation businesses – mechanical and manual – in each city. Contact with the service providers was made by seeking information from various sources including utility officials, registered service providers lists, household surveys, consultants own network, etc.

Based on the common analytical framework, specific information on revenue and expenditure sources of the service providers was collected by interviewing the operators. Financial statements for these businesses were subsequently created based on this data. As expected, there was scepticism on the part of the service providers about the intent of this data collection exercise – especially by the informal operators with unaudited and undeclared business operations. All transactions are made in cash (except in Kenya were the mobile phone payment system M-PESA is used as a method of payment). With no paper trail to track the accuracy of information provided with regards to income and expenditure, the teams had to do cross checking of the information by various means.

Focus groups were first held with the FSM operators to explain the purpose of the study. Interviews were conducted then with the owner and separately with the employees to validate the data. Information was also verified by talking to household members who had used these

[3] See http://www.ifad.org/gender/tools/hfs/anthropometry/ant_3.htm

services, as well as to mechanics and repair shops that serviced these trucks. Ultimately, the teams also shadowed the trucks on their rounds to observe the operation firsthand.

This study generated financial statements through interviews with 119 mechanical and 35 manual emptying businesses across the 30 cities. This sample includes 383 trucks in these cities with a majority (55%) belonging to private operators (Figure 4).

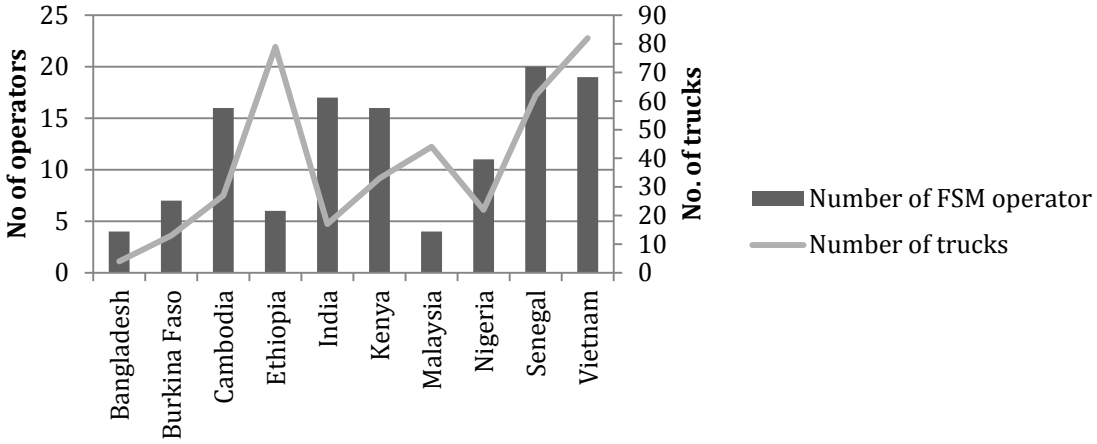


Figure 4: Number of FSM service providers surveyed

2.5 Data Analysis

2.5.1 Data consolidation

Compilation of all the surveys from the 30 cities was subsequently done into a database using common survey questions. Country data sets in various formats- Microsoft Excel, Statistical Package for the Social Sciences (SPSS), Sphinx – were consolidated into an Excel-based database.

Moreover, the total number of questions asked in each country varied widely from 59 Ethiopia to 200 in Cambodia, as countries edited questions to the common survey framework to make it more relevant to the local context. Also, responses were sometimes in numeric format and sometimes encoded as texts. Due to this heterogeneity in different countries survey responses, the data needed to be codified into smaller clusters.

In all, the consolidated master databases compiled responses to 61 common questions across 30 cities in Africa and Asia (Appendix E), gathered from 13,144 households and 154 income statements of the emptying businesses. These are the databases that have been used to do the comparative analysis from, in addition to using country specific information from the country teams' final reports and from the many discussions with them.

2.5.2 Comparative analysis

Although the data reflects a vast diversity of city sizes across 10 countries, the analysis identified trends and similarities across the database. Rather than taking averages of the income statements,

the analysis took the median of the businesses data to allow for a more representative picture to emerge.

Business profitability was consolidated at a city, country and regional (Africa, Asia) level. The purpose of comparing data across Africa versus Asia, was to be able to identify trends in the regions in order to inform future investments in FSM that take these differences in the regions into account.

In order to compare the financial models of the emptying businesses, three levels of analysis were used to determine trends their impact on the profitability:

Size of business: This was segmented into small (1 truck only), medium (2 to 4 trucks) and large (over 5 trucks) sized companies. The financial viability of different sized businesses was then evaluated by looking at annual cash-flows and return on investment at the a) city level, (b) country level and finally (c) at the regional level

Size of trucks: This analysis was done to determine if the physical capacity of the trucks has an impact on profitability. Country level analysis was done to compare (a) very small capacity trucks (under 2.5 m3) against (b) small capacity (2.5 to 5 m3), medium capacity (6 to 10 m3) and large capacity (over 11 m3) trucks

Size of city: Finally, independent of country or continent, cities were grouped by population sizes of small (under 500k), medium (500 to 1 million) and large (over 1 million)

These three segmentations were considered as these were the key differentiations seen among businesses and cities.

Most of the entrepreneurs considered cash flow as the only measure of their profitability. However, in the analysis in this report, depreciation has also been included to show the impact of eroding asset value of the trucks. The profitability of the businesses was evaluated in this report both with and without depreciation.

All financial data in this report has been converted to USD ($). Also, it should be mentioned that when speaking of Africa or Asia, this report is referring only to those ten countries investigated in this study and as such, the analysis does not necessarily reflect the situation for the entire continents.

CHAPTER 3: OPERATIONAL ENVIRONMENT

There are multiple stakeholders involved in the on-site sanitation value chain: truck assemblers, repair and maintenance workers, mechanical-truck operators, manual emptiers, dumping site and treatment-plant operators, customers (households, commercial sites), financing institutions and last, but not least, government institutions. As urban sanitation relates to environmental issues as well as health, land planning or water resource protection issues, responsibilities at the governmental level are shared between various ministries, agencies or local authorities, with responsibility for the full sanitation value chain being dispersed.

In most of the countries in the study, urban sanitation is a decentralized responsibility (with the exception of Malaysia), with no clear roles and responsibility assigned for fecal sludge management. The public authorities primarily view sanitation in terms of infrastructure provision like latrine construction, sewerage network and wastewater treatment facilities. Fecal-sludge management related to household on-site sanitation emptying and transportation is – with some exceptions – by and large ignored by the public authorities. The business of emptying and transporting fecal sludge is dominated by private entrepreneurs – as is detailed in Chapter 4. Treatment and re-use of fecal sludge in these countries is also either absent or very limited. This issue is dealt with in further detail in Chapter 5.

3.1 Institutional Framework: Africa

In **Burkina Faso**, the central government entrusts responsibility for urban sanitation to the National Water and Sanitation utility ONEA (Office National de l'Eau et de l'Assainissement). ONEA has concluded Strategic Sanitation Plans with the local governments to provide sanitation services for 60% of its cities in order to meet the Millennium Development Goals targets.

In Ouagadougou and Bobo-Dioulasso, ONEA is implementing a project that aims to develop a fecal sludge management model with the financial support from French Development Agency and the World Bank. The three main components of this model are: (i) institutional arrangements between stakeholders, (ii) regulation of fecal sludge management in the city by municipal authorities, (iii) construction of 3 fecal sludge treatment plants. The private sector is involved in the implementation of the project through participating to define: treatment sites; the appropriate models of regulation; requirements for fecal sludge extraction and transportation; dumping fees, etc.

Private operators carry out emptying activities in Burkina Faso – with the only public trucks being owned by institutions for their own use ((National Police, Army, Municipality of Ouagadougou, and the prison). The main challenge for both manual and mechanical operators is the lack of treatment plants or official dumping sites for fecal sludge.

In **Ethiopia,** the study indicated that the policy and regulatory framework of the country is conducive to the proper disposal of sludge. Some differences in the implementation of the regulations were, however, observed across the different cities. The Environmental Protection Authority (EPA) at the Federal level was established to ensure that the country's social and economic development activities are carried out in a manner that will protect the welfare of human beings, and that the resources will be sustainably protected, developed and utilized. Among its key functions is to develop environmental protection policies and ensure their implementation.

At the city level, the Addis Ababa City Administration has its own environmental agency – the Environmental Protection Bureau (EPB) – to implement the federal environmental policy and to supervise the disposal of solid, liquid and industrial waste. The Addis Ababa Water and Sewerage Authority (AAWASA) is responsible for water supply and sewerage in the city and also offers household pit and septic tank emptying services. Besides AAWASA private companies are also involved in the collection and transportation of fecal sludge. Addis Ababa is the only city in Ethiopia with a conventional sewerage system. The public utility in the city of Dire Dawa has a similar mandate to that in Addis Ababa for the provision of wastewater and sludge collection and disposal – with the three vacuum trucks of the Dire Dawa Water and Sewerage Authority carrying out 60% of the desludging services. In Hosaena this service is officially the responsibility of the town municipality. However, the municipality has no vacuum truck or sewerage system to adequately execute their role. For the moment, the municipality registers those who require a vacuum truck service for desludging pit latrines and septic tanks and arranges such services from Addis Ababa.

In **Kenya,** the main institutional context for the effective delivery of FSM is outlined in the National Environmental Sanitation and Hygiene (ESH) Policy of 2007. The document outlines the roles and responsibilities of all the ESH actors. These include government departments (such as the Ministry of Public Health and Sanitation (the lead agency), Ministry of Water, Ministry of Local Government) as well as the associated Municipal Councils, and the National Environment Management Authority (NEMA). The ESH document also outlines the critical roles of non-profit organizations, the private sector and, importantly, the communities concerned so as "to create and enhance an enabling environment in which Kenyans will be motivated to improve their hygiene behavior and environmental sanitation." Of particular relevance to this study, the ESH Policy outlines the roles and responsibilities of all the ESH actors. This includes Division of Environmental Health (for ensuring conformity of standards), City and Municipal Councils (for enforcement of environment protection laws) and Water Service Boards (for developing water and sewer facilities). With regards to FSM, the ESH policy raises the concern that the currently installed treatment plants are often non-functional due to poor operation and maintenance. This has resulted in discharge of raw sewage into the watercourses, posing a grave danger to public health.

Mechanical emptying services are provided by the private sector with the public sector playing a varied regulatory and oversight role. This oversight across the cities is generally concerned with licensing and less with regulatory enforcement. The environmental agencies in their licensing role apply a specific fee to fecal sludge extraction trucks. This fee is on a truck basis, is not transferable and works as a certification of fitness for use for the truck. Each and every truck providing fecal sludge extraction is classified broadly as a sanitation truck and is required to meet design and fitting requirements. Each of the Kenyan cities in the study has two treatment plants, one conventional type and another of the stabilization pond type. Dumping in the three cities is centralized and as such there is only one designated tipping point in each.

Nigeria has a comprehensive water and sanitation policy in place. However, safe excreta disposal is not any institution's primary responsibility. Water and sanitation services have been devolved to Local Government Agencies (LGAs) in every state. LGAs are solely responsible for ensuring access to and use of these services. However, lack of autonomy, budget limitations, and poor capacity, have hampered their ability to carry out these duties effectively. In donor-assisted states, the LGA water, sanitation and hygiene units tasked with management and implementation of various projects, are dynamic, energetic and display a higher capacity to deliver quality services than those LGAs with no donor driven projects. Civil society participation in water and sanitation issues is limited and the overall capacity of the sanitation sector is weak.

The collection and transportation of sludge is carried out by private companies while setting up of disposal sites is the responsibility of the local authorities. Abuja Environmental Protection Board (AEPB) is responsible for monitoring waste disposal and environmental cleanliness with regards to sanitation. In Abuja fecal sludge collected from households by mechanical operators is discharged through three designated manholes located strategically in the city, and treated at the city's waste-water treatment plant. In Ibadan and Yenegoa, neither city has a central sewerage system, and the State Ministries of Environment have formal responsibility for implementing federal guidelines for solid and liquid waste management. They have a role in ensuring the waste management service providers comply with existing laws governing emptying and disposal. However, in Ibadan, one of the Environmental Health Services officers interviewed stressed that the shortage of attendants has minimized effective enforcement of regulations. Besides, in Ibadan, the open dump approach is used for waste disposal. This occurs at the municipal disposal sites and several unofficial dumpsites scattered across the city, resulting in indiscriminate disposal of waste with limited measures to control operations.

In **Senegal** at the national level environmental management as a whole, and sanitation in particular, are the subjects of legal regulation codified by various ministries. These regulations include the Environment Code, the Water Code, the Urban Development Code, the Health Code, the Local Authorities Code and the new Sanitation Code that regulates and deals more precisely with issues in the field of fecal sludge management at the local level. In the 1990s responsibility for water supply and sanitation in Senegal lay with a single entity (Société Nationale des Eaux du

Senegal, SONES), but this was eventually split into three entities. SONES remained the state-owned water network asset-holder, while responsibility for water supply management was passed under a lease agreement to a private utility with majority French ownership (Sénégalaise des Eaux, SDE), and responsibility for sanitation to the state-owned Office National de l'Assainissement du Sénégal (ONAS). ONAS is thus the asset-holder for the sewerage system.

The collection and transportation of fecal sludge is the responsibility of private companies while setting up and operation of fecal sludge treatment plant and dumping sites are the responsibility of ONAS and the municipalities. ONAS does not, however, offer emptying services to households – such services are provided by private entrepreneurs. While ONAS does not regulate the tariffs charged by the private operators, it does require them to pay dumping fees at the official dumping sites. In Dakar these fees are $0.6/m3 per trip to the Fecal Sludge Treatment Plant and in Touba it is $50 per month - the site in Touba is simply open land with no treatment facility.

3.2 Institutional Framework: Asia

Various agencies and authorities in **Bangladesh** carry out urban sanitation services. The water, sewerage and storm-water drainage sector in Dhaka come under a governance and legislative framework specifically applicable to Dhaka i.e., the Water and Sewerage Authority (WASA) Act (1996). In Khulna too, the Khulna WASA is responsible for the same. In the cities where no WASA has yet been established (such as Faridpur), the respective Water Supply and Sewerage Sections of City Corporations or Municipalities are responsible for water and sanitation services. According to the Local Government Act (2009), municipalities must manage all types of waste including fecal sludge, solid waste, liquid and industrial wastes. Further to this, Schedule II of the Act describes the responsibility of the municipality to provide/identify places for dumping of wastes and instructs city dwellers to follow guidelines for dumping of wastes. Although the municipality is supposed to prepare and disseminate detailed guidelines, this has not yet been done.

Dhaka is the only city of the three in the study that has a sewerage network, and that only covers about 20% of the city. In these latrine-based cities, emptying of domestic sludge is mostly performed manually with mechanical emptying being almost non-existent. Mechanical emptying is provided by two non-profit organizations in Dhaka each using one $2m^3$ Vacutug,[4] in Khulna by the city corporation that operates two tank lorries towed by a tractor, and in Faridpur, by the municipality that operates a single $0.6m^3$ Vacutug.

[4] A UN-HABITAT designed mechanical system capable of being manufactured locally using readily available components that would be affordable, easily serviceable and able to operate in narrow passageways. See http://www.unhabitat.org/content.asp?cid=4958&catid=548&typeid=24&subMenuId=0

The **Cambodian** government issued a National Policy on Water Supply and Sanitation in 2003 that is the only document that addresses urban sanitation and consists of three parts: urban water supply, urban sanitation and rural water supply and sanitation. The document identifies the need for "separate responsibilities" (for operation and regulation) among "the Ministry, other responsible ministries and local authorities," without naming any of them. The policy does, however, assign responsibility for urban sanitation to "Municipal and Provincial authorities." The last chapter of the policy is explicitly focused on "expanding service to the poor" but guidelines provided do not consider non-sewer solutions and only address financing mechanisms, including "target subsidies" in "exceptional circumstances" (Kopotopolous 2005). As Kopotopolous noted,

> "while this document offers a broad framework, and lofty goals, it is not a strategy document with a clear road map of how to proceed, nor does it delineate who has the responsibility for carrying out the strategy. The lack of an implementation strategy probably reflects the low priority accorded sanitation by the authorities."

In relation to urban sanitation, multiple ministries at the national level are responsible for urban drainage and sanitation, water-pollution control, regulation of sanitation facilities and construction permits. At the provincial level, in each of the cities in the study, local departments of the ministries are responsible for construction and management of treatment plants, pumping stations and sewer networks.

In Cambodia, private operators perform household sludge emptying and the public municiple trucks are used to maintain the sewerage systems. These private operators have to apply for three different permits or licenses from the ministries –to transport more that $10m^3$ a day, for use of the vehicle and to provide sanitation services

In **India**, separate regulation for fecal sludge does not exist in the surveyed cities although current laws do deal with diverse water, wastewater and sanitation services. Local governments are responsible for local sanitation regulations but in the absence of any policy or norms on fecal discharge or management, these local governments have no direct control in relation to fecal sludge management. The frequency of septic-tank emptying is left to the discretion of households and emptiers take care of disposal of sludge with no guidance or regulation enforcement. Septage management is not covered in a holistic manner beyond the prohibition of its discharge into water bodies.

Toilet, septic tank, and sewer design and maintenance are regulated through the 1983 National Building Code of India. The section on "Drainage and Sewerage" specifies the sizing and design of septic tanks, sewers, toilets and other sanitation devices. However, it is worth noting that these specifications may only be theoretical as there is no system in place to ensure that these

standards are actually applied. Furthermore, guidelines for sludge management do not exist. In Delhi, the Delhi Pollution Control Committee is the agency with the responsibility of establishing standards and in Jaipur and Madurai, it is the responsibility of their respective State Pollution Control Boards. However, regulations for empting tanks are notably absent.

In India private service providers do not need profession-specific licenses to operate, other than a drivers license for any vehicle being used. Due to subsidized loans available in the agriculture sector, many operators apply for these to purchase tractors that are later converted into sludge emptying trucks by addition of appropriate pumps and hoses.

Sewerage development and management in **Malaysia** has seen a transition over the years. Although responsibility used to rest with local authorities, water supply and sewerage services are currently a federal responsibility. The regulator for these services is the National Water Services Commission (SPAN) under provisions contained in the Water Services Industry Act, 2006 (WSIA). Fecal sludge management is regulated by SPAN under provisions within this act with the Department of Environment (DOE) playing a secondary regulatory role through the enforcement of the Environmental Quality Act 1974. Through this act the DOE has responsibility for protection of the environment through the control of pollution from sewage and fecal sludge discharge or disposal. The other main players in fecal sludge management are the service providers, which include the Service Licensee Indah Water Konsortium (IWK), which provides nationwide sewerage services and other private contractors (permit holders) who are licensed by SPAN.

IWK, has been entrusted with the task of developing and maintaining a modern and efficient sewerage system for the country. The provision of sewerage services is regulated and licensed by SPAN and this includes fecal sludge extraction, transportation, and treatment and disposal. Prior to enforcement of WSIA in January 2008, FSM services for ISTs within IWK's concession areas (including the 3 cities), were scheduled by IWK and undertaken on a 2-year cycle. Since then, emptying of on-site facilities has been made demand driven and not pre-scheduled, although desludging every three years is now recommended. While private entrepreneurs are allowed now to compete with IWK for the business, many operate as sub-contractors to IWK due to the security provided by the latter in securing work for them

Septic tanks form the foundation of **Vietnam**'s urban sanitation infrastructure as the most popular means for sanitation pretreatment. The National Design Standard of Vietnam for Wastewater Systems, which applies mainly to urban areas, sets the technical specifications and standards for the size and design of septic tanks. The Ministry of Health has issued the Manual for Septic Tank Design, Installation and Maintenance. In practice, however, most cities lack the enforcement capacity to ensure compliance of household septic tanks with the standard.

At the central-government level in Vietnam, several agencies are responsible for issuing and guiding the implementation of policies for the development of water supply, drainage, and sewerage infrastructure. The national government has not, however, mandated septage management or provided relevant policy guidance. There is no information on fecal sludge management in either Decree 88 (Urban and industrial wastewater management) or in Decree 59 (Urban and industrial Solid Wastes Management). There are, however, penalties for dumping of sludge in the open: "fine from 100,000 to 300,000 VND for dropping of fecal sludge during transportation in the City or not maintaining hygienic conditions''[5]. While it is the Ministry of Planning and Investment that arranges for funds for sanitation programs across the country, it is the Ministry of Construction that is responsible for establishing and implementing policies on sanitation and wastewater infrastructure in Vietnam. In particular, it develops infrastructure for flood control, water supply, sanitation, and wastewater programs and monitors the implementation and adoption of these plans and codes.

The most common public waste-collection service provider is the Urban Environment Company (URENCO). This company is responsible for collection and treatment of domestic, commercial, industrial and construction waste and operates the landfills in the cities. In Hanoi, it operates a small (14,000 tons a year capacity) waste treatment facility for co-composting solid waste with fecal sludge collected from public toilets. In Hanoi, Hanoi Sewerage and Drainage Company (HN SADCO) is the public utility responsible for wastewater management in the city. Its current function is to provide operation and maintenance of the sewer network in the city to alleviate localized flooding during the rainy season. In Hai Phong the utility Hai Phong Sewerage and Drainage Company Limited (Hai Phong SADCO) is responsible for operations and maintenance, rehabilitation, construction of sewerage and drainage, wastewater and sludge treatment systems. In Ho Chi Minh City, the utility Ho Chi Minh City for Environmental Sanitation (HCMC CITENCO), leases out mobile public toilets and provides emptying services for public toilets

While the public utilities are engaged in fecal sludge collection in Vietnam, most of the domestic sludge collection is conducted by private businesses. All de-sludging operators in urban areas are required to obtain a business license to open and run the business and are fined for illegal dumping.

[5] Article No. 9 in the government's Decree No 150/2005/ND-CP regulating administrative fines

CHAPTER 4: EMPTYING AND TRANSPORTATION BUSINESSES

In order to capture the composite picture of the business of collection and transportation of fecal sludge from on-site sanitation facilities, it is important to understand the contexts in which these businesses operate. Towards that end, this study gathered data from household surveys on users profile, types of on-site sanitation systems, emptying frequency, fees and choice of services selected. This allowed for an estimation of the size of the market that is available to the service providers – public and private. Further analysis of the business operators' income statements, then provided a comprehensive view of the conditions, trends and profitability models of the service providers.

4.1 Demand For Emptying Services: Household Survey Results

4.1.1 Sanitation systems

As the focus of the study was emptying and transportation of the sludge, the on-site sanitation technologies surveyed specifically considered the type of on-site technology without including user interface as part of this study. If the sanitation facilities were directly connected to the storm water drainage pipes or to the environment, they were not captured in the household survey as these systems – like the ones linked to sewerage network – did not require emptying services.

A septic tank is defined as " a watertight chamber made of concrete, fiberglass, PVC or plastic, for the storage and treatment of blackwater and greywater. Settling and anaerobic processes reduce solids and organics, but the treatment is only moderate. A Septic Tank should typically have at least two chambers." (Tilley et al., 2008). However, as there is some variation in what different people commonly refer to as a "septic tank", it is important to clarify the descriptions used by the country teams. With the exception of India, all country teams defined septic tanks as multi chamber receptors with effluent discharged in soak away pits or the environment. In the case of the surveyed areas in India, it would appear that what are described as septic tanks in Delhi and Jaipur, are actually large holding tanks. The Central Public Health & Environment Engineering Organization (CPHEEO) in India prescribes septic tanks as double chambered with specified sizes, but in practice these standards are rarely followed. CPHEEO is only a technical advisory body and it has no mechanism to ensure that these standards are adhered to by individual households or by urban local bodies that are responsible for public sanitation. Thus there remains a big gap between prescription and practice.

	Septic tank descriptions used by country teams
Bangladesh	Multi-chamber tanks that have outflows connected to available drains. If the tank was a single chamber with or without an outflow, it was recorded as a pit
Burkina Faso	A double chamber system made of concrete, the septic tank receives wastewater from the household. After decantation of the suspended solids in the second chamber, the effluent is dispersed by infiltration from a sump.
Cambodia	Most of the septic tanks were built under the French rule during the 50s. Sealed at the bottom to prevent infiltration to the environment, they are composed of two chambers with average volume from 2 to 3 cubic meters.
Ethiopia	An underground masonry wall or reinforced concrete tank having a compartment, with its effluent discharged to a soak away pit
India	Septic tanks are mostly single chambered units with variable sizes, depending on space availability, family size and affordability factors. A large number of single chamber septic tanks in urban poor settlements are deliberately designed with the mouths open to drain out excess water into the environment. In Jaipur, in addition to the commonly used single chamber septic tanks, the other widely used septic tank equivalents consist of "off-the-shelf" cylindrical concrete frames, bottom sealed, with holes on the sides to allow percolation. Households in Madurai generally prefer double-chambered septic tanks.
Kenya	Septic tanks refer to waterproof chambers (usually double rectangular) installed below ground to receive sewage. Septic tanks separate solid components (sludge) and liquid components. After separation, the liquid components leave the septic tank and are filtered through soakage pits or drainage fields and discharged to the soil.
Malaysia	The general capacity of a septic tank is designed based on a per capita wastewater generation rate of 225 liters per day (consisting of toilet waste and sullage) and a household size of 5 persons per residential premise (household survey results shown that this is generally true for the 3 cities studied). The minimum volumetric capacity of a septic tank should not be less than 2cu.m and consists of at least 2 compartments to allow for effective settlement of solid and retention of floatables
Nigeria	Rectangular single chambers cited below ground level, that receives both excreta and flush water from the toilets before the effluent is discharged into a soak-away pit.

Senegal	Underground tank for the preliminary treatment of domestic wastewater, generally rectangular in shape, compartmentalized into two or three chambers, depending on the amount of water to be treated.
Vietnam	Septic tanks are usually two or three chamber systems made from bricks, or reinforced concrete. The first, receiving chamber, often is built with largest portion of the total tank volume, giving space for solids accumulation and anaerobic digestion. Total volume of the household septic tank, depending on available space and financial availability, often ranges from 1.5 to 5 m3.

A wide range of on-site sanitation solutions exists in the Asian countries. Malaysia, on the one hand, has very scripted collection chamber designs, sizes and even emptying frequency, well enforced by the local authorities. While on the other are cities like Dhaka in Bangladesh where millions of households are connected directly to open drainage canals as a means to discharge the sewage.

In both Cambodia and Vietnam, a large percentage of the urban households are connected to the sewer network, but both countries use septic tanks or pits as pre-treatment sites before the sewer connection. In Vietnam, septic tanks are the most popular sanitation pretreatment means in the cities. Most of the septic tanks in Vietnamese urban households receive only black wastewater. Grey wastewater from kitchen, bathroom and washing sink is often discharged directly to the city's sewer. The National Design Standard of Vietnam for Wastewater Systems, sets the technical specifications and standards for the size and design of septic tanks, but lacks enforcement of the use of these systems. As a result, fecal sludge from most of septic tanks is not emptied regularly, leading to poor treatment performance. Though they does not meet effluent standards, until the cities build centralized wastewater treatment plants these household septic tanks play a very important pretreatment role

In Cambodia, pits play a similar pre-treatment role. Most common in urban Cambodia are single or multiple pits linked in series (Figure 5), and connected to a sewer or sometimes discharged directly into the environment. The pits are rarely sealed at the bottom to permit the infiltration of wastewater into the ground. Consequently, only the supernatant is discharged into the sewer system or into the environment. The pit is composed of three concrete rings with a diameter of 0.90 meters. Average volume is estimated from 0.75 cubic meters to 1.5 cubic meters.

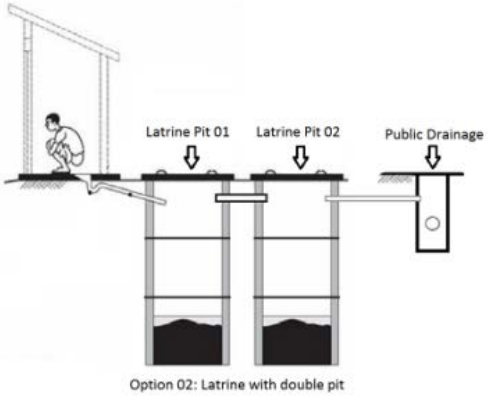


Figure 5: Multi-chambered pits

4.1.2 User profile

The survey questionnaire helped determine the profile of the households that use on-site sanitation facilities and services. This information was not compared to similar data for the general population in these countries, as that was not part of the scope of this study.

The interviewees of the household surveys across the 30 cities were 51% female and 49% male. The typical person living in a house with on-site sanitation works in the private sector in service or business (55%), has received some form of education, whether formal or non-formal schooling (87%), and owns his/her own house (77%).

A more detailed breakdown of the occupations of the head of the household is listed in Table 3 below:

Table 3: Occupation of the household heads with on-site sanitation

		Private sector	Industry/ Handicraft	Civil servant	Agriculture	Other	No answer
Asia							
	India	62%	0%	15%	1%	19%	4%
	Malaysia	70%	0%	16%	1%	13%	0%
	Bangladesh	63%	10%	21%	0%	7%	0%
	Cambodia	56%	5%	18%	4%	0%	17%
	Vietnam	22%	0%	42%	15%	20%	0%
Africa							
	Ethiopia	65%	1%	31%	2%	1%	0%
	Nigeria	41%	0%	29%	5%	25%	0%
	Kenya	91%	3%	0%	2%	5%	0%
	Burkina	62%	23%	0%	7%	7%	1%
	Senegal	35%	15%	14%	4%	31%	1%

The most common asset owned by the households is a telephone (72%), followed closely by a television (69%). A motorcycle is the typical transport vehicle a household has (38%), with 24% households owning a bicycle and a surprisingly high number with a car (19%). Details by country are shown in Table 4.

Table 4: Assets owned by the households

		Bicycle	Motorcycle	Car	TV	Telephone
Asia						
	Bangladesh	0%	0%	0%	91%	9%*
	Cambodia	56%	86%	20%	0%	97%
	India	43%	62%	7%	92%	67%
	Vietnam	36%	95%	5%	97%	92%
Africa						
	Burkina	56%	78%	25%	81%	24%
	Ethiopia	1%	4%	13%	72%	58%
	Nigeria	1%	7%	37%	87%	91%
	Kenya	16%	12%	26%	59%	89%
	Senegal	11%	13%	24%	86%	92%

* Bangladesh team considered only landline phones in their survey

In the surveyed areas in the countries of Africa, income per household for people living in houses with on-site sanitation facilities is the highest in Senegal at $393 per month, which is still lower than Cambodia, Vietnam and Malaysia. Figure 6 shows the monthly income per household and provides an indication of the economic status of the persons living in urban households not connected to central sewerage systems.

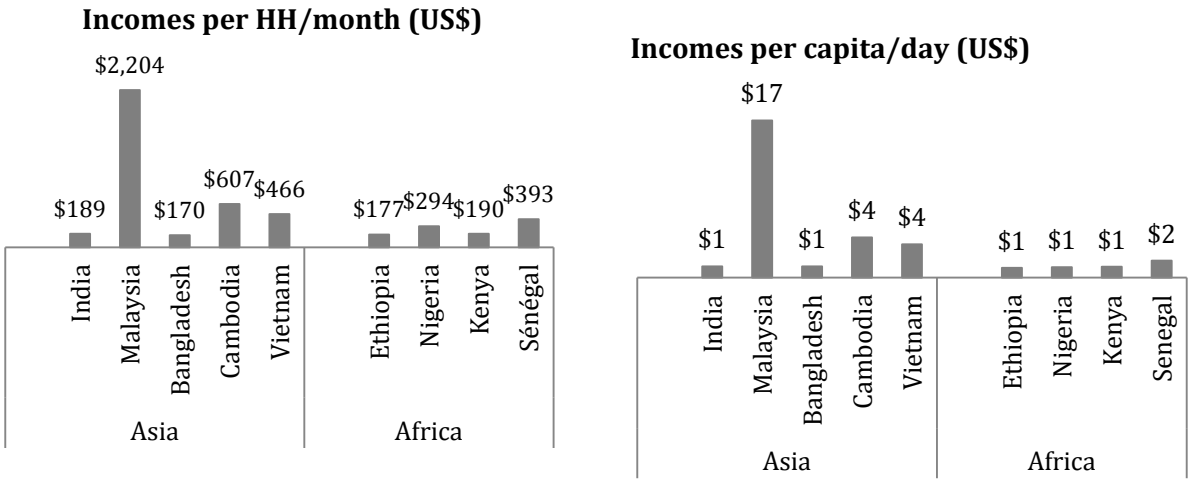


Figure 6: Income per household and per capita

The monthly expenses on basic services like electricity, phone and water, show Senegal, Burkina Faso in Africa and Cambodia and Vietnam in Asia as the costliest (Malaysia data was only recorded for water which averaged $11). Also, of all the services, electricity charges per month were highest in all countries – 15% of monthly income in Senegal, but only 4% and 5% respectively in Cambodia and Vietnam (Figure 7).

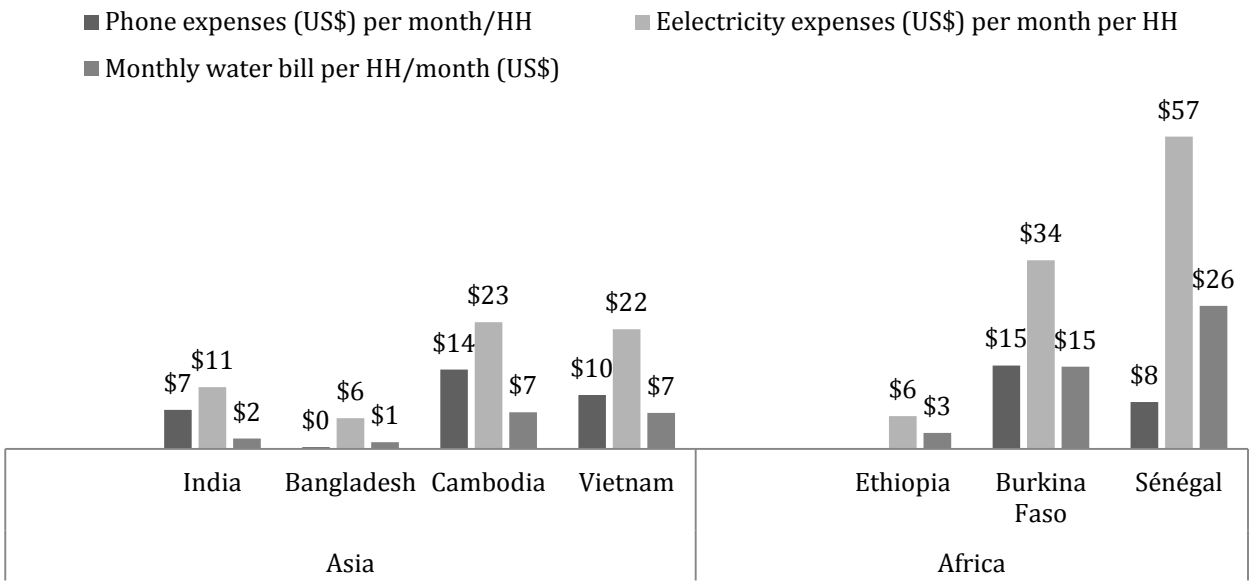


Figure 7: Monthly household expenses

The households' fees for mechanical emptying service ranges from a low of $8 (Addis Ababa) to a high of $171 (Mombasa) country to country. Using the frequency of emptying (also determined during the surveys), the prorated monthly expenses for emptying services was computed, and found to be relatively small when compared to that for electricity, water and telephone (Figure 8). The emptying expenses are between 1% to 5% of the monthly income across the countries. The maximum spend per month on emptying services thus computed, is estimated at $7.6 in Kenya and the lowest in Cambodia at $1.4. The key difference with other expenses of course, is that the emptying fees are paid in lump sum at the time of service, typically every few years, rather than in these smaller payments monthly.

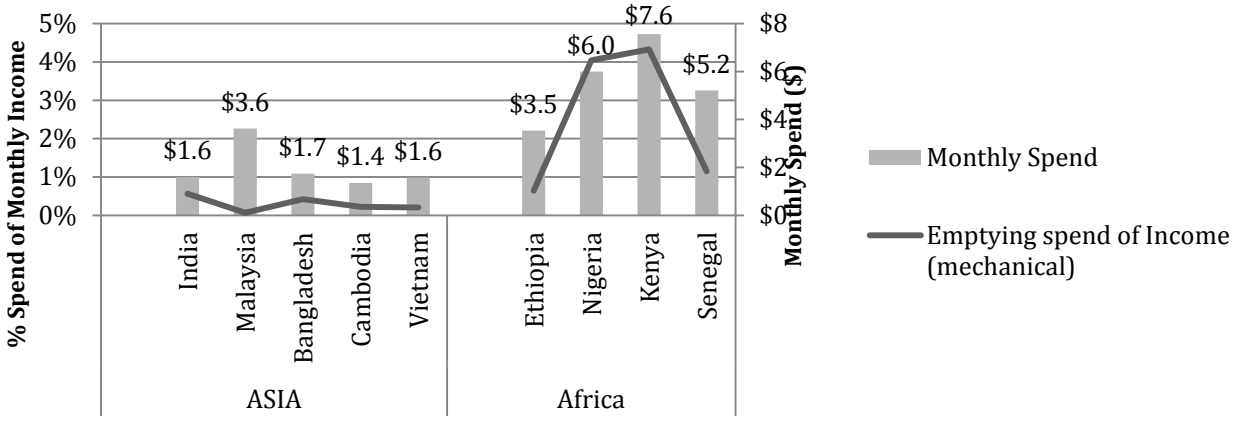


Figure 8: Monthly expenditure on emptying services

Access to drinking water for all countries is fairly good (Table 5), with over 50% of the households in most cities receiving piped water (private or public). In Nigeria however, the main source of water for households surveyed was through boreholes.

Table 5: Access to drinking water

		Piped water	Public stand post	Borehole	Bottles	Water vendors	Surface water	Other
Asia								
	India	20%	23%	33%	0%	7%	0%	12%
	Malaysia	100%	0%	0%	0%	0%	0%	0%
	Bangladesh	60%	9%	31%	1%	0%	0%	0%
	Cambodia	78%	0%	19%	0%	1%	1%	1%
	Vietnam	81%	1%	0%	0%	0%	16%	1%
Africa								
	Ethiopia	76%	3%	0%	0%	19%	1%	0%
	Nigeria	0%	22%	64%	0%	14%	0%	0%
	Kenya	35%	26%	20%	0%	15%	3%	1%
	Burkina	68%	20%	4%	0%	7%	0%	0%
	Senegal	71%	5%	17%	0%	4%	0%	2%

4.1.3 On-site Sanitation systems in use

Secondary research by the country teams was done to determine the access to sewer networks. Findings by city are shown in Figure 9. Not even 50% of the urban households in any of the 15 cities in Africa have sewer connectivity. In Asia, only five cities in India and Malaysia had direct sewer connectivity to more than 50% of its households.

While both Vietnam and Cambodia also have a high percentage of sewer connections, it is important to note that as mentioned before, the data for these countries includes septic tanks and pits respectively that serve as pre-treatment sites prior to the sewer connections and so have a need for emptying. In Cambodia, of the sewerage connections, 70% in Phnom Penh, 100% in Siem Reap and Kampot, first go through pre-treatment pits. In Vietnam, the percentage of the network connections that are direct connections to the sewer are only 5%, 2% and 18% in Hanoi, Hai Phong and Ho Chi Minh City respectively. So even in Asia, cities in Bangladesh, Vietnam and Cambodia either have minimal network connection, or have pits and septic tanks prior to the sewer network connectivity.

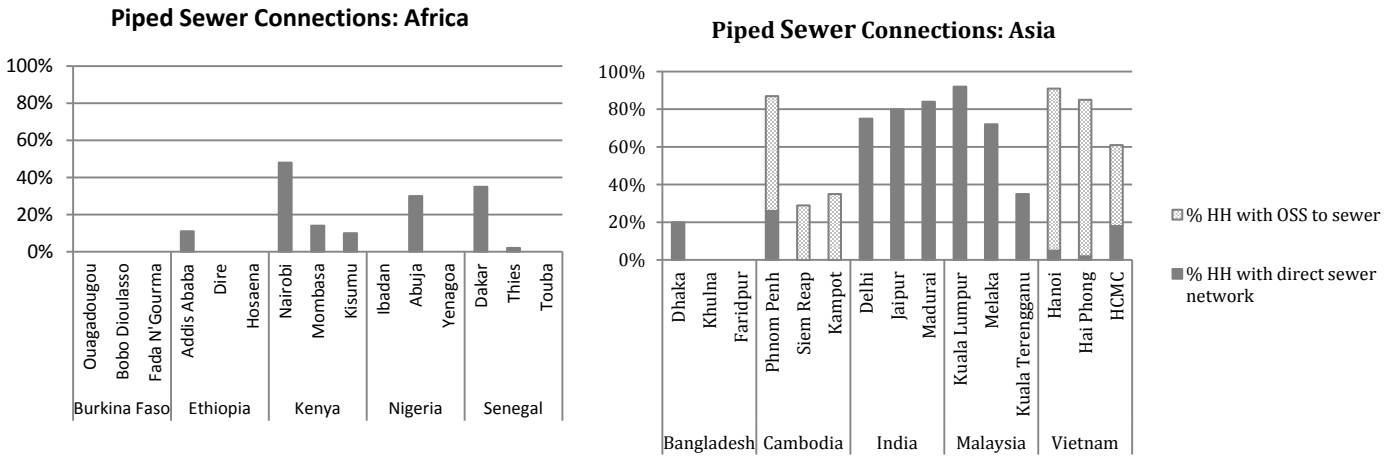


Figure 9: Piped sewer connectivity in Asia and Africa

City-level specifics of the on-site sanitation technologies used by the households are reflected in Figures 10 and 11 below. In Asia, most cities surveyed in the five countries use septic tanks, except for in Cambodia (95% pit use) and Bangladesh (54% pit use), whereas in Africa, most of the surveyed cities use pit latrines, except for in Senegal and Nigeria where 84% and 58% of the households respectively have septic tanks. Again, note the high percentages of pits or septic tanks that are used are pre-treatment systems before linking to the sewerage network in Cambodia and Vietnam respectively.

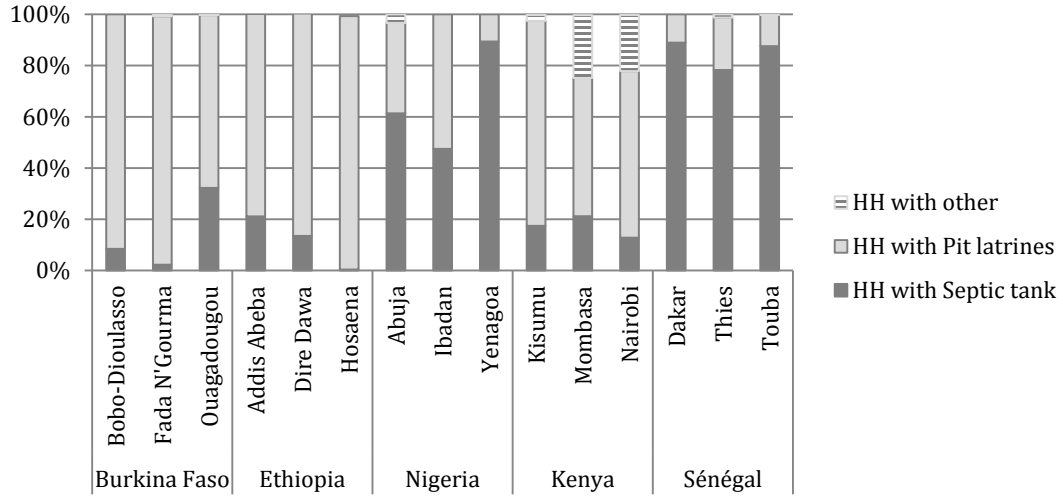


Figure 10: On-site sanitation technologies in Africa

The "Other" asset in Kenya in Figure 10 refers to cesspools, while for Abuja it is in reference to comfort stations, which are aqua privy systems for excreta disposal (essentially a holding tank located directly underneath a squatting plate. In Vietnam, "other" in Figure 11 refers to connections directly to the sewer and composting vaults.

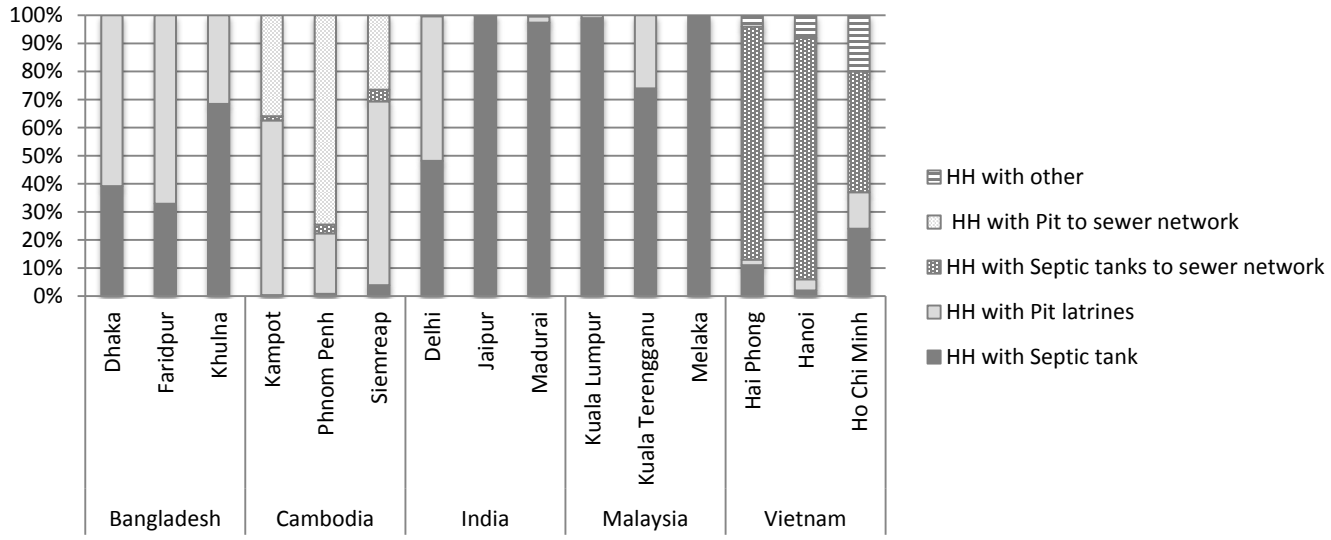
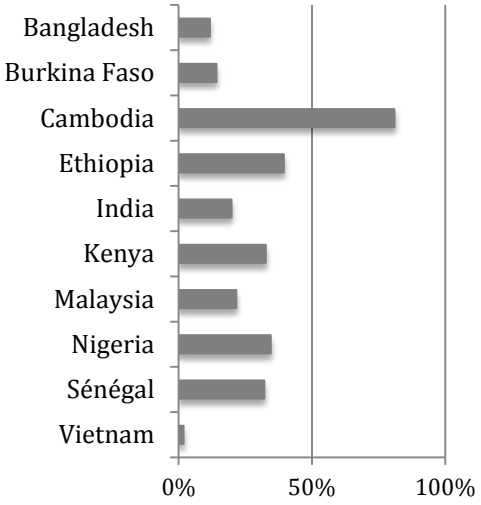


Figure 11: On-site sanitation technologies in Asia

The number of persons using the on-site sanitation facilities per household, on average is 5 in Asia and twice that many in Africa. This, and the size and design of the pits and septic tanks, will have a bearing on the required emptying frequencies. For effective operation of the septic tanks they must be emptied at a regular interval - before they get blocked. Regular emptying of the septic tanks would allow for removal efficiencies of 50 % of solids, 30 to 40 % of biochemical oxygen demand (Tilley et al., 2008). Except for scheduled desludging practiced in Malaysia and Hai Phong city in Vietnam, households seek out emptying services only when the pits and tanks get full and are overflowing.



In the surveyed areas, there were households that reported never having emptied their latrines (Figure 12). Of the households that reported having used emptying services, the frequency of emptying was typically at least once every two years, except in Cambodia and Vietnam where it was between three to five years (Table 6).

The Vietnam team had chosen only those households that had lived in the premises for more than 10 years, so it is not surprising to see that Vietnam has the lowest percentage of households that had not emptied the latrines yet.

Figure 12: Percentage of households that have never emptied

Table 6: Households' Emptying frequency of the on-site systems

	≥3 times per year	Twice a year	Every year	Every 2 years	3-5 years	6-10 years	> 10 years
Asia							
Bangladesh	3%	4%	13%	37%	23%	11%	10%
Cambodia	2%	2%	14%	13%	34%	21%	15%
India		16%	23%	23%	17%	18%	2%
Malaysia		6%	16%	42%	19%	14%	2%
Vietnam		7%	18%	0%	39%	35%	0%
Africa							
Burkina Faso		13%	19%	26%	20%	15%	7%
Ethiopia	3%	18%	30%	48%	1%	0%	0%
Kenya		30%	29%	41%	0%	0%	0%
Nigeria		11%	32%	57%	0%	0%	0%
Senegal	5%	30%	39%	16%	7%	1%	2%

Cambodia, on the other hand had a very high percentage (81%) of households not having emptied. The team tried to investigate the reason for this – from correlating to the year of construction of the pits, mapping the location of the pits to water-clogged areas of the city and type of pit or tank - but were unable to pinpoint the cause. One possible explanation could be the design with multiple pits connected in series that prolong the need for emptying, or due to the connection to the sewer line that prolongs the time needed for emptying the solid sludge.

4.2 Supply Of Emptying Services: Operator Survey Results

Emptying of the on-site sanitation facilities is done both manually and mechanically. Of the households surveyed that reported having emptied their latrines, a majority of them (63.4%) used mechanical emptying. With the exception of Dhaka, capital cities in all countries see the use of mechanical emptying as the more common method of collection. However 34.3% still use manual emptying services and 1.4% use a combination of both (Figure 13). Use of both occurs in instances where the sludge is too thick to be pumped completely mechanically, manual emptiers are brought in to complete the job. In addition to the solid content of the sludge, variety of other factors also enter into the efficacy of the vacuum trucks for emptying – the pump, length of hose and hose inlet (Bosch & Schertenleib, 1985).

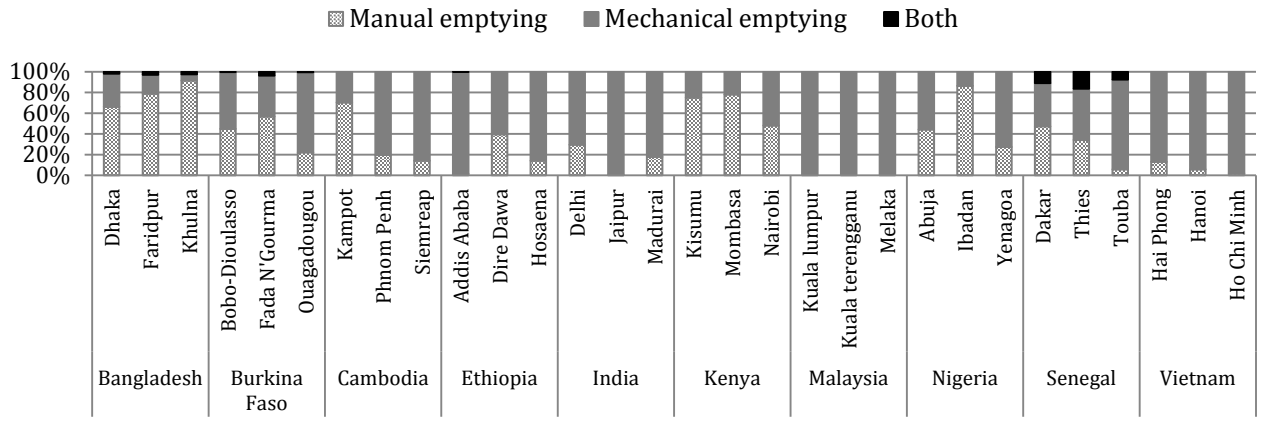


Figure 13: Method for emptying: Manual vs. Mechanical

The number of households in these 30 cities with on-site sanitation is approximately 5.6 million. With 34.3% of these households using manual emptying services, this translates to 1.9 million households across these cities that are still emptying the latrines manually.

For every private mechanical truck operating in each city, on average, there are 14,860 households in Africa and 5006 in Asia (Figure 14). The best household to private truck ratio in Africa was seen in Dakar with 1,118 households per truck.

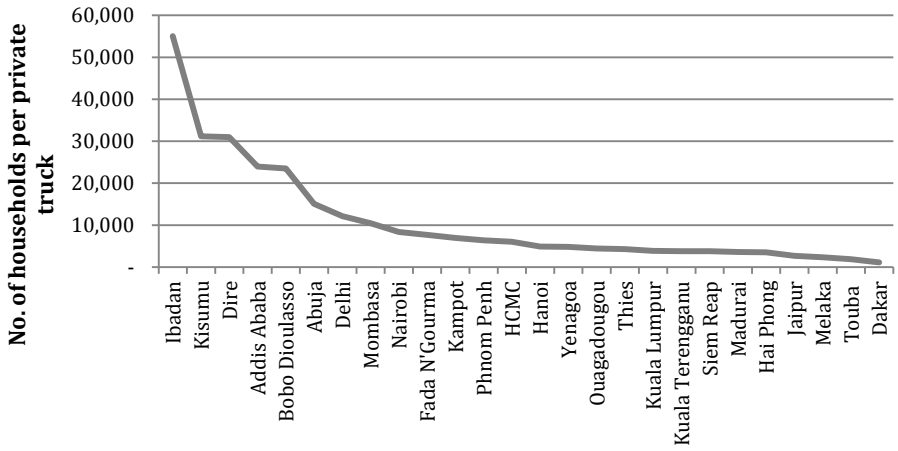


Figure 14: Number of households served per private truck

Regarding criteria for choosing the emptying service, only the households in Addis Ababa, Kisumu and Melaka reported selecting primarily on the basis of cost (Figure 15). The rest of the cities were evenly split between choosing quality of service or availability as the main factor for selecting the emptying service. The choice of cost as the primary criteria in Addis Ababa is understandable as the utility heavily subsidizes the emptying service at under $5, while the private operators charge five times as much. Similarly in Kisumu, with only 4 mechanical trucks for the city, the private operators charge on average $52 while manual emptying costs only $30. In Malaysia, the survey showed dissatisfaction with the new government regulated tariffs. Prior to the Water Services Industry Act 2006, the rates had been based on the types of premises, with lower rates for cheaper housing and higher rates for commercial premises, under an implied cross-subsidization approach. However, the new fee structure is based on volumetric consumption, and will result in increased costs for some of the households.

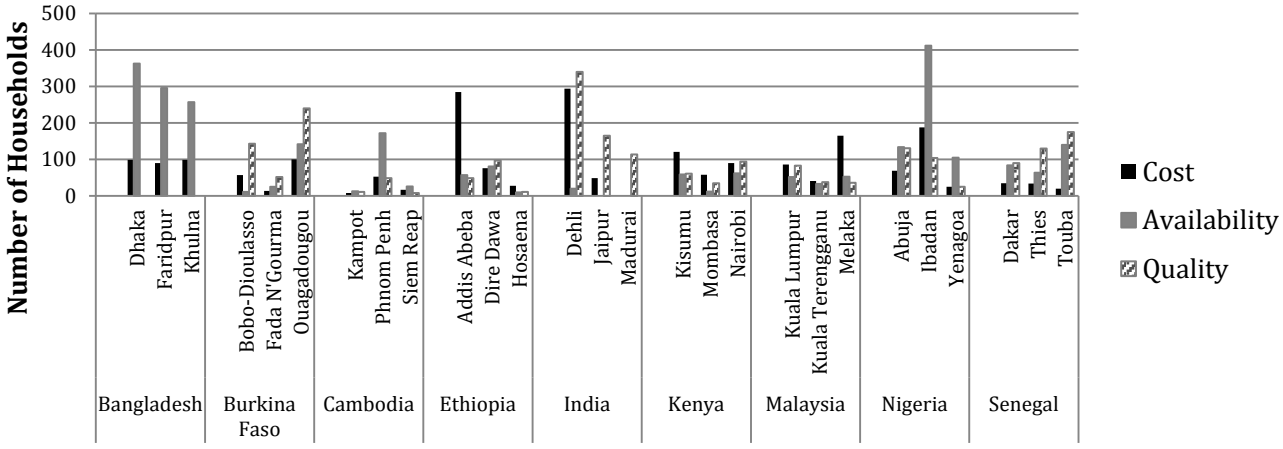


Figure 15: Criteria of the households for selection of emptying services

The following section provides a profile of the emptying service providers.

4.2.1 Manual Emptying Service Provision

While the family members of the household do some of this manual emptying, almost 90% of the times, a manual emptier is hired for this job.

Manual emptying is conducted as an informal activity by the very poor in need of additional source of income. The emptiers who do manual work, are engaged in other manual labor like construction, road sweeping, cleaning public toilets etc. In India, the manual emptiers belong to the lowest social rung called "dalits'; In Bangladesh, this work is done by the manual sweepers in the cities; In Ethiopia, it is the daily laborers in the community that take on this work for extra income; In Cambodia, these are the unemployed who wait in specific parts of the city looking for any work that is given or are solid waste collectors that also do manual emptying for some households (See Box 1).

Typically the manual emptying is done in areas that are inaccessible by mechanical trucks – usually slums and informal settlements. In Kenya, manual labor is also being used to empty out the public sanitation blocks or bio-centers, which are located in low-income areas unreachable by trucks. Given the social stigma, illegality of the work and difficulty of performing this job, many choose to do this in the middle of the night for fear of being arrested or recognized. Some reported needing to use alcohol before starting the work in order to get through it.

In Kenya, teams of five workers provide emptying services in the urban informal settlements, and lease the equipment from an umbrella group that rents the equipment to the various manual emptiers operating in the settlements.

In all countries, tools used for manual emptying are simple - usually no more than a bucket, shovel, ropes and bare hands. Some workers own these tools, while others rent it from local equipment suppliers as needed. For an activity so hazardous, minimal or no protection like hand gloves or body suits is used to prevent direct contact with the feces. Manual emptiers often spoke of skin rashes and other diseases that develop due to contact with fecal matter. Even the use of the rubber boots or gloves, if available, do not offer ample protection, as the sludge is so deep in the pits and septic tanks. With limited capital costs to run this business, the manual operators make an average of $20 to almost $400 per month in profits.

The sludge collected manually is either buried in nearby land, or dumped in the fields or open drains. If it needs to be carried some distance for disposal, a variety of cheap local transportation methods are used - handcarts, bullock carts, and rickshaws or loaded into drums and carried atop trucks as in Nairobi.

Box 1: Manual emptying

Cambodia

Standing on the side of the road in a busy part of Phnom Penh, Mr. Por, a father of two, waits like he has for the past 5 years. Waiting to be hired for any one of the jobs workers on this street corner are hired for - manual desludging, construction labor, cleaning or other little jobs that can be negotiated for a price. He estimates the desludging represents 20-30% of his income, as he's called for an emptying job once or twice a week, earning between $100 to $200 a month from the pit emptying. Rainy seasons are better for business.

He uses his own buckets but the bags are provided by the client. It usually takes him 1-2 hours for a single pit, with at least one more person helping. But if the job requires emptying the pit and unblocking the sewerage in front of the house, it would take up to 8 hours for 3 people for a fee of $70 that is shared by all.

Source: Cambodia country team's final report for this study

Senegal

"Manual operators (known as "Baay Pelles") begin by removing the slab of the septic tank. With wet tanks, buckets attached to a rope are used to draw out excreta and the operators can stay out of the tank. With a dry tank, the excreta are usually very compact and the operators must then descend into the pit and use shovels to loosen the material and bring it up to the surface. Where possible, the material is buried in another pit dug nearby in the street or surrounding area. If there is no space for this, the excreta are transported by bucket or wheelbarrow to another location where a pit is dug for the purpose.

The working conditions of the operators are particularly difficult. The use of boots, gloves and masks may offer some protection, but in practice they are rarely used, either because the operators are not official employees, because the sludge operating companies do not have the financial means to provide them, or because they interfere too much with the work. The presence of waste in the tank impedes their work, and it is common to encounter medical waste (syringes, in particular) which endangers the lives of the operators."

Source: Extract from Final Report of Senegal country team

4.2.2 Mechanical Emptying Service Providers

The private operators in most countries are the primary providers of mechanical fecal sludge emptying services, rather than the water and sanitation utilities (Figure 16). In Africa, only in Addis Ababa and Dire were public utilities taking the lead as the main service provider. In Asia, public role was dominant in Malaysia and Bangladesh- albeit in very different scale and impact.

In Malaysia, while it is not the national utility that operates the emptying operation, the Finance Ministry owns Indah Water Konsortium (IWK) who is the concession holder for providing national sewerage services. IWK is the primary service licensee of the National Water Services Commission (SPAN) with private operators as permit holders. In Kuala Terengganu, IWK is the sole operator, while in Melaka and Kuala Lumpur, IWK sub-contracts the private operators to assist with the services. Private operators may also seek out their own clients.

In Bangladesh, where emptying is done manually for the most part, limited mechanical emptying is provided by the municipality in Khulna and Faridpur. In Dhaka, the mechanical emptying is done via tiered pricing by two non-profit organizations using the Vacutug.

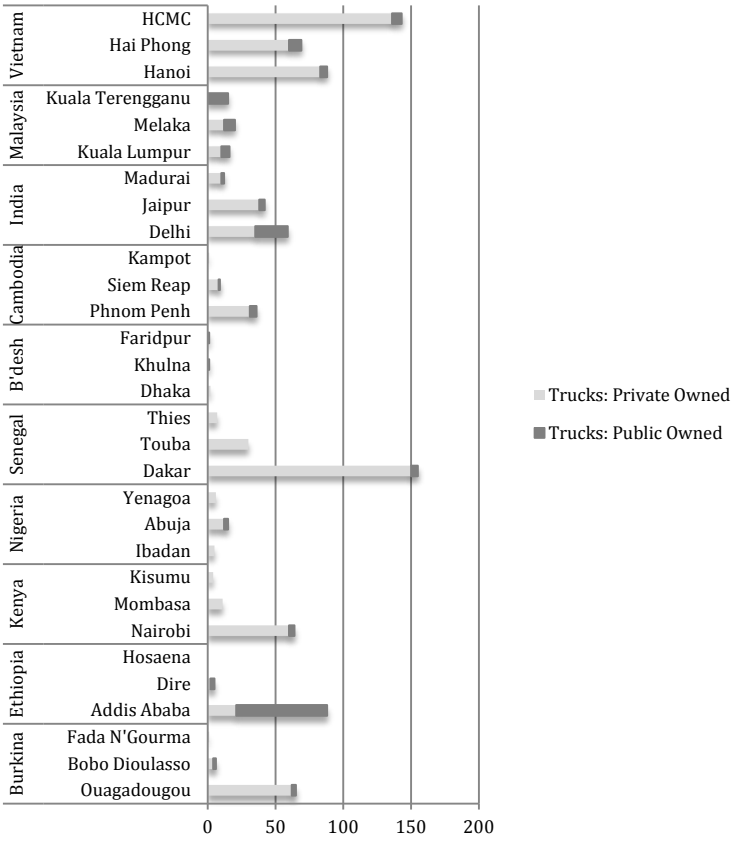


Figure 16: Household-emptying trucks: Public vs. private

Even in those cities that have emptying trucks that are owned and operated by the public authorities, these trucks are not always used for household emptying purposes, but are mostly deployed for collecting sludge from public buildings or cleaning out sewage lines.

Collectively, the 112 private business owners that were interviewed for this study owned and operated 249 trucks across these cities.

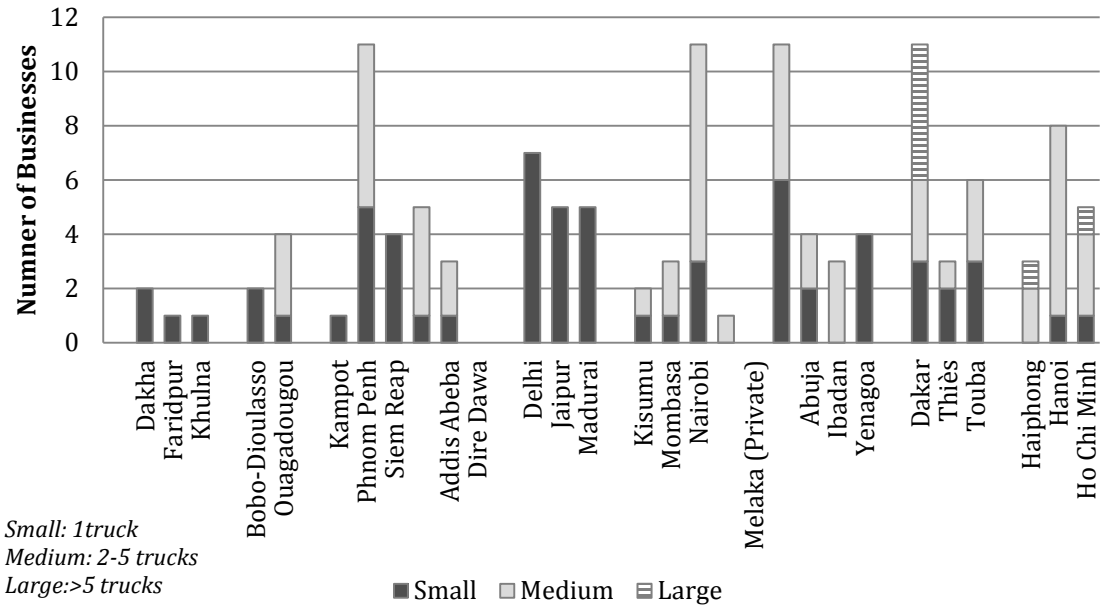


Figure 17: Size of mechanical emptying businesses

Segmenting the size of the businesses as small (1 truck), medium (2 to 5 trucks) or large (>5 trucks) based on number of trucks owned, it was noted that most of the businesses (50%) are single truck operations. Of the remaining, 44% owners had between 2 to 5 trucks and only 6% of the private business owners manage a large fleet of trucks (Figure 17).

The typical profile of a mechanical business is a self-financed sole proprietorship, which is operated formally or informally. India was the only country where all private operators' businesses were informal. Start-up capital comes from personal savings or loans from family and friends. Bank credit is hard to come by due to a lack of collateral and high interest rates for what is perceived as risky business by the financial sector. In Kenya, with trucks requiring three licenses to operate, the vehicle logbook acts as the collateral for the loan facility. In India, entrepreneurs are able to get bank loans at 12-14% for the purchase of tractors that are then patched up with tanks and pumps for emptying services. Commercial loans in India that can run as high as 18-24% are avoided by the purchase of tractors, as loans for tractors - not the tank and other accessories - are considered agricultural loans following priority sector lending guidelines. Of the 112 private businesses in the ten countries, only 20% reported having taken a loan.

Most of the business owners also engage in other income generating activities besides fecal sludge emptying to supplement their income. These activities range from using the trucks for transportation of industrial or solid waste to the use of tractors in agriculture.

Organizational structure of the emptying businesses is a loose one, with typically 2 to 3 employees forming the crew for each per truck – the driver and pump operator and an assistant.

Cambodia is the only country with a fixed cost associated with marketing – for personnel, leaflet printing and distribution. Advertisement of services is done informally – by writing the contact phone number of the side of trucks, printing leaflets and flyers or simply by word of mouth from existing clients. All have expenses related to telephone charges as that is the main source of contact from customers. Some have fixed costs of an office while others operate from their homes. Trucks are parked in personal spaces or streets. In Abuja, the registered trucks are allowed parking at the Abuja Environmental Board premises free of charge.

Box 2: Impact of marketing expenditure on increased market share in Phnom Penh

In Cambodia, there is an intense competition for the household emptying services. As noted before, over 80% of the households reported never having their latrines emptied. The market, especially in Phnom Penh, seems to be over-saturated with supply of the 31 trucks among 19 operators. The number of customers for these businesses varies a lot with 73% having less than 30 clients per month, but some managing to do over 100 household emptying jobs each month.

Operating in a competitive market like Phnom Penh, saw the emergence of aggressive marketing strategies used by the operators. The businesses spending the most on marketing campaigns demonstrated a direct correlation to their ability to secure more customers and profits (Figure 18).

The marketing approach focussed on the use of leaflets and painting telephone numbers on the trucks, poles and signboards in the city. The country team estimated that in Phnom Penh, more than seven million leaflets are printed and distributed each year to stay ahead of the competition.

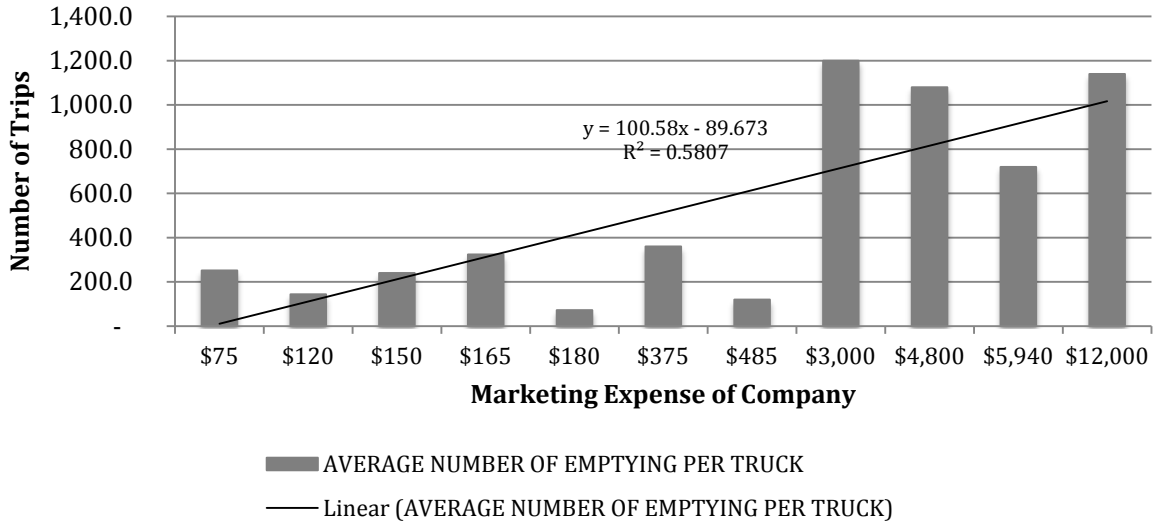


Figure 18 : Correlation of number of trips with marketing expenses in Cambodia

4.3 Market Size For Emptying Services

The annual fecal sludge produced in each city was calculated based on the physical size of the pits, septic tanks or cesspools and the emptying frequency reported by the households during the survey. The calculations were then extrapolated to the city population using on-site facilities i.e. not just the survey population. Details of the calculation used are shown in Appendix D.

Assuming that households use the emptying services only when the latrines are full and need emptying, this method provided the annual production of sludge for households with on-site sanitation systems. The size of the pits and septic tanks were physically measured during the conduct of the household surveys by the teams and the averages are shown in Table 7 below:

Table 7: Average volumes of pits and septic tanks and users per latrine

	Septic Tank (m^3)	Pit (m^3)	Number of users per latrine
Bangladesh	16.2	3.2	5*
Cambodia	2.2	1.5	5
India	5.2	1.6	6
Malaysia	2.0	1.3	4
Vietnam	2.0	1.4	5
Burkina Faso	6.0	4.6	11
Kenya	5.0	2.6	8
Ethiopia	18.8	12.0	7
Nigeria	18.0	10.3	16
Senegal	9.0	3.0	13

* Septic tanks are shared by multiple households with individual household latrines

Emptying fees per city were gathered during household surveys as well as during interviews with the operators themselves. Also obtained was information about the range of truck capacities in each city. Figure 19 shows the average fee per cubic meter reportedly paid by the households as well as the fee per cubic meter charged as reported by the operators.

For the most part these two data points were close, but in some instances, the fees the households stated they paid versus what the operators said they charged were quite different. A couple of reasons could explain this variation – the household data is typically dated, in that, it is based on what was paid the past time emptying services were

used. This could be a few months to a few years ago, and fees could have changed in the interim – as they indeed did in the case of Malaysia where the entire tariff system was completely revised by the authorities. In Delhi where there was a big difference noted, it is believed to be due to under-reporting of expenses of the residents in the low income communities of the survey. The households are mindful of the effort to find out their income levels through expenditure surveys, and higher expenses/income levels could exclude them from many government subsidy benefits for the poor. For these reasons, the teams believe the fee determined during business surveys is more accurate as it reflects the current market. It is for these reasons that the fee data gathered from the interviews of the operators, has been considered as the accurate data on emptying fees, and been utilized in computation of the market size.

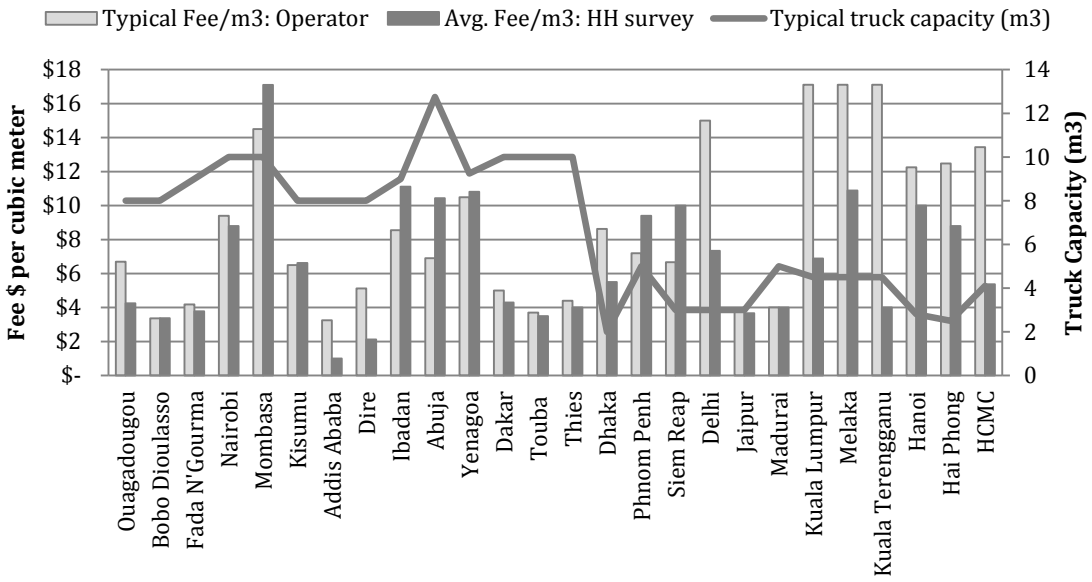


Figure 19: Emptying fees and truck capacity per city

From the secondary data on the number of households per city and the percentage of households with on-site sanitation, the number of households per city with on-site sanitation systems was computed. This, along with the surveyed data on the size of the pit/tank and the emptying frequency, allows for a determination of the volume of fecal sludge produced by households per city. However, what is produced is not what remains in the pits or septic tanks at the time of emptying, as the remains is what has been accumulated after losing content from degradation and outflow. The fecal sludge *accumulated* in on-site sanitation facilities in these 30 cities is computed to be over 17 million cubic meters – 80% of it being in the African cities. (City specific data is shown in Tables 8 and 9).

By knowing the number of users per latrine (also gathered during household surveys), fecal sludge accumulated per capita per day was also computed. The accumulation rate

ranges from 0.1 to 2.6 liter/capita/day, with the higher production tracking the cities containing larger portion of septic tanks. Research data has shown that for a typical pit latrine, the average addition per person per year is a total volume of 550 liters (Foxon et al., 2011). The rate of filling is varies in different studies as it depends on the rate of addition and degradation. Given the range of pit filling in literature, Foxon et al suggest a mean of 40 liters per person per year and 60 liters per person for septic tanks. This translates to 0.1 liter/day/capita for pit accumulation and 0.16 liter/day/capita for septic tanks.

Data from our study however shows the accumulation rates to be higher than these. In Burkina Faso and Ethiopia where the on-site facilities are mostly pits, the accumulation rates are between 0.1 to 0.7 liters/day/capita, and in Senegal, the septic tanks fill up at rates between 1.7 to 2.6 liters/day/capita. Our data is more aligned with the results of Montangero & Strauss (2002) who reported daily per capita volumes of 1.0 liter/day/capita for septic tanks and 0.15-0.20 liters/day/capita for pit latrines.

The different volumes of accumulation seen in this study could be due to variations in the pit and tank design, size, intrusion of groundwater, amount of greywater disposal in the latrines, along with other items like rags and garbage.

Table 8: FS accumulation in cities in Africa

	Ouagadougou	Bobo Dioulasso	Fada N'Gourma	Dakar	Touba	Thies	Addis Ababa	Dire	Hosaena	Ibadan	Abuja	Yenagoa	Nairobi	Kisumu
FS accumulated per year (m3)	439,122	59,361	4,045	2,079,107	696,960	201,514	793,239	49,333	10,972	1,829,663	1,247,193	218,022	4,604,702	691,903
# of HH in city	277,988	94,947	8,440	279,790	56,941	30,725	628,985	72,936	16,081	327,676	226,333	80,565	985,016	148,494
% HH with On-site sanitation	99%	99%	91%	60%	100%	98%	80%	85%	93%	84%	80%	36%	51%	84%
No. of HH with on-site sanitation	275,208	93,998	7,680	167,874	56,941	30,111	503,188	61,996	14,955	275,248	181,066	29,003	502,358	124,735
FS accumulated/HH (m3/yr)	2	1	1	12	12	7	2	1	1	7	7	8	9	6
No. of persons using HH latrine	9	15	9	14	13	11	7	8	7	18	14	14	12	8
FS accumulated/day/person (l/day)	0.5	0.1	0.2	2.4	2.6	1.7	0.7	0.3	0.3	1.0	1.3	1.5	2.1	1.9

Table 9: FS accumulation in cities in Asia

	Delhi	Jaipur	Madurai	Dhaka	Khulna	Faridpur	Phnom Penh	Siem Reap	Kampot	Kuala Lumpur	Melaka	Kuala Terengganu	Hanoi	Hai Phong	Ho Chi Minh City
FS accumulated per year (m3)	98,806	126,004	66,212	564,689	892,051	90,149	25,764	3,684	1,013	56,142	44,443	48,276	280,376	166,466	894,087
# of HH in city	1,700,714	508,571	224,209	3,337,470	384,169	25,342	270,942	34,421	7,922	436,900	122,600	69,700	430,638	218,795	1,017,019
% HH with On-site sanitation	25%	20%	16%	*10%*	99%	98%	73%	88%	88%	13%	38%	82%	94%	97%	81%
No. of HH with on-site sanitation	425,179	101,714	35,873	333,747	380,327	24,835	197,788	30,290	6,971	58,108	46,833	57,084	404,800	212,231	823,785
FS accumulated/HH (m3/yr)	0	1	2	2	2	4	0	0	0	1	1	1	1	1	1
No. of persons using HH latrine	6	7	5	*5*	5	5	6.3	5.4	5.6	3.3	3.4	4.1	4.7	4.1	4.8
FS accumulated/day/person (l/day)	0.1	0.5	1.0	0.9	1.2	1.9	0.1	0.1	0.1	0.8	0.8	0.6	0.4	0.5	0.6

With this data of fecal sludge accumulation in households with on-site sanitation and the emptying fees charged by the mechanical operators, the total available market across the 30 cities is estimated to be almost $134 million (Figure 20). Market size in the 10 capital cities ranges from almost $200k in Phnom Penh to over $40million in Nairobi (Table 10).

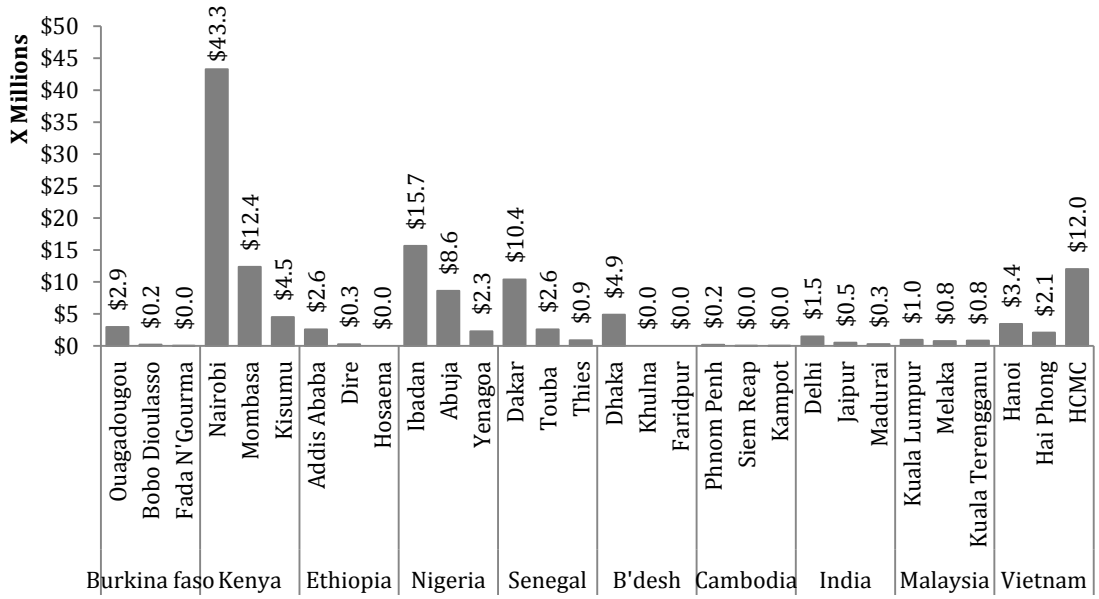


Figure 20: Market size for FS emptying services per city

Table 10: Revenue potential for FS emptying in the ten capital cities

Ouagadougou	Dakar	Addis Ababa	Abuja	Nairobi	Delhi	Dhaka	Phnom Penh	Kuala Lumpur	Hanoi
$2.9 M	$10.4 M	$2.6 M	$8.6 M	$43.3 M	$1.5 M	$4.9 M	$0.2 M	$1.0 M	$3.4 M

Comparable scale of market size has also been observed in Latin America, where a similar study of emptying services in four cities by the World Bank reported a market size between $1.8M to $5.3M (Ortuste, 2012). There is an enormous opportunity globally for revenue generation for the emptying service providers if properly tapped.

4.4 Financial Analysis Of FSM Service Provision

During the interviews with service providers, detailed income statement information was gathered for the 119 surveyed mechanical emptying businesses. A sample income statement of a medium business from Abuja is presented in Appendix C to show the various expense items captured for the businesses. There appear to be very limited number of published papers with comparable financial details of fecal sludge emptying businesses. Four studies focused on Senegal (Mbeguere et al. 2010), Uganda (Advani, R. 2008), ten countries in Africa (Collignon B. and Vezina M. 2000) and four cities in Latin America (Ortuste, F.R. 2012), were found to contain financial data of the emptying businesses.

4.4.1 Profitability versus size of the business

A comparative analysis of the business profitability was conducted by segmenting the market by (i) its size i.e. number of trucks owned: small, medium large, (ii) the truck capacity and (iii) the size of the city. These were the three key categories that were seen in the study sample relating to the size of the trucks and city.

Profitability indicators evaluated were:

- Cash flows: This is a straight forward income-minus-expenses metric that is also monitored by the business owners
- Return on investment (ROI): Ratio of profit over investment cost of the truck that captures the impact of the capital cost of the truck on profitability
- Impact of depreciation on ROI: A straight-line depreciation of purchase price over 10 years is used in this analysis. Use of depreciation accounts for the diminishing value of the asset (truck). As this is an intangible non-cash expense, most business owners do not consider it, but by doing so, they miss accounting for replacement costs of their fleet.

Source of income were broken into what was derived from households emptying services versus non-household i.e. commercial, industrial, institutional contracts, to determine if diversification of services made a difference in revenue generation. The sources of expenses were similarly divided into different categories of variable costs in order to identify which category was most expensive and needed to be reduced for increasing profitability.

At The City Level

Comparing the median monthly cash flow of the 30 cities side-by-side, grouped within the category of small, medium and large business sizes, shows an interesting trend as seen in Table 11. Irrespective of country and region, for the most part (with the exception of Hanoi, Nairobi and Phnom Penh), single truck companies – which form the

predominant global business model – earn much less *per truck* when compared to multi-truck businesses. This was also seen in data collected of one versus three truck operations in Ouagadougou by surveys conducted by Collignon B. and Vezina M.

Table 11: Monthly cash flows per truck of private businesses in 30 cities

	Small	Medium	Large
Abuja	$1,383	$11,164	
Addis Ababa	$648	$869	
Bobo-Dioulasso	$244		
Dakar	$283	$1,090	$1,629
Dhaka	-$58		
Delhi	$422		
Dire Dawa		$337	
Faridpur	-$91		
Haiphong		$708	
Hanoi	$684	$474	
Ho Chi Minh	$715	$999	$903
Ibadan		$2,457	
Jaipur	$310		
Kampot	$93		
Khulna	$375		$349
Kisumu	$353	$438	
Madurai	$210		
Melaka		-$1,887	
Mombassa	$353	$3,231	
Nairobi	$836	$300	
Ouagadougou	$577	$1,223	
Phnom Penh	$650	$333	
Siem Reap	$92		
Thiès	$103	$365	
Touba	-$145	$1,199	
Yenagoa	-$203		
Average	**$356**	**$1,456**	**$960**

Profit levels of Abuja operators are so high due to the average emptying fee charged of $88 and almost 2000 trips per year per truck. The loss borne by the private operator in Melaka (Malaysia) is due to the removal of scheduled de-sludging in 2008 that has had a negative impact of state and private operations. Private business owners in Malaysia have been impacted more severely due to reduced household demand, and the state services, while also impacted, continue to make significant profits due to sole service provider status for governmental institutions. More will be discussed on the Malaysia model in a later section.

Monthly cash flow is the profitability indicator that the operators consider when determining the viability of their operations. The business owners rarely consider depreciation when determining profits, as it is a non-cash transaction. If depreciation were to be included (as they should be), the profit levels drop significantly. And as highlighted in Figure 21, some small operators that show positive monthly cash flow are actually running overall losses for the business when 10-year depreciation costs are factored in. A total of 56 single truck private companies make up the data shown in Figure 21. The individual financial statements of each of these companies can be seen in Appendix F.

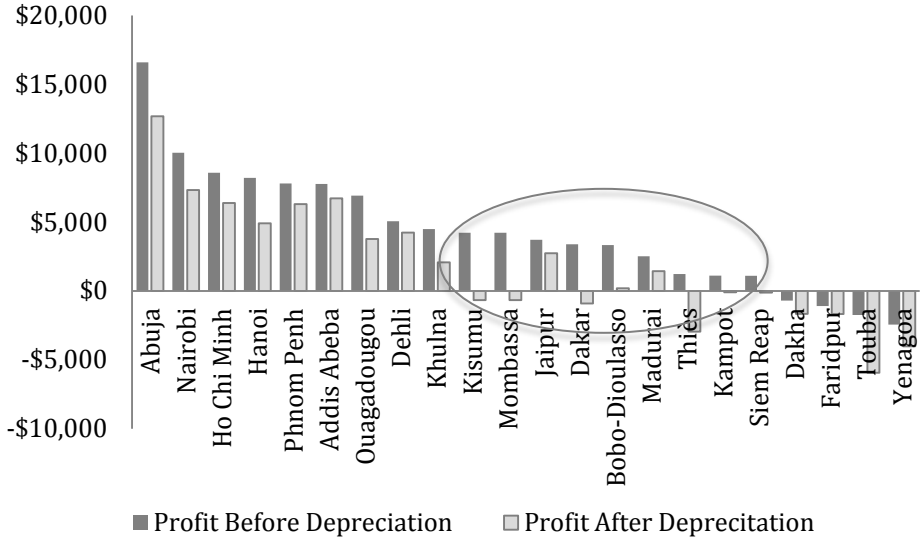


Figure 21: Profitability of small private businesses – with and without depreciation

Single truck ownership may be less profitable than other sizes because of additional efficiency and less susceptibility to downtime of a single truck. A multi-truck fleet is also able to take on non- domestic emptying contracts. Commercial emptying allows for more income as the size of tanks to be emptied in relation to the residential ones require more number of trips, and the emptying fees charged can be higher per cubic meter as seen in Senegal and Ethiopia.

A study of emptying companies in Dakar (Mbeguere et al., 2010) had reported that it was this diversification of revenue sources – that is, addition of non-domestic emptying contracts – is that factor that allowed for increased profitability of the fleet. The study had shown that a business with only domestic emptying business in Dakar was running at a loss, but one with a mix of domestic and non-domestic business was profitable. However, the data was not clear regarding if this comparison was made at a unit truck level for both companies, nor whether both these companies had multiple trucks in the fleet.

From our date we believe that inclusion of non-domestic business has a bearing on profitability, as does the number of trucks in the fleet. This is particularly true in the case of Dakar where non-domestic business carries higher tariffs than household emptying (average of $50 for domestic emptying vs. $100-$160 per trip for commercial contracts and $600 per eight hour day for a utility contract). Of the four companies in Dakar that did only domestic emptying, 75% ran at losses if depreciation was included, whereas only 28% of the companies engaged in domestic plus non-domestic emptying ran at a loss, thus supporting the findings of Mbeguere et al. In addition, we found that 100% of the single truck owners engaged in exclusively domestic emptying, whereas only 13% of the companies with a larger fleet did so, pointing to the conclusion that a larger fleet is better able to solicit non-domestic revenue and contracts.

Figure 22 shows the percentage of emptying business that is domestic vs. non-domestic. Data shown here is only for those cities that had *both* small and medium businesses for a side-by-side comparison. Medium business get 22% of their revenue from non-domestic services compared to only 7% for the small business owners. Only Abuja had both small and medium operators reaching more than 25% of non-domestic customers.

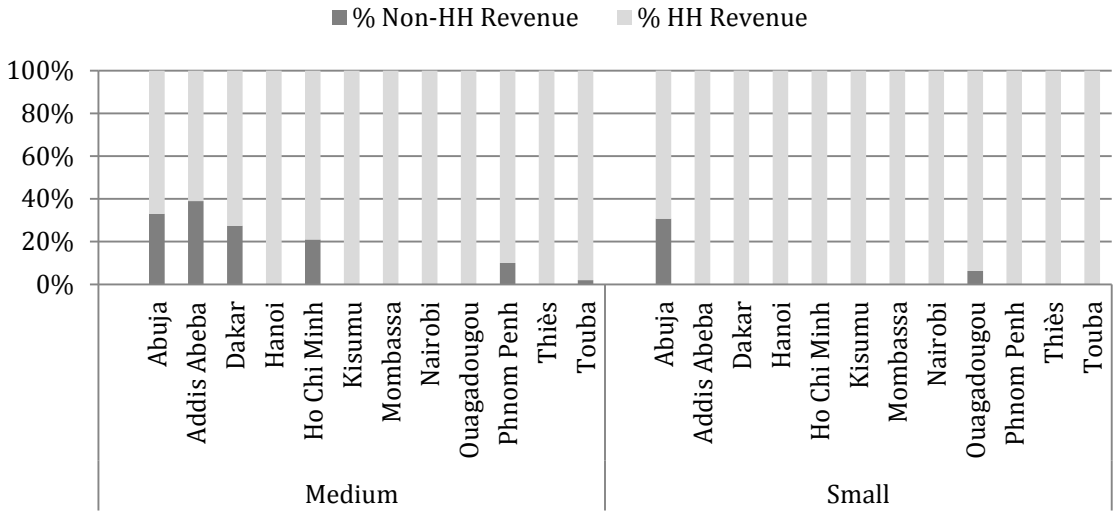


Figure 22: Percentage of non-domestic emptying customers vs. size of business

At The Country Level

Cost and Capacity: Consolidating all the operator data of various fleet sizes and capacities at a country level, a few patterns emerge. The typical cost of purchasing a truck in any of the Asia countries is well under $20,000 – with the exception of Malaysia – compared to African countries where the costs are between $27,000 and $44,000. Average investment needed per truck in Asia stands at $13,000 and $34,000 in Africa.

As mentioned before, one of the reasons for this regional variation is the capacity of trucks used by each country that is under $4m^3$ in Asia and $10m^3$ on average in Africa

(Figure 23). It is also due to the fact that in Asia these smaller trucks are assembled locally, whereas in Africa the trucks are imported second hand. In Malaysia, while trucks range within from 2.5 to 11.5 m^3 averaging $4m^3$, the cost is the highest amongst the countries surveyed. IWK in Malaysia purchases locally assembled trucks with new parts, which are later mostly bought by the private operators. The most common truck capacity in Malaysia is $4.5m^3$, which costs about US$95,000 newly assembled and $57,000 used.

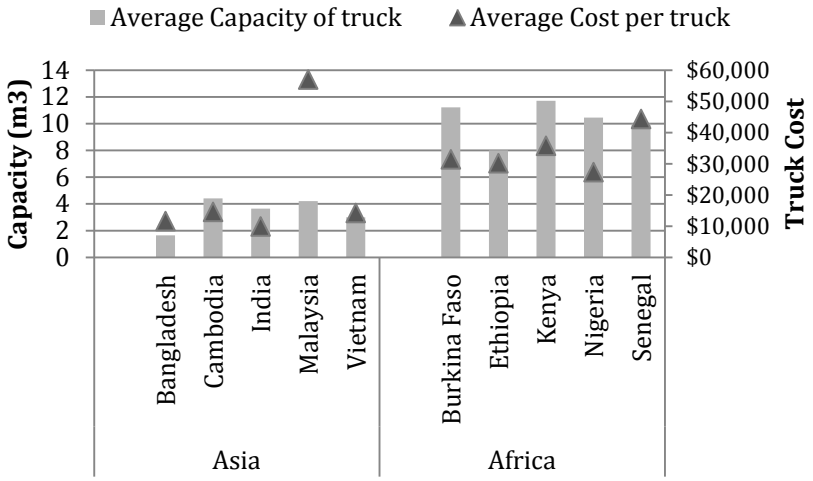


Figure 23: Truck capacity and cost

Revenues and tariffs: The median annual revenue per truck in Asian countries is lower than in Africa - $12,222 versus $36,663 (Figure 24). This can be explained by two factors:

1. The emptying fees charged in Africa are higher ($60) while in Asia the average fees are $28 (excluding Malaysia, where the fees are set by the government)
2. The number of household emptying trips made per day in African countries is between three to four, while in Asia, the typical number is under two trips daily.

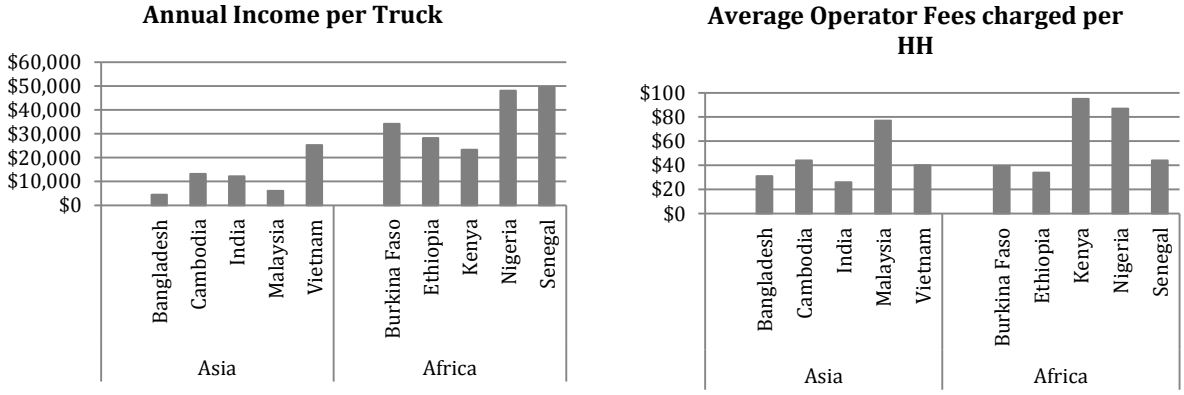


Figure 24: Average Revenue per truck and emptying fees of by private operators

Key performance indicators are listed for each country in Table 12, showing companies with the most revenue generation *and* expenses per truck are found in Africa.

Table 12: Key performance indicators of private businesses consolidated at the country level

	Incomes / truck	Monthly Cash Flow	ROI (%) with no depreciation	ROI (%) with depreciation	Gross Margin	Variable/Total Costs per truck(%)	Fixed/Total Costs per truck (%)	Personal/Total costs per truck (%)	Fuel/Total Costs per truck (%)	Maintenance/Total costs per truck%
Bangladesh	$4,492	($58)	-8%	-18%	51%	32%	68%	49%	9%	26%
Burkina Faso	$34,149	$1,974	29%	19%	44%	78%	22%	10%	48%	28%
Cambodia	$13,158	$398	17%	7%	64%	53%	47%	40%	26%	5%
Ethiopia	$28,213	$1,095	53%	43%	45%	77%	23%	17%	58%	19%
India	$12,177	$375	38%	28%	67%	52%	48%	26%	39%	12%
Kenya	$23,326	$520	13%	3%	44%	79%	21%	30%	39%	14%
Malaysia	$6,056	($5,661)	-40%	-50%	9%	19%	81%	46%	8%	8%
Nigeria	$48,083	$6,480	95%	85%	59%	69%	31%	28%	34%	25%
Senegal	$49,546	$5,776	25%	15%	38%	78%	22%	18%	46%	14%
Vietnam	$25,226	$2,382	67%	57%	83%	27%	73%	52%	17%	5%

At The Regional Level

Cost structure of the business:

It's already been seen that the cost of investment for trucks is three times as high in Africa as in Asia. Another key difference between the regions is the distribution of the operating costs themselves. The overall operating costs of running the business itself are much higher in Africa. At a unit truck level, it costs about $11,000 annually in Asia to operate a truck. On the other hand, in Africa, the unit operational expense is three times as high at $31,000 (Figure 25).

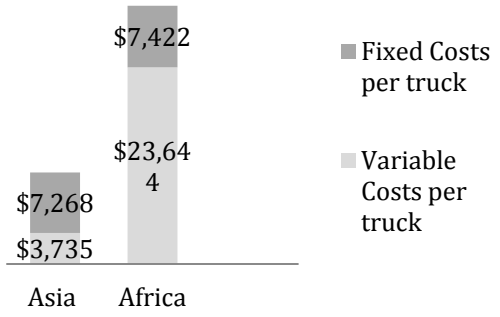


Figure 25: Regional Fixed vs. Variable costs

Not only is the total amount different between the regions, so is the distribution of the fixed and variable costs. 76% of the operating expenses for African businesses are variable costs, while in Asia, fixed costs make up 62% of the operating expenses.

Fixed costs include personal wages, contributions to staff pension and medical coverage, office rent, office equipment depreciation costs, overhead costs, phone, electricity, supplies, transportation, marketing, company registration, licensing fees, loan payments and other fixed miscellaneous charges. Truck depreciation costs are added separately to highlight the impact of them to the overall profitability levels

Variable costs include truck maintenance, fuel costs, dumping fees, and daily wages paid.

Taking a closer look at the breakdown of these costs, we found that the biggest expense for African operators is fuel charges and for Asian businesses it is the staff wages (Figure 26). The high fuel costs in Africa could be due to combination reasons: the large capacity of these trucks, the age of these trucks (that can be as old as over 30 years in the field), the large capacities of these trucks that are typically $10m^3$ and the distances that they have to travel to collect the sludge from households and to the dumping grounds, making for a round trip in some cases to be between 25 to 30 km.

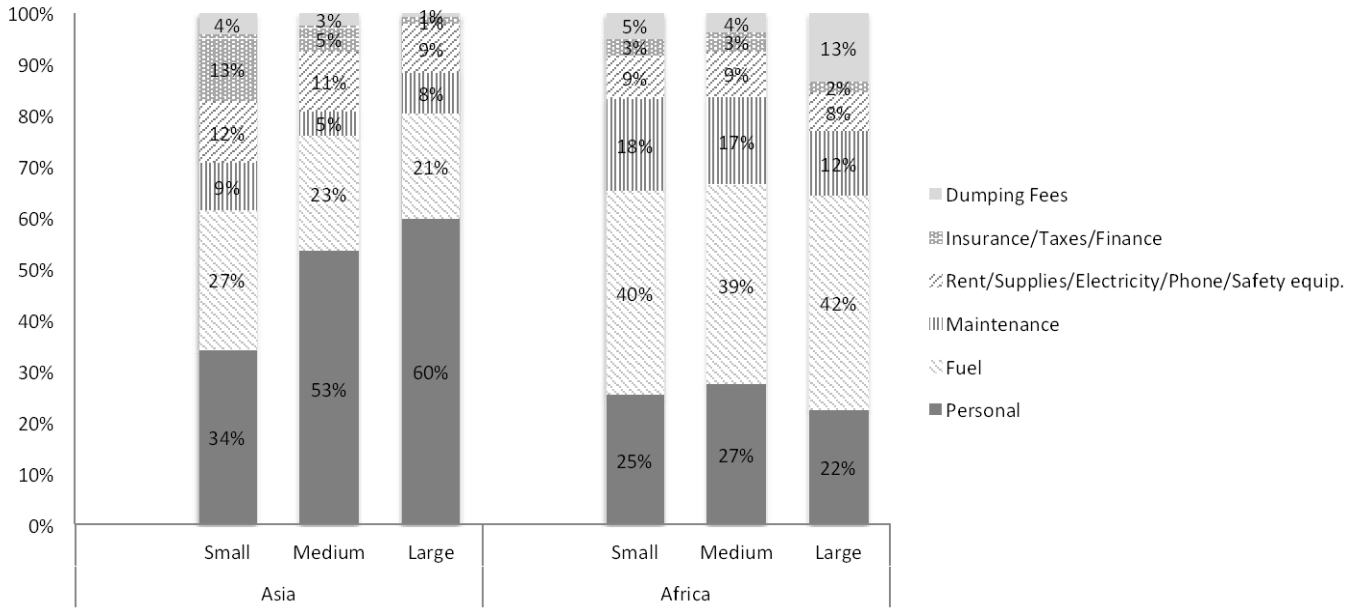
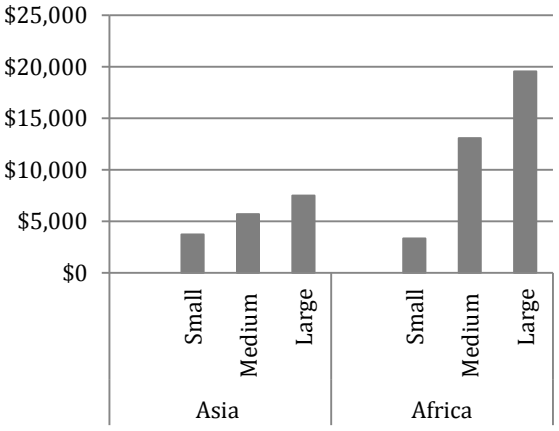


Figure 26: Distribution of expenses for different sized businesses

The breakdown of the operating expenses across Africa and Asia is vastly different. Of the average $31,000 a year in expenses to operate a truck in Africa, 40% of the expenses are for fuel and 16% used for maintenance of the large capacity and old trucks. In Asia on the other hand operating a truck costs only about $11,000 a year, of which fuel makes up 24% and maintenance only 7% of the total expenses. Very high initial capital costs and the subsequent high operating costs per truck makes this a very difficult market to enter in Africa. Similar fuel expenditure was seen in a study by the World Bank (Advani R., 2008) for private operators in Uganda, where the costs for fuel were seen to be 46% of the total expenses.

Profit per truck



The average profit per truck in Africa is $12,000 and only $5,600 profit in Asia. As seen in Figure 27, in both regions, profit increases as the size of the business grows. The higher profits in Africa are due to the significantly higher revenues they capture with the higher fees and three to four trips per day as seen in previous sections.

Figure 27: Annual profit per truck

Return on Investment (ROI)

While the profit per truck is lower in Asia, the return on investment (profit/purchase price) is actually much higher in Asia than in Africa, with an average of 53% vs. 19% after a 10-year straight line depreciation is factored in (Figure 28). This is due to the fact that even though cash flow per truck is higher in Africa, the cost of investment per truck is even higher, thereby lowering its effective return on investment. As mentioned before, the costs of trucks in Africa are 3 times higher than the locally assembled trucks in Asia.

(The ROI before depreciation is shown here for comparison, as the business owners usually do not consider depreciation as an expense when accounting for profitability -unless they are formal businesses and paying taxes to the government).

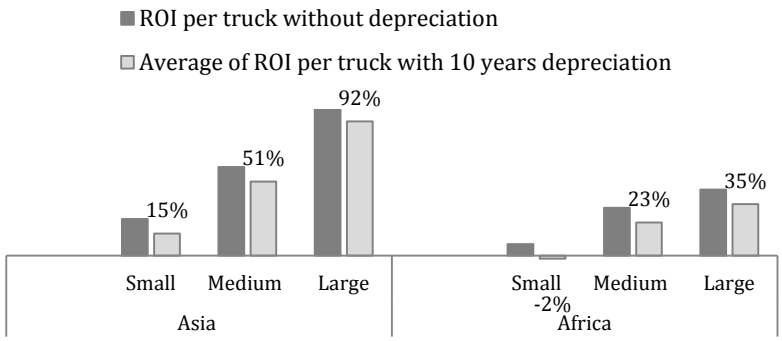


Figure 28: Return on Investment by size of business in Asia and Africa

The ROI increases with the size of the company, as profits per truck rise with additional trucks in the fleet.

Gross Margin

The gross margin (that is the contribution to the business after paying the variable costs), of operations in Asia are almost twice that in Africa at 76% versus 43% (Figure 29). So while businesses in Asia make less profit per truck, because of the lower initial capital outlay and lower operating expenses, their ROI and gross margins are higher. In other words, they get to keep a higher portion of the earnings.

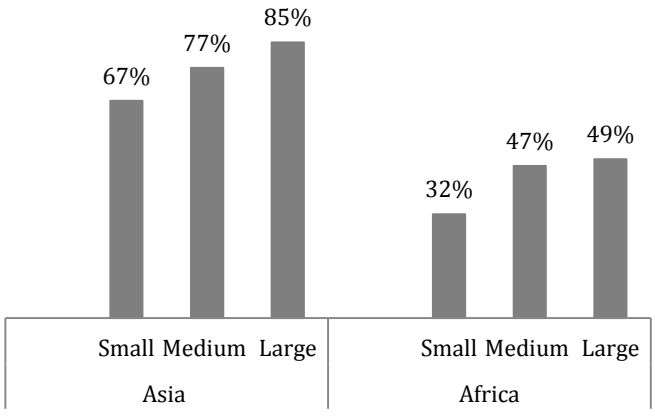


Figure 29: Gross margins by size of business in Asia and Africa

4.4.2 Profitability versus Truck Capacity

The capacity of trucks in the two regions is significantly different as discussed earlier, with Asia using trucks around 5m^3 capacity and Africa opting for sizes twice as large. The smallest mechanical truck used was seen in Bangladesh, which used the Vacutug – 0.6 m^3 or 2 m^3 - for household emptying. The range of capacities of the trucks by country and their associated cost of investment is listed in Table 13 and 14.

Table 13: Cost per truck by capacity

	Truck capacities (m^3)
Africa:	
Burkina Faso	3 - 20 m^3
Ethiopia	7 - 16 m^3
Kenya	6 -22 m^3
Nigeria	8 - 25 m^3
Senegal	8 - 15 m^3
Asia:	
Bangladesh	0.6 - 2 m^3
Cambodia	3 - 5 m^3
India	2.5 - 6 m^3
Malaysia	4.5 - 11.5 m^3
Vietnam	1 - 6 m^3

Table 14: Range of truck capacities by country

	Cost of investment/truck
Large cap (>11m^3)	**$37,511**
Burkina	$31,425
Ethiopia	$45,258
Kenya	$37,500
Nigeria	$35,860
Medium cap (6 – 10 m^3)	**$28,169**
Burkina	$31,425
Ethiopia	$10,473
Kenya	$34,338
Nigeria	$28,311
Senegal	$43,770
Vietnam	$20,699
Small cap (2.5 – 5 m^3)	**$18,822**
Cambodia	$15,000
India	$9,758
Vietnam	$31,707
Very small capacity (<2.5 m^3)	**$10,978**
Bangladesh	$9,674
Vietnam	$12,282

With the average cost of investment per truck ranging from $10,000 locally assembled, to over $45,000 for imported trucks, only 6% of the private companies surveyed owned more than 5 trucks (in Dakar, Ho Chi Minh City and Haiphong).

However, aside from the difference in initial capital expense, there was no correlation was seen between the profitability of the businesses with the capacity of the trucks in the cities (Table 15).

Table 15: Profitability vs. truck capacity for private operators

	Net Margin	ROI (%) with 10 years depreciation	Monthly Cash Flow
Large capacity	**-31%**	**-3%**	**($23,795)**
Burkina	44%	19%	$1,974
Ethiopia	-246%	-42%	($99,006)
Kenya	26%	-7%	$114
Nigeria	51%	17%	$1,738
Medium capacity	**54%**	**37%**	**$7,540**
Burkina	51%	30%	$1,056
Ethiopia	43%	64%	$648
Kenya	15%	-12%	($19)
Malaysia	80%	66%	$47,401
Nigeria	59%	72%	$2,382
Senegal	31%	-1%	$457
Vietnam	98%	37%	$853
Small capacity	**57%**	**15%**	**($520)**
Cambodia	64%	4%	$289
India	67%	28%	$375
Malaysia	9%	-50%	($5,661)
Vietnam	89%	77%	$2,917
Very small capacity	**69%**	**12%**	**$846**
Bangladesh	51%	-18%	($58)
Vietnam	86%	43%	$1,750

4.4.3 Profitability versus Size of the City

Another classification of the data was done according to the size of the cities, irrespective of country or region to determine if the size of the city was a measure of profitability.

i) Medium city were taken as those with population under 500,000,
ii) Large cities were ones with population between 500,000 and 2 million; and
iii) Very large cities were considered those with more than 2 million inhabitants.

As seen in Figure 30, the profit per truck is the smallest in small sized cities. On closer inspection, not surprisingly, it was seen that the smaller cities have a larger percentage of single truck, i.e. small-sized operators (Figure 31). And as already established, single truck operations are the least profitable in any country.

It is not clear why the large sized cities showed less profit than medium sized ones.

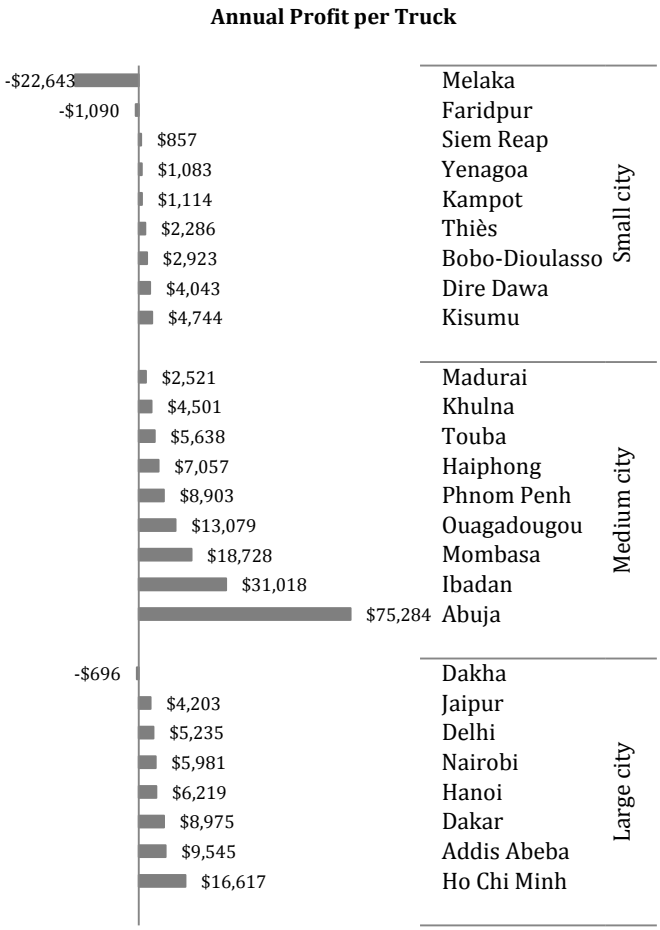


Figure 30: Annual profit per truck in different sized cities

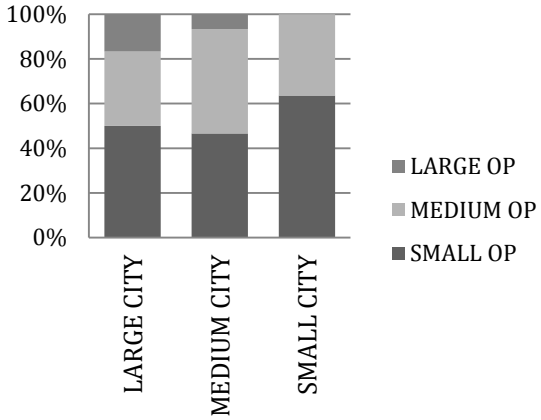


Figure 31 : Distribution of business sizes

Once again, the only correlation to profitability seen across the regions was to the size of the business, that is the number of trucks operated, rather that to the capacity of the trucks or the size of the city served.

4.5 Conclusion

While over 50% of the households in most cities have access to piped water – public or private – a majority of these 30 cities are latrine-based with limited, if any, sewer connectivity. None of the 15 cities in Africa and only 5 cities in Asia had direct connections to a sewer network. The on-site sanitation technologies are a mix of pits and septic tanks, with cities in Vietnam and Cambodia using septic tanks and pits for pre-treatment before linking to the sewer lines. Residents pay for emptying services when the pits or septic tanks are full rather than at

preventative intervals, unless a scheduled desludging service is initiated and managed by the government.

While tariffs for other utility services like electricity and phones are regulated by the government, fees for fecal sludge emptying services in sanitation are left to market forces. At a monthly-prorated rate, these fees are still cheaper than what households pay for electricity and phone. However, given that payments need to be made in one lump sum every few years, a price tag ranging from an average of $26 to $95 country to country, the households wait until the latrines become unusable. Given that the households which are off the sewer grid and use on-site sanitation latrines, make between $1 to $4 per capita per day in all countries (except Malaysia), this resistance in understandable. The most common emptying frequency across countries is once every two years, except for Vietnam and Cambodia, where the emptying frequencies are between 3-5 years.

The supply of emptying services is dominated by the private sector in all cities except in Malaysia, Addis Ababa and parts of Hai Phong. Emptying is done mechanically for the most part, but manual emptying is still practised by 34% of all households, that is by almost 2 million homes.

The market potential for this business is extremely large with 17 million cubic meters of fecal sludge needing to be emptied each year resulting in a market size of $134 million across these 30 cities. The emptying businesses themselves are found to be profitable – *if* they own more than one truck. However, the most common model for these private entrepreneurs is single truck ownership due to the prohibitively expensive capital outlay that is required for the purchase of a vacuum truck. Ownership of more than one truck allows the business owners more efficiency in covering more households across the city, repair and downtime of one truck is less devastating to the business and more trucks allow them to capture the non-household market of commercial and industrial sites that tend to be more lucrative due to the larger volumes of sludge to be emptied.

Some significant trends were uncovered in the business models in Africa versus Asia. While both regions had private entrepreneurs as the main service providers, using self-financing for truck purchase, and in the most common model, owning a single truck, there were several key differences in their models and profitability levels.

Size of trucks in Asia were on average 3.5m^3 while those in Africa are 10m^3 and cost $13,000 compared to $34,000 respectively. The choice of the truck capacities is determined by the size of the pits and septic tanks, that are twice as large in Africa. The cost is so much higher in Africa as these trucks are imported from Europe, and even while they are second-hand, are much more costly that the locally assembled trucks in Asia.

Asian operators earn only about $12,000 a year per truck compared to $37,000 a year by their African counterparts due to average lower tariffs ($28 vs. $60) and half as many emptying trips per day. Operators in Africa are more profitable than in Asia due to the higher revenues in spite of much higher operating costs, paying almost $24,000 per truck in variable expenses compared to only $4,000 in Asia. The main reason for this higher expense is the spend on fuel charges that is 40% of all expenses in Africa compared with only 24% in Asia. Reasons for this huge difference is the large size of the trucks and the age of the second hand trucks in Africa that can be over 30 years. However, in spite of the higher profitability of trucks in Africa, the return on investment for them is actually lower due to the significantly higher purchase price of the trucks.

A couple of areas for further investigation that were not answered in this study were why the such a high percentage of households in Cambodia reported never having emptied their pits, as this will help define the market size and determine if the supply of emptying services is saturated there. Also, it needs to be understood as to why the trucks in Asia make only one to two trips per day compared to three to four made by the vacuum trucks in Africa.

CHAPTER 5: MECHANISMS SUPPORTING FSM BUSINESSES

The environment in which emptying businesses operate, encompass a number of factors that impact on their potential success. It is not only the financial viability of these businesses that is at stake but also the quality and affordability of their services to households as well as the impact of sludge collection on the environment. An entire eco-system involving both the private and public sector needs to be in place to make this sanitation value chain effective and viable and support is needed at several levels.

The supporting mechanisms that these businesses need include: access to finance for the purchase of trucks; access to fuel-efficient and affordable trucks; access to spare parts and timely maintenance; availability of treatment sites to which sludge can be taken and effective regulatory oversight by the public authorities. Malaysia was the only country in this study that had taken steps to make emptying services accessible to all and had made provision for safe disposal and treatment of the collected sludge. In all other countries in this study these critical supporting elements are not completely addressed even at the policy level. As is seen in this chapter, for the most part entrepreneurs are left to find their own solutions.

5.1 Finance

As previously stated, the purchase price of the trucks in the five African countries averages $34,000 per truck and in Asia around $13,000. Access to finance for the purchase of these trucks is the biggest barrier to market entry faced by entrepreneurs. With onerous terms for loans – high interest rates, ranging from 11% to 22% (except in Malaysia), short repayment cycles, and requirements of collateral – most business owners are unable to qualify for loans and have to rely on personal savings or loans from family and friends. This lack of access to finance slows down the growth potential of these businesses. One outcome of this is the dominance of single truck ownerships in this sector that are barely profitable. Table 16 sets out the interest rates and repayment terms for each country at the time of study.

Table 16: Source of funding for the mechanical truck owners

	Burkina Faso	Senegal	Ethiopia	Nigeria	Kenya	India	Bangladesh	Cambodia	Malaysia	Vietnam
Primary source of funds	Self	Self	Self	Self	Self	Self/loan	NGO	Self	Self/Lease	Self
% owners taking loans	100%	15%	33%	9%	40%	10%	N/A	0%	67%	15%
Bank interest rate and terms	12% 3 years	14% 5 years	10.5%, 5 -10 yrs	22% 2 years	18% 3 years	12% -14% 3-5 years	17-18% 3-5 years	18% 3 years	4.5% 5 years	18% 10 years
Engaged in other businesses?	Yes	Only one	Yes	Yes	No	Yes, agriculture		Yes	Yes	Yes
% with FSM as main business	0%	unknown	50%	13%	50%	80%	N/A	50%	77%	90%

Information from various countries demonstrates that access to loans presents a major constraints for the development of FSM businesses.

In Ethiopia, FSM companies can borrow at a 10.5% interest rate to be repaid in five to ten years. Proof of collateral of up to 70% of the investment is required to secure these loans. Although there are some schemes through the Development Bank of Ethiopia that support small businesses and provide soft loans under better conditions, these loans are not available for the purchase of vacuum trucks.

In Nigeria, loans are, in theory, available on the satisfaction of certain criteria are met, i.e. customer contracts, collateral, and guarantors. It is important to realize however, that most FSM borrowers are unable to meet these criteria. Banks typically require evidence that the business has regular customers, and unless the emptier has contracts with commercial or corporate entities such evidence is hard to provide. The commercial banks do not have special concessional loans for small businesses and the interest rates, loan period and loan collateral requirements make it difficult for small businesses to obtain commercial loans. The situation is amplified in FSM because the commercial banks tend not to be familiar with the business. The recent collapse of a number of banks due to a high number of non-performing loans makes it even more difficult for small businesses to access loan facilities. Lending can cover 50% to 80% of the purchase value. The Bank of Industry will give an initial $1,000 loan at an interest rate of 4% for 12 months. Based on the borrower's repayment record with the initial $1,000, the bank will either increase the credit facility amount or no longer extend credit to the borrower. However, $1000 loans are too small to meet what is needed to purchase trucks.

In Kenya, most loans from commercial banks or micro-finance institutions for small and medium sized entities have a period not exceeding 3 years. Commercial banks do offer loans of three to six years to high net-worth individuals. These loans have to be secured by collateral or are based on salary that has attained a certain threshold. These conditions are unlikely to be met by FSM entrepreneurs. Secured loans depend on the collateral offered by the borrower and the proven ability to make regular payments. Because banks are not keen on using second-hand motor vehicles as collateral, mechanical emptiers and operators do not have access to large credit facilities and, depending on their cash flow, are not likely to be more than $10,000 of unsecured credit. As a result, most operators are unable to use debt to finance start up operations.

In India, direct business-related financial support to emptiers from the formal banking system is lacking, although limited “surrogate” financing through agricultural lending schemes does take place. As agriculture is a priority-financing sector in India, tractor loans can get covered under agriculture financing. The banks however finance only the tractor units and not the tankers and other accessories. Investment for tanks and other accessories comes from the business owner’s own sources or borrowings from the open market. The open market interest rates are as high as

24% per annum. Private entrepreneurs thus take loans for tractors (in Delhi and Jaipur) under agriculture financing schemes that are easily accessible to borrowers, but only available if the borrower has title to agriculture land. If the borrower does not own land, s/he is not eligible and then has to apply under a commercial borrowing category. In Madurai (and other similar towns across India), where tractors are not used, a loan is given only under a commercial category. The duration of these loans for up to 80% of the purchase price ranges from three to eight years with rates of 12-14% per annum. Special loans are also available in India, such as from the National Safai Karmacharis Finance Development Corporation. To be eligible for such loans, the borrower must belong to one of the special social categories such as scavengers and most "backward" castes. These loans are intended for the rehabilitation of manual scavengers. The loan amount is capped at $10,000 with interest rates ranging from 4% to 6% per annum.

In Malaysia, loans terms require that businesses have a guarantor or collateral to support their loan and this can come in the form of contracts, fixed assets, or profitable businesses. New trucks are financed up to 80% the cost, with effective rates of 7.5-8%.

In Vietnam, an 18% commercial interest rate is common, and enterprises can apply for the loans for buying cars, business development, etc. up to a maximum of 70% of the project cost. There is no special loan facility for the purchase of a fecal sludge emptying truck. Small businesses, in theory, can apply for the loans, but in practice they face a number of challenges and may have to use land as collateral. The Vietnam Environmental Protection Fund (VEPF) provides loans for special environmental improvement projects at very good interest rates: 5.4%/year over a ten year period, for a maximum of 70% of project cost. It is, however, not easy to fulfill all the requirements to access the loans. In 2010, only 20 projects obtained these loans from VEPF with an average loan size of $500,000 per project.

Under such conditions, the private business owners are effectively left to their own means of accessing funds for starting their business and purchasing the trucks or other necessary equipment. Inevitably the source of these funds comes is their own personal savings or money borrowed from friends and family. Table 17 below provides data on the length of time required for a single truck owner to accumulate sufficient profit to purchase a second truck.

By synthesizing the available data of all private companies in Africa, Table 17 captures a typical income statement for different sized companies. The revenue and costs shown are median figures based on actual data. This data was taken from 23 small sized, 31 medium sized and 5 large sized private businesses in Africa. Cost per truck was taken as $42,000 for all businesses.

Table 17: Income statement of typical small, medium and large private business in Africa

USD	(1 trucks / business) **Small**	(2 trucks / business) **Medium**	(7 trucks / business) **Large**	(7 trucks / business) **Large** (no dumping fees)
Revenue	$31,853	$104,311	$489,294	$489,294
Expenses				
Fixed Costs				
Personnel	$2,772	$6,449	$66,254	$66,254
Fixed OpEx	$1,781	$2,584	$30,189	$30,189
Variable Costs				
Personnel	$778	$4,992	$18,302	$18,302
Variable OpEx	$15,483	$33,497	$272,713	$214,741
Depreciation (10yr)				
Truck	$8,400	$16,800	$58,800	$58,800
Total Expenses	$29,214	$64,322	$446,258	$388,286
Profit/(loss)	$2,639	$39,990	$43,036	$101,008
Key Performance Indicators				
Average Revenue per truck	$31,853	$52,156	$69,899	$69,899
Fixed Personnel cost per truck	$2,640	$3,017	$9,370	$9,370
Variable OpEx per truck	$15,483	$16,748	$38,959	$30,677
Profit	$2,639	$39,990	$43,036	$101,008
Annual free cash flow (FCF)	$11,039	$56,790	$101,836	$159,808
Years to new truck*	**15.9**	**1.1**	**1.0**	**0.4**

*Number of years it will take to save enough to purchase one new truck

Dumping fees of $58,000 are paid by the five large companies in Dakar. However, there are many more medium sized companies – 31 including some from Dakar – for whom the median dumping fee is $0. As such, the large business' data are shown here with and without the dumping fees. The annual profit (or loss) factors in a linear ten-year depreciation, and the free cash flow (FCF) shows cash at hand for purchase of additional trucks.

The data above reveals that if trying to pay for expansion of the fleet through profits it will take almost 16 years for the small operator to save enough to buy an additional truck at a cost of $42,000. (The 16 years could actually be significantly longer, if inflation was factored in). The annual profit levels are too low and on the brink of loss for banks to consider loaning money for expansion. The medium sized company with only two trucks, on the other hand, has enough

annual profits to be able to purchase a new truck every 1.1 years. The only options for single truck owners are to borrow funds from family and friends or to borrow from private lenders at high interest rates. Survey results from ten African countries of hundreds of independent water and sanitation service providers of all sizes, showed 100% of them had self-financed their start-ups with family funds and then funded their expansion costs with profits. (Collignon B. and Vezin M. 2000).

As set out in Chapter 3, the data revealed the most profitable businesses to be ones that had at least 2 or more trucks. The data also showed that the profitability per truck increases with the size of the company, the company's efficiency growing with each additional revenue producing truck. The question that then arises is what is the most effective way to finance growth from single truck to multiple truck ownership – whether continuing the current approach of self-funding or securing debt financing (if it were available).

In regard to this question, data from Table 17, is analyzed to determine what the impact on growing the business from two to seven trucks would be if taking a loan versus complete self-financing.

A five-year projection of the two alternatives provides the answer by comparing the net present value (NPV) as seen in Table 18. Revenue and expenses are projected linearly between year one and six. The comparative profitability analysis is conducted for the no dumping fees scenario, to make for an equitable comparison.

In the case of self-funding, the entrepreneur has sufficient annual profits to add a new truck each year, reaching a total of seven by year six. However, in the case of debt-finance, the entrepreneur is able to add five more trucks in year two itself.

The assumptions used in Table 18 are:

1. Truck down payment: 20%
2. Interest rate 20%
3. Loan amount: $168,000 (for five trucks)
4. Income statement of large company without dumping fees was used
5. No inflation rate has been used for the side-by-side comparison

Table 18: Financing options for growing business from medium to large

Growing the business from Medium (2 trucks) to Large (7 trucks) : Self-funded vs Loan-funded

	Income (self-funded growth)						Income (growth through borrowing)					
Year	1	2	3	4	5	6	1	2	3	4	5	6
USD												
Revenue	$104,311	$167,113	$237,012	$314,009	$398,103	$489,294	$104,311	$489,294	$489,294	$489,294	$489,294	$489,294
Expenses												
Fixed Costs												
Personnel	$6,449	$18,410	$30,371	$42,332	$54,293	$66,254	$6,449	$66,254	$66,254	$66,254	$66,254	$66,254
Fixed OpEx	$2,584	$8,105	$13,626	$19,147	$24,668	$30,189	$2,584	$30,189	$30,189	$30,189	$30,189	$30,189
Variable Costs												
Personnel	$4,992	$7,559	$10,174	$12,836	$15,545	$18,302	$4,992	$18,302	$18,302	$18,302	$18,302	$18,302
Variable OpEx	$33,497	$58,603	$89,280	$125,529	$167,349	$214,741	$33,497	$214,741	$214,741	$214,741	$214,741	$214,741
Depreciation (over 10 years)												
Truck	$16,800	$25,200	$33,600	$42,000	$50,400	$58,800	$16,800	$58,800	$58,800	$58,800	$58,800	$58,800
Interest Payment							$0	$31,679	$26,911	$21,097	$14,008	$5,363
Total Expenses	$64,322	$117,877	$177,050	$241,843	$312,255	$388,286	$64,322	$419,965	$415,197	$409,384	$402,294	$393,649
Profit/(loss)	$39,990	$49,237	$59,962	$72,165	$85,848	$101,008	$39,990	$69,329	$74,097	$79,911	$87,000	$95,645
Annual FCF	$14,790	$32,437	$51,562	$72,165	$94,248	$117,808	$56,790	$106,396	$106,396	$106,396	$106,396	$106,396
PV of FCF	$212,185						$374,980					

While both financing options result in continued profits and growth, the scenario with taking a loan provides the business owner with a much better NPV: $374,980 with loan and $223,904 self funded.

As a worst-case scenario, the NPV was also calculated assuming that the business efficiency does *not* increase with additional trucks, but that the revenue per truck stays the same as more trucks are added to the fleet. The profits now are lower, yet at a present value of $180,859 if self-funded and $297,605 with a loan, the medium operator should *still* strive to add more trucks and do so by taking a loan instead of self-funding the growth.

While financing start-ups and expansion is a critical constraint for emptying businesses, studies and discussions in literature on on-site sanitation are focused on financing approaches for latrine construction, demand generation of financing of conventional sewerage systems. In a comprehensive six-country review of financing on-site sanitation for the poor, the World Bank identified an urgent need for conducting work on understanding the financing mechanisms of other elements of the sanitation value chain like pit emptying and waste reuse (Tremolet S. et al. 2010).

5.2 Sourcing of Trucks

The largest capital expense for which financing is needed – and the greatest barrier to market entry – is the cost of the truck itself. There are significant differences in the sourcing and associated expenses for the trucks in Africa and Asia. Key findings from the study are that:

- Trucks in Africa are primarily imported second-hand, mostly from Europe, whereas in Asia each country has locally-assembled trucks. Truck costs listed in this report are inclusive of import taxes.
- The capacity of the trucks in Africa is twice that of trucks in Asia. ($4m^3$ vs. $10m^3$)
- Trucks in use in Africa are much older than those in Asia. They are already 15 to 20 years old at the time of import and are used for emptying for as long as they last. The typical age of trucks used for emptying by private operators is anywhere from 15 to 30 years in the African countries in the study, while the Asian countries reported truck age as being between 5 and 10 years.

In India, locally manufactured vehicles are purchased and modified for use in mechanical emptying. Tractors manufactured by Mahindra or Sonalika are purchased for this purpose and attached to trailers carrying the locally fabricated tanks. A suction pump and

10m hose are fitted to complete the assembly. Tractors are preferred over larger trucks due to their lower price ($10,000 for a tractor compared to $66,000 for a truck) and better maneuverability through narrow lanes. The other reason that makes purchasing tractors attractive is the availability of subsidized low-interest bank finance for tractors under priority sector lending for agricultural purposes. In the southern city of Madurai, the operators use mini-trucks instead of tractors. These trucks are also locally manufactured by TATA or Eicher, and then similarly retrofitted with a tank, pump and a hose (Figure 32).

Figure 32: Tractors and locally manufactured trucks in India

While of limited use and scope, the mechanical 'truck' used in Bangladesh should be mentioned here, as it is unique in its use among all countries studied. In Dhaka, the mechanized emptying service is provided by two NGOs – Dustha Shystha Kendra and Population Services and Training Centre . Each serves low-income communities with the use of a $2m^3$ Vacutug towed by a refurbished pickup truck. In spite of having no competition in the market for mechanical emptying and an enormous market potential in a city of over 14 million residents, the number of pits and septic tanks emptied by these NGOs collectively in 2010 was a mere 300.

Unfortunately there are a variety of issues with the use of the Vacutug that prevents it from being a viable business opportunity for the service providers in Dhaka. Septic tanks can be as large as 16 m^3 in Dhaka and so using a $2m^3$ Vacutug means at least 8 trips to empty one tank. It normally takes 3-4 people to push/operate it, and with the vehicles' speed of ~5km/hour and inability to climb roads with more that a 3 degree slope, it makes it more efficient to push manually than to drive it. It is for this reason that the NGOs chose to tug it with a pickup truck

In Phnom Penh, Cambodia, the emptying trucks have a built-in separate compartment for storing water to be used for diluting the thick sludge in the pits. These trucks are assembled locally by modifying second-hand imported transportation trucks (usually from Korea, Japan or France). The back of these trucks are re-tooled to attach a vacuum pump for suction on one side of the 5m3 tank, and, on the other side, a small pressure motor is connected to a clean water tank of 0.75m3, for diluting the sludge and cleaning the area after each operation.

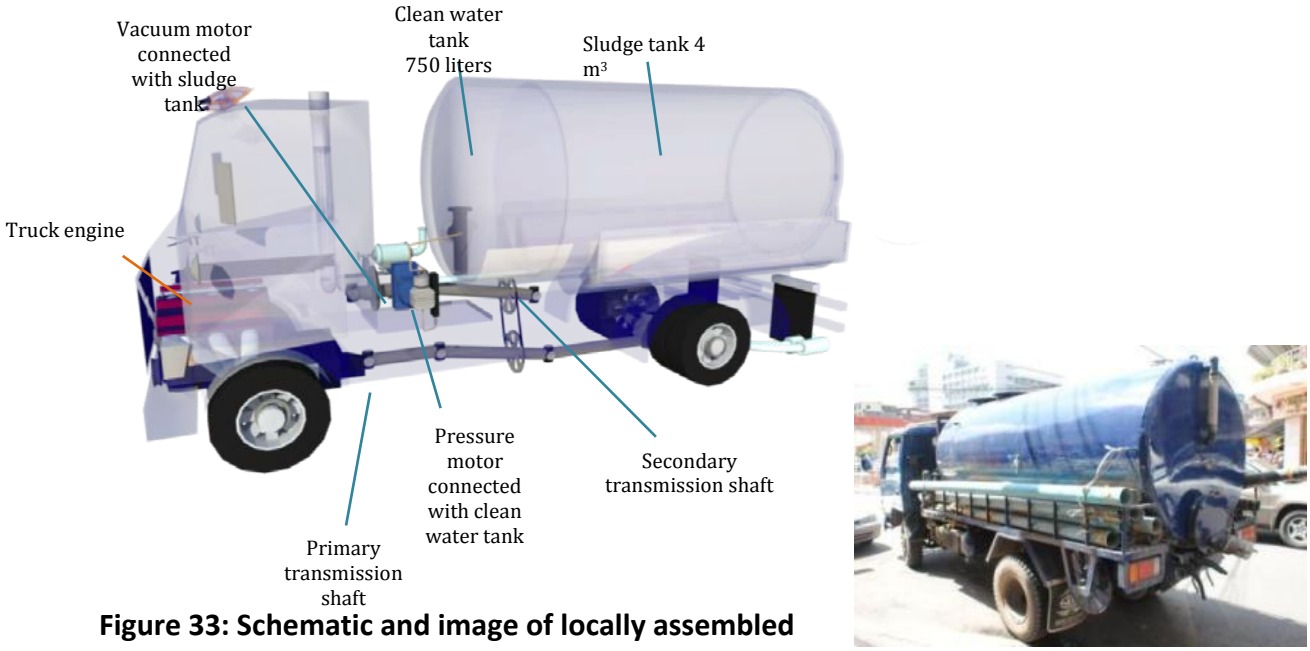


Figure 33: Schematic and image of locally assembled truck in Phnom Penh

The other customized feature that is built in to make these trucks more fuel-efficient is a secondary transmission for the two pumps. The primary transmission shaft is then used only for the engine and rear wheels. (Figure 33 shows the schematic details). The vacuum and pressure pumps and other accessories are also purchased used. Second-hand Korean trucks are available in Phnom Penh for $9,500 to $14,500 and after re-assembly cost $19,000 to $25,000 for use as fecal sludge-emptying trucks.

Trucks in Malaysia are also locally assembled, albeit with all new imported parts i.e. vehicle chassis, engine and vacuum pump motors. Only the 2-compartment tank (for water and sludge) is fully locally manufactured. The full cost of a typical new 4.5 m^3 truck, inclusive of import taxes and insurance, can run as high as $95,000. The research team considered the price of a similar truck in China that was about 60% cheaper, but estimated that after import, sales and other taxes were applied the cost of the imported truck would be as high or higher than the current market price of locally assembled trucks. Desludging trucks also require special assembly and have to meet various requirements that normal transport trucks do not have to meet (for example safety

standards in relation to the vacuum tank) and these result in high costs. IWK purchases new trucks made out of mostly new imported parts (chassis, engine and vacuum pumps excluding the pressure vessel). These trucks, after being retired by the utility (after about 15 years) are then purchased by private contractors for approximately $57,000.

Figure 34: Vacuum truck in Malaysia

In the four countries in Africa (except Kenya), there was no local assembly of trucks, and fully assembled emptying trucks were being imported. With a recognized association of emptying-service providers and the largest fleet of trucks of all the 15 African cities in the study, Dakar is also the only city with private operators running large businesses with more than 5 trucks. Dakar alone has about 150 trucks operated by private businesses. Mechanical emptying by private operators in Dakar is done by using vacuum trucks or hydro-evacuating trucks. It is the vacuum trucks that constitute the most common and largest fleet for emptying services – there are only 10 hydro- evacuating trucks in Dakar. Due to the availability of spare parts and durability of the brands, operators prefer to purchase used Mercedes or Renault trucks. Capacities of the trucks in Dakar range from 4 to 14 m^3 and these are purchased second-hand from Europe for prices ranging between $20,000 and $60,000.

These are trucks that have usually been discarded in Europe and are purchased by operators in Senegal to be repaired and put to use again. The typical age of these trucks is estimated to be over 25 years. Dakar alone has about 150 trucks operated by private businesses. The hydro-evacuating trucks are the more powerful ones using a pumping device to discharge high-pressure water in the sludge to loosen it for improved pumping.

Figure 35: Imported 2nd-hand truck in Senegal

Due to the higher fuel consumption of these vehicles they are more often engaged by commercial enterprises for emptying their septic tanks, rather than for households emptying.

In Kenya the study found a variety of sources for trucks being used, including local manufacturing with used parts. Of the 10 trucks in Mombasa, three have a unique transportation system, whereby they load 200-liter drum at the back of the truck (instead of a sludge tank) for a total capacity of 5.6 to 7.2 m^3 (Figure 36). Collection is not easy as a simple water pump or manual emptiers are employed to fill these drums. Disposing of the collected sludge in the drums at the designated manholes at the fecal sludge treatment plant then becomes an equally challenging operation.

Figure 36: Drum truck and imported 2nd-hand vacuum truck in Kenya

The second type of truck used in Kenya is that which is locally assembled. The truck engine is used to run the pump, with the engine revved to drive the pump system and thereby consuming more fuel. The most sophisticated version used is the large capacity trucks of 18 to 22 m^3, with oil-cooled rather than water-cooled systems. These are imported trucks and are much more fuel-efficient with separate pump engines. The pump technologies in the imported trucks require 30 minutes to fill a 20 m^3 tank, whereas the local assembled trucks fill only 8 m^3 in the same time. While Mombasa trucks are at least 15 years old, trucks in Nairobi are a mix of new and old with a fleet of 60 trucks in all. A variety of brands of imported trucks are found in Nairobi including Mercedes, Isuzu, Nissan, Renault, Ford and Tata.

Capital investment costs are minimized in Asia by assembling the trucks locally. Similar alternatives need to be developed in Africa to reduce the dependence on old and expensive imports. According to the Nigerian teams' survey of the local market, Tata Motors of India has a sales showroom in Nigeria where they sell heavy-duty vehicles including a 6m^3 cesspit tanker, which is sold for over $81,000. The tanker trucks are currently manufactured and assembled in India. One option to consider to lower the price

would be to manufacture locally the components of trucks such as the cesspit tanker. The benefit of purchasing trucks manufactured locally in Africa (Tata Motors is just one example to investigate) would be the accompanying service warranty and presence of maintenance workshops.

5.3 Supply Chain

To optimize the revenue potential of the businesses and lower maintenance costs, the trucks need to have high utilization with minimum downtime. A specialized supply chain for repair and maintenance of emptying trucks needs to be established – this is especially the case in Africa where the trucks are imported, large and very old. Maintenance costs per truck as a percentage of all costs range from 14% to 28% in the African countries, with trucks in Burkina Faso spending 28% and in Nigeria an average of 25% of overall costs on maintenance alone. In Yenegoa, 80% of the truck operators also served as their own mechanics to save on maintenance costs incurred with the frequent breakdowns of the old trucks. The availability of repair parts was reported as an issue in Burkina Faso resulting in long idle time waiting for parts and a consequent loss of income. Lack of skilled craftsmen for the repair of vacuum pumps was another challenge for the emptiers in Burkina Faso. In Senegal, with an average fleet age of over 30 years and breakdowns occurring frequently, maintenance costs per truck are the lowest in Dakar where typically each business pays to have its own mechanic on staff. Due to this proactive step, Dakar operators spend only 10% of costs per truck on maintenance compared to 21% in Thies and Touba.

Parts that need replacement are hard to come by as the number of models of trucks are diverse and mechanics do not maintain an inventory of specific spare parts. One reason that Renault models are the preferred choice for imports in Senegal is the accessibility of Renault parts in the cities. In Dire Dawa operators reported a downtime for trucks as high as 50%, while in Addis Ababa, which has more repair shops, truck down times ranged from 20% to 40%, still severely limiting the number of trips and income.

In Asia on the other hand, where the trucks are locally assembled, the operators have the advantage of having the local assembly shops do the maintenance work too and downtime and loss of income is far more limited.

5.4 Public Sector Emptying Services

As seen in previous section, household-emptying services and the tariffs for these are managed by private entrepreneurs. The public authorities are more focused on projects related to sanitation infrastructure such as expanding the piped sewer network and

building wastewater treatment plants for the sewage. Vacuum trucks owned by public utilities are used for the maintenance of these sewerage systems or for emptying of public institutions – not for households. There are a few instances in which the public sector is engaged in emptying service provision for households. These cases in Malaysia, Ethiopia and Vietnam are discussed below.

Scheduled Desludging and Fee Regulation: Malaysia

In Malaysia, water and sewerage services are a federal responsibility of the National Water Services Commission (SPAN) acting as the regulator overseeing provisions contained in the Water Services Industry Act, 2006 (WSIA).

Sewerage services – fecal sludge extraction, transportation, and treatment and disposal – are regulated and licensed by SPAN. Indah Water Konsortium (IWK) is the nationally registered service licensee for the provision of FSM services and is wholly owned by the Minister of Finance Incorporated, while private service providers or contractors are registered as 'Permit Holders'.

The enforcement of WSIA has changed this situation to make the FSM services sector competitive and open it to all licensed providers – which includes IWK and the private operators. Scheduled desludging was also replaced by service-on-demand, which has now changed the nature of the business from both the user and provider perspective. Scheduling a service, which is now proposed to be once every three years, is now the responsibility of, and must be initiated by, the occupier of the premises.

The tariff structure too was changed by SPAN from a monthly instalment for commercial institutions and a bi-annual fee for households, to a volumetric one. It also went from tiered pricing based on type of property to a flat rate based on volume (Table 19). The fees are capped at lower rates for the private operators, who are allowed to give more competitive discounted rates at their discretion, while IWK services are fixed.

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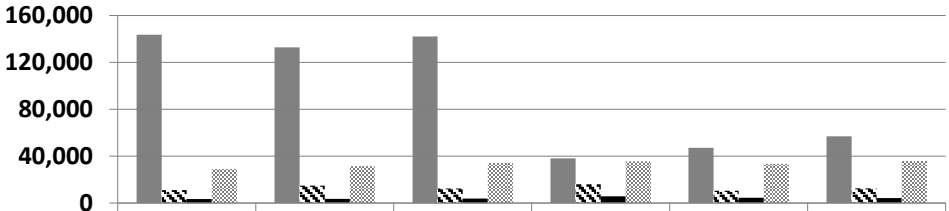
Table 19: Service Fees for FSM

Capacity of Septic Tank/ Pour-Flush	Private Operators	IWK
Up to 2 m^3	No more than $77	$100
Additional 1 m^3 thereafter	$38	$38
Sludge treatment and disposal	$18 / m^3	$18 / m^3

As seen in Figure 37, the demand for desludging dropped dramatically once the mandatory frequency requirement was removed. Between 2005 and 2007, IWK serviced about 185,000 on-site sanitation systems annually. After 2007, this dropped by almost 50% to about 95,000 services only.

Clearly in the case of Malaysia, even customers used to regular desludging services at affordable prices, tended to ignore the need to follow the recommended emptying cycles without legal enforcement.



	2005	2006	2007	2008	2009	2010
Demand & Scheduled	143,670	132,857	142,144	38,091	47,040	56,874
Repeat	11,079	14,786	12,320	16,171	10,510	12,459
Responsive	3,345	3,548	3,766	5,699	4,451	4,198
Pour Flush	29,020	31,566	34,250	35,606	33,435	35,838

Description of code:

1) Scheduled: Customers who get their desludging within the 2 year cycle (normally 1 month before their due date notice is send to them to fix date)

2) Demand: First time customers

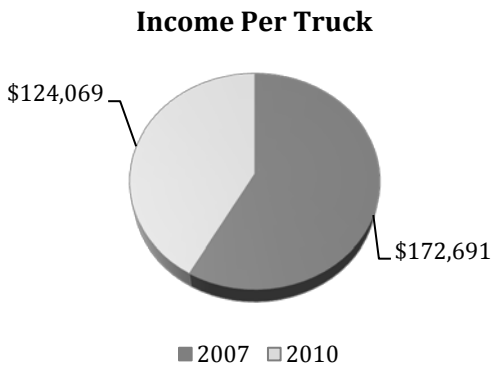
3) Repeat: Customers who request service before the due date (18th months and below).

4) Responsive: Non-customers who have to pay cash on service e.g. Hotels, Factories

Figure 37: Desludging services by IWK from 2005 to 2010

Another impact of this drastically reduced demand was on the viability of the businesses providing these emptying services. Many private service providers had to cease operations as they were dependent on IWK for sub-contract business to stay afloat. One

medium size business in Melaka that is still operating, was running heavy losses in 2010 as seen in Table 11.



IWK itself has seen a significant reduction in profitability levels pre- and post- 2007 (Figure 38). IWK has remained profitable because while the desludging revenue has dropped due to the reduced household demand, it still gets sufficient business from emptying government premises that account for up to 80% of it's desludging revenue.

Figure 38: IWK Income per truck before and after mandatory desludging

Public vs. Private Emptying Service Models in Ethiopia, Malaysia, Vietnam

Ethiopia, Vietnam and Malaysia are the only three countries of the ten studied where public utilities are also engaged in providing household emptying services. The business model in each of these countries is unique. Only in Vietnam do both private and public companies have large businesses of more than five trucks. In Ethiopia, and to some extent in Malaysia, all large companies are state owned. In Malaysia, as discussed above, the business model had, until 2007, included fee-based scheduled. Hai Phong city in Vietnam is also doing scheduled desludging for the very poor, but in their case, the services are provided free of charge. Addis Ababa's water and sewerage utility tries to cover the city's needs by heavily subsidizing the emptying fees for all (at under $5) to the detriment of their own budget and the tariff structure of the private markets. A comparison of the business models of the private and public emptying operations is made below.

In Vietnam, the state owned enterprises provide desludging services, operate the landfill and manage the sewage treatment and co-composting facilities of the fecal sludge at Cai Dzian in Hanoi and Trang Cat in Hai Phong. In addition to these state run enterprises, Hanoi has 40 private businesses, Hai Phong 14 and Ho Chi Minh City 50 such businesses engaged in fecal sludge management. Limited scheduled desludging is practiced in Hai Phong. Unlike paid services in Malaysia, however, in Hai Phong, the scheduled desludging is done free of charge. It is done in four urban districts for only just over 86,000 household septic tanks with an emptying frequency of once every 5 to 6 years.

Revenue sources for these Vietnamese state enterprises are varied. In Hanoi, the business model focuses on small-scale compost production and sale of fecal sludge and organic

waste and de-sludging services for public toilets. Household emptying is a marginal activity for these public enterprises. In Hai Phong, the utility derives it's annual income from emptying services from three sources: a subsidy from the city to provide fee scheduled desludging services to households ($86,202), emptying fees from households ($25,767) and sale of compost ($728). A large number of households receive free scheduled emptying services as part of a World Bank funded project. However all households in the city pay a 15% surcharge for wastewater in their water bills, instead of 10% as in other cities. It is this surcharge that is used by the city to subsidize the free desludging services. Ho Chi Minh City is the only state-run large service provider that charges fees that are competitive with the private operators for domestic desludging. It also gets a significant amount of its revenue from leasing public toilets. Revenue streams and profit per truck for Vietnam are detailed in Table 20.

Table 20: Sources of revenue large desludging companies in Vietnam

	Household Desludging Income	Commercial Desludging Income	Public Toilet Desludging Income	Public Toilet Lease Income	Sale of Compost	Total Revenue	Profit Per Truck
Haiphong							
Private	$67,820					$67,820	$4,183
State	$111,969				$728	$112,697	-$2,508
Hanoi							
State	$2,018		$15,414		$21,845	$39,277	-$16,036
Ho Chi Minh							
Private	$110,978	$27,744				$138,722	$10,834
State	$158,592	$39,648		$260,971		$459,211	$37,113

The state enterprise in Ethiopia is by far the largest FSM emptying service provider to households in Addis Ababa, and the only one with more than 5 trucks in the country. With an aim to reach as many households as possible, it provides the services at extremely subsidized fees of $4.8 per service with their 67 trucks compared to fees of between $20 to $30 per service charged by the private operators. With such low fees, the cities households have no need for manual emptying. On the other hand, this pricing model is not sustainable for the utility that runs losses of over a $1 million annually in emptying service provision.

Figures 39 and 40 capture the monthly cash-flows per truck and the return on investment respectively, for the businesses in Ethiopia, Malaysia and Vietnam.

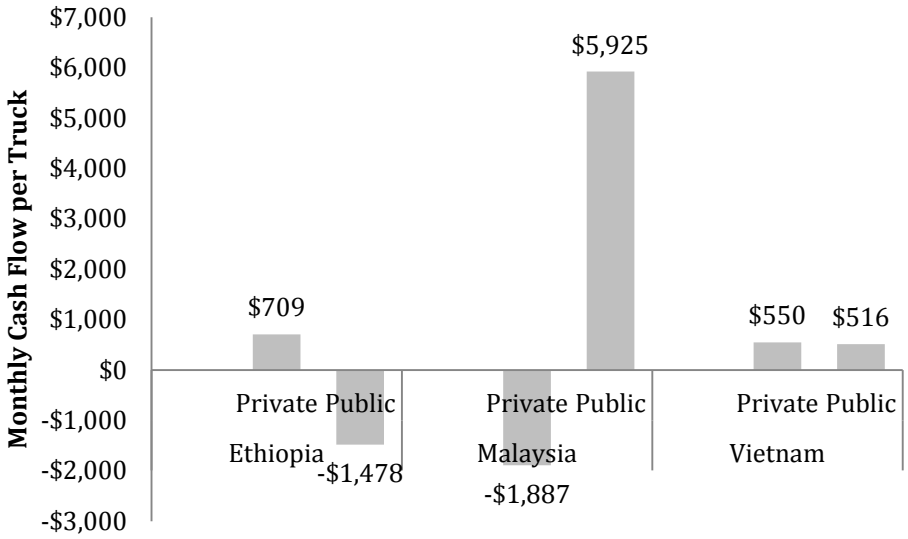


Figure 39 : Monthly Cash-flow per truck for private vs. public companies

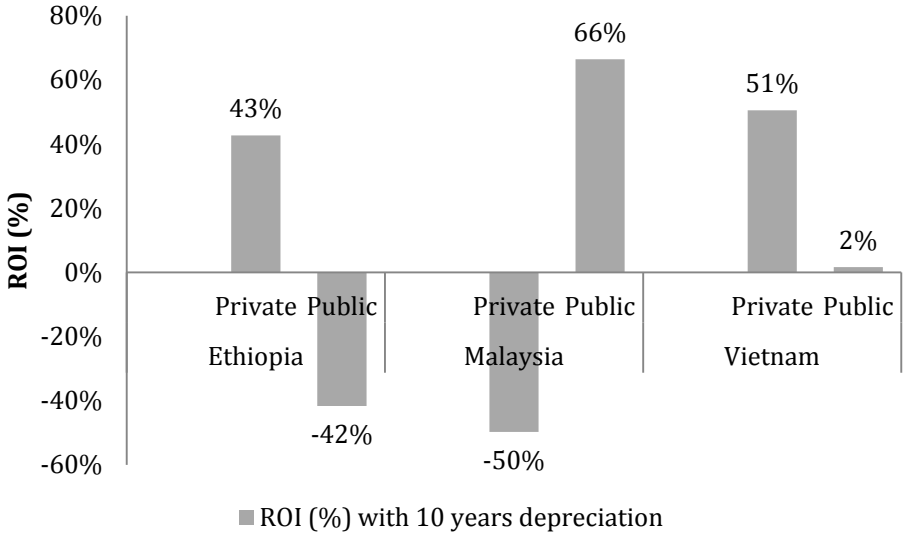


Figure 40: Return on Investment for private vs public emptying companies

The impact of the different business models is apparent if the profitability of the private versus public enterprises in these countries is examined. The private sector is more profitable in Ethiopia, less so in Malaysia and on par with the public sector in Vietnam (Figure 38). In Ethiopia, the heavily subsidized fees charged by the utility gives them a larger share of the domestic market, but at the same time make the service financially unsustainable as compared with the private operations.

In Malaysia, as mentioned previously, the state owned IWK continues to make a significant profit per truck even after the removal of scheduled desludging that reduced household demand, since 80% of their revenue comes from services provided to the governmental sector. Their private counterparts on the other hand are struggling to survive after the passage of the WSIA, and are running at a loss.

In Vietnam, both private and public enterprises make very similar profit per truck (Fig. 38), but the return on investment for the private truck owners is much higher (Fig. 39). A significant portion of the utility's income and profit comes from *not* subsidizing the emptying fees (as in Ho Chi Minh City), leasing of public toilets (in Ho Chi Minh City) and payment from the city budget for free scheduled desludging (in Hai Phong). However, the return on their investments is much higher for private operators due to the fact that they make comparable profits, but use second-hand, cheaper trucks.

5.5 Treatment And Reuse Of Fecal Sludge

Within the sanitation value chain, it is also important to ensure that the human waste generated and collected by mechanical and manual emptiers is safely disposed of. Treatment of the collected sludge from on-site systems is handled in a variety of manners across the 30 cities – from dumping in the environment to having official, but open dumping grounds, to using wetlands, stabilization ponds, mixing into wastewater treatment plants and lastly, dedicated fecal sludge treatment plants (Figure 41).

Figure 41: Official dumping site in Touba (left) and FSTP in Dakar

Disposal of fecal sludge collected from on-site systems into wastewater treatment plants (WWTP) with no pretreatment is not a proper solution. The total and suspended solids content in fecal matter is much higher than in wastewater. Data on fecal sludge compared with sewage shows total solids of over 3.5% in the sludge versus under 1% in the sewage. Suspended solids are over 30,000 mg/l in the fecal sludge compared to

between 200-700 mg/l in the sewage (Montangero & Strauss, 2002). With such different characteristics and high concentrations, fecal sludge cannot be considered in the same manner as wastewater, and requires specific treatment systems. The use of a geo-tube could be considered as a more efficient and cheaper alternative to the conventional fecal sludge drying beds. A report published by the Macomb/St. Clair Inter-county Watershed Management Advisory Group on septage disposal facilities for Michgan, USA, cited costs for the geotube treatment system to be $0.02-$0.04 cents per gallon. Site work would be necessary to provide an impermeable pad for the geotubes to drain onto, a system to collect the drainage and disposal of both the liquid and solids. More details on geo-tubes will be covered in section 5.3.

However, as seen in Table 21, barely 30% of the 30 cities in the study have designed dedicated solutions for treating fecal sludge, and fewer than 60% of them have a WWTP. Failing the option to dispose of the sludge in a fecal sludge treatment plant (FSTP), if there is a WWTP, the operators either dump into manholes leading to the plant or simply out in the open somewhere.

Even if the fecal sludge treatment sites exist, in many instances, they are not designed to manage and treat the volume of sludge that is generated in the city. In Addis Ababa for example, there are two FSTPs with a combined capacity to treat 980 m^3 of the sludge per day. However, according to the data collected in this study, a total of about 530,000 m^3 of sludge is collected each year, or about 1450 m^3/day – far more than can be safely accommodated at the treatment plants.

In Kenya, treatment of wastewater and fecal sludge is done at the same plants. Fecal sludge collection operators are required to discharge the sludge at designated tipping points that are connected to the sewage lines. Figure 42 shows a typical tipping scenario in Nairobi where a maximum of four trucks can discharge at the same time.

Figure 42: Njiru tiiping point in Nairobi

The lack of environmentally sound fecal sludge dumping and treatment options is a big concern and bottleneck in the formulation of good fecal sludge management solutions. Studies have shown that the capital and operating costs of FSM system is ten times cheaper than s centralized sewer-based system (Dodane P. et al., 2012). In a comparison of sanitation systems in Dakar, Dodane et al showed that the annualized capital costs for a sewer based system at over $42 per capital per year, were ten times higher than the FSM system. Similarly, its' operating expenses at almost $12 per capital per year were

also higher than for FSM which was $7.6 per capital per year.

Given the limited focus on sludge treatment, it comes as no surprise that productive re-use of the bio-solids in these cities is, at best, rare and experimental. In Hanoi, a co-composting plant (Cau Dzien) producing 5000 tons of compost per year is operated by the city (Figure 43). It operates more as an experimental facility whose designed capacity is 13,600 tons per year. Solid waste from city markets is brought here for composting and mixed along with a small amount of fecal sludge (10 – 50 tons per day) collected from public toilets. While the demand for fertilizer is high in the Hanoi area (estimated to be 60,000 tons a year), limited production capacity and high travel expenses inhibit any volume sales to farmers.

Figure 43: Cao Dzien co-composting plant in Hanoi

Treated fecal sludge, when available, is sold in Kisumu and Nairobi at a price of $1.25 to $1.45 per ton. No sales were reported in Mombasa in the past 12 months. The main challenges with sales of treated fecal sludge in Kenya are that the product is bulky and not packaged. Logistical problems therefore arise in the transportation and distribution process. However, fecal sludge re-use in Kenya does take place in what are referred to as bio-centers. Bio-centers are public sanitation toilet and bathroom-facilities operated on a pay for use basis. More than 100 bio centers exist in the three cities studied (Figure 44). At these bio-centers, fecal sludge re-use takes place through the generation of biogas that is used for cooking purpose at the cooking facilities present at these centers. Typical output of the bio-centers is 12 m^3 of gas per day.

Figure 44: Bio-center in Nairobi

In Malaysia, in spite of sophisticated treatment facilities, bio-solids from treatment plants are disposed of in landfills. The amount generated in total may be large but individual treatment plants each generate small amounts. This presents logistical problems for collection and with high transportation costs it is not economical to do so. In many cases the user expects to be paid to remove the material and this is not acceptable to IWK as with this additional cost it is cheaper to send the waste to a landfill.

In most of the other cities in the study it was reported that raw, untreated sludge is either just dumped in the open environment or, on rare occasions, sold directly to farmers for use in their fields.

Table 21 : WasterWater and Fecal Sludge Treatement Facilities

Country	City	WWTP	FSTP	FSTP Capacity	Comments
Bangladesh	Dhaka	□	□		Dumped in manholes of sewer network and taken to WWTP that serves 20% of the city
	Khulna	□	□		Sludge is dumped at solid waste dumping site
	Faridpur	□	□		
Burkina Faso	Ouagadougou	□	□		New FSTP under construction
	Bobo Dioulasso	□	□		New FSTP under construction
	Fada N'Gourma	□	□		
Cambodia	Phnom Penh	Wetlands	Wetlands		
	Siem Reap	□	□		
	Kampot	□	□		
Ethiopia	Addis Ababa	□	□	980 m3/day	Two sites of sludge drying beds and lagoons. Also have four transfer stations
	Dire Dawa		□	130 m3/day	Four of six drying beds are full and not operational
	Hosaena	□	□		Current official dumping site in open field
India	Delhi	□	□		FS operators dump sludge in the open or manholes into sewage pipeline
	Jaipur	□	□		FS operators dump sludge in the open or manholes into sewage pipeline
	Madurai	□	□		FS operators dump sludge in the open or manholes into sewage pipeline
Kenya	Nairobi	□	□		FS dumped at designated tipping points connected to wastewater treatment sites
	Kisumu	□	□		FS dumped at designated tipping points connected to wastewater treatment sites
	Mombasa	□	□		FS dumped at designated tipping points connected to wastewater treatment sites
Nigeria	Abuja	□	□		FS operators dump sludge in designated manholes
	Ibadan	□	□		Receiving 146 m3 of industrial wastewater and household sludge daily
	Yenegoa	□	□		
Malaysia	Kuala Lumpur	□	□	300-400 m3/day	
	Kuala Terrenganu	□	□	80 – 160 m3/day	
	Melaka	□	□	300-400 m3/day	
Senegal	Dakar	□	□	270 m3/day	Three FSTP sites in Dakar are paired with the WWTPs
	Thies	□	□		
	Touba	□	□		Official dump site is an open field
Vietnam	Hanoi	□	□		New WWTP with 200K m3/day capacity operational in 2012; Current WWTPs at 6K m3/day
	Ho Chi Minh City	□	□	180 m3/day	FSTP with capacity of 180 m3/day
	Hai Phong	□	□	700 m3/day	Only 10-25 m3/year of sludge is currently treated here

5.6 Transfer Stations

In each of the surveyed cities, the emptying trucks need to travel long distances per trip in order to discharge the sludge at the designated dumpsites. Round trips can average 30 km in the capital cities of Africa and can take two hours to complete under normal traffic conditions. In Delhi a round trip is on average 24km and takes 2-3 hours and in Kuala Lumpur, the distances can be 50 km round trip. This results in high fuel costs for the trucks – which is the largest operating expense for them – and lower net profits. It also means higher emptying fees for the households, as truck operators charge higher rates for the longer distances they have to travel per household. In Nairobi, where the longest trip from client to dumpsite to parking bay can be as long as 50km, charges can vary from $50 for short distances to almost $100 for longer trips.

The correlation of transportation costs to the distance of the dumping site as indicated in the map below for Phnom Penh (Figure 45), is a common situation among all the cities surveyed. While multiple dumping sites or treatment plants cannot be built throughout the city, dispersed transfer stations are an option.

Figure 45: Increase in fuel costs with distance of dumping site in Phnom Penh

Transfer stations have been used or tested out in Ethiopia and Malaysia. In Abuja, the manholes stationed around the city serve as pseudo transfer stations since the emptiers can discharge into certain manholes connected to the main sewer trunk lines. In Addis Ababa, there are four transfer

stations built by the public utility AAWASA, to reduce, by an average of 12 km, the travel distance to the treatment sites that are located at the outskirts of the city. Only the utility trucks are allowed use of the transfer stations. Capacity limitations are so severe that only 35% of the utility trucks are using these stations. One of the stations has already been demolished to clear the land for residential construction. The operations of the remaining existing sites has been compromised due to improper use.

Box 3: Use of geo-tube for fecal sludge storage

The geo-tube material is made of a porous membrane with the sludge received through a hose from the truck. Discharge can be achieved by using a pump or gravity. Sludge in the geo-tube is gradually dewatered by leaching through the porous membrane, and the leachate is treated in the nearby sewage treatment plant, while the solids are retained inside. Exposure to the outdoor heat further dries the remaining sludge, and the geo tube is eventually lifted onto a truck and transported out to a landfill or a recovery facility.

In Malaysia the public utility is evaluating the use of geo tube as a novel transfer station (See Box 3). A pilot project was executed successfully by IWK in 2010 by locating geo tube in several strategic locations (at existing sewage treatment plants) to shorten the travel time for the trucks.

The data showed that the operational cost per emptying event was reduced by 8%, revenues increased by 35% due to more trips per day being possible and overall operations expenses decreased by 37%. The model, when applied to the medium-size operator in Melaka, demonstrated that the geo-tube extension into the "standard" FSM service model is a key determinant in improving the financial viability of the medium-size business.

Figure 46: Geo-tube before and after use in Malaysia

The advantages of using a geo-tube as opposed to a conventional sludge drying bed (SDB) are numerous and include: (1) that it can be used under all weather conditions whereas a sludge drying bed is effective only in dry weather unless built with a roof; (2) The Geo-tube or Geobag

is better contained to prevent flies and other pest problems; (3) A Geobag can be continuously filled up while the SDB normally must be left to dewater for a period of 4-6 weeks, depending on weather and drainage efficiency, before the dry sludge cake can be removed and the bed reused; (4) Geo-tube is easy to handle after it has been dewatered compared to a SDB which requires the material be scrapped off each time and this is likely to include some sand; (5) there are few odor issues with the Geobag since it is contained unlike an SDB which is operated as an open system; (6) three is ease of replacement with Geobag as when one bag is full, another bag can be installed unlike the SDB which is fixed and requires a large area.

As compared to the use of a Geo-tube/Gobag, the construction of transfer stations entail high capital and operational costs due to mechanical operations and the need for transfer trucks. The geo-tube option is preferable even in the absence of a receiving wastewater treatment plant as other alternatives such as a facultative lagoon or pond may be sufficient to treat the leachate generated from the Geo-tube.

5.7 Conclusion

The supportive mechanisms needed for economically and ecologically sound fecal sludge emptying businesses are those that would address the constraints and challenges currently faced by these businesses. No special financing schemes are available to the private entrepreneurs wanting to expand their fleet and business sizes. A lack of information about this sector and lack of guarantors for loans makes it virtually impossible for most entrepreneurs to be able to afford the commercial interest rates and conditions of the banks.

This lack of financial access proves to be the biggest barrier to market entry for the private operators. Without finances and the high cost of trucks that are imported from Europe to Africa, business owners are forced to purchase old, second-hand trucks, resulting in fuel inefficient trucks that require frequent and expensive maintenance. The situation is further exacerbated in Africa, by the lack of easy access to spare parts for the diverse models of the imported trucks. Trucks that are already sometimes over 30 years old and in need of frequent repairs, also suffer from long delays in getting the required spare parts resulting in high downtimes of the vehicles. This situation is particularly devastating for single truck owners.

Collection of sludge is not the complete solution for on-site sanitation, unless safe disposal of this sludge is planned for. This is another area where much work remains to be done. Only 30% of the cities had designed fecal sludge treatment plants where the trucks could discharge of the waste. Just over 50% of the cities surveyed had a wastewater treatment plant to treat the sewage. Operators are expected to dispose of the sludge at the fecal sludge treatment plants or in sewer lines connected to the waste water treatment plants in cities in which these options exist. It

should be noted that a total of ten cities had neither option available. In some places, official dumpsites are no more than open fields where the waste is dropped off into the environment.

Making matters worse for the truck operators are the long distances that they are expected to travel to discharge the sludge in official dumping sites and plants that are usually on the outer fringes of the cities. With each round trip averaging as many as 30km, and a tipping fee required at the dumpsite, the operators save time and fuel by dumping the sludge illegally by the roadside or open spaces in the cities.

To shorten these travel distances, only Ethiopia and Malaysia have looked at implementing transfer stations at different points inside the city. In Addis Ababa, while there are four transfer stations for this purpose, they are not as effective as they could be due to lack of capacity to handle the amount of sludge collected and poor operations at the stations. In Malaysia the government is experimenting with the use of geo-tubes as low-cost transfer stations and alternatives to fecal sludge treatment land sites.

Without comprehensive fecal sludge treatment solutions in place, the re-use of sludge is an even more remote activity. Re-use of fecal sludge is happening only on an experimental and very small-scale basis. In Vietnam ongoing efforts are being made at co-composting the fecal sludge with solid waste and sale as fertilizer. In Kenya, sludge is being converted to biogas for use in cooking at bio-centers in the city slums.

CHAPTER 6: CONCLUSION AND RECOMMENDATIONS

The ten country teams conducted a total of 13,143 household surveys and compiled financial statements of 154 emptying businesses. We believe this depth and breadth of this data is the first of its kind in providing detailed information of fecal sludge management practices across multiple countries.

Some of the key overall findings that emerge from this study are highlighted below:

- Emptying and transportation of fecal sludge is a profitable business – the highest cash flow per month was seen in Abuja at $15,000 per truck
- The potential for earned revenue in household emptying services across the 30 cities is $134 million, as more than 50% of the households in 25 of the 30 cities surveyed rely on on-site sanitation systems
- While a majority of the on-site sanitation emptying is done mechanically, 34% of the households in these cities still depend on manual emptiers
- The income per capita for the households with on-site sanitation facilities is between $1 and $4 a day, with the households paying less than 5% of their income as emptying fees.
- The most profitable businesses are those operated by private entrepreneurs who own at least two trucks. However, over 50% of the entrepreneurs can afford only one truck.
- The biggest challenges faced by the entrepreneurs are:
    - Lack of access to finance to increase fleet size. Most entrepreneurs rely on personal savings or loans from informal sources;
    - High costs of purchasing a truck (especially in Africa where these are imported);
    - Poor supply chain of spare parts for the maintenance of the trucks;
    - Large, second hand and old trucks in Africa have high operating costs with variable costs of operating a truck in Africa being six times more costly than in Asia; and
    - Long distances to dump sites cause very high fuel costs (especially in Africa) and erode profitability and encourage illegal dumping in the environment.
- The biggest failure of the FSM value chain is the lack of appropriate fecal sludge treatment facilities.
- Two vastly different models of public sector engagement in household emptying service provision were seen: Highly regulated market with scheduled desludging in Malaysia allowed for proper operations of the septic tanks while providing for a predictable and profitable emptying business. On the other hand, highly subsidized emptying fees in Ethiopia allowed the public utility to capture two-thirds of the market in Addis Ababa, but with heavy service backlogs and financial losses.

Based on these findings, some recommendations are offered here for consideration by donors and local governments in planning for future investments in FSM. These are not intended as a 'one-size-fits-all' model, but rather as a set of basic ideas that will have a strong likelihood of improving the transportation market in a city; prevailing market conditions in each city will heavily influence the specific business model in each case.

6.1 Market Structure

The current service model in most countries is one where the market is served by private businesses rather than the public sector. The tariffs are set by market demand and competition. These businesses need to be multi-truck establishments in order to maximize their share of the $134 million on-site sanitation emptying market.

The typical profile of a profitable emptying business is evident in a review of the top 15 most profitable operations (ranked by monthly cash-flows in Table 22):

Table 22 : Top 15 profitable businesses based on cash flow per truck

Location		Status	No. of trucks	Annual Revenue	Total Expenses	Annual Profit After Depreciation	Monthly Cash-flow per truck
Country	City						
Nigeria	**Abuja**	Private	4	$1,022,581	$303,075	$708,181	$14,990
Malaysia	**Kuala Lumpur**	Public	14	$2,249,079	$408,761	$1,759,391	$10,954
Nigeria	**Abuja**	Private	4	$499,211	$146,956	$333,382	$7,339
Malaysia	**Melaka**	Public	8	$1,155,483	$586,673	$494,411	$5,925
Kenya	**Mombasa**	Private	4	$267,844	$39,015	$209,264	$4,767
Nigeria	**Ibadan**	Private	3	$226,485	$72,879	$149,712	$4,267
Vietnam	**Ho Chi Minh**	Private	3	$201,320	$73,388	$123,534	$3,554
Malaysia	**Kuala Treng.**	Public	19	$1,275,352	$569,834	$594,273	$3,094
Vietnam	**Ho Chi Minh**	Public	7	$459,211	$199,420	$246,131	$3,093
Senegal	**Dakar**	Private	6	$489,294	$310,392	$152,656	$2,485
Nigeria	**Ibadan**	Private	2	$137,295	$78,328	$52,676	$2,457
Nigeria	**Abuja**	Private	1	$61,151	$32,568	$25,091	$2,382
Senegal	**Dakar**	Private	7	$612,901	$413,693	$168,551	$2,372
Cambodia	**Phnom Penh**	Private	1	$42,000	$20,004	$20,496	$1,833
Cambodia	**Phnom Penh**	Private	1	$43,200	$22,235	$18,965	$1,747

a) A majority (80%) of these top businesses operate two or more trucks. There are two single truck operators in Phnom Penh on this list. The market in Phnom Penh is highly competitive, where the supply of services providers is greater than what the demand warrants. These two businesses perform above the rest because of aggressive marketing campaigns and average spending of almost $4000 per year on such in marketing.

b) As seen in Chapter 5, the larger the fleet size, the greater the profitability achieved per truck through increased operational efficiencies and the ability to attract commercial emptying contracts.
c) Private companies dominate fecal sludge service provision. The only exception to public companies operating profitable models for household emptying is in Malaysia (as noted in Table 22). There, financial viability is achieved through services that are highly regulated, with the publically owned IWK allowed to charge higher tariffs than those mandated for the private permit holders, and monopolizing contracts for servicing governmental institutions. While Ho Chi Minh public company also made it to the top 15 list, it derives most of its revenue from leasing public toilets rather than from just household emptying services.
d) Almost 40% of the operating expenses for the African businesses is spent on fuel.

The optimum market structure then is one with the private businesses taking the lead in FSM service provision, with the support of the public sector (in areas of regulation and infrastructure such as transfer stations and sludge treatment plants) in a partnership to provide quality and affordable services to all.

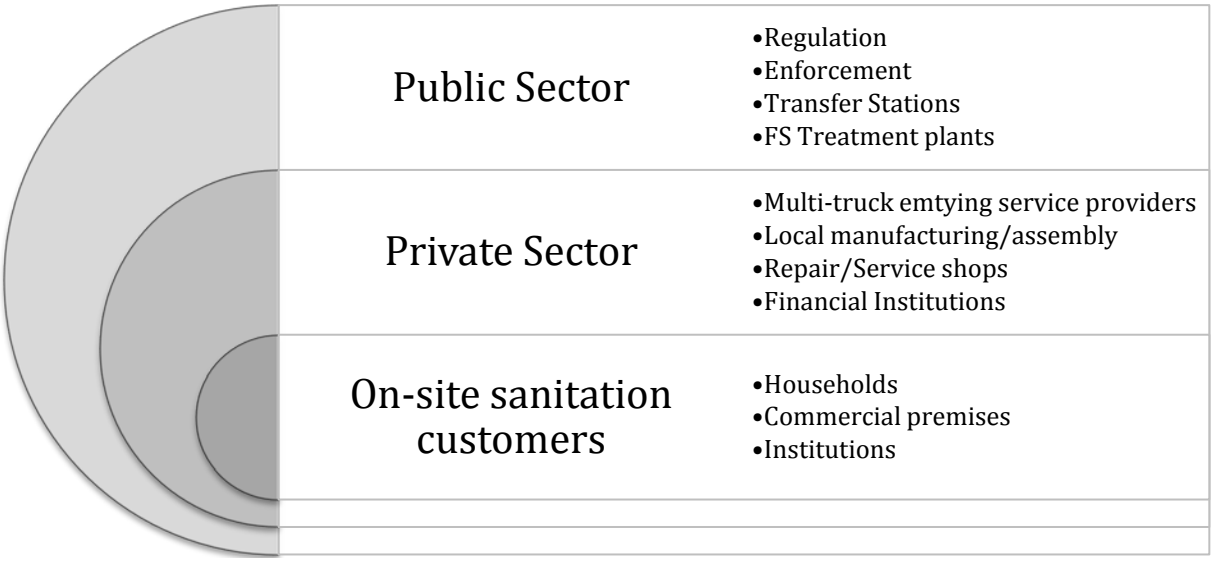


Figure 47: Public-private partnership in FSM service provision

To help private entrepreneurs establish multi-truck businesses, several measures are needed to improve the business environment for a suitable FSM service operation. These measures include reducing the costs of setting up and expanding the business (by reducing purchase price of the trucks through local manufacturing or lower import taxes plus subsidies) and reducing the operational costs (such as on fuel and maintenance) through the establishement of transfer stations, spare-parts inventories and service shops.

6.2 Market Regulations

In each country, many disparate governmental agencies oversee the provision of water and sanitation services from creating wastewater treatment plants; providing and maintaining sewer networks; and establishing water and sanitation policy, building and design codes for household facilities, and environmental guidelines for septage discharge. Fecal sludge management of private onsite facilities is, however, almost completely ignored in these various efforts. Sludge emptying trucks owned by the utilities are used primarily for emptying at governmental institutions or cleaning of the sewerage systems. Small and medium sized entrepreneurs, running operations that can be formal or informal, manage household, commercial and industrial emptying.

Regulating the operations of the private operators is also weakly done by the local authorities: every city (other than in Malaysia), has reported seeing emptying trucks that dump their contents in open environments and near water bodies instead of spending the fuel and time in transporting to the official dumping sites. To compound this problem of resistance to going to the dumping sites, the city authorities in Senegal, Kenya, Vietnam and Cambodia charge dumping fees for the sludge brought to the sites.

Public utilities manage to provide far better services to households in other areas like electricity, water and even solid waste collection, but largely fail in addressing waste collection and disposal from on-site sanitation systems. As a majority of the urban population lacks access to centralized sewer networks, it is imperative for public agencies to focus on establishing policies and regulatory frameworks to support on-site sanitation.

Policy instruments used to establish priorities, procedures and rules take the form of regulations, economic measures, information programs and assignment of roles and responsibility for service provision (Elledge M.F. 2003). Regulations are needed to facilitate the growth of the FSM private businesses by formalizing them and creating a supportive environment within which they can operate. FSM service providers need to be registered, licensed for FSM business operation and monitored for compliance to environmental discharge provisions.

As seen in the case of Malaysia, removing mandatory desludging at fixed intervals and making it demand-based led to the destabilization of a functioning service. When given the choice of when to empty, even a population well versed in the practice of emptying septic tanks every two years chose to delay emptying until unavoidable. As a result, most of the operators in Malaysia with fewer than three trucks have gone out of business. Delaying emptying will also have a detrimental effect on the effectiveness of septic tanks, as waiting until the septic tanks are full and overflowing, means that the septic tanks are not allowed enough reaction space for the settling and anaerobic digestion to occur effectively. Regulating demand through scheduled

desludging will have a positive impact on the business as well as the quality of effluent from the septic tanks and pits.

Another aspect in regulating services that local authorities could consider is to assign areas of operation to the licensed service providers. This would alleviate monopolistic situations in certain zones within the city and provide equal opportunity for all.

In order to assign households to zones for emptying services, a robust and accurate database must be maintained on the number and types of on-site sanitation systems in the city. Scheduling desludging is also possible only when this information is known and the systems are not too varied so as to keep the determination of the emptying schedule manageable. In too many instances, poor design and inaccessibility of the pit or tank made for a much more difficult and destructive emptying process (as a result of having to break the cover of the pit or tank to access the contents). For these various reasons, having standard codes for the design of the on-site sanitation systems is another area that needs to be addressed and enforced. Some countries do have standard building codes, but lack of enforcement and penalties for violation has led to large-scale non-compliance.

Where utilities are the primary providers of emptying services, economic measures such as regulating the tariff structure for household and commercial emptying would give users a clear idea of expenses for which they should budget and plan. Tariffs could be based on either the volume of sludge emptied or the number of trips the trucks need to make to empty the septic tank, as well as the distance that they need to travel to dispose of the sludge. The situation in Malaysia should be studied further to learn from their experience of regulating fees and payment options. Penalties for illegal roadside dumping are in place in come countries, but need to be more strictly enforced, especially if tariffs include extra charges for traveling longer distances to official dumping sites. Elimination of tipping fees should also be considered by the utilities in charge of the disposal sites, to remove a dis-incentive for the truck operators to come to these sites.

Public awareness and education campaigns will also be needed to provide information about the regulations, the need for them and the need for regular desludging and safe disposal.

6.3 Capital Investments

The utilities need to take fecal sludge management more seriously in order to provide the elements needed for the full sanitation service delivery chain all the way to treatment and reuse. Besides a strong regulatory framework, this will require investment in supportive infrastructure such as transfer stations, sludge treatment plants and reuse facilities. Fecal sludge management

must be environmentally sound while enabling financially sustainable businesses for the service providers and affordable services for the users.

Developing sustainable solutions will take more than just viable emptying and transportation models. As long as there is no safe disposal of the collected sludge, the sanitation value chain will remain broken with the problem merely migrating to a different part of the system. In Touba in Senegal, for example, the official dumping ground is 25 km outside the city and is just an open field where the operators have to pay to dump the sludge. Construction of wastewater treatment plants are needed for sewage, but investments must also be made in fecal sludge treatment plants to allow for effective treatment of the on-site sanitation sludge which has a much different composition and treatment requirement than wastewater.

Another key issue that must be addressed to improve the profitability of the businesses is to lower the businesses' fuel costs. While the notion of having transfer stations for efficiency is not new, the data from this study shows conclusively that this is imperative for the viability of the businesses, as fuel costs making up 40% of the operating costs across the businesses in Africa. Locating transfer stations across the city to lower the distances travelled will have a two-fold impact on profits: it will lower the main cost driver – the amount spent on fuel – and also allow more time for more revenue-generating trips per day. The private operators (and public, where they exist) will be able to dispose of the sludge at nearby transfer stations, from which point the utility trucks can transport the sludge to treatment plants.

Clearly, funding for infrastructure like transfer stations and treatment plants will require high financial investment and political will. Some of the operational costs could be recovered from an additional surcharge to monthly water bills or sale and reuse of the treated sludge, but full cost recovery may not be possible. However, economic costs may be more than recouped through the benefits to public health and productivity as highlighted in Chapter 1.

Given the amounts of public finance that are needed for sewerage expansion, the governments could consider prioritizing on-site sanitation and fecal sludge management as a lower cost alternative. The investments and operating expenses will be lower than that required for sewer-based systems (as demonstrated by Dodane et al.) and will provide access to safe sanitation to more households that conventional sewer systems have in these cities.

6.4 Capital Equipment

One of the greatest challenges to efficient and profitable collection and transportation service provision is the lack of access to affordable, fuel-efficient new trucks – especially in Africa. As the data in this study shows, second-hand trucks imported into Africa cost on average more than $30,000 to purchase, are fuel inefficient, costly to maintain and sometimes over 30 years old.

For these old imported trucks, the maintenance required is not only frequent and therefore costly, but is also challenging due to the lack of availability of spare parts.

If facilitating the creation of private, large businesses is necessary for creating sustainable FSM models, as this study has demonstrated, the growth from small to large businesses is critical. With capital expenses being so high in Africa, financing this growth remains a challenge. The private entrepreneurs do not have easy access to commercial loans and purchasing these expensive trucks with personal savings or informal loans, is not the optimal solution for rapid expansion.

Innovative financing solutions are needed to assist these private service providers and ideas such as output-based-aid financing mechanisms should be looked into for service providers (Tremolet, S. 2011). Clear and well-defined output metrics – for example, number of households served, evidence of safe disposal – will need to be established for purposes of funding and monitoring. A further idea is for donors and governments to partner with commercial financial institutions in providing loan guarantees for fleet expansion.

Asset ownership of new trucks by the public sector with operation by the private entrepreneurs can take shape under different financial arrangements such as straight leasing, or shared profits. State governments could purchase new sewage trucks and transfer lease management operations to financially capable and competent management companies with proven track records in leasing operations and fleet management services. Alternatively, state governments can partner with leasing companies to handle both the purchase and management of the fleet of sewage vehicles.

The financial products introduced to address this sector should in the first instance be designed to support the shift from one truck to two. As the data in this study demonstrates, a multi-truck business is the optimum model, but growing from two trucks to more than five will likely require gradual growth over time, as there are considerations beyond finance that need to be taken into account. Each additional truck will require time and marketing to build demand and there will likely be a time lag before each new truck can be utilized fully even with the addition of further staff. These factors will need to be evaluated to determine the optimal pace of growth but the move beyond one truck is a crucial first step.

Another option would be to consolidate the small truck owners into a cooperative entity; effectively creating a large sized business comprised of individual owners and shared profits.

These suggestions are based on the current sources of trucks in the various geographies. Further investigation is needed to determine the viability of local manufacturing and/or assembly within Africa and exporting across free trade zones within Africa rather than importing from Europe.

Besides manufacturing and funding the existing vacuum trucks, research on improving the emptying technologies may provide another avenue to reducing truck operating costs. For example, the Omni-Ingestor under development by Bill & Melinda Gates Foundation, is a machine intended to make pit and tank emptying a more viable business. Its goal is to drive the costs of emptying down so that more people can afford it and increase the number of pits that can be emptied in a community to increase the revenue of the operators. The operating costs will be reduced by increasing the number of pits that can be emptied in a day and reduce the number of times the operator must drive to the waste treatment processing facility. This efficiency can be achieved by removing inorganic material (trash and sand) from the waste and by reducing the water content to the minimum that is feasible. The trash will be containerized for trash pickup, the sand will be cleaned and "sanitized" and ejected, and the water will be clarified, sanitized, deodorized and ejected. The water quality should permit it to be used for crop irrigation, washing, injection or absorption into the soil, or release into streams and rivers.

6.5 Capacity Building

Attention also needs to be paid to building the business management capacity of private entrepreneurs. Funding for business training and accounting would assist a large number of entrepreneurs that enter the market but are not fully well versed in the creation and management of their financial statements. Assistance on planning for and meeting the requirements to access commercial capital will help these businesses be more proactive and successful applying for loans.

As these recommendations suggest, there are various avenues that need to be explored as governments and funders look for ways to provide access to safe and universal sanitation. In these efforts we must not lose sight of solutions that already exist but that must be better coordinated, funded and implemented. Sewer connectivity to all households is only one option, and an expensive one at that. Priority must be given to improving access to on-site sanitation and creating viable solutions for collection, transportation and treatment of the fecal sludge. In the end, this approach might be the fastest, most effective way to achieve universal sanitation coverage.

Appendix A: African Country Teams

		Current Organization * (Contract with)	Stengths of key team members
BURKINA FASO			
Consultant name	**Role/Skills**		
Denis Zoungrana	Project lead, study coordinator	Consultant*	Project lead also teaches at International Institute for Water and Environmental Engineering and was Deputy Director at ONEA (national utility); Team members include expertise in FSM, previous work experience at CREPA, 2iE, ONEA and private
Christian Béré	Socio-economic expert	Consultant	
Halidou Koanda	Backstopping/guidance	WaterAid Burkina Faso	
ETHIOPIA			
Consultant name	**Role/Skills**		
Abebe Belete	Project manager	Inependent Consultant	Team lead has over 10 years experience in on-site sanitation and is consultant on waster water and sludge mnanagement; Other members include ex-senior officials from public utility (AAWSA)
Hailu Yemane	Wastewater & Sludge mgment specialist	Hywas Engineering Consultants *	
Getahun Worku	On-site sanitation expert	Inependent Consultant	
Eyob Defere	Socio-economist	Eyob Defere Management	
Dr. Ase Kemal	Sludge Management	Hywas Engineering Consultants	
KENYA			
Consultant name	**Role/Skills**		Team lead is the ex-CEOof Athi Water Services Board (AWSB). Mr Mwangi was also Director of Environment for Nairobi City Council and worked for the Water & Sewerage Department of Nairobi for 15 years prior to that. Other team members include Mr. Muvelah with 14 years of experience in financial and strategic management, Mr Nzainga a project management professional with 25 years of water/sanitation experience and an ex-General Manager of Water&Sanitation Dept. in Nairobi. Also part of the team is WASPA - Water Services Providers Association- for coordination across the 3 cities and with the utilities
Lawrence Mwangi	Team lead	Losai Management Ltd *	
Jackson Nzainga	Deputy Team Lead	Losai Management Ltd	
Sammy Muvelah	Finance& Institutional Management Specialist	Losai Management Ltd	
Abonyai Kiogora	Social-Economic Specialist	Losai Management Ltd	
WASPA	Overall Coordination	WASPA	
NIGERIA			
Consultant name	**Role/Skills**		
Prof. M.K.C Sridhar	Team lead	Professor @Niger Delta University *	Dr M. K. C. Sridhar, has been working in WSH in Nigeria since 1977 and in sewage treatment for a decade prior to that in India. Currently taching at Niger Delta University, his team includes lecturers from Ibadan University and , specialist in Supply Chain Management, Business Planning and Analysis from a consulting firm.
Dr. Bolanle Wahab	Urban planning &development expert	University of Ibadan	
Dr. Elizabeth Oloruntoba	Data analysis, training survey team	University of Ibadan	
Ms. Achenyo Idachaba	Finance expert; Business model analysis	Greennovative Chain Consulting	
SENEGAL			
Key team members	**Role/Skills**		
Cheikh Sidia Toure	Project Lead/Coordinator	EDE Development Engineering *	EDE Development Engineering and H2O Engineering are two Senegalese consulting firms specialized in sanitation and environment; Clients include ONAS, Sandec, SNV, World Bank; Cheikh Toure has extensive experience in WSH and was Director of Regional Centre for Water Supply and Sanitation (CREPA) for 13 years; Dr Mbeguere conducts research on FSM for EAWAG
Mbaye Mbeguere	FSM expert	H2O Engineering	
Françoise Toure	Socio-economist Expert	EDE Development Engineering	
Jean Birane Gning	Business Model analysis	H2O Engineering	

Appendix A (contd.): Asian Country Teams

BANGLADESH		Current Organization	Stengths of key team members
Consultant name	**Role/Skills**	(WaterAid America)*	
Technical Committee	Advisory committee	Government, NGO,private sector exp	WaterAid Bangladesh has worked with different community based approaches for better management of sludge. Core team constitutes of members specializing in policy analysis, management, government advisory and entrepreneurship development and a s10 member Technical Advisory Committee
Aftab Opel	Research Coordinator	WaterAid Bangladesh	
M Feroze Ahmed	Technical expert	Bangladesh University	
M Khairul Bashar	Business Expert	Faircon Management Services	
CAMBODIA			
Consultant name	**Role/Skills**		A 30 year old French NGO, operates projects funded by international organizations, public and private entities; In this time, GRET has worked on the professionalization process of the stakeholders in water/sanitation service delivery in eight countries and facilitating the institutionalisation of these services. Team skills are in small scale sanitation service delivery business assessment, FSM value chain analysis.
Clément Frenoux	WASH institution specialist	GRET*	
Benjamin Clouet	FSM expert	GRET	
Alicia Tsitsikalis	Service delivery business assessment	GRET	
INDIA		*** (Contract with)**	
Consultant name	**Role/Skills**		
Narayan Bhat	Lead/Country Coordinator	The Right Angle*	Team lead has over 25 years experience in program management, WSH and institutional development. Team experience includes projects funded by the World Bank, DFID, ADB, CARE in addition to a key assignment for ECO-ASIA on assessment on Water & Sanitation and Septage Management Status in India.
Navin Chopra	Sanitation treatment and city sanitation planning	Independent Consultant	
Anupam Vasishta	Socio-economics and market analysis Expert	Neuro Bricks	
Baskaran C	Finance Modeling Expert	Community Consulting India Pvt Ltd	
MALAYSIA			
Consultant name	**Role/Skills**		
Peter Yueh Chuen Ho	Team Lead	ERE Consulting Group*	ERE is anenvironmental consultancy company, working with the government and provate sector in Malaysia and across Asia. They will understake this study in collboration with IWK - the national sewerage company- and complement the strengths of IWK's technical expertise and network with program management and socio-economic expertise
Ir Zakaria Md Yassin	Co-team lead	Indah Water Konsortium (IWK): utility	
Dr Siew Hooi Tan	Socio economic consultant	ERE Consulting Group	
Cheng Liat Lean	Financial analyst	LTL Resources	
Ir Teik Hoe Teh	Sludge management expert	IWK	
Sasidharan Velayudham	Technical expert - market regulations	IWK	
Ir Mazura Mazlan	Sr.consultant/Data collection and analysis	ERE Consulting Group	
VIETNAM			
Consultant name	**Role/Skills**		Prof. Nguyen has 18 years experience in the water & sanitation sector in Vietnam. He was part of a project with EAWAG on low-cost decentralized sanitation and in the USAID / Borda / GHK on fecal sludge management study in Asia. Team experienced in financial analysis and assessment for water and sanitation companies, treatment efficiency of on-site sanitation facilities, public utility enterprise and sustainability experise.
Prof. Dr. Nguyen Viet Anh	Team leader	Professor @Hanoi Univeristy*	
Prof. Dr. Nguyen Phuoc Dan	Sanitation expert	Ho Chi Minh National University	
Nguyen Hong Sam	Economist, Business model analysis	Consultant	
Hoang Thuy Lan socio-economics expe	Field survey coordinator; socio-economic expert	CEFACOM (NGO)	

African Regional Coordinator: Dr. Mbaye Mbeguere

Asia Regional Coordinator: SNV Asia

Global Coordinator: Sangeeta Chowdhry

Appendix B: Household survey data – Level of confidence

Continent	Country	City	Population	# HH	Type of survey	*P*	Theoretical Size at 99%	Theoretical Size at 95%	Theoretical Size at 90%	Real size	Remarks
Africa	Burkina Faso	Ouagadougou	1,339,458	277,988	Total	0.5	662	384	271	634	99%
Africa	Burkina Faso	Bobo Dioulasso	489,967	94,947	Total	0.5	663	384	271	315	90%
Africa	Burkina Faso	Fada N'Gourma	41,785	8,440	Total	0.5	654	381	269	150	75%
Africa	Ethiopia	Addis Ababa	3,000,000	697,815	Total	0.5	663	384	271	600	95%
Africa	Ethiopia	Dire	350,000	79,373	Total	0.5	658	383	270	404	95%
Africa	Ethiopia	Hosaena	75,000	17,902	Total	0.5	640	377	267	302	90%
Africa	Nigeria	Ibadan	1,338,259	340,024	Total	0.5	663	384	271	927	99%
Africa	Nigeria	Abuja	778,567	179,674	Total	0.5	662	384	271	801	99%
Africa	Nigeria	Yenagoa	353,344	72,390	Total	0.5	658	383	270	264	89%
Africa	Senegal	Dakar	2,574,065	279,790	Total	0.5	662	384	271	501	95%
Africa	Senegal	Thies	293,112	30,725	Total	0.5	650	380	269	500	95%
Africa	Senegal	Touba	617,813	56,941	Total	0.5	656	382	270	500	95%
Asia	Bangladesh	Dhaka	15,018,594	3,337,470	Total	0.5	664	385	271	467	95%
Asia	Bangladesh	Khulna	1,728,760	384,169	Specific	0.5	663	384	271	358	90%
Asia	Bangladesh	Faridpur	135,837	25,342	Specific	0.5	647	379	268	395	95%
Asia	Cambodia	Phnom Penh	1,242,992	253,672	Total	0.5	662	384	271	1320	99%
Asia	Cambodia	Siem Reap	168,662	34,421	Total	0.5	651	380	269	428	95%
Asia	Cambodia	Kampot	38,819	7,922	Total	0.5	613	367	262	308	90%
Asia	India	Delhi	10,204,284	1,700,714	Specific	0.9	239	139	98	589	99%
Asia	India	Jaipur	3,560,000	508,571	Specific	0.9	239	139	98	292	99%
Asia	India	Madurai	1,121,043	224,209	Specific	0.9	239	139	98	270	99%
Asia	Malaysia	Kuala Lumpur	1,627,200	436,900	Specific	0.9	239	139	98	200	95%
Asia	Malaysia	Melaka	483,700	122,600	Specific	0.9	239	139	98	200	95%
Asia	Malaysia	Kuala Terengganu	337,000	69,700	Specific	0.9	239	139	98	200	95%
Asia	Vietnam	Hanoi	2,300,000	489,362	Total	0.5	663	384	271	401	95%
Asia	Vietnam	Hai Phong	839,800	232,760	Total	0.5	662	384	271	297	90%
Asia	Vietnam	HCMC	7,396,500	1,540,938	Total	0.5	664	385	271	302	90%

Appendix C: Typical Income statement data gathered during operator interviews

(Data for Medium sized business in Abuja)

Personnel Costs		
Permanent staff	USD	23,040
Fixed Operating Costs		
Registration fees of company	USD	448
Licensing fees for truck	USD	2,240
Insurance costs for trucks, vehicles	USD	3,680
Office building rent	USD	6,400
Safety Equipment	USD	307
Marketing	USD	3,072
Telephone	USD	2,304
Variable Operating Costs		
Daily wage workers	USD	22,464
Trucks Maintenance and repair	USD	4,608
Trucks servicing	USD	7,680
Pump servicing	USD	2,304
Fuel (pumping & transport)	USD	53,222
Sludge dumping/tipping Fees	USD	
Tires	USD	11,200
Suction pipe	USD	256
Total operating costs	USD	**120,186**
Loan Interest paid to Bank	USD	6,270
Truck Depreciation Cost	USD	38,400
Revenue Sources		
Emptying (Households only)	USD	368,640
Emptying (Other)	USD	137,472
Other uses of the trucks	USD	1,728
Total revenues	USD	**507,840**
Profit /Loss		
Revenue before Tax	USD	319,944
Revenue Tax	USD	95,983
Profit (loss) after Tax	USD	223,961

Appendix D: Calculations for Fecal Sludge produced based on Household surveys

Number of households inthe city =	HH
% of the city HH with On-site sanitation=	OSS%
Number of the city HH with On-site sanitation =	OSS% x HH= OSS
Number of the adjusted city HH with On-site sanitation =	Adj OSS
% of the HH with OSS having pits in the city (from HH survey) =	PIT%
% of the HH with OSS having septic tanks in the city (from HH survey) =	ST%
% of the HH with OSS having OTHER (i.e. cesspols, holding tanks) in the city (from HH survey) =	CES%
Number of the HH with OSS having pits in the city (from HH survey) =	PITS% x Adj OSS = PITS
Number of the HH with OSS having septic tanks in the city (fromHH survey) =	ST% x Adj OSS = ST
Typical volume of the septic tank =	SV m^3
Typical volume of the pits =	PV m^3
Typical volume of the Cesspool/Holding tanks =	CV m^3

Survey Data	Emptying Frequency	No. of pits to be Emptied/yr	Emptying Frequency Septic Tanks	# Septic tanks to be Emptied/yr	Emptying Frequency cesspools	# Fequency cesspools to be Emptied/yr
2 times/yr	a%	PITS x a% x 2	h%	ST x h% x 2	o%	CES x o% x 2
Once/yr	b%	PITS x b% x 1	i%	ST x i% x 1	p%	CES x p% x 1
Once/2 yrs	c%	PITS x c% x 0.5	j%	ST x j% x 0.5	q%	CES xq0% x 0.5
Once/3yrs	d%	PITS x d% x 0.33	k%	ST x k% x 0.33	r%	CES x r% x 0.33
Once/4 yrs	e%	PITS x e% x 0.25	l%	ST xlh% x 0.25	s%	CES x s% x 0.25
Once/5-10 yrs	f%	PITS x f% x 0.13	m%	ST x m% x 0.13	t%	CES x t% x 0.13
Once 10 yrs	g%	PITS x g% x 0.1	n%	ST x n% x 0.1	u%	CES x u% x 0.1
	TOTAL Pits to be emptied per year =	**A**	**B. TOTAL Septic tanks to be emptied/ year =**	**B**	**TOTAL cesspools to be emptied/ year =**	**C**

Market Size : Total VOLUME (in m3) of sludge TO BE emptied / year = (A x PV) + (B x SV) +(C x CV)

Appendix E: Household Survey Questions

A. General Information

Number of Survey per cities/countries
Q.2 What is the name of the city?
Q.4 Is the interviewee is the head of HH?
Q.5 What is the sex of interviewee?

B. Socio-economic Survey

Q.6 What is the highest level of education of the HH?
Q.7 What is the status of HH housing?
Q.8 What is the number of person per house?
Q.9 What is the number of users per latrine?
Q.10 What is the main occupation of the head of HH?
Q.11 Is the household have bicycle?
Q.12 Is the household have a motocycle?
Q.13 Is the household have a car?
Q.14 Is the household have a TV?
Q.15 Is the household have a phone/cellphone?
Q.16 What are the phone expenses (US$) per month/HH?
Q.17 Is the household have an acess to electricity?
Q.18 What the electricity expenses (US$) per month per HH?
Q.19 What the Incomes per HH/month (US$)?
Q.20 What is the incomes per capita/day (US$)?

C. Water and Sanitation Profil

Q.21 What is the main access to water?
Q. 22 What is the monthly water consumption per HH (m3)?
Q.23 What is the monthly water bill per HH/month (US$)?
Q.24 What is the profil of sanitation assets?
Q. 25 What is the type sanitation assets?
Q.26 If no toilet at home where do you go?
Q. 27 Are you satisfied with your sanitation assets?
Q.28 What are the reasons of satisfaction/unsatisfaction reasons?

D. Fecal Sludge Management Practices

Q.29 What did you do when your pit/septic tank are full?
Q.30 Have you ever emptied your pit/septic tank?
Q.31 If Yes, Who have emptied your pit/septic tank manual or mechanical?
Q.32 If manual, did you made it yourself or by a manual operator?
Q.33 What HH choose regarding the cost?
Q.34 What HH choose regarding the avaibility?
Q.35 What HH choose regarding the quality of service?
Q.36 What HH choose other reasons?
Q.37 Where did you found the contact?
Q.38 Did call the same FSM operator?
Q.39 How did you pay the FSM service?
Q.40 If manual, How much did you pay for the FSM service?
Q.41 If mechnical, How much did you pay for the FSM service?
Q.42 Are you satisfied by the fee amount?
Q.43 How can improve the FSM paiement modality ?
Q.44 Are you satisfied by the FSM service?

E. Satisfaction and Willingness to pay

Q.45 If Yes, why?
Q.46 If No, Why?
Q.47 What is the frequency of empyting (text)?
Q.48 What is the frequency of emptying (num)?
Q.49 Do you know where the FS are dumped?
Q.50 Do you know if the FS are reuse?
Q.51 If Yes, how?
Q.52 What is the impact of the FSM?
Q.53 If Yes, why?
Q.54 What is your willigness to pay to FSM improvement or
Q.55 What is your willigness to pay to FSM improvement or
Q.56 Do you the laws that are applied on FS Management?

F. Role of stakeholders

Q.57 Do you feel normal to follow these legal obligations?
Q.58 What can be the role of the Public authorities in FSM?
Q.59 What can be the role of Sanitation Utilities in FSM?
Q.60 What can be the role of local NGO in FSM?
Q.61 What can be the role of private FSM operator in FSM?

Appendix F: Financial Summary of Emptying Business Operations (Ranked by monthly Cash Flows per truck)

SMALL SIZED BUSINESSES

Country	City	Status	No. of trucks	Annual Revenue	Annual Expenses	Annual Profit After Depreciation	Monthly Cash-flow per truck	ROI per truck (post depreciation)	Cost of investment per truck	% Fuel cost per truck	% Maintenance cost per truck	% Dumping costs per truck
Nigeria	Abuja	Private	1	$61,151	$32,568	$25,091	$2,382	72%	$34,916	37%	15%	0%
Cambodia	Phnom Penh	Private	1	$42,000	$20,004	$20,496	$1,833	137%	$15,000	17%	0%	9%
Cambodia	Phnom Penh	Private	1	$43,200	$22,235	$18,965	$1,747	95%	$20,000	19%	2%	7%
Nigeria	Yenagoa	Private	1	$44,844	$25,423	$16,275	$1,618	52%	$31,456	47%	21%	4%
Kenya	Nairobi	Private	1	$31,532	$19,206	$7,326	$1,027	15%	$50,000	45%	18%	4%
Kenya	Nairobi	Private	1	$27,893	$17,858	$8,335	$836	49%	$17,000	49%	13%	4%
Vietnam	Ho Chi Minh	Private	1	$41,942	$33,357	$6,396	$715	29%	$21,883	7%	1%	0%
Vietnam	Hanoi	Private	1	$29,971	$21,760	$4,910	$684	15%	$33,010	10%	6%	27%
Cambodia	Phnom Penh	Private	1	$18,000	$10,196	$6,304	$650	42%	$15,000	24%	9%	5%
Ethiopia	Addis Ababa	Private	1	$32,544	$24,774	$6,723	$648	64%	$10,473	62%	13%	0%
Senegal	Dakar	Private	1	$51,761	$44,196	$3,043	$630	7%	$45,218	37%	11%	14%
Burkina	Ouagadougou	Private	1	$32,263	$25,342	$3,778	$577	12%	$31,425	41%	24%	10%
India	Delhi	Private	1	$16,400	$9,770	$5,731	$552	64%	$8,989	55%	7%	0%
India	Delhi	Private	1	$17,343	$11,205	$5,239	$511	58%	$8,989	48%	6%	0%
India	Jaipur	Private	1	$12,177	$6,416	$5,093	$480	76%	$6,683	35%	15%	0%
India	Delhi	Private	1	$13,940	$8,817	$4,157	$427	43%	$9,656	47%	11%	0%
India	Delhi	Private	1	$13,940	$8,838	$4,137	$425	43%	$9,656	46%	11%	0%
India	Jaipur	Private	1	$12,054	$7,289	$3,236	$397	21%	$15,293	39%	15%	0%
India	Delhi	Private	1	$17,425	$12,772	$3,954	$388	57%	$6,991	43%	8%	1%
Nigeria	Abuja	Private	1	$28,056	$23,441	$274	$385	1%	$43,410	35%	14%	0%
Bangladesh	Khulna	Private	1	$9,195	$4,694	$2,083	$375	9%	$24,175	12%	11%	0%
India	Delhi	Private	1	$12,300	$7,800	$3,793	$375	54%	$7,073	39%	13%	0%
India	Delhi	Private	1	$12,300	$7,800	$3,793	$375	54%	$7,073	39%	13%	0%
Kenya	KISUMU	Private	1	$14,832	$10,598	$(657)	$353	-1%	$48,913	30%	14%	0%
Kenya	Nairobi	Private	1	$24,602	$20,386	$(2,785)	$351	-4%	$70,000	42%	11%	3%
Cambodia	Phnom Penh	Private	1	$9,300	$5,145	$3,099	$346	29%	$10,560	21%	6%	7%

India	Jaipur	Private	1	$7,872	$4,150	$2,746	$310	28%	$9,758	63%	35%	0%
India	Jaipur	Private	1	$13,653	$10,155	$2,071	$291	15%	$14,268	24%	27%	0%
Senegal	Dakar	Private	1	$79,632	$76,239	$(907)	$283	-2%	$43,006	37%	10%	13%
Burkina	Bobo-Dioulasso	Private	1	$31,425	$28,084	$199	$278	1%	$31,425	48%	28%	0%
India	Jaipur	Private	1	$11,316	$8,047	$2,242	$272	22%	$10,271	51%	22%	0%
Senegal	Thiès	Private	1	$41,409	$38,312	$(1,093)	$258	-3%	$41,900	43%	25%	0%
India	Madurai	Private	1	$9,225	$6,533	$1,617	$224	15%	$10,742	21%	12%	0%
India	Madurai	Private	1	$9,225	$6,652	$1,499	$214	14%	$10,742	21%	12%	0%
India	Madurai	Private	1	$9,225	$6,706	$1,445	$210	13%	$10,742	22%	12%	0%
Burkina	Bobo-Dioulasso	Private	1	$19,066	$16,560	$(637)	$209	-2%	$31,425	44%	31%	0%
India	Madurai	Private	1	$9,225	$6,747	$1,404	$207	13%	$10,742	22%	12%	0%
India	Madurai	Private	1	$9,225	$6,882	$1,269	$195	12%	$10,742	23%	11%	0%
Cambodia	Phnom Penh	Private	1	$4,800	$2,972	$328	$152	2%	$15,000	23%	4%	6%
Cambodia	Siem Reap	Private	1	$6,480	$5,184	$146	$108	1%	$11,500	42%	4%	9%
Cambodia	Siem Reap	Private	1	$7,992	$6,722	$30	$106	0%	$12,400	52%	6%	9%
Senegal	Dakar	Private	1	$34,507	$33,357	$(3,217)	$96	-7%	$43,670	33%	13%	12%
Cambodia	Kampot	Private	1	$3,600	$2,486	$(86)	$93	-1%	$12,000	45%	0%	0%
Cambodia	Siem Reap	Private	1	$5,760	$4,817	$(257)	$79	-2%	$12,000	41%	26%	7%
Cambodia	Siem Reap	Private	1	$3,600	$3,680	$(1,280)	$(7)	-11%	$12,000	17%	0%	10%
Senegal	Touba	Private	1	$35,339	$35,952	$(5,466)	$(51)	-11%	$48,536	58%	19%	2%
Senegal	Thiès	Private	1	$31,853	$32,472	$(4,809)	$(52)	-11%	$41,900	39%	15%	0%
Bangladesh	Dhaka	Private	1	$1,858	$2,522	$(1,968)	$(55)	-15%	$13,045	7%	44%	0%
Bangladesh	Dakha	Private	1	$7,126	$7,855	$(1,359)	$(61)	-22%	$6,302	11%	14%	0%
Nigeria	Yenagoa	Private	1	$5,285	$6,063	$(2,634)	$(65)	-14%	$18,559	9%	46%	12%
Bangladesh	Faridpur	Private	1	$690	$1,780	$(1,389)	$(91)	-46%	$2,988	1%	38%	0%
Senegal	Touba	Private	1	$35,197	$36,937	$(5,930)	$(145)	-14%	$41,900	45%	29%	2%
Senegal	Touba	Private	1	$35,197	$37,931	$(7,698)	$(228)	-16%	$49,642	55%	22%	2%
Nigeria	Yenagoa	Private	1	$13,287	$17,389	$(5,392)	$(342)	-42%	$12,897	25%	35%	4%
Nigeria	Yenagoa	Private	1	$4,152	$14,361	$(11,316)	$(851)	-102%	$11,073	43%	35%	5%
Kenya	MOMBASA	Private	1	$17,608	$38,970	$(26,253)	$(1,780)	-54%	$48,913	4%	4%	0%

Appendix F (contd): Financial Summary of Emptying Business Operations (Ranked by monthly Cash Flows per truck)

MEDIUM SIZED BUSINESSES

Country	City	Status	No. of trucks	Annual Revenue	TOTAL OPEX	Annual Profit After Depreciation	Monthly Cash-flow per truck	ROI per truck (post depreciation)	Cost of investment per truck	% Fuel cost per truck	% Maintenance cost per truck	% Dumping costs per truck
Nigeria	Abuja	Private	4	$1,022,581	$303,075	$708,181	$14,990	625%	$28,311	12%	4%	0%
Nigeria	Abuja	Private	4	$499,211	$146,956	$333,382	$7,339	177%	$47,184	36%	17%	0%
Kenya	Mombasa	Private	4	$267,844	$39,015	$209,264	$4,767	107%	$48,913	9%	36%	0%
Nigeria	Ibadan	Private	3	$226,485	$72,879	$149,712	$4,267	384%	$12,982	40%	22%	0%
Vietnam	Ho Chi Minh	Private	3	$201,320	$73,388	$123,534	$3,554	281%	$14,660	35%	2%	2%
Nigeria	Ibadan	Private	2	$137,295	$78,328	$52,676	$2,457	84%	$31,456	31%	38%	0%
Kenya	Mombasa	Private	2	$55,470	$14,794	$30,894	$1,695	32%	$48,913	19%	19%	0%
Cambodia	Phnom Penh	Private	4	$172,800	$97,690	$67,610	$1,565	90%	$18,750	18%	6%	7%
Senegal	Dakar	Private	3	$164,683	$110,777	$40,009	$1,497	29%	$46,324	35%	16%	13%
Burkina	Ouagadougou	Private	4	$160,896	$92,302	$56,024	$1,429	45%	$31,425	54%	27%	0%
Senegal	Touba	Private	2	$101,372	$71,808	$20,520	$1,232	23%	$45,218	54%	15%	2%
Burkina	Ouagadougou	Private	3	$110,616	$66,580	$34,608	$1,223	37%	$31,425	52%	28%	0%
Cambodia	Phnom Penh	Private	4	$155,520	$96,970	$49,550	$1,220	55%	$22,500	19%	6%	7%
Senegal	Touba	Private	2	$104,311	$75,546	$19,942	$1,199	23%	$44,112	51%	22%	2%
Burkina	Ouagadougou	Private	2	$73,409	$46,275	$20,849	$1,131	33%	$31,425	51%	26%	0%
Kenya	Nairobi	Private	2	$57,024	$30,322	$23,902	$1,113	85%	$14,000	44%	15%	0%
Ethiopia	Addis Ababa	Private	4	$152,662	$100,224	$40,604	$1,092	34%	$29,586	61%	18%	0%
Senegal	Dakar	Private	3	$303,553	$264,305	$26,014	$1,090	20%	$44,112	36%	10%	11%
Nigeria	Ibadan	Private	3	$119,924	$82,817	$28,613	$1,031	34%	$28,311	19%	57%	0%
Kenya	Nairobi	Private	4	$128,928	$80,206	$33,722	$1,015	22%	$37,500	51%	14%	4%
Vietnam	Ho Chi Minh	Private	3	$77,068	$41,090	$31,601	$999	72%	$14,592	29%	3%	2%
Vietnam	Haiphong	Private	3	$54,853	$20,983	$30,142	$941	81%	$12,427	14%	3%	0%
Ethiopia	Dire Dawa	Private	2	$51,775	$30,262	$9,678	$896	8%	$59,172	41%	29%	0%
Senegal	Touba	Private	2	$104,902	$85,405	$10,675	$812	12%	$44,112	65%	16%	2%
Vietnam	Ho Chi Minh	Private	4	$88,078	$51,960	$31,835	$752	74%	$10,708	26%	12%	2%
Vietnam	Hanoi	Private	3	$78,291	$54,943	$19,950	$649	59%	$11,327	16%	3%	0%
Ethiopia	Addis Ababa	Private	2	$43,754	$28,244	$13,066	$646	53%	$12,219	61%	22%	1%
Vietnam	Hanoi	Private	3	$70,340	$51,917	$13,569	$512	28%	$16,181	19%	3%	0%
Vietnam	Hanoi	Private	2	$47,709	$36,139	$9,725	$482	53%	$9,223	16%	3%	0%

Vietnam	Haiphong	Private	3	$40,369	$23,277	$14,810	$475	65%	$7,605	16%	4%	0%
Vietnam	Hanoi	Private	3	$82,573	$65,494	$14,263	$474	51%	$9,385	33%	4%	0%
Vietnam	Hanoi	Private	3	$63,691	$46,923	$13,795	$466	46%	$9,909	27%	4%	0%
Vietnam	Hanoi	Private	3	$76,429	$60,600	$12,189	$440	33%	$12,136	18%	3%	0%
Vietnam	Hanoi	Private	4	$67,113	$46,025	$8,952	$439	7%	$30,340	30%	4%	0%
Kenya	KISUMU	Private	2	$27,192	$16,683	$727	$438	1%	$48,913	34%	17%	0%
Cambodia	Phnom Penh	Private	2	$54,720	$44,544	$6,776	$424	20%	$17,000	37%	2%	5%
Senegal	Thiès	Private	2	$63,706	$54,946	$380	$365	0%	$41,900	43%	21%	0%
Kenya	Nairobi	Private	2	$41,712	$33,466	$2,346	$344	4%	$29,500	47%	14%	0%
Kenya	Nairobi	Private	2	$44,100	$35,962	$4,738	$339	14%	$17,000	35%	13%	0%
Kenya	Nairobi	Private	2	$52,200	$45,946	$2,754	$261	8%	$17,500	38%	10%	0%
Cambodia	Phnom Penh	Private	2	$21,600	$15,794	$2,206	$242	6%	$18,000	52%	3%	7%
Kenya	Nairobi	Private	2	$39,360	$34,634	$(274)	$197	-1%	$25,000	31%	16%	0%
Cambodia	Phnom Penh	Private	3	$7,920	$5,146	$(2,226)	$77	-4%	$16,667	33%	9%	4%
Kenya	Nairobi	Private	2	$43,368	$42,202	$(2,634)	$49	-7%	$19,000	37%	11%	0%
Kenya	Nairobi	Private	4	$81,312	$83,630	$(14,788)	$(48)	-12%	$31,175	32%	15%	3%
Cambodia	Phnom Penh	Private	2	$4,320	$6,613	$(3,293)	$(96)	-33%	$5,000	26%	9%	3%
Ethiopia	Dire Dawa	Private	3	$32,387	$40,400	$(19,847)	$(223)	-17%	$39,448	46%	32%	0%
Senegal	Dakar	Private	2	$152,628	$162,573	$(19,984)	$(414)	-20%	$50,195	59%	6%	18%
Malaysia	Melaka	Private	3	$18,167	$86,096	$(85,029)	$(1,887)	-50%	$57,000	8%	8%	4%

Appendix F (contd.): Financial Summary of Emptying Business Operations (Ranked by monthly Cash Flows per truck)

LARGE SIZED BUSINESSES

Country	City	Status	No. of trucks	Annual Revenue	TOTAL OPEX	Annual Profit After Depreciation	Monthly Cash-flow per truck	ROI per truck (post depreciation)	Cost of investment per truck	% Fuel cost per truck	% Maintenance cost per truck	% Dumping costs per truck
Malaysia	Kuala Lumpur	State co.	14	$2,249,079	$408,761	$1,759,391	$10,954	217%	$57,805	5%	40%	3%
Malaysia	Melaka	State co.	8	$1,155,483	$586,673	$494,411	$5,925	66%	$93,000	8%	31%	1%
Malaysia	Kuala Trengganu	State co.	19	$1,275,352	$569,834	$594,273	$3,094	53%	$58,550	13%	23%	1%
Vietnam	Ho Chi Minh	State co.	7	$459,211	$199,420	$246,131	$3,093	180%	$19,515	13%	5%	2%
Senegal	Dakar	Private	6	$489,294	$310,392	$152,656	$2,485	58%	$43,743	45%	9%	12%
Senegal	Dakar	Private	7	$612,901	$413,693	$168,551	$2,372	55%	$43,796	47%	10%	14%
Senegal	Dakar	Private	10	$609,185	$413,693	$152,265	$1,629	35%	$43,227	47%	10%	14%
Vietnam	Ho Chi Minh	Private	6	$138,722	$73,717	$60,327	$903	129%	$7,796	29%	13%	2%
Vietnam	Haiphong	Private	12	$108,238	$58,037	$42,434	$349	55%	$6,472	10%	2%	0%
Vietnam	Haiphong	State co.	13	$112,881	$145,488	$(101,582)	$(209)	-15%	$53,058	11%	16%	0%
Senegal	Dakar	Private	5	$158,733	$189,414	$(52,073)	$(511)	-24%	$42,785	36%	29%	11%
Senegal	Dakar	Private	10	$396,833	$508,362	$(153,429)	$(929)	-37%	$41,900	34%	13%	14%
Vietnam	Hanoi	State co.	5	$39,277	$119,457	$(87,461)	$(1,336)	-120%	$14,563	12%	2%	0%
Ethiopia	Addis Ababa	State co.	67	$301,574	$1,489,643	$(1,563,269)	$(1,478)	-42%	$56,000	51%	20%	0%

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