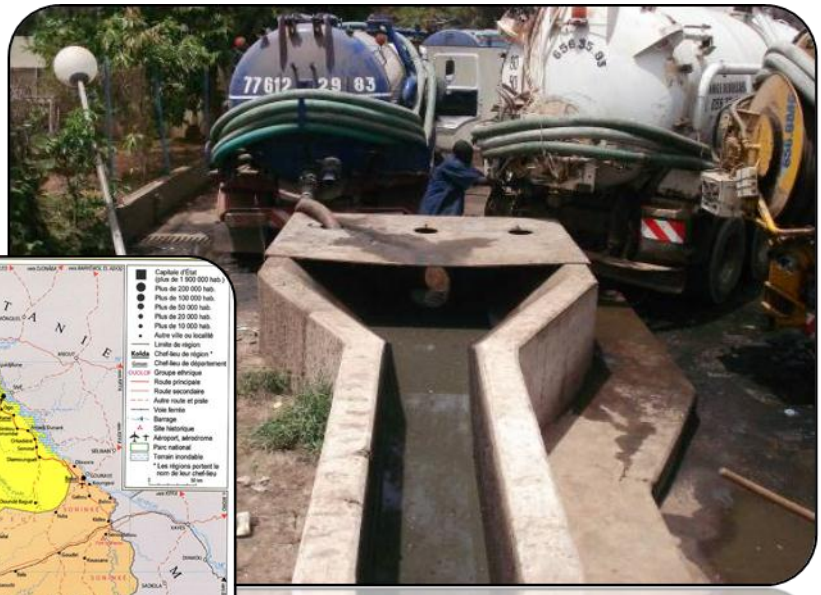
REPUBLIC OF SENEGAL

LANDSCAPE ANALYSIS & BUSINESS MODEL ASSESSMENT IN FECAL SLUDGE MANAGEMENT: EXTRACTION & TRANSPORTATION MODELS IN AFRICA – SENEGAL



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1. COUNTRY FSM BACKGROUND

- **Senegal Overview**

Senegal is located on the western tip of Africa, lying between latitudes 12.5° and 16.5°N and longitudes 11.5° and 17.5°W. It is externally bounded by the Atlantic Ocean to the west, Mauritania to the north, Mali to the east, and Guinea Conakry and Guinea Bissau to the south, with a coastline of over 500 km. Internally, it almost completely surrounds the Gambia, save for the latter's short coastline. Senegal has a population of over 12 million, comprising slightly more women than men.
The country covers a land area of 196 722 km^2, with 2.1% of the surface area covered by water. The climate is tropical with two seasons, the dry season, from November to May, and the wet season, from June to October. The average annual rainfall follows a decreasing gradient, from 1,200 mm in the south to 300 mm in the north, with variations from one year to another. There are three main areas of rainfall, corresponding to three climatic zones: forest area to the south, savannah in the center and semi-desert in the north.
In terms of hydrography, Senegal's water resources are formed by four rivers and their tributaries, as well as several seasonal rivers. The river basins traversing the country form two important systems: the lower course of the Senegal River and the middle course of the Gambia River. The Sine Saloum and the Casamance River are smaller coastal rivers. Other rivers and valleys complete the hydrological landscape. The construction of large dams, in particular the Diama Dam, which Senegal shares with Mali and Mauritania through the Organization for the Development of the Senegal River (OMVS), contributes to the management of water resources and thus to the development of agriculture, animal husbandry, navigation, potable water and energy for the benefit of the general population.

Figure 1: Map of Senegal

Source: www.valdedrome.com, map produced by the Franco-Senegalese Cooperation, 1994 – 2008

- **Sanitation in Senegal**

High population growth in Senegal has led to an increased demand for basic services such as wastewater management. However, around 2.6 billion people in developing countries. One third of the world's population use individual sanitation facilities such as latrines and septic tanks for the disposal of feces (Koné et al, 2006). Mainly because of housing structure and economic constraints, sanitation using a sewer system only covers a small fraction of people in developing countries.

In recent years, the sanitation sector in Senegal has increasingly moved to the top of the agenda for the State. Senegal has committed to the achievement of the Millennium Development Goal of halving the number of people without access to sanitation by 2015. The institutional sector has undergone several reforms leading to the development of the sector and the delegation of functions across different stakeholders including State departments, the Department of Sanitation (urban and rural), ONAS, implementing agencies (in particular the AGETIP), local governments, donors, NGOs and the private sector.

Field research on systems of waste collection has identified the different types of facilities installed and used by communities. It was found that the type of infrastructure used depends on whether the system is collective (public), semi-collective or private (individual).

- **Fecal sludge management in Senegal**

Although the political authorities are becoming more focused on solving sanitation problems, it is nonetheless the case that the management of fecal sludge has long been neglected in favor of collective sanitation. Even if, in certain cases, the "semi-collective" small diameter sewage system can be a viable alternative, it remains unlikely that a classic sewage sanitation system is feasible for the country. In developing countries, individual sanitation is therefore viewed as the solution for the achievement of the Millennium Development Goal of reducing the number of people without access to sanitation by half by 2015 (Koanda, 2006). Large amounts of sludge are increasingly produced and sludge management will become a success factor for any sustainable environmental management policy.
Fecal sludge management is a key issue in public health, and for the successful implementation of water and sanitation projects. For example, one uncontrolled fecal matter discharge is equivalent to approximately 5,000 people defecating in the open air! Despite the significant progress made in the last 10 to 15 years, fecal sludge management remains the poor cousin of urban and peri-urban sanitation. As a result, a fecal threat remains in urban areas in most developing countries, having adverse effects on human health, quality of life and the environment.
In Senegal, almost 92% of the population is affected by the problem of fecal sludge. Of the seven (7) treatment plants in the country (Cambérène, Rufisque, Thiès, Saly, Saint louis, Kaolack and Louga), only two, Cambérène and Rufisque, are equipped with fecal sludge treatment plants. Both of these are found in the Dakar region, in addition to a third, Niayes, also in the region of Dakar. Other parts of the country do not have treatment sites, making do with "tolerated" spaces (sites where there is supposedly no significant impact on the environment), for the disposal of fecal waste.
In addition, fecal sludge treatment plants (FSTP) in Dakar deal with loads far beyond their capacity. Cambérène, for example, has been designed to handle 100 m^3/day but in fact currently receives 500 m^3/day.
In general, fecal sludge management can be considered the weak point in sanitation because raw sludge is disposed of illegally. However, meetings have taken place between decision-makers and sludge operators throughout the country in order to discuss the problem and find sustainable solutions for the improvement of the sector. In recent years, fecal sludge management has become a major concern for city authorities in developing countries and institutions working in the field, and significant investments have been made. These include the construction of individual systems for the pre-collection and dumping of sludge. The Sanitation Program for Peri-urban Regions of Dakar (PAQPUD) as well as the present study, "Landscape Analysis and Business Model Assessment in Fecal Sludge Management, Extraction and Transportation in Three Cities of Senegal (Dakar, Thiès and Touba)" commissioned by the Bill and Melinda Gates Foundation, are inspiring examples. These three cities, different in many respects, were chosen for a comparative analysis to efficiently identify all aspects of fecal management at the three sites.

Dakar, the capital of Senegal, has a population of 2,167,793. The city has both collective and individual sanitation facilities. 25% of the population is connected to the sewer system while 75% uses individual sanitation facilities. Large quantities of household sludge are collected, either manually or mechanically, and directly discharged into the environment (manual desludging), or transferred to dumping sites (mechanical desludging). There are also three treatment stations in Dakar with fecal sludge treatment plants in operation, equipped with settling/thickening tanks and drying beds.

Touba is a city notable for its annual religious event (the Magal), during which over 2 million people descend on the city for a period of 3 days. The city normally has a population of around 600 000. The sanitation system consists entirely of individual sanitation facilities, but the implementation of a centralized sanitation system is underway, which aims to serve 10% of the population. Because of the Magal, the city is marked by a high frequency of desludging, either manually or mechanically. The city has over 50 sludge trucks, as well an illegal dumping site installed by the National Sanitation Office of Senegal (ONAS).

Thiès is the second largest city in Senegal after Dakar, and has a population of 1,317,067. The majority of the population use individual sanitation facilities, with only 5% connected to the collective sewer network and waste water treatment plant (WWTP). ONAS aims to increase this rate of connection to 15% over the next ten years. However this means that individual facilities will remain the primary form of sanitation used in Thiès. Sludge is emptied either manually or mechanically and discharged directly into the environment, at multiple sites, without prior treatment.

2. METHODOLOGY

2.1. Literature review

The literature review involved the study of reports, dissertations, theses, courses, technical studies and feasibility studies. The review began with the identification of stakeholders related to fecal sludge management. The main literature sources were as follows:

- The Department of Sanitation;
- ONAS (National Sanitation Office of Senegal);
- Resource center of the Regional Center for Low-cost Sanitation and Potable Water (CREPA);
- Resources centers of the consulting firms EDE and H2O Engineering;
- The National Hygiene Service;
- The Department of Statistical Forecasting;

The literature review was conducted throughout this study. The main themes of the documentary research were as follows:

- General aspects of on-site sanitation and fecal sludge management in the African context in general and in Senegal in particular;
- Appraisal of the fecal sludge management sector in Senegal;
- Economic and financial aspects of fecal sludge management;
- Case studies on the collection and transportation of fecal sludge.

2.2. Situational analysis methodology

2.2.1. Household survey design

1,500 households were surveyed, 500 in each city. Given the specificity of each city, the survey design and sampling methods was not the same for each. The sample design for Dakar was slightly more complicated to establish due to the array of different sanitation facilities in the city. In addition, two sampling methods were used: a three-level stratification for Dakar with systematic selection of households and a randomized two-level sample for the two other cities, Thiès and Touba, (details attached).

Regarding Willingness to Pay (WTP), the auction method was used in order to capture the real will and capacity to pay of households (see Appendix 1), as well as the wealth index, designed to circumvent the lack of data on household income. This index classified the difference between rich and poor (see

Appendix 2).

2.2.2. FSM practices and data collection

Focus groups: Focus group interviews were conducted in each city with fecal sludge operators (manual and mechanical) and business leaders. These focus groups were an opportunity to present the research project as well as benefit from the contribution of fecal sludge operators, and took place in Dakar, (May 31, 2011), in Touba (June 25, 2011) and in Thiès (August 27, 2011). We owe the success of these focus groups to the availability and strong collaboration of the leaders of the AAAS, Ibra Sow and Doudou Ndiour.

Routing of sludge truck: this took place on June 18 and 19, 2011, in Dakar. During this activity, we accompanied a sludge truck over two full days of operation in the field, noting the following information:

- Operation time (including desludging, transportation, dumping etc.);
- Location of truck stops;
- Profile of sludge and estimate of dimensions;
- Fuel consumption.

Profile of individual sanitation facilities: The dimensions of the facilities were measured during the routing of the sludge truck and while accompanying a manual sludge operator (3 traditional latrines and 5 septic tanks).

Interviews: these were conducted throughout the field study, using two complementary approaches:

Profile of the sludge operator: this was established on the basis of focus groups, interviews and official documents.

Reconstitution of sludge operator income statement: the income statement of 20 sludge operating companies (small, medium and large) was reconstituted on the basis of:

- Documents : invoices, balance sheets (for those with an accounting system);
- Field data: fuel consumption, reconstitution of fuel consumption during routing. Operating times, distances covered, breakdowns observed;
- Interviews: presentation, discussion and validation of figures.

Choice of sludge operating companies: This was preceded by visits, participant observation and focus groups. These activities were an opportunity to observe the technologies developed for the collection of sludge, and to identify and contact operators adhering to the idea of the project. Indeed, the consent of operators to be interviewed was one of the conditions for achieving our goals.

Following this step, the sludge operating companies to be visited were divided into 3 categories:

- Small enterprises, with one sludge truck;
- Medium enterprises, with between 2 and 5 sludge trucks;
- Large enterprises, with at least 5 sludge trucks.

In total, 6 income statements from manual sludge operators were examined.

Interviews: these were conducted with various stakeholders in the sector of fecal sludge management, including ONAS, sludge operators, private enterprises, local communities, members of the public and NGOs, and took several forms:

- Informal interviews consisted primarily of informal discussions with resources persons who can provide answers to our questions about fecal sludge management. These interviews were conducted with people who, for lack of time, comprehension or other impediments, are unable to provide the full co-operation required by semi-structured and structured interviews;
- Semi-structured interviews were conducted on the basis of pre-prepared interview guides and were conducted with sludge operators, business leaders, the president of the fecal sludge operators' association, waste disposal managers, mayors or their representatives, technicians and other resource persons. These interviews took place in Dakar, from May 15 to June 24, 2011, in Touba from June 25 to July 13, 2011, and in Thiès from August 27 to September 12, 2011.
- Open-ended interviews consisted of one or more open questions, leading to answers which generally were not predictable.

2.2.3.Methods to validate financial data

Numerous approaches were considered for the validation of financial data and the management of uncertainty, depending on the type of data:

• Multiplication of sources and comparison: as much as possible, all data was estimated using different methods. Duplication of data and comparison with bibliographic data was used to validate or reject the estimates in each case.

• Statistical indicator: standard deviation was used to quantify errors in the analysis of the truck routing data.
• Precautionary principle: during the financial analysis, in cases of uncertainty, the worst case was considered.

2.2.4. Treatment plant/Dumping sites model

Dakar, unlike the other cities, has sanitation infrastructure in place. It has 3 wastewater treatment plants and 4 deposit sites, of which 3 have fecal sludge treatment plants. In Touba, as in Thiès, there are official deposit sites, but these are not monitored by ONAS.There are no environmental standards or procedures to ensure compliance with capacity loads. Fecal sludge is dumped into the environment on the outskirts of the city. In this case, dumping into the environment is authorized, as opposed to illicit dumping on non-authorized sites.

Following the site visits, semi-structured interviews were conducted to understand how the deposit sites work, to obtain information such as site distance from residential areas, handling capacities and financial flows etc.

2.3. Determination of financial flows and key stakeholders

The various stakeholders involved in fecal sludge management in Senegal in general and in Dakar in particular, are the State, NGOs, the private sector and the general population. Each of these actors has a role to play in improving fecal sludge management.
All stakeholders were involved in this study, in order to get the maximum information possible. We also received responses from fecal sludge operators and various other stakeholders through focus group interviews.

2.4. Market size calculation method

In order to assess the size of the mechanical desludging market in Dakar, we started with the frequency of desludging using individual sewage facilities. The household questionnaire allowed us to take into account the frequency of desludging. However, as respondents usually do not give very reliable answers, we therefore calculated sludge production through another method, assuming that one latrine user produces 0.3 liters/day and an individual using a septic tank produces 0.7 liters/day.

2.4.1. FS production and collection computation

Information on sludge production was collected from household surveys. We did not examine other forms of production such as public toilets, commercial business and institutions, as these represent a very small proportion in comparison to domestic facilities.
Desludging is undertaken by either manual or mechanical operators, whom we interviewed and accompanied on field trips.
Questions focused *inter alia* on truck capacity, volumes deposited, frequency of desludging, number of rotations by day and the number of crew operating each truck.

2.5. Financial analysis methodology

The financial analysis consisted of the reconstitution of the income statements of sludge operators, the establishment of financial flows between stakeholders, the rates of return (equilibrium prices) for sludge operators, and the financial viability of the fecal sludge sector. Audit techniques were combined with interviews and qualitative and quantitative methods.
Truck routing: The age of the trucks meant that certain data was unavailable. Other data, such as mileage, the exact volume of loads, and actual fuel consumption were also unavailable.
Interviews: As is often the case with investigative interviews, the task was not an easy one, not only because the moods of those interviewed must be considered, but bias must also be taken into account. In fact, a marked reluctance to participate was noted on the part of the sludge operators. A good

command of the Wolof language[1] was also required, in order to avoid any kind of underestimation or devaluation of the work of the operators, or of the operators themselves.

3. RESULTS AND ANALYSIS OF URBAN FSM PRACTICE

3.1. Situational analysis of extraction/transportation

3.1.1. Demographics of the three cities

Population and number of households is displayed in the table below. Projections were made until 2015.

Table 1: Population of cities

Projections	Cities	2011	2012	2013	2014	2015
Population	DAKAR	2,574,065	2,627,974	2,699,509	2,772,202	2,845,959
Households		279,790	285,649	293,425	301,326	309,343
Population	THIÈS	293,112	300,927	309,116	317,432	325,874
Households		30,724.53	31,543.71	32,402.09	33,273.79	34,158.70
Population	TOUBA	617,813	636,841	654,154	671,745	689,594
Households		56,941.29	58,695.02	60,290.69	61,911.98	63,557.05

3.1.2. Drinking water supply coverage

Modes of access to drinking water are highly variable and in general private connections are the most prevalent. However, some diversity was noted between the three cities, with Touba being unusual in providing tap water for free, with a large number of people benefiting from this service.
Of note is the fact that the rich tend to use improved water sources and other types of water supply. Most often, they buy water either from water kiosks or water vendors.

Table 2: Modes of water supply in the study area

Modes of water supply	Dakar	Thiès	Touba	Total
Private connection (direct piped connection)	82.2%	78.0%	56.0%	72.0%
Borehole	-	1.0%	40.0%	14.0%
Water kiosk(public tap)	8.3%	7.0%	-	5.0%
Water vendors	8.1%	2.0%	0.4%	4.0%
Well	-	11.0%	0.2%	3.0%
Others	1.4%	1.0%	3.2%	2.0%

Consumption varies from one city to the next. The problem of estimating consumption was raised in Touba, for example, where households were unable to furnish such information. Average consumption was estimated at 146 liters/person/day for all three cities.
Water consumption also varies considerably by social class (between rich and poor). The richest people consume more water but pay less than the poor (by invoice).

3.1.3. Sanitation coverage

Most households have a sanitation facility, and in each of the three cities surveyed it was quite unusual to find any without them. In these rare cases, the absence of facilities was due to lack of financial means. Most of the time, these people used their neighbors' latrines or public toilets. Open air defecation has largely disappeared in each of the three cities, with the few reported cases occurring in the city of Thiès. It is interesting to note that this phenomenon is very complex, and relates to the embarrassment of households, who are reluctant to report on their need to resort to such practices. It would be

[1] A local language in Senegal

erroneous to report for example, that such practices do not occur in Dakar, where field observations showed that feces are often found on street corners, in vacant lots or in buildings under construction, early in the morning. People are probably doing this late at night, out of sight.
Different types of sanitation were found throughout the region. Dakar and Thiès have a sewer network. The Thiès network is very old and only serves **2%** of the population. The Dakar network reaches **35**% of households and as well as this collective network, there exists a semi-collective sanitation system in certain neighborhoods. Touba is largely characterized by the presence of individual on-site sewer facilities.
In terms of on-site sanitation, a large range of facilities is in operation. However the most commonly used are household septic tanks (**75 %** of households in the study area). Often the distribution of types of sanitation is not dependent on the level of wealth because sometimes the poor live in areas served by the network whereas the rich have their own individual sanitation facilities (septic tanks etc.). However, the quality of facilities varies depending on the wealth of the population.

Table 3: Types of sanitation facilities

Types of sanitation facilities	Dakar	Thiès	Touba	Cumul
Wastewater connection	34.7%			**12.0%**
Semi-collective sewerage system (small bore network)	5.0%	2.0%		**2.0%**
Simple pit	0.8%	4.0%	5.0%	**4.0%**
VIP	0.8%	13.0%	5.0%	**6.0%**
Septic tank	58.3%	79.0%	89.0%	**75.0%**
Other	0.4%	1.0%	0.4%	**0.7%**

See definition of technologies in Appendix 6

3.1.4.Institutional and legal framework

- **Organizational framework:**

Relations in the fecal sludge sector directly or indirectly involve six main stakeholders, as follows: households, the State (ONAS), private companies, “Baay Pelles” (manual operators), local authorities and NGOs. The figure below shows the relationship between the different stakeholders in the sector. Of note is the central position of households, who are the main consumers of the services of the other stakeholders.

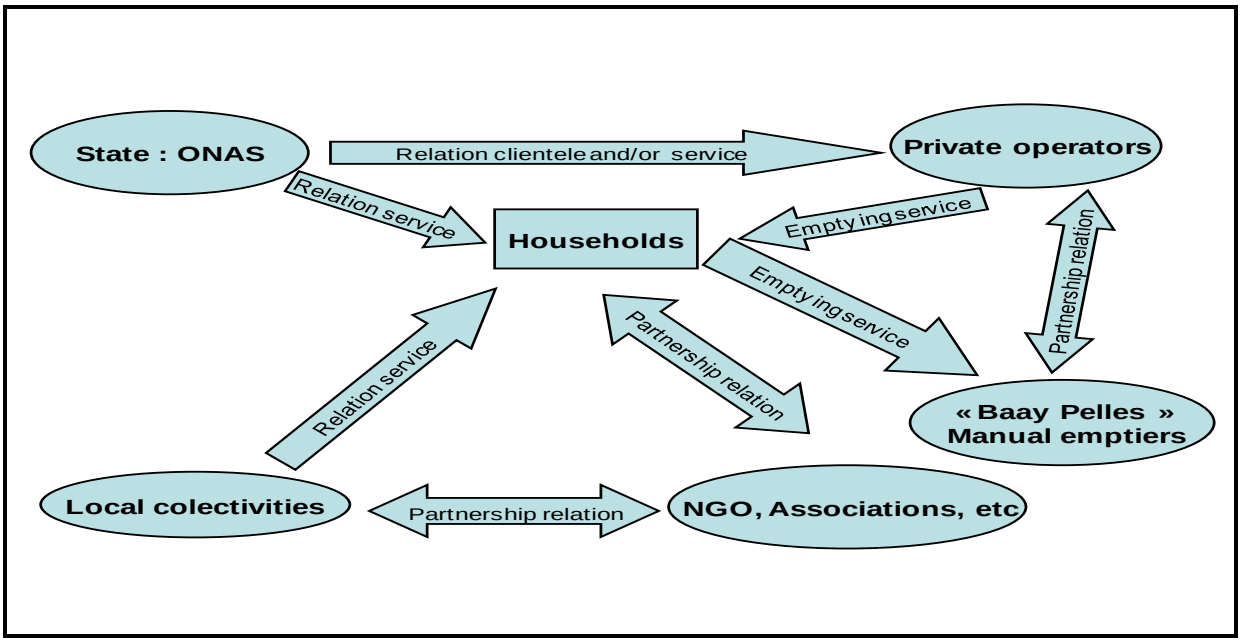


Figure 2: Relations between different stakeholders in the sector

- **Institutional framework**:

State intervention in the sanitation sector is undertaken through government departments. These include:

- The Ministry of Urban Development, Housing, Water and Sanitation
- The Ministry of the Environment and Nature Conservation
- The Ministry of Health, Prevention and Public Hygiene
- The Ministry of Education

- The Ministry of Economy and Finance
- Local authorities

Details of the institutional and organizational framework are presented in Appendix 7.

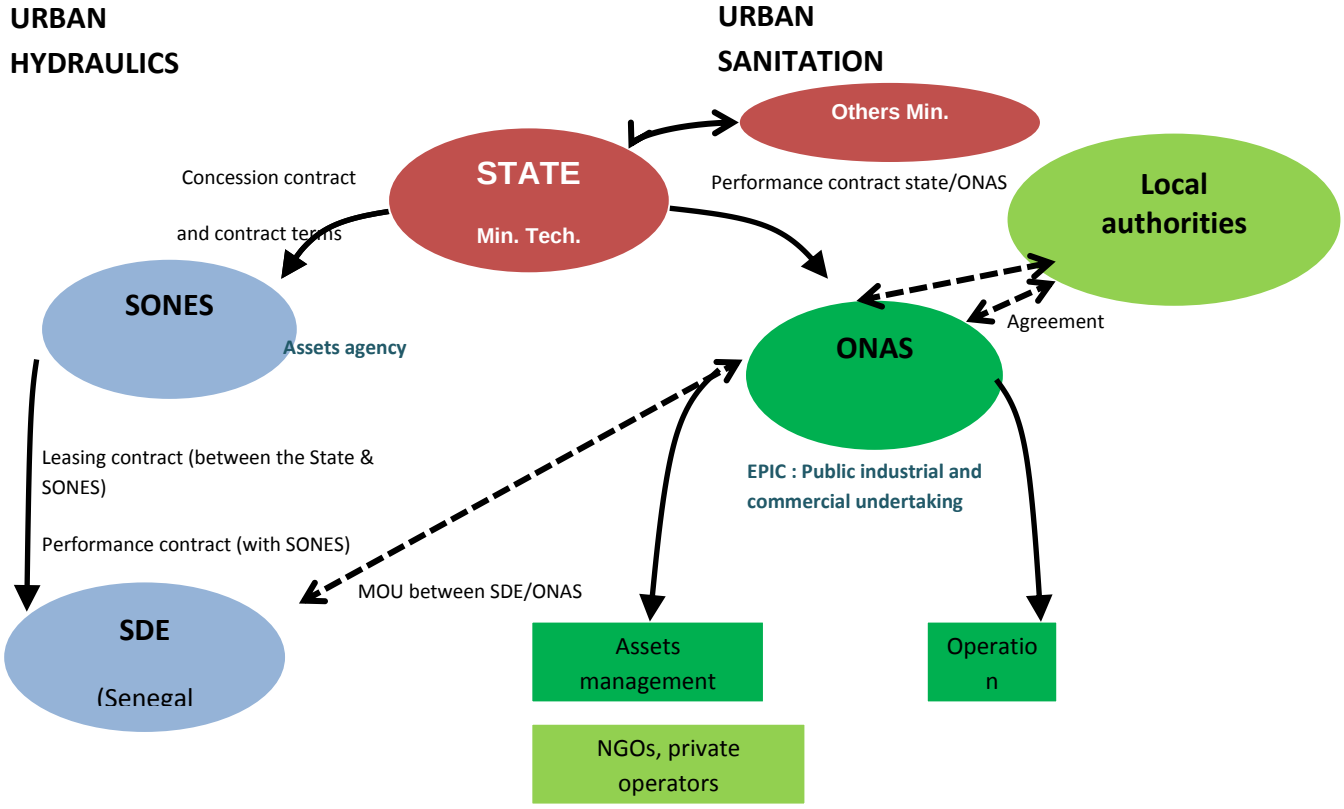


Figure 3: Organization of the sector in urban areas

- **Regulatory framework:**

Concerned with the well-being of the population and with the aim of breaking the cycle of disease related to poverty and poor sanitation, the government of Senegal has subscribed to a set of principles, strategies and international commitments, including the United Nations Convention on Environment and Development (Rio de Janeiro 1992).

At the national level, environmental management as a whole and sanitation in particular are the subject of legal regulation codified by various State ministries. This legal and legislative framework relates closely to the sanitation sector and is regulated by the following codes: the Environment Code, the Water Code, the Urban Development Code, the Heath Code, the Local Authorities Code, the program for wastewater discharge standards and the new Sanitation Code.

Several articles in the Environment Code contain provisions related to sanitation that affect fecal sludge management.

However, while the institutional framework shows a coordinated action led by ONAS, the Sanitation Code regulates and deals more precisely with issues in the field of fecal sludge management, at the

local level.

3.1.5.Flow of money chart for FSM transactions

The financial flows of fecal sludge management (FSM) are derived from the cost per beneficiary of the system, according to the stakeholders. We distinguish between financial flows for investment in FSM and operating flows in FSM.
FSM Investment Flows: Investment in the FSM system concerns all stakeholders in the chain, although households are the direct beneficiaries. The breakdown of costs details the investment costs of each stakeholder.
FSM Operating Flows: Operating flows, like all investments in FSM, concern all stakeholders in the chain. Indeed the operation of FSM generates periodic costs which are borne by all stakeholders.

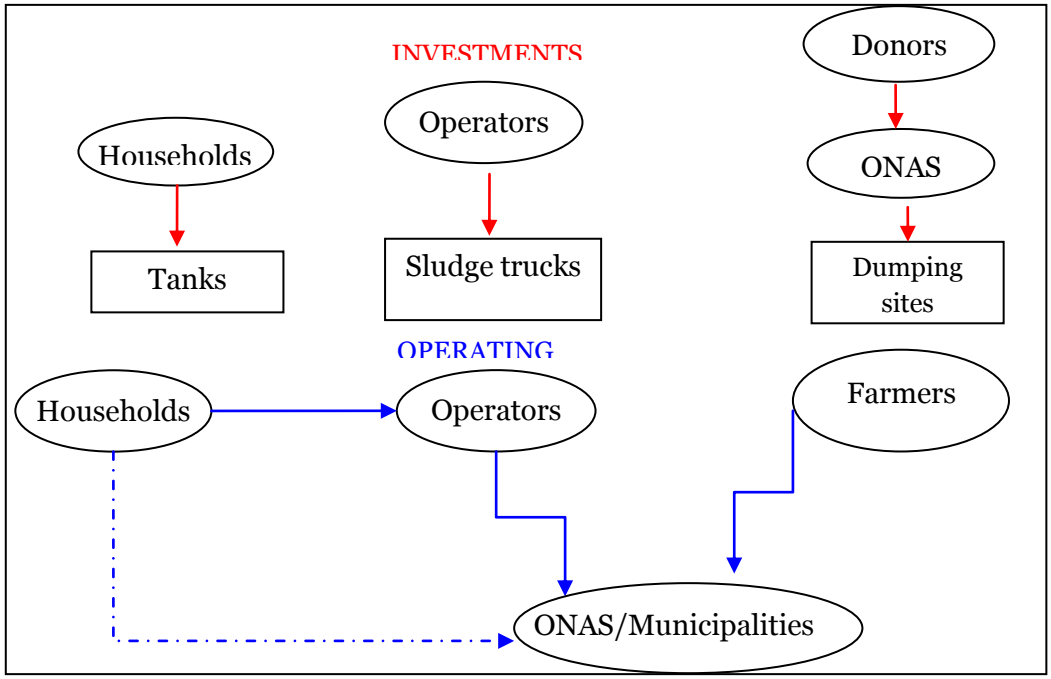


Figure 4: Financial flows

3.1.6. Profile of fecal sludge business owners

Private mechanical operators generally fall into one of two categories: limited liability companies/ economic interest groups (GIE), or individual operators. The latter generally own one sludge truck which they manage by themselves. The former usually have at least one truck, as well as premises and staff, which they manage in a more or less formal way. It must be noted however, that most of these actors operate on an informal basis.
In this sector, there are two categories of employees: permanent employees and day laborers. The number of people employed by sludge operating business varies according to their size, number of trucks, and the nature of their operations. The companies consulted for this study generally consisted of teams of at least one director who coordinates activities, a salesman, an accounting secretary and a mechanic in charge of the maintenance of the trucks. Each truck has a team of one driver and two operators.
Most small business are thus run by individuals or on an informal basis, and do not employ a full team, but usually employ a driver, who may also function as both manager and salesman, along with two accompanying operators.

For large and medium-sized informal companies, in addition to the three-person team accompanying each truck, there is usually a manager and a salesman.

Formal companies (mostly large-sized, only rarely medium-sized) have full teams, consisting of a manager, a salesman, a secretary, a mechanic and three staff for each truck in operation.
Depending on the size of the market, the company may make use of day laborers, paying them between 2,000 and 3,000 FCFA per day ($4 to $6 per day).

According to the President of the Association of Sanitation Actors of Senegal, sludge trucks are mainly imported from Europe. These secondhand trucks generally come from France, Belgium and Holland. In spite of the law prohibiting the importation of trucks over ten years old into Senegal, fleets remains dilapidated, even though the State provides tax incentives to the sector, such as tax exemptions, customs duties at the very low rate of 5%, and a 50% to 100% exemption rate for insurance.
According to operators, despite these incentives, the cost of importing secondhand trucks remains very high, at between $20,000 and $60,000, depending on whether the vehicle is a vacuum truck or a hydro-excavating truck. After purchasing these newer and more expensive trucks, the operators are left with no additional funds in order to make them operational, however the trucks are imported in an operational state. On the other hand, those operators who import old or dilapidated trucks tend to spend between $8,000 and $20,000 on the trucks themselves as well as repair costs ranging from $4,000 to $10,000. These trucks are also more unreliable and do not last as long as trucks imported in an operational state.
In terms of the price-capacity ratio, prices varies in proportion to the tank volume of the truck, the quality of the engine, the pump and the make of the vehicle. Note also that hydro-excavating trucks which have high-pressure pumps capable of emptying tanks in the cleanest and most efficient way, may cost twice as much as regular vacuum trucks. The latter cannot fully empty tanks with a higher percentage of solid materials.

Hydro-excavating trucks, the most expensive type of truck, are the most efficient at desludging and are therefore preferred by both operators and households because of the quality of service they offer. However the high cost of this type of truck, even those with lower volume capacities, makes them unaffordable for most desludging companies, a fact which explains the small number of hydro-excavating trucks in operation in each of the three cities surveyed (none in either Touba or Thiès and less than 10 in Dakar).

Note also that in terms of truck depreciation, we use the exact price as reported by operators, a price which depends significantly on the type of truck, location of purchase and state of the truck at the time of purchase.

For this reason operators prefer to import old trucks into the country at more affordable costs, ranging from $8,000 to $20,000, which they then repair or modify.

Another equally important aspect is the fact that in Senegal, operators prefer the Renault and Mercedes car brands. The choice of Renault lies in the ease of access to spare parts at lower prices. The operators also favor Mercedes vehicles because of their durability and resistance, which affect the productivity and profitability of the activity.
The operators are unanimous on the dilapidation of their fleets, but their limited financial resources do not enable them to renew them. They believe the State should be responsible for the renewal of the fleets.
According to many operators interviewed, desludging alone is not a profitable activity and they have thus attempted to diversify or substitute with other activities. These include the maintenance of the collective sewage network, and industrial wastewater and rainwater drainage. These activities make up only around 30% of their operating hours but count for 60% of their turnover.

Diversification activities are usually carried out by large and medium-sized companies. Formal companies are also much more likely to be contracted by ONAS and other public and private institutions. Formal enterprise pay taxes to the State and thus have proper accounting procedures and can bid on all markets in the sector. This is not the case for informal companies which tend to subcontract on the markets.

3.1.7.Household survey results and analysis

The data was analyzed using SPSS software. An input mask was first designed and the data was entered directly into it, thus significantly reducing the risk of errors. Data entry operators were trained on the use of the input mask, and began work two days after the start of field surveys. Although most of the data analysis was done using SPSS, Excel was also used for certain graphic representations.

The consultant used different analysis methods, including frequency distribution, with numerous average and frequency calculations; the creation of a wealth index (WI) (methodology in Appendix) in order to categorize households and differentiate the analysis between rich and poor households; and a multiple component analysis to highlight the general characteristics rich and poor groups in terms of fecal sludge management as well as other socio-economic elements that may explain the behaviors mentioned above. A brief presentation of the overall results is given below:

Table 4: Average household size

Variable	Dakar	Thiès	Touba	Cumul
Average household size	9.90	9.54	10.85	**9.91**
Average number of households per concession	2.33	1.25	1.30	**1.66**

The average number of persons per household was **9.9** and the number of households per concession was **1.66** In general, with the average number of people using latrines higher than the number of family members, to include others such as neighbors or other inhabitants of the concession.

3.1.8. Desludging practices and technologies: manual and mechanical

- **Desludging methods and frequency**

In Senegal, there are usually two facilities for the collection of sludge at the concession level: latrines and septic tanks. Septic tanks have an average volume of 9m^3 while latrines have an average capacity of 3 m^3.

Households may use several types of desludging service, but it is usually either manual or mechanical. The use of a particular service usually depends on the availability of financial resources. **64%** of respondents report using mechanical desludging most of the time, while **26%** use manual desludging and **9%** use both types simultaneously. It therefore appears that manual desludging is done at a lower cost, occupying an important proportion of the domestic market, but under very poor hygiene conditions. Manual desludging is more widely used in Dakar, but less so in Touba, the city with the highest rate of mechanical desludging.

This high rate of mechanical desludging is due to the fact that before each Magal, ONAS rents desludging trucks, in support of the religious leaders. In general, the fleet provided by ONAS stays in Touba for a total of 15 days (both before and after the Magal).

Most households, even those without the means to pay for mechanical desludging, take advantage of the Magal period to empty their septic tanks. Thus, the prevalence of manual desludging is very low in Touba.

In addition to all this, the recommendations of religious leaders are effectively law. Therefore, any prohibition on manual desludging or illicit dumping into the environment is followed to the letter out of respect for the religious leaders.

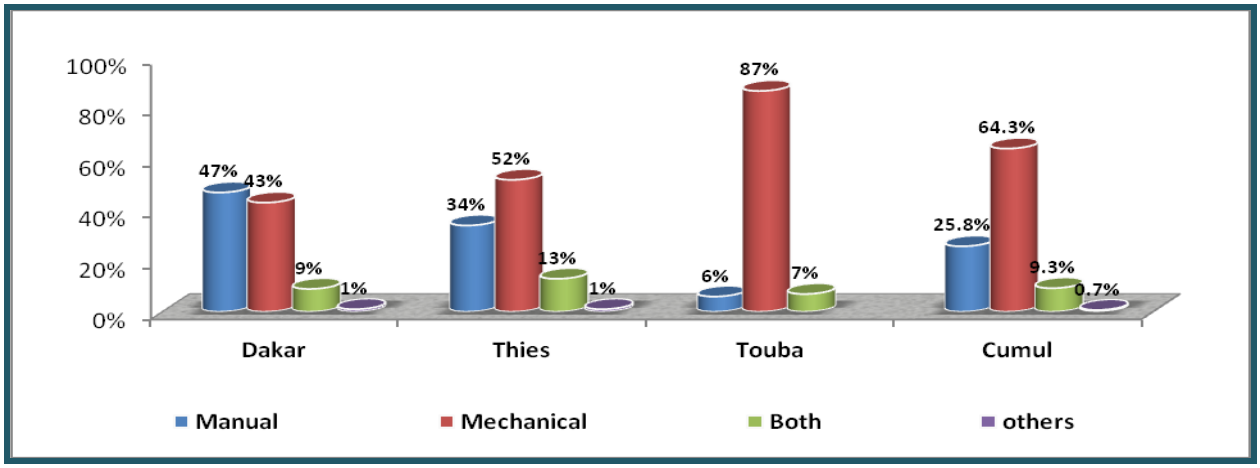


Figure 5: Desludging methods

Manual desludging is provided either by professionals (**58%)**, **"Baay Pelles"** (manual operators) or family members (**41**%).

Lack of funds prohibits the use of mechanical systems and some neighborhoods have very high population densities and narrow streets, which inhibit the passage of vehicles larger than a bicycle or a wheelbarrow. In these areas, septic tanks are usually emptied manually, using shovels and buckets to remove excreta.
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.
In addition to health hazards, the operators also suffer from the stigma associated with their work. They work in the informal sector and their activities are illegal in the eyes of the authorities and so they risk penalties such as fines and imprisonment – all the more reason to work at night.

Motorized desludging and transportation are done using a sludge truck or other vehicle equipped with a motorized pump and a storage tank to empty and transport sludge. Operators are required to operate the pump and maneuver the pipes. The pump is connected to a pipe buried in the septic tank and the sludge is pumped into the storage tank mounted on the truck.
Mechanical desludging is done using vacuum trucks or hydro-excavating trucks. These hydro-excavating trucks are used for cleaning septic tanks, in cases where the use of vacuum trucks is more limited. The price of this superior desludging service is therefore higher, also because hydro-excavating trucks consume more fuel in order to operate their high-pressure pumps.

Vacuum trucks are equipped with pumps which suck the compact sludge from the septic tank. Hydro-excavating trucks are the most powerful trucks, and are equipped with a pumping device which discharges water under pressure enabling the resuspension of the sludge for better pumping. Unfortunately, the high cost of the latter means that they are less accessible to households. In addition to these two types of vehicles, there are also slurry tankers, drawn by tractors and equipped with a similar pump to that of the vacuum trucks. Vacuum trucks constitute the largest proportion of the fleet in the FSM sector.
In Senegal, the capacity of sludge trucks varies between 4,000 and 14,000 liters. Mechanical desludging is done by sludge companies, most of whom operate informally. Most of these businesses do not keep regular financial accounts. Desludging equipment consists of vacuum trucks, slurry and hydro-excavating trucks.

The best way to contact a sludge operator is through neighbors and **56%** of households use this method. Others develop their own strategies such as going out onto main roads to find sludge trucks while some simply wait for them at dumping sites. The association of fecal sludge operators is also sought out for this purpose.
The choice of desludging service is often a function of households' socio-economic conditions. Results show that richer households are more likely to use mechanical desludging methods and that poorer households tend to use manual desludging. The rich also frequently use a combination of both methods for a more efficient service, their financial autonomy doubtless enabling this option.
In the study area, the choice of type of service is usually determined by three main factors: quality of service (**46%),** availability and responsiveness of operators (**34%)** and price (**11%**). Despite the fact that they do not comply with Senegalese environmental standards, manual desludging services most closely satisfy the main criteria of the target populations. For households, the service offered must be of good quality (full emptying of septic tanks), accessible (the desludging operators are available when needed or indeed live in the same neighborhood) and of affordable price. Manual desludging, as well as being currently the only solution for hard-to reach neighborhoods (such as those with narrow streets), meets these criteria, even if it is not the recommended solution.

These criteria may vary slightly from city to city but generally remain the same. In a city such as Touba, for example, the price criteria are not as important.
The average price of mechanical desludging in the three cities is **18,526 FCFA** (**US$37**), an amount usually rounded up in discussions to **20,000 FCFA** (**US$40**).

Prices are determined by the operators, and there are no approved prices in Dakar, Touba and Thiès. Prices range in each city, depending on distance to the dumping site (the neighborhoods furthest from the dumping site face the highest prices), the price of fuel (when fuel prices increase, the price of desludging increases), septic tank volume and household income (households in residential areas pay more than other households).
Households are also involved in setting prices. Indeed, in Senegal, negotiating prices is part of the culture. Even the offer of a low price is met with an attempt to reduce it further. However, even following negotiation, households rarely succeed in securing a major reduction in the price of mechanical desludging, which is usually fixed by the operators. Note also that neither ONAS nor any State service is involved in regulating the price of desludging services. The final price is a function of the price offered by the operator, household negotiation of same and competition, which is a feature of the mechanical desludging market.

Manual desludging prices are considerably more affordable, and sometimes up to half as expensive as mechanical emptying. Prices are not fixed, however, and can sometimes be about the same as for mechanical emptying. As the market is not structured, many factors affect the setting of prices. These prices are not always objective and may vary greatly from one area to another and from one operator to another. On average, manual emptying costs **9,193 FCFA** (**US$18**), usually rounded up to **10,000 FCFA** (**US$20**).
Prices are slightly higher in Dakar where operators pay a tax at the dumping sites.
Even with high prices, mechanical desludging operators only practice illicit dumping when the authorized dumping sites are closed (from 4pm to 8am on working days and all day long on weekends).

Even at those times, the sanitation authorities constantly follow the operators. Any operators caught illicitly dumping into the environment face fines or penalties including imprisonment. However, this does not prevent illicit dumping which continues in Dakar, albeit out of sight.
They also face higher fuel consumption because of the heavy traffic jams encountered by the trucks on their journeys.
It must be noted that differences in price are not significant across the three cities, even though in Thiès and Touba dumping charges are borne by the sludge operators. In Touba, however, a monthly tax of

25,000 FCFA (US$50) is paid to the municipality.

All mechanical operators may this monthly tax for each truck, as they have no way to avoid the control of the municipality, which is under the direction of a religious leader. As was already explained when describing the situation in Touba, religious leaders dictate the rules of conduct, which no-one dares to oppose. Therefore operators, as good disciples, do not violate the rules laid down by their leaders prohibiting illicit dumping. In addition, each operator monitors his neighbor. This type of monitoring is considerably more efficient than that of Dakar. What is also interesting about Touba is that the president of the local rural community association (a religious leader) is also a mechanical desludging operator. Thus the difficulty of monitoring dumping does not exist, as each new truck must be declared on arrival to the holy city.

Table 5: Desludging prices

Types of emptying	Dakar	Thiès	Touba	Total
Manual desludging prices	11,599 FCFA ($26)	7,051 FCFA ($16)	9,337 FCFA ($21)	**9,193 FCFA ($20)**
Mechanical desludging prices	22,448 FCFA ($50)	19,726 FCFA ($44)	16,558 FCFA ($37)	**18,526 FCFA ($41)**

The service does not take into account the socio-economic conditions of households, and usually both rich and poor are charged the same rates. Sometimes rich households are overcharged by the operators, but this is quite rare.
Poor households, living far out in the suburbs, are often forced to pay prices equivalent to those of the rich as sludge trucks struggle to access the hemmed in areas in which they live (the result of poor urban planning) or deal with the long distances to dumping sites.
Frequency of desludging is also very variable, with several criteria influencing this. On average, households in each city desludge their septic tanks **2.5 times per year**, with a higher frequency in Thiès and Touba. However, frequency varies throughout the year. For example, in Dakar and Thiès desludging activities peak during the winter period, whereas in Touba desludging is more likely to take place before and after the Magal[2], when the population is at its peak. In Dakar, two problems were highlighted by the households themselves during the survey - the proximity of the water table in certain areas, and the poor quality of septic tanks, one reason why desludging operations take place at very close proximity to some households.

Poor quality septic tanks are in violation of technical standards. In Dakar, for example, some low-income households rely on day laborers or handymen to construct their tanks. These builders may not take into consideration the size of the household, rates of water consumption and the nature of the soil, and this can result in the construction of undersized tanks, or tanks located less than one meter from the water table. Because of this, tanks fill up very rapidly, due to the large number of individuals in the household, as well as proximity to the water table.

[2]A religious festival which takes place annually in Touba.

Table 6: Frequency of desludging

	Dakar	Thiès	Touba	Total
Once per year	24%	20%	44%	**32%**
Twice per year	33%	13%	27%	**24%**
Every two years	6%	26%	8%	**13%**
Other	37%	41%	21%	**31%**
Average frequency of desludging per year	**2.6**	**2.9**	**2.08**	**2.5**

The service is usually paid for immediately following the operation, a mode of payment which satisfies **78%** of the population, with those dissatisfied preferring to defer payment. Some felt that payment should be staggered across the year (**38**%), while others thought that payment within one month would suffice (**26%).**

- **Willingness to Pay (WTP)**

The cost of desludging services is already considered high by households, who in the majority are not prepared to accept a price increase. In order to identify the willingness of households to pay for an improved[3] desludging service the auction method was used. This corresponds best to the purchasing method of people in developing countries.
An auction begins immediately after the key amount of **25,000 FCFA** (**US$50),** defined through previous studies and interviews with operators as the minimum price of an improved mechanical desludging service. The results are detailed in Table 7, below:

Table 7: Average household WTP

WTP	Dakar	Thiès	Touba	Total
WTP before auction	14,270 FCFA ($32)	17,360 FCFA ($39)	14,600 FCFA ($32)	**15,431 FCFA ($34)**
Final WTP	16,337 FCFA ($36)	20,169 FCFA ($45)	16,311 FCFA ($36)	**17,589 FCFA ($39)**

It is important to note that those surveyed were not in favor of price increases. In Dakar and Touba, the final WTP was lower than current market prices. The situation in Thiès is a little different as the population seemed more willing to make efforts to improve their desludging service.
It must also be noted that the WTP was not too low and that a desludging service can be supplied at these prices. Operators simply need to be supported and trained in order to enable a lowering of prices and a service of benefit to everyone.
A more detailed analysis of the WTP also identified three groups of people in this regard – those with a High WTP, those with a Low WTP and those with an Intermediate WTP (these are grouped by city in the Appendix 3, 4, 5).
The percentage of households with an Intermediate WTP was largest in Touba. A High WTP was most evident in Thiès, probably because it is the city most willing to make an effort to improve the desludging service. Dakar had the largest proportion of Low WTP, due to the fact that it has the highest concentration of poor households, who lack the financial means to pay for an improved service. The cost of living in Dakar is also very high, and the poorest struggle to afford essentials such as food, rent, electricity, water and health services. They are therefore not willing to accept further price increases.

[3] An improved desludging service consists of a quality service (the complete emptying of all sludge in septic tanks), which is swift and clean (complying with hygiene standards), and accessible (desludging takes places when the household requires it).

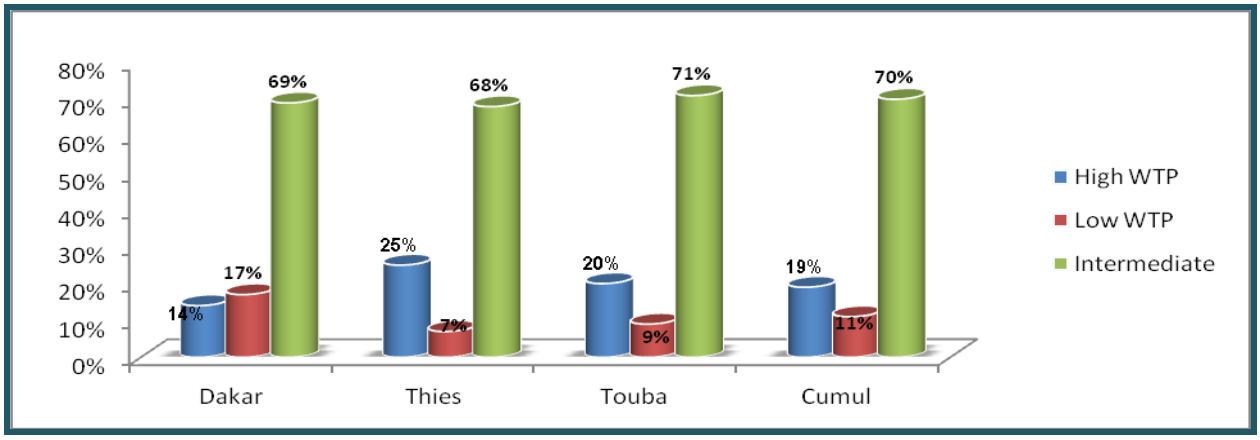


Figure 6: Breakdown of WTP

The average High WTP was **31 334 FCFA** (**US$63**), Intermediate WTP was **15 870 FCFA** (**US$32**) and Low WTP was **4 278 FCFA (US$9).**

Households' WTP for an improved desludging service is more or less equal to the price that they currently pay for a service which they consider non-improved. This implies first of all that households are not willing to increase the prices that they pay for desludging and also that the prices they currently pay are high compared to the quality of service provided by mechanical operators (e.g., when mechanical desludging does not completely empty septic tanks which may contain abnormal discharges).

In general, the highest WTP was reported among rich households and the lowest was found among poor households. In Dakar some rich households reported a Low WTP but these tended to be those who were already connected to a sewer network or had a high performance on-site sanitation facility, and saw no immediate need for an improved desludging service.
In many cases, households believe that they can fund the payment of the future service through economizing on daily expenses (44%), family help (19%), savings (18%) or loans (2%). These methods varied according to social class. The rich were more likely to revert to savings whereas the poor relied on family help, economies on daily expenses and loans. Households did not identify any structure currently in operation to help them pay for this service.

- **Other results:**

This section presents other results concerning solid waste management, household wastewater, the expectations of the population and different authorities in relation to an improved service, and public knowledge of the risks related to fecal sludge, summarized through a multivariate analysis that aims to address the key factors affecting different user groups.

Solid waste management:
Solid waste management is frequently not ideal, with **51%** of households storing their waste in open containers before disposal and **44%** in closed containers. The remainder, **(5%)** use no containers at all.
Almost **75%** benefit from an organized collection system for solid waste. The rest bury waste close by or burn it. Some households continue to engage in illegal dumping **(13%).** Waste management is often free, although some pay small amounts, on average **693 FCFA/month** (**US$1.40 /month**).

Wastewater:
For wastewater, the practice is to drain water at street level (**47%** of households), directly within the concession (**6%**) or in open canals (**9%**). **27%** use sumps to drain their wastewater and **8%** directly via their latrines. The latter two methods, considered better practice, are usually used by the rich. The poor often have less desirable habits, namely water discharge directly into the streets or in their concessions.

Knowledge of risks:
46% of respondents believe that the way they manage their excreta can have an impact on aspects such

as the environment (**60%**), quality of life (**27%**), the water table (**7%**) and therefore water pollution. For the remainder, **34%** think that their choice and practice of managing excreta has no known impact on the community and **20%** had no response to this issue.

Expectations of the public:

For the establishment of an improved desludging service, households were keen to specify some points and strategies for the main actors in the industry, which were noted. For each actor, the expectations were classed in order of importance.

Table 8: Householder expectations vis-à-vis various stakeholders

ACTORS	EXPECTATIONS
Mayor/local authorities	– Communal desludging service – Financial support for sludge operators
ONAS	– Technical support for operators – Financial support for operators
Private operators	– Lower prices – Transparency in pricing
Manual operators	– Comply with the Hygiene Code – Comply with the Environment Code
NGOs	– Technical support – Financial support and awareness-raising

Multivariate Analysis:

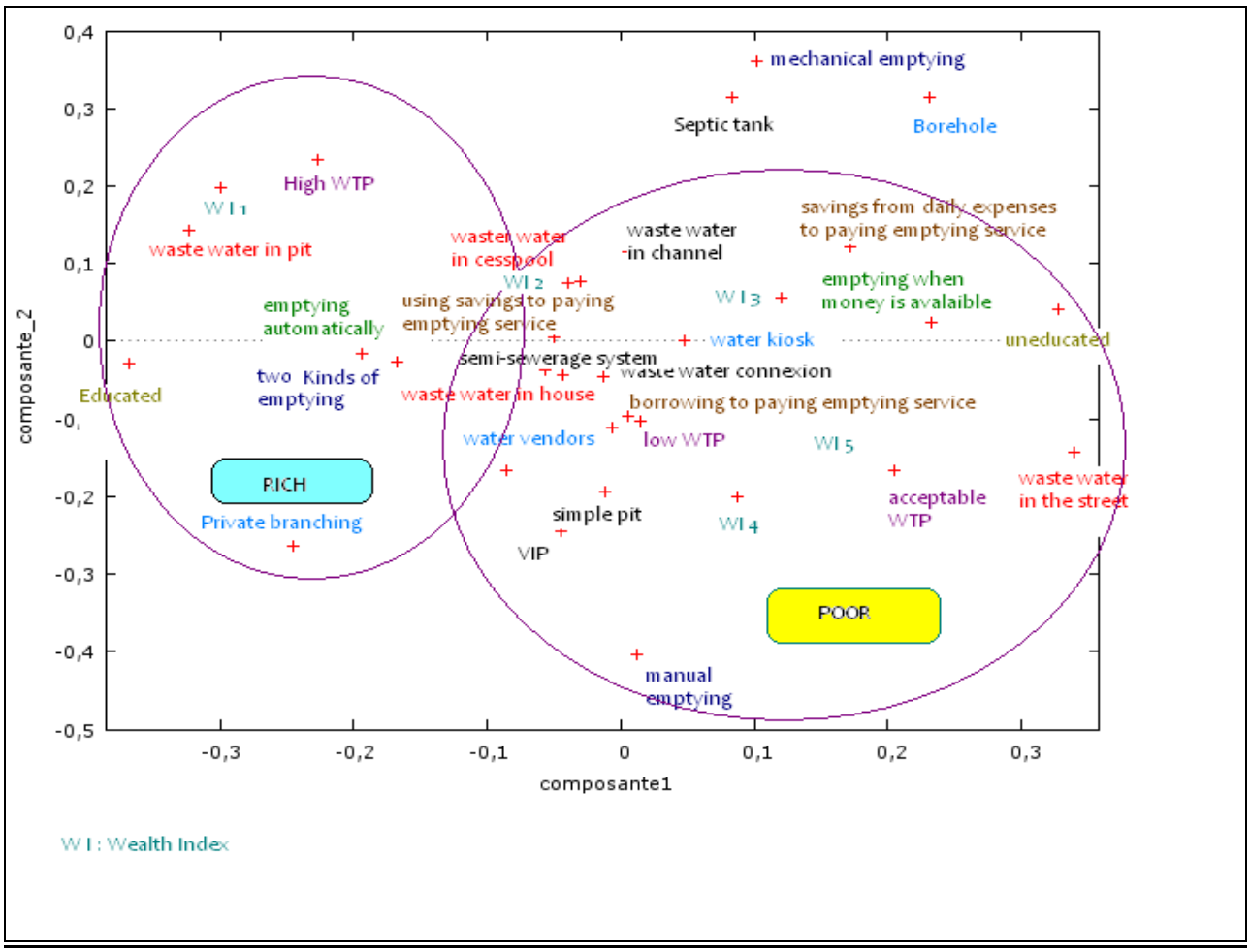


Figure 7: Map of Multivariate Analysis – Factor Map

Multivariate analysis enables a rough analysis of the characteristics of the two groups of users (rich and poor) in the three cities.

The rich:

These are people who have attained a certain level of education. They have no difficulty in accessing drinking water. They are the most likely to have a private connection even in the case of a city like Touba where tap water is available for free to all.
Given their financial independence, many resort to both types of desludging (manual and mechanical) in order to have the most efficient service. They empty their septic tanks as soon as they become full.
They have a real capacity to pay for an improved service, reflected in by a High WTP reported in the survey. This also indicates a potential market for operators to exploit by offering a more complete and sophisticated service which also performs well enough to meet the strong demand of this demographic. The rich plan to pay for such services using their savings.
Concerning wastewater management, the rich are equally willing to make every effort in terms of latrines. Often, for fear that their septic tanks are filling up quickly, they drain water directly into the concession. This is practiced in cities such as Touba and Thiès where there is sufficient space around the house to enable this practice. In a city such as Dakar where often there are no such large spaces these practices are not condoned. In the capital, the discharge of water directly into the concession is usually resorted to by the poor. The intersection of the circles of these two groups of individuals is illustrated in the Factor Map above.

The poor:

This group is generally not well-educated. They also suffer the most from water shortages. They usually

source water from water kiosks, water vendors, wells or boreholes.
Their problems are similar in terms of sanitation. They are the least well-equipped when it comes to infrastructure and in most cases they have unimproved latrine facilities. Technologies such as ventilated improved pit latrines are highest reported in this section of the population.
Practices in the management of domestic sewage are many and varied, and most, such as the use of sumps by the majority of people, are not desirable in terms of health and hygiene. Wastewater is drained directly into the concession, into open canals and even directly onto the street. The poor are also more likely to engage in this practice.
Given the difficulties they face in accessing financial resource in times of need, they often wait until they have enough money to empty their septic tanks when they become full. As this financial constraint is usually significant, they can rarely afford mechanical desludging services, but instead use the more affordable manual desludging services.
They are more likely to have a Low WTP for an improved desludging service but they are also likely to have an Intermediate WTP. They plan to pay for the future service through loans, family help or by economizing on daily expenses.

Common features of the rich and poor:

Overall mechanical desludging is used in almost the same way by the poor and the rich. However, this result was largely influenced by Touba, where manual desludging is not significantly used. In the two other cities, it is usually the rich who use this service.
The septic tank is a facility used by both the rich and the poor, the only difference may lie in the quality of the structure.
Boreholes are also used by both poor and rich, depending on where they live. Rich households in areas where there private connections have not yet been installed use boreholes as well as poor households in the same area where this is the only alternative available. This is the case in Touba, where, as highlighted above, methods of water supply is not an issue for impoverished groups.

3.1.9. Overview of WWTP, FSTP and dumping sites

In Senegal, dumping sites only exist in Dakar, where they are paired with fecal sludge treatment plants which continue the processing of the sludge.
The three dumping sites, at Cambérène (handling 150 m^3/day), Niayes and Rufisque (60 m^3/day each), are controlled by ONAS. However, their capacities are usually exceeded (e.g. Cambérène receives on average 500 m^3/day). A sludge deposit tax of US$0.60/$m^3$ in Dakar and US$50/month in Touba is levied. There is no sludge deposit tax levied in Thiès.
On the technical side, these dumping sites include a screening system, a settling/thickening system and drying beds. The screening system is designed to hold solid waste and helps reduce visual pollution in the settling/thickening tanks. At the majority of dumping sites in Dakar, the screening is not comprehensive, so a significant amount of solids are found in the settling tanks which often leads to the breakdown of pumps. Another problem with the system lies in the treatment of the refuse from this process, which is stored without any treatment at the dumping site before being sent to landfills.

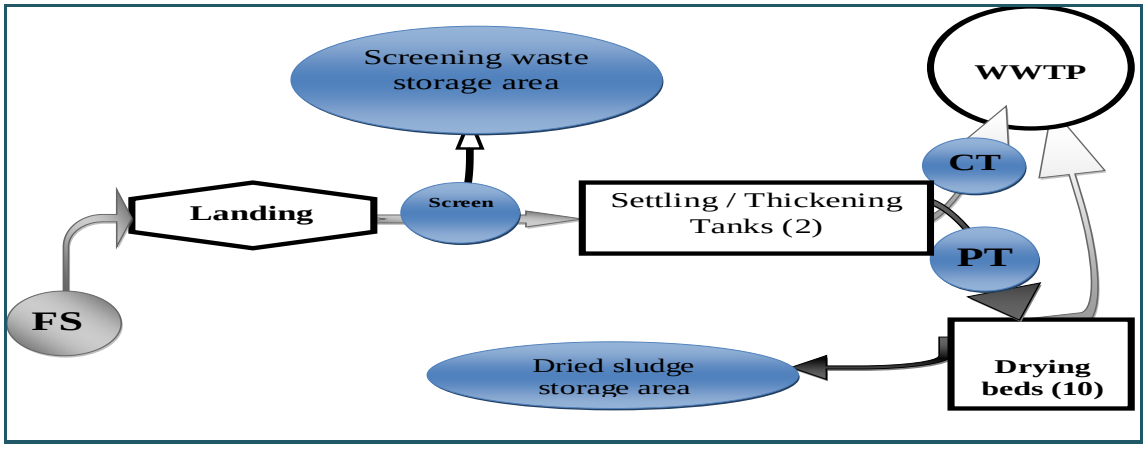


Figure 8: Diagram of Dumping Site Operations
FS: Fecal Sludge; **WWTP :** Waste Water Treatment Plant; **CB:** Control Tank; **PB:** Pumping Tank

After the screening, the sludge passes through the settling/thickening tanks which perform the first phase of solid/liquid separation. The tanks are two in number and operate alternately. Each tank operates for one or two weeks before being cleaned out.
A good quantity of the sludge settles in the settling/thickening tanks. The intermediary liquid portion is discharged from the tank by overflow to undergo a finishing treatment while the remainder is left to be drained. Above this liquid is a scum composed of floating materials and fats. The main problem related to the tanks is the delay in cleaning them out.
In normal operation, the liquid phase of the sludge passes through a regulator tank before being routed to the WWTP. The discharged sludge is sent to the pumping tank before being spread on the drying beds.
These are three actived sludge treatment plants in the three cities examined, one in Thiès and two in Dakar (Cambérène and Niayes). Both of these stations are built on the same model. Let us examine the example of the Cambérène station, constructed between 1987 and 1989. This station collects effluent from the northern part of the city of Dakar. It is designed to serve a population of 200,000 (i.e. according to accepted standards, it can treat the waste of 200,000 people). More specifically, it cannot handle more than 19,200 m^3/ day (its initial capacity was only 9,800 m^3/day but this was increased). It currently receives only 15,000 m^3/day, whereas the total amount of effluent produced in Dakar is approximately 100,000 m^3/day.(**M. K. Badji, 2008)**

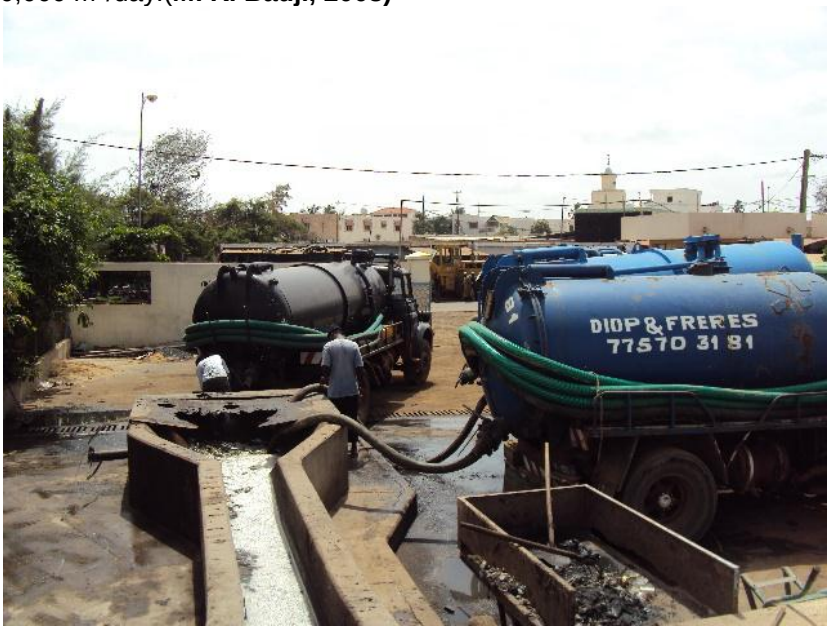


Figure 9: Sludge trucks discharging at the Cambérène FSTP

3.1.10. FS re-use in the three cities

In Dakar, sludge is re-used in the first instance by market gardeners and gardeners located next to the WWTP and the FSTP. We also noted the presence of sludge buyers who are beginning to make contact with ONAS. Thus in 2008, 620 m^3 of dried sludge was stripped and sold at 400 FCFA (US$0.80) per $meter^3$. This good management of fecal sludge was not recorded in either Thiès or Touba, where we did not observe any cases of sludge recycling.
Thus the small amount of sludge re-used in Dakar and the total absence of re-use in Thiès and Touba show the necessity of developing a policy for the valorization of sludge by-products from on-site sanitation facilities. In fact, not only can the sludge be used for soil enrichment but the effluent is also good for irrigation, aquaculture and possibly for mixing water in civil construction works.

3.2. Market analysis per city

According to our surveys, the aggregate rate of sanitation in the three cities studied is 88%, although the coverage varies considerably from one city to the next. However, sludge production continues to grow. This therefore raises the issue of its collection and treatment.
For the city of Dakar, 65.3% households are served by on-site (individual) sanitation facilities, producing

around **2,921,184.10 m^3/ year.** This figure, representing the amount of domestic sludge produced is calculated on the basis of responses regarding types of on-site sanitation facilities and the frequency of desludging. The results are presented in the table below.

Table 9: Sludge production in Dakar

Survey Data	Emptying Frequency Pits	pits to be Emptied/yr	Emptying Frequency Septic Tanks	Septic tanks to be Emptied/yr	Emptying Frequency cesspools	Frequency cesspools to be Emptied/yr
More than 3 times /year	0.0%	0.00	16%	104067.43		
2 to 3 times/yr	0.0%	4,565.74	32%	156101.15	10%	48,781.61
Once/yr	1.0%	44.76	21%	34147.13	10%	16,260.54
Once/2 yrs	0.0%	0.00	8%	6504.21	0%	0.00
Once/3yrs	0.0%	0.00	1%	536.60	0%	0.00
Once/4 yrs	0.0%	0.00	0%	0.00	0%	0.00
5-10 yrs	1.0%	5.82	0%	0.00	0%	0.00
Over 10 yrs	0.0%	0.00	0%	0.00	0%	0.00
Not yet undertaken	0.0%	0.00	4%	0.00	0%	-
	TOTAL Pits to be emptied per year =	**4,616.32**	**TOTAL Septic tanks to be emptied/ year =**	**301,356.52**	**TOTAL cesspools to be emptied/ year =**	**65,042.15**

According to focus group interviews with operators in Dakar, as well as with the president of the association of sanitation operators in Senegal, sludge trucks handle domestic sludge while simultaneously practicing other diversification activities. According to these interviews, diversification activities make up 30% of sludge operators' total activities. Therefore, desludging activities occupy 70% of the working hours of fecal sludge operators in Dakar, the quantity of domestic sludge collected is estimated at **2,207,272.97 $m^{3.}$** The volume of sludge collected is calculated on the basis of the statements of operators as well as the average number of trucks observed (150) and the average capacity of the trucks (10 m^3). The difference between the production and collection of sludge is 713,911.13 m^3.

In Thiès, 98% of the population surveyed is served by individual sanitation facilities. Annual sludge production is estimated to be **193,099.37 m^3.** This calculation of the volume of sludge produced is based on the following table:

Table 10: Sludge production in Thiès

Survey Data	Emptying Frequency Pits	# pits to be Emptied/ yr	Emptying Frequency Septic Tanks	# Septic tanks to be Emptied/ yr	Emptying Frequency cesspools	# Fequency cesspools to be Emptied/yr
more than 3 times /year			2.86%	2811.82		
2 to 3 times/yr	4%	663.75	11.71%	8634.54	0%	0%
Once/yr	5%	276.56	22.14%	5441.75	0%	0%
Once/2 yrs	5%	138.28	25.00%	3072.35	0%	0%
Once/3yrs		0.00	4.29%	347.96	0%	0%
Once/4 yrs		0.00	8.57%	526.60	0%	0%
5-10 yrs	2%	14.38	7.57%	241.88	0%	0%
Over 10 yrs	2%	11.06	0.43%	10.57	0%	0%
Not done Yet	0%	0.00	2.00%	0.00	0%	-
	TOTAL Pits TO BE emptied per year =	**1104.03**	**TOTAL Septic tanks To BE emptied/ year =**	**21087.48**	**TOTAL cesspools To BE emptied/ year =**	**Sum of all these cells = C**

During interviews, sludge operators reported 7 trucks for the city of Thiès with an average volume of 10 m^3 and an average of 2 rotations per truck per day. Thus the total volume of sludge collected is estimated to be **109,333.79 m^3.**

Concerning the religious city of Touba, the rate of individual sanitation coverage is 100% due to the total absence of public sanitation.
Like Thiès, Touba has no sludge treatment site. Sludge is dumped into fields. The annual production of sludge in Touba is estimated to be **696,959.71 m^3**, and only **322 617.58 m^3** is collected by emptying trucs.
These results are based on the same calculations as that of the cities of Dakar and Thiès (see table below).

Table 11: Sludge production in Touba

Survey Data	Emptying Frequency Pits	Pits to be Emptied/yr	Emptying Frequency Septic Tanks	Septic tanks to be Emptied/yr	Emptying Frequency cesspools	Fequency cesspools to be Emptied/yr
more than 3 times /year			4.64%	9405.79		
2 to 3 times/yr	6%	1033.48	26.98%	41018.57	0%	0.00
Once/yr	3%	172.25	48.29%	24472.28	0%	0.00
Once/2 yrs	3%	86.12	7.69%	1948.56	0%	0.00
Once/3yrs	0%	0.00	0.35%	58.53	0%	0.00
Once/4 yrs	0%	0.00	0.35%	44.34	0%	0.00
5-10 yrs	0%	0.00	0.93%	61.27	0%	0.00
Over 10 yrs	0%	0.00	0.00%	0.00	0%	0.00
Not done Yet	0%	0.00	0.00%	0.00	0%	0.00
	TOTAL Pits TO BE emptied per year =	**1291.86**	**TOTAL Septic tanks To BE emptied/ year =**	**77009.35**	**TOTAL cesspools To BE emptied/ year =**	**Sum of all these cells = C**

In all three cities, we found that not all sludge produced was collected. Therefore we can conclude that the market is not yet saturated.

3.3. Service delivery models review

3.3.1. Overview of existing models

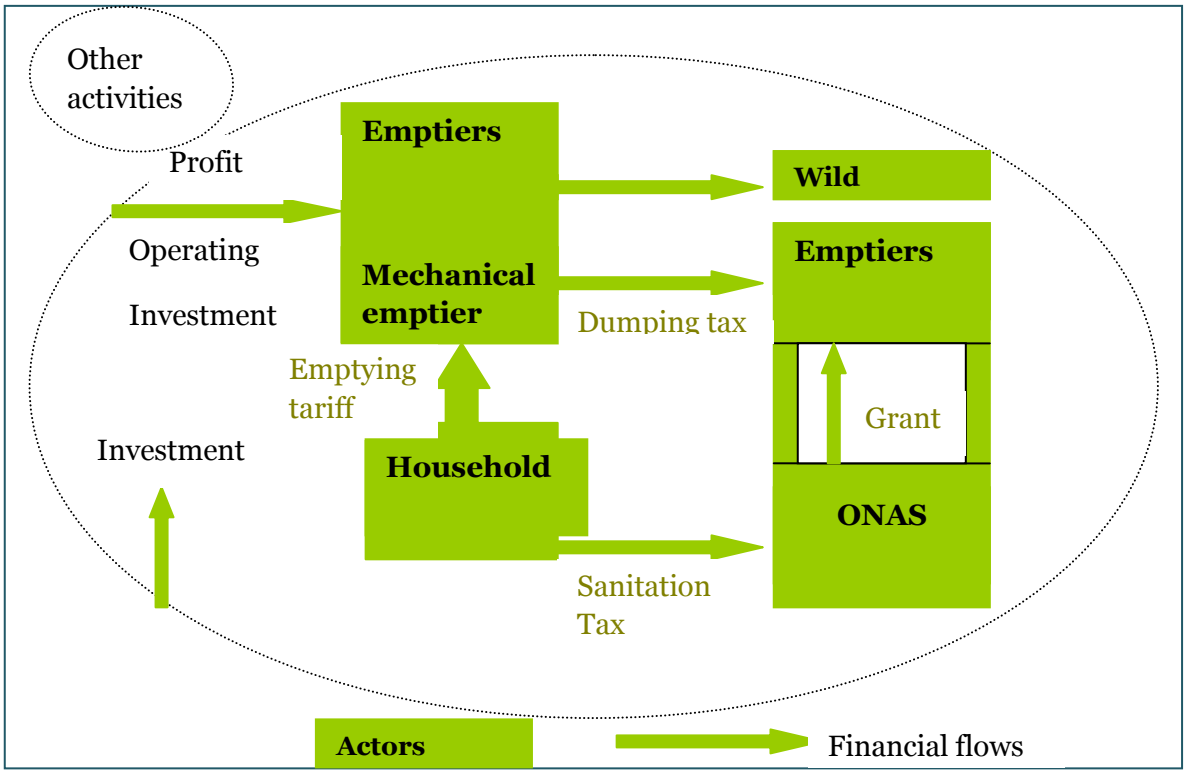


Figure 10: Organization of the sludge management sector

3.3.2.Comparison with solid waste management service models

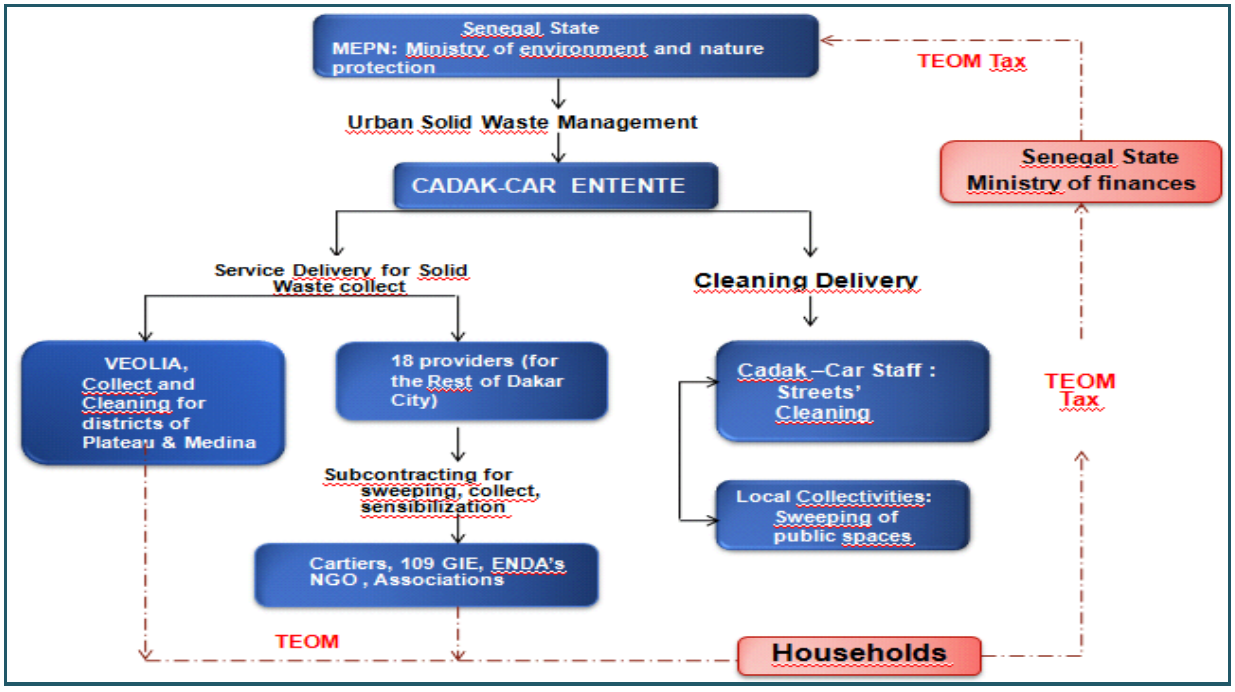


Figure 11: Organizational model of solid waste management (case study: city of Dakar)

3.4. Financial and Business Model analysis

3.4.1. City level (each city)

Table 12: Profile of the fecal sludge sector

	Dakar	Thiès	Touba
HOUSEHOLD INCOME/MONTH			
Average income (US$/HH/month)	$541	$302	$280
EMPTYING COST			
Annual average of manual emptying cost per HH	$60.30	$40.90	$38.84
Annual average of mechanical emptying cost per HH	$116.70	$ 114.40	$68.88
PRODUCTION PER YEAR			
Based on survey data = P1	2,079,106.56	189,242.96	696,959.71
Theoretical calc = P2 (state assumptions used)	1,638,020.67	201,514.44	485,595.32
FS Collected per year =C	1,948,767.13	108,022.61	32,2617.58
MECHANICAL BUSINESS INFORMATION			
# of private mechanical businesses in city (average)	50	5	12
# of trucks run by private businesses (average)	150	7	30

3.4.1.1. Demand and supply in each city

ONAS does not offer desludging facilities in any of the three cities even though sludge operating companies fail to cover the whole market.
Analysis of the fecal sludge market is summarized in the tables below. The results presented in the table for each city are based on national statistical data (the population of each city), interviews with sludge operators and household surveys.
The average capacity that we use in these calculations is 10 m^3. The number of rotations per truck per day is the only criterion which varies according to each city.

The prediction that emerges from this project is that a sizable proportion of the sludge produced in the city will not be collected over the years.

Table 13: Fecal sludge market in Dakar

		2011	2012	2013	2014	2015
DAKAR URBAN AREA	**Population**	**2574065**	**2627974**	**2699509**	**2772202**	**2845959**
	FS collected in Dakar	2921184	2982363	3063545	3146040	3229744
	Collected from other sources	876355	894709	919063	943812	968923
	HH Sludge production in m3	2079107	2122650	2180429	2239144	2298719
	FS collected from HH	1948767	1989580	2043738	2098772	2154612
	Emptying services (Nomber of trucks)	150	153	157	162	166
	Gap between demand and supply	130339	133069	136691	140372	144107
	Gap of emptying services (Nomber of trucks)	10	10	11	11	11
	Emptying services need (Nomber of trucks)	160	163	168	172	177

For the city of Dakar, the average number of rotations as reported by sludge operators was 4 per truck

per day. Considering the 10 m^3 trucks surveyed, we found that with a fleet of 150 trucks, 1,948,767 m^3 of domestic sludge could be collected by the end of 2011. Therefore, to absorb the gap between production and collection (130,339 m^3), the fleet must be increased by 10 additional trucks of 10 m^3 capacity.

Table 14: Fecal sludge market in Touba

		2011	2012	2013	2014	2015
TOUBA	**Population**	**617813**	**636841**	**654154**	**671745**	**689594**
	HH sludge production in m3	696960	718425	737956	757801	777936
	FS collected	322618	332554	341595	350780	360101
	Emptying services (Number of trucks)	30	31	32	33	33
	Gap between demand and supply	374342	385871	396362	407020	417835
	Gap of emptying services (Number of trucks)	35	36	37	38	39
	Emptying services need (Number of trucks)	65	67	69	70	72

In Touba, the average number of rotations is 3 per truck per day. Considering the 10 m^3 trucks surveyed, we found that with a fleet of 30 trucks, 322,618 m^3 of domestic sludge could be collected by the end of 2011. Thus to make up the gap between production and that which is actually collected by trucks in Touba (374,342 m^3), the fleet must be increased by at least 35 extra 10m^3 trucks. It must be remembered that in the case of the holy city of Touba, trucks from Dakar and other cities operate during the period of the Magal and that the production of sludge during this period (which brings together on average 3 million people each year) is not taken into account in our calculations. We only consider the resident population of Touba..

Table 15: Fecal sludge market in Thiès

		2011	2012	2013	2014	2015
THIES	**Population**	**293112**	**300927**	**309116**	**317432**	**325874**
	HH sludge production in m3	201514	206887	212517	218234	224038
	FS collected	108023	110903	113921	116985	120097
	Emptying services (Nomber of trucks)	7	7	7	8	8
	Gap between demand and supply	93492	95985	98597	101249	103942
	Gap of emptying services (Nomber of trucks)	6	6	6	7	7
	Emptying services need (Nomber of trucks)	13	13	14	14	15

In Thiès, the average number of rotations is 2 per truck per day. This low number of daily rotations is related to two factors. The first is the high cost for households of manual desludging services. The second is the fact that the standard of living is somewhat lower in Thiès, in comparison to the two other cities surveyed, meaning that households do not have sufficient purchasing power to allow them to avail of mechanical desludging services.

Considering the 10 m^3 trucks surveyed, we found that with a fleet of 7 trucks, 108,023 m^3 of domestic

sludge could be collected by the end of 2011. Thus to make up the gap between production and that which is actually collected by trucks in Touba (93,492 m^3), the fleet must be increased by at least 6 extra $10m^3$ trucks.

3.4.1.2. Company level financial analysis: (for manual vs small/medium/large mechanical businesses*)*

3.4.1.2.1. Income statements

- Manual desludging :

Manual desludging activities are entirely informal, and do not require significant means. This result does not take into account the impacts on the health of the operators or on the environment. Indeed, a small value assessment of these impacts would completely change the result.

- Dakar: Average of **30 Emptying per Month**

Table 16: Income statement for manual desludging in Dakar

Item	Units	Annual amount	Monthly amount	Cost per emptying
Capital Costs				
Wages for all employees	USD	11 944,81	995,40	33,18
Small equipment (wheelbarrows, shovels, buckets, etc.).	USD	22,12	1,84	0,06
Safety equipment (gloves, boots, etc.).	USD	0,00	0,00	0,00
Others (lunch)	USD	796,32	66,36	1,11
Subtotal	**USD**	**12 763,26**	**1 063,60**	**34,35**
Operating Costs				
Fees paid for emptying support	USD	0,00	0,00	0,00
Transport support fees paid	USD	0,00	0,00	0,00
Disinfectants	USD	159,26	13,27	0,22
Medicine used	USD	0,00	0,00	0,00
Material renting	USD	0,00	0,00	0,00
“baksheesh” for Harassment	USD	0,00	0,00	0,00
If sold for re-use: Transportation costs to buyer	USD	0,00	0,00	0,00
Subtotal	**USD**	**159,26**	**13,27**	**0,22**
Revenue				
Emptying (HH)	USD	11 944,81	995,40	33,18
If sold for re-use: Income from sale to buyer		0,00	0,00	0,00
* Other uses of the equipment (unclodding)		0,00	0,00	0,00
Subtotal	**USD**	**11 944,81**	**995,40**	**33,18**
Profit/ Loss		0,00	0,00	0,00
Profit / Loss	**USD**	**-977,71**	**-81,48**	**-1,39**

- Thies: Average of **60 Emptying per Month**

Table 17: Income statement for manual desludging in Thiès

Item	Units	Annual amount	Monthly amount	Cost per emptying
Capital Costs				
Wages for all employees	USD	37851,79	3154,32	52,57
Small equipment (wheelbarrows, shovels, buckets, etc.).	USD	33,18	2,77	0,05
Safety equipment (gloves, boots, etc.).	USD	0,00	0,00	0,00
Others (lunch)	USD	132,72	11,06	0,18
Subtotal	**USD**	**38017,69**	**3168,14**	52,80
Operating Costs		0,00	0,00	0,00
Fees paid for emptying support	USD	0,00	0,00	0,00
Disinfectants	USD	0,00	0,00	0,00
Medicine used	USD	99,54	8,30	0,14
Material renting	USD	0,00	0,00	0,00
“baksheesh” for Harassment	USD	0,00	0,00	0,00
If sold for re-use: Transportation costs to buyer	USD	0,00	0,00	0,00
Subtotal	**USD**	**99,54**	**8,30**	0,14
Total		**38117,23**	**3176,44**	52,94
Revenue				0,00
Emptying (HH)		35197,39	2933,12	48,89
If sold for re-use: Income from sale to buyer	USD	0	0	0,00
* Other uses of the equipment (unclogging)		2654,40	221,20	3,69
Total		**37851,79**	**3154,32**	52,57
Profit / Loss	USD	-265,44	-22,12	-0,37

- Touba: Average of **60 Emptying per Month**

Table 18: Income statement for manual desludging in Touba

Item	Units	Annual amount	Monthly amount	Cost per emptying
Capital Costs				
Wages for all employees	USD	19589,50	1632,46	31,28
Small equipment (wheelbarrows, shovels, buckets, etc.).	USD	22,12	1,84	0,11
Safety equipment (gloves, boots, etc.).	USD	0,00	0,00	0,00
Others (lunch)	USD	265,44	22,12	3,39
Subtotal	**USD**	19877,06	1656,42	34,78
Operating Costs		0,00	0,00	0,00
Fees paid for emptying support	USD	0,00	0,00	0,00
Disinfectants	USD	6,64	0,55	0,11
Medicine used	USD	49,77	4,15	0,28
Material renting	USD	0,00	0,00	0,00
"baksheesh" for Harassment	USD	0,00	0,00	0,00
If sold for re-use: Transportation costs to buyer	USD	0,00	0,00	0,00
Subtotal	**USD**	56,41	4,70	0,39
Total		19933,46	1661,12	35,17
Revenue		0,00	0,00	0,00
Emptying (HH)		18262,29	1521,86	29,86
If sold for re-use: Income from sale to buyer	USD	0,00	0,00	0,00
*** Other uses of the equipment (unclogging)**		1393,56	116,13	0,00
Total		19655,86	1637,99	29,86
Profit / Loss	USD	-277,61	-23,13	-5,30

Table 19: Income Consolidated statement of manual desludging in three cities

Item	Units	Annual amount Touba	Annual amount Dakar	Annual amount Thiès
Capital Costs	**USD**	19,877.06	12,763.26	38,017.69
Operating Costs	**USD**	56.41	159.26	99.54
Total costs	**USD**	19,933.46	19,933.46	38,117.23
Revenue				
Emptying (HH)		18,262.29	11,944.81	35,197.39
Other uses of the equipment (deblocking)		1,393.56		2,654.40
Total revenue		19,655.86	11,944.81	37,851.79
Loss	USD	-277.61	-977.71	-265.44

The table above summarizes the consolidated financial statement referred to earlier. High capital costs are clearly evident across all three cities. These capital costs principally stem from salaries, since manual operators work in teams.

It is clear from the consolidated statement table that manual desludging activities are not profitable in

each of the three cities.

Revenues are more significant in Thies and in fact the results of the household survey indicate that the manual desludging activities are highly developed in the city, hence the importance of the income to these sludge operators.

Touba comes second in this regard even if manual desludging is not significant in the city. The uniqueness of the city in regard to manual desludging lies in the fact that here sludge operators are somewhat more organized, often working in teams, and with an official in charge of a more or less permanent team of staff that he can solicit when necessary. This team often performs several desludging operations in a day.

In Dakar the operators encountered often work alone or in a team of no more than two, generally obtaining lower revenues compared to those in the other two cities.

Manual desludging is not profitable, a loss which is even greater when the health costs are taken into account. These workers have no health coverage and often total revenues are equal to salaries.

- Mechanical desludging :

The number of desludging trips is not proportional to the size of the company. For this study, we simply reported the average of the real figures obtained on the ground. It should also be noted that certain costs being fixed, they do not vary according to the size of company (both large or small companies only need an office, a mechanic, a secretary, a salesman and a manager). Similarly, variable costs, due to economies of scale, do not vary in proportion to the number of trucks owned.

- **Dakar**

Table 20: Consolidated income statement for small companies: average of 3 companies, each having 1 truck and an annual average of 1000 trips.

Item	Units	Annual Amount	Monthly amount	Cost/trip	%charges
Personnel Costs					
Wages paid:	USD	0.00	0.00	0.00	0.00
Permanent staff	USD	4901.79	408.48	4.90	0.09
Daily wage workers	USD	6574.06	547.84	6.57	0.11
Social Contribution to permanent staff	USD	106.18	8.85	0.11	0.00
Medical expenses	USD	1459.92	121.66	1.46	0.03
Subtotal 1		**13041.95**	**1086.83**	**13.04**	**0.23**
Operating and dumping costs					
Registration fees of company	USD	656.23	54.69	0.66	0.01
Licensing fees for truck	USD	0.00	0.00	0.00	0.00
Office building rent	USD	663.60	55.30	0.66	0.01
Telephone	USD	1291.81	107.65	1.29	0.02
Electricity	USD	495.49	41.29	0.50	0.01
Water	USD	221.20	18.43	0.22	0.00
Offices supplies, computer	USD	88.48	7.37	0.09	0.00
Trucks Maintenance and repair	USD	2477.44	206.45	2.48	0.04
Safety Equipment	USD	440.93	36.74	0.44	0.01
Fuel (pumping & transport)	USD	18492.32	1541.03	18.49	0.32
Sludge dumping/tipping Fees	USD	6636.00	553.00	6.64	0.12

If sold for re-use: Transportation costs to buyer	USD	0.00	0.00	0.00	0.00
Others (Harassment, emptying free for relatives, friends and colleagues)	USD	3211.79	267.65	3.21	0.06
Subtotal 2	**USD**	**34675.28**	**2889.61**	**34.68**	**0.60**
Equipment Capital costs					
Loan Interest paid to Bank	USD	221.20	18.43	0.22	0.00
Insurance costs for trucks, vehicles	USD	258.07	21.51	0.26	0.00
If used, costs to refurbish truck (one time-upfront)	USD	2064.53	172.04	2.06	0.04
Truck Depreciation Cost	USD	4276.53	356.38	4.28	0.07
Tyres annual depreciation Cost	USD	2123.52	176.96	2.12	0.04
Suction pipes depreciation Cost	USD	796.32	66.36	0.80	0.01
Office equipment depreciation costs	USD	147.47	12.29	0.15	0.00
Vehical rental cost	USD	0.00	0.00	0.00	0.00
Subtotal 3	**USD**	**9887.64**	**823.97**	**9.89**	**0.17**
Total charges		**57604.87**	**4800.41**	**57.60**	**1.00**
Revenue Sources					
Emptying (Households only)	USD	55300.00	4608.33	55.30	0.96
Emptying (Other*) Specify each	USD	0.00	0.00	0.00	0.00
Other uses** of the trucks (specify each)	USD	0.00	0.00	0.00	0.00
If sold for re-use: Income from sale to buyer	USD	0.00	0.00	0.00	0.00
Total revenue	**USD**	**55300.00**	**4608.33**	**55.30**	**0.96**
Profit /Loss					
Revenue before Tax	USD	-2304.87	-192.07	-2.30	-0.04
Revenue Tax	USD	0.00	0.00	0.00	0.00
Profit (loss) after Tax	**USD**	**-2304.87**	**-192.07**	**-2.30**	**-0.04**

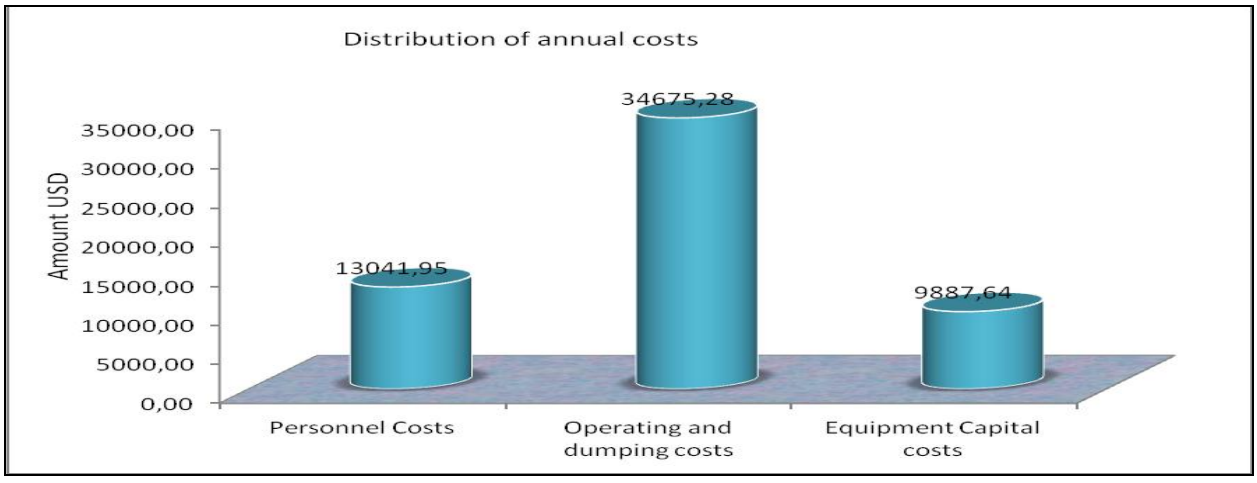


Figure 12: Distribution of annual costs for small enterprise

The main costs for desludging businesses relate to operating and dumping costs. The average distribution of these costs for small companies is detailed in the figure below. The distribution of operating and dumping costs shows that 54% of costs are related to fuel purchase and 19% are related to dumping site tax payments. Free desludging services, other social works and police harassment

account for 9%, followed by maintenance and repair costs, which represent 7%. Even if the cost of maintenance and repair is low in comparison to the rest, the fact remains that the age of the trucks partly explains the high cost of fuel consumption.

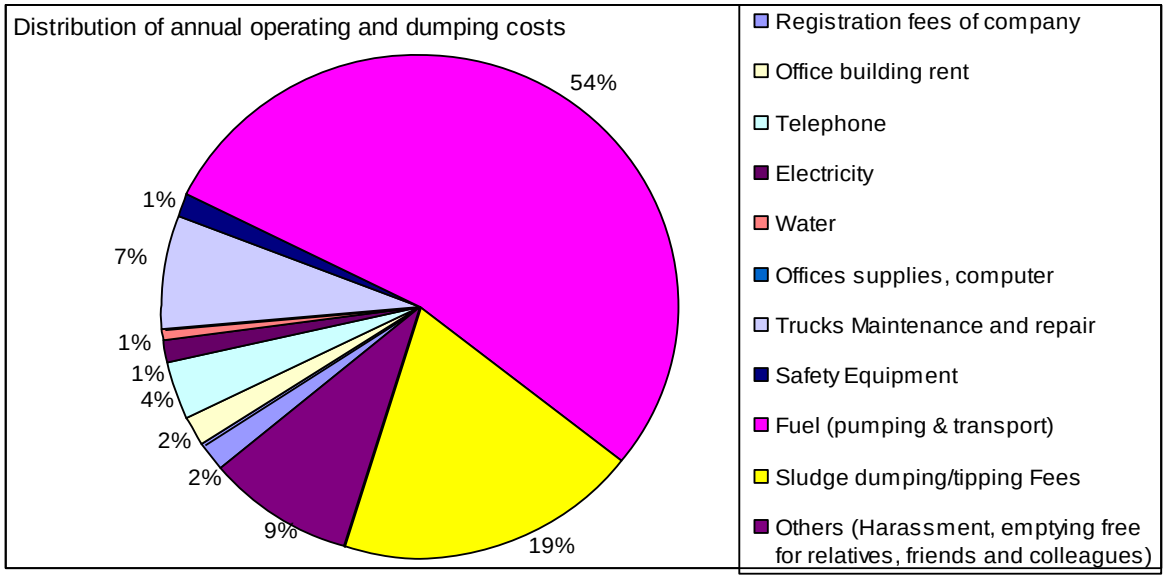


Figure 13: Distribution of operating cost for small enterprise

Tableau 21: Consolidated income statement for medium-sized companies: average of 3 companies, having a total of 8 trucks, or an average of 2.6 trucks per company and an annual average of 2,880 trips per company.

Item	Units	Annual Amount	Monthly amount	Cost per trip	%charge
Personnel Costs					
Wages paid:	USD	0.00	0.00	0.00	0.00
Permanent staff	USD	11042.30	920.19	4.08	0.06
Daily wage workers	USD	12050.98	1004.25	4.94	0.07
Social Contribution to permanent staff	USD	0.00	0.00	0.00	0.00
Medical expenses	USD	663.60	55.30	0.27	0.00
Subtotal 1		**23756.88**	**1979.74**	**9.29**	**0.13**
Operating and dumping costs					
Registration fees of company	USD	1468.77	122.40	0.54	0.01
Licensing fees for truck	USD	0.00	0.00	0.00	0.00
Office building rent	USD	0.00	0.00	0.00	0.00
Telephone	USD	4450.54	370.88	1.77	0.02
Electricity	USD	0.00	0.00	0.00	0.00
Water	USD	0.00	0.00	0.00	0.00
Offices supplies, computer	USD	0.00	0.00	0.00	0.00
Trucks Maintenance and repair	USD	9201.92	766.83	3.03	0.05
Safety Equipment	USD	361.29	30.11	0.13	0.00
Fuel (pumping & transport)	USD	76446.72	6370.56	28.02	0.38
Sludge dumping/tipping Fees	USD	23889.60	1990.80	8.85	0.12

If sold for re-use: Transportation costs to buyer	USD	0.00	0.00	0.00	0.00
Others (Harassment, emptying free for relatives, friends and colleagues)	USD	29198.40	2433.20	7.13	0.11
Subtotal 2	**USD**	**145017.25**	**12084.77**	**49.46**	0.69
Equipment Capital costs					
Loan Interest paid to Bank	USD	129.03	10.75	0.03	0.00
Insurance costs for trucks, vehicles	USD	1113.37	92.78	0.44	0.01
If used, costs to refurbish truck (one time-upfront)	USD	12166.00	1013.83	5.12	0.07
Truck Depreciation Cost	USD	9069.20	755.77	3.35	0.05
Tyres annual depreciation Cost	USD	7078.40	589.87	2.57	0.04
Suction pipes depreciation Cost	USD	2123.52	176.96	0.80	0.01
Office equipment depreciation costs	USD	0.00	0.00	0.00	0.00
Vehical rental cost	USD	0.00	0.00	0.00	0.00
Subtotal 3	**USD**	**31679.53**	**2639.96**	**12.30**	**0.18**
Total charges		**200453.65**	**16704.47**	**71.04**	**1.00**
Revenue Sources					
Emptying (Households only)	USD	175190.40	14599.20	58.99	0.85
Emptying (Other*) Specify each	USD	31764.32	2647.03		
Other uses** of the trucks (specify each)	USD	0.00	0.00	0.00	0.00
If sold for re-use: Income from sale to buyer	USD	0.00	0.00	0.00	0.00
Total revenue	**USD**	**206954.72**	**17246.23**	**58.99**	**0.85**
Profit /Loss					
Revenue before Tax	USD	6501.07	541.76	-12.06	-0.15
Revenue Tax	USD	0.00	0.00	0.00	0.00
Profit (loss) after Tax	**USD**	6501.07	541.76	-12.06	-0.15

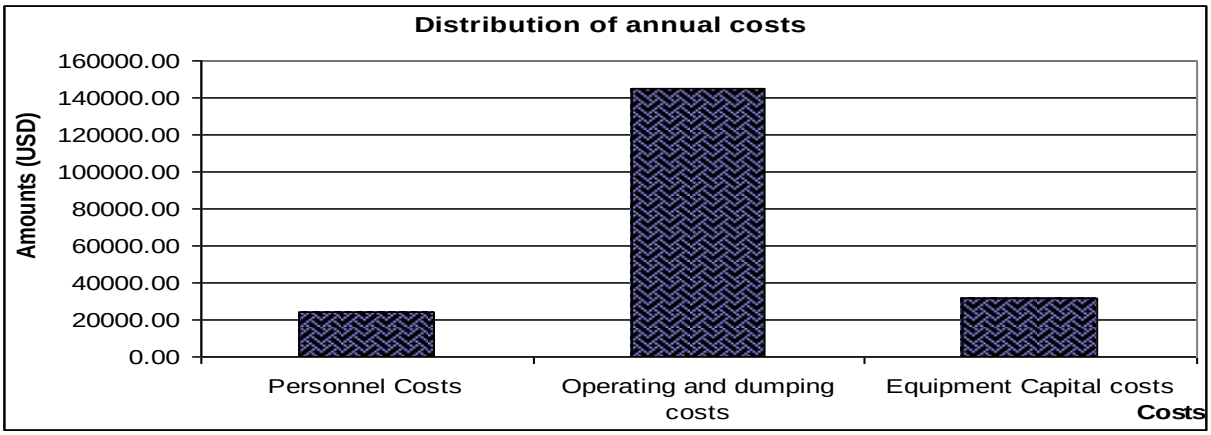


Figure 14: Distribution of annual costs for medium enterprise

The main charges faced by medium-sized mechanical desludging companies are related to operating and dumping costs. The average distribution of these costs for medium-sized companies is detailed in the figure below. The distribution of operating and dumping costs shows that 54% of costs are related to fuel purchase. Free desludging services, other social works and police harassment account for 20%, and

16% is related to dumping site tax payments. These are followed by maintenance costs, which represent 6%. Even if the cost of maintenance and repair is low in comparison to the rest, age of the trucks and traffic congestion partly explain the high cost of fuel consumption.

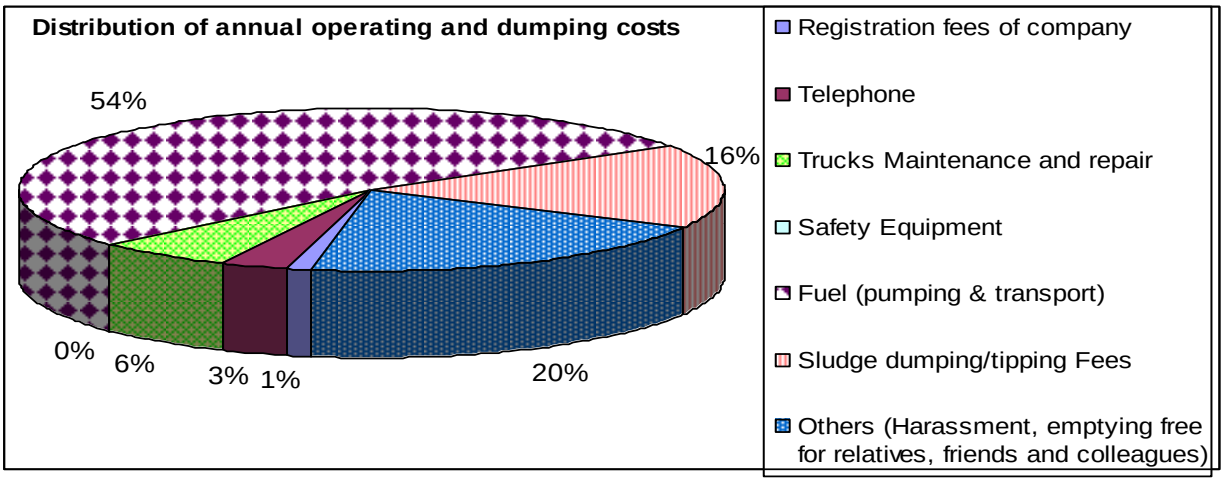


Figure 15: Distribution of operating cost for medium enterprise

Table 22: Consolidated income statement for large companies: average of 5 companies, having a total of 38 trucks, or an average of 7.6 trucks per company and an annual average of 7,766.4 trips per company.

Item	Units	Annual Amount	Monthly amount	Cost per trip	%charge
Personnel Costs					
Wages paid:	USD	0.00	0.00	0.00	0.00
Permanent staff	USD	56018.46	4668.20	6.52	0.12
Daily wage workers	USD	24760.24	2063.35	3.72	0.06
Social Contribution to permanent staff	USD	0.00	0.00	0.00	0.00
Medical expenses	USD	1486.46	123.87	0.18	0.00
Subtotal 1		**82265.16**	**6855.43**	**10.42**	**0.19**
Operating and dumping costs					
Registration fees of company	USD	3941.78	328.48	0.55	0.01
Licensing fees for truck	USD	0.00	0.00	0.00	0.00
Office building rent	USD	0.00	0.00	0.00	0.00
Telephone	USD	11222.80	935.23	1.61	0.03
Electricity	USD	1592.64	132.72	0.15	0.00
Water	USD	371.62	30.97	0.04	0.00
Offices supplies, computer	USD	796.32	66.36	0.08	0.00
Trucks Maintenance and repair	USD	20545.06	1712.09	3.91	0.06
Safety Equipment	USD	4224.92	352.08	0.47	0.01
Fuel (pumping & transport)	USD	154008.29	12834.02	20.71	0.38
Sludge dumping/tipping Fees	USD	48798.49	4066.54	6.38	0.12
If sold for re-use: Transportation costs to buyer	USD	0.00	0.00	0.00	0.00

Others (Harassment, emptying free for relatives, friends and colleagues)	USD	10065.48	838.79	1.51	0.03
Subtotal 2	**USD**	**255567.40**	**21297.28**	**35.40**	**0.64**
Equipment Capital costs					
Loan Interest paid to Bank	USD	1282.96	106.91	0.23	0.00
Insurance costs for trucks, vehicles	USD	3008.32	250.69	0.40	0.01
If used, costs to refurbish truck (one time-upfront)	USD	8405.60	700.47	1.23	0.02
Truck Depreciation Cost	USD	28313.60	2359.47	3.88	0.07
Tyres annual depreciation Cost	USD	18970.11	1580.84	2.66	0.05
Suction pipes depreciation Cost	USD	5574.24	464.52	0.81	0.01
Office equipment depreciation costs	USD	442.40	36.87	0.04	0.00
Vehical rental cost	USD	0.00	0.00	0.00	0.00
Subtotal 3	**USD**	**65997.23**	**5499.77**	**9.25**	**0.17**
Total charges		**403829.80**	**33652.48**	**55.07**	**1.00**
Revenue Sources					
Emptying (Households only)	USD	399327.94	33277.33	52.20	0.97
Emptying (Other*) Specify each	USD	54061.28	4505.11		
Other uses** of the trucks (specify each)	USD	0.00	0.00	0.00	0.00
If sold for re-use: Income from sale to buyer	USD	0.00	0.00	0.00	0.00
Total revenue	**USD**	**453389.22**	**37782.43**		
Profit /Loss					
Revenue before Tax	USD	49559.42	4129.95	-55.07	0.12
Revenue Tax	USD	12389.85	1032.49	-13.77	0.03
Profit (loss) after Tax	**USD**	**37169.56**	**3097.46**	**-41.30**	**0.09**

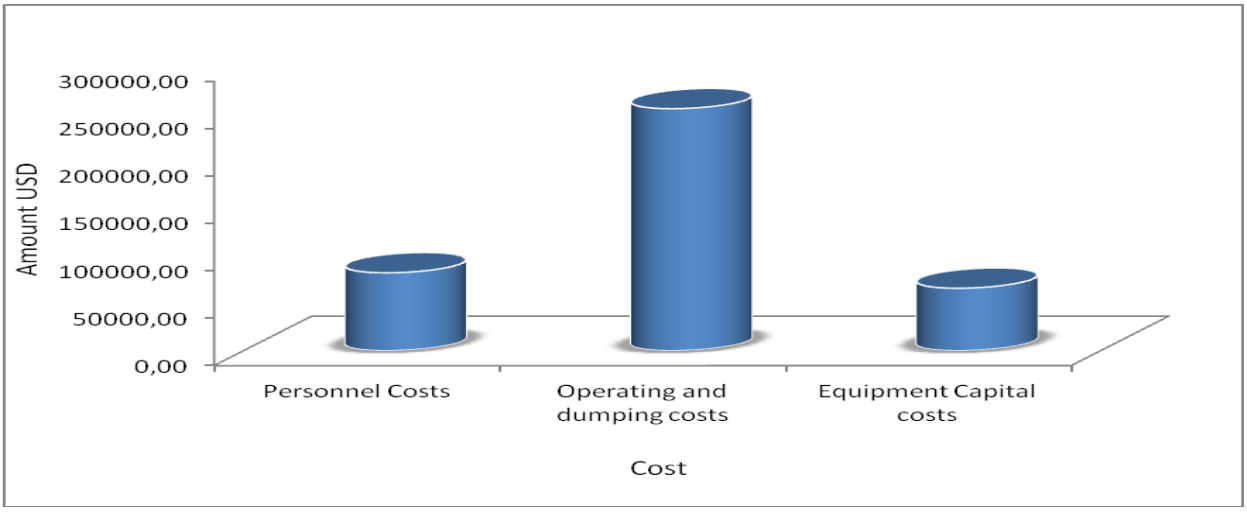


Figure 16: Distribution of annual costs for large enterprise

The main charges faced by large mechanical desludging companies are related to operating and dumping costs. The average distribution of these costs for large companies is detailed in the figure below. The distribution of operating and dumping costs shows that 60% of costs are related to fuel purchase and 19% are related to dumping site tax payments, followed by maintenance and repair costs

which represent 8%. Free desludging services, other social works and police harassment account for 4%. Even if the cost of maintenance and repair is low in comparison to the rest, the fact remains that the age of the trucks and traffic congestion partly explain the high cost of fuel consumption.

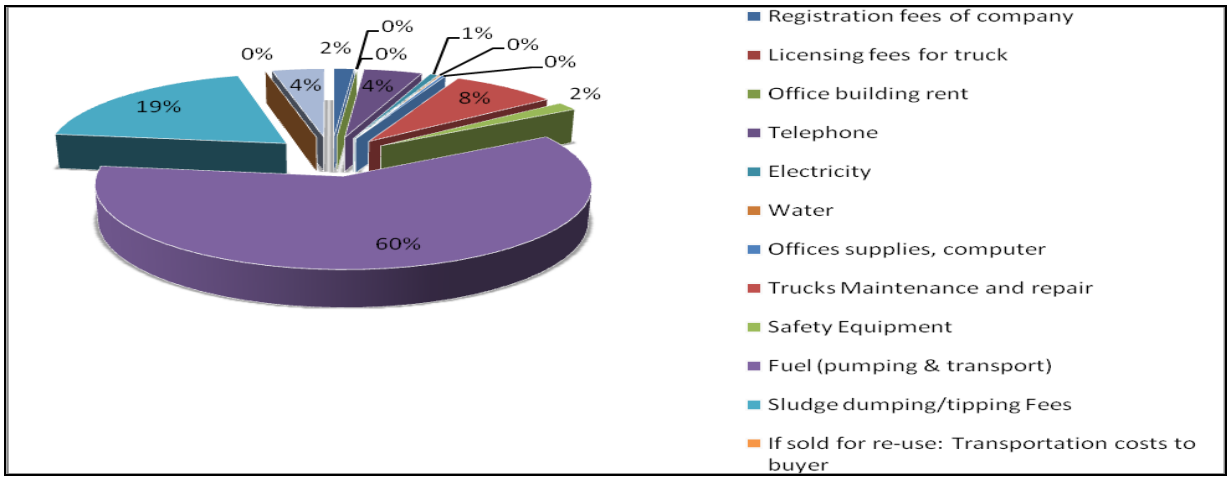


Figure 17: Distribution of operating cost for medium enterprise

The table below summarizes mechanical desludging activities in Dakar.

Table 23: Income statement mechanical desludging in Dakar

Item Dakar	Units	Small	Medium	Large
Average		1 truck of 10m^3 1000 trip/year HH emptying only	2.6 trucks of 10m^3 2970HH trip/year (1113.7 trips/truck)	7.6 truck of 10 m^3 7649.49HH trip/year (1006.5 trips/truck)
Personnel Costs	USD	13,041.95	23,756.88	82,265.16
Operating and dumping costs	USD	34,675.28	14,5017.25	255,567.40
Equipment Capital costs	USD	9,887.64	31,679.53	65,997.23
Total Charges	**USD**	**57,604.87**	**200,453.65**	**403,829.80**
Revenue Sources				
Emptying (Households only)	USD	55,300.00	175,190.40	399,327.94
Emptying (Other*) Specify each	USD	0.00	31,764.32	54,061.28
Total Revenue	**USD**	**55,300.00**	**206,954.72**	**453,389.22**
Profit /Loss				
Revenue before Tax	USD/	-2,304.87	6,501.07	49,559.42
Revenue Tax	USD/	0.00	0.00	12,389.85
Profit (loss) after Tax	USD	**-2,304.87**	6,501.07	**37,169.56**
Break-even point		**-4.17%**	3.14%	**8.20%**

These are the operational costs of dumping which constitute more than half of charges for the three categories of businesses (small, medium and large). Operating costs and dumping costs are increased by fuel expenditures, which account for over 53% of costs, and dumping expenses, which represent 19% of costs.

Domestic desludging activities are the only forms of revenue for small businesses, whereas medium and large businesses often provide services. It is important to note that medium-sized enterprises are usually positioned mostly as sub-contractors and do not sign contract with clients, hence the lack of tax revenue from these types of businesses.

Desludging activities are profitable for medium and large businesses which have the possibility of other side activities, but it is not profitable for small businesses. It follows therefore that domestic desludging itself is not profitable and diversification is necessary.

- **Touba**

Table 24: Consolidated income statement for small companies: average of 3 companies, each having 1 truck and an annual average of 936 trips per company.

CONSOLIDEE: Petite,78 trip per month					
Item	**Units**	**Annual Amount**	**Monthly amount**	**Cost per trip**	**%charge**
Personnel Costs					
Wages paid:	USD	0.00	0.00	0.00	0.00%
Permanent staff	USD	1778.45	148.20	0.16	3.95%
Daily wage workers	USD	2645.55	220.46	0.24	5.88%
Social Contribution to permanent staff	USD	0.00	0.00	0.00	0.00%
Medical expenses	USD	132.72	11.06	0.01	0.30%
Subtotal		**4556.72**	**379.73**	**0.41**	**10.13%**
Operating and dumping costs					
Registration fees of company	USD	143.04	11.92	0.01	0.32%
Licensing fees for truck	USD	14.01	1.17	0.00	0.03%
Office building rent	USD	0.00	0.00	0.00	0.00%
Telephone	USD	1150.24	95.85	0.10	2.56%
Electricity	USD	0.00	0.00	0.00	0.00%
Water	USD	0.00	0.00	0.00	0.00%
Offices supplies, computer	USD	0.00	0.00	0.00	0.00%
Trucks Maintenance and repair	USD	5724.66	477.05	0.51	12.73%
Safety Equipment	USD	307.03	25.59	0.03	0.68%
Fuel (pumping & transport)	USD	19324.03	1610.34	1.72	42.96%
Sludge dumping/tipping Fees	USD	663.60	55.30	0.06	1.48%
If sold for re-use: Transportation costs to buyer	USD	847.93	70.66	0.08	1.89%
Others (specify)	USD	805.17	67.10	0.07	1.79%
Subtotal	**USD**	**28979.71**	**2414.98**	**2.58**	**64.43%**
Equipment Capital costs					
Loan Interest paid to Bank	USD	0.00	0.00	0.00	0.00%
Insurance costs for trucks, vehicles	USD	483.69	40.31	0.04	1.08%
If used, costs to refurbish truck (one time-upfront)	USD	4792.67	399.39	0.43	10.66%
Truck Depreciation Cost	USD	3244.27	270.36	0.29	7.21%
Tyres annual depreciation Cost	USD	2123.52	176.96	0.19	4.72%

Suction pipes depreciation Cost	USD	796.32	66.36	0.07	1.77%
Office equipment depreciation costs	USD	0.00	0.00	0.00	0.00%
Vehical rental cost	USD	0.00	0.00	0.00	0.00%
Subtotal	**USD**	**11440.46**	**953.37**	**1.02**	**25.44%**
Total charges		**44976.89**	**3748.07**	**4.00**	**100.00%**
Revenue Sources					
Emptying (Households only)	USD	34507.20	2875.60	3.07	76.72%
Emptying (Other*) Specify each	USD	737.33	61.44	0.07	1.64%
Other uses** of the trucks (specify each)	USD	0.00	0.00	0.00	0.00%
If sold for re-use: Income from sale to buyer	USD	0.00	0.00	0.00	0.00%
Total revenue	**USD**	**35244.53**	**2937.04**	**3.14**	**78.36%**
Profit /Loss					
Revenue before Tax	**USD**	**-9732.36**	**-811.03**	**-10.40**	**-21.64%**
Revenue Tax	USD	0.00	0.00	0.00	0.00%
Profit (loss) after Tax	**USD**	**-9732.36**	**-811.03**	**-10.40**	**-21.64%**

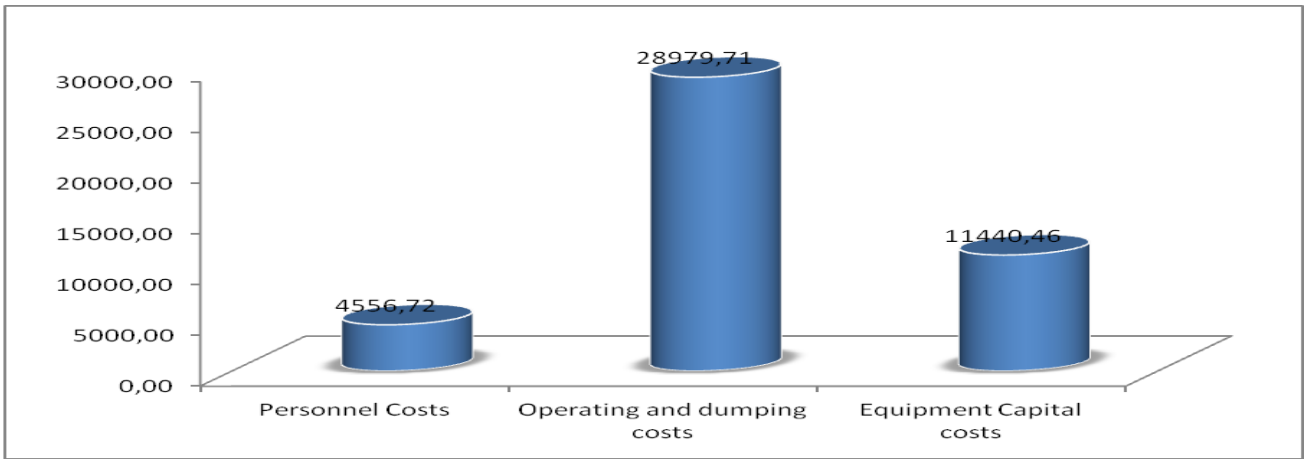


Figure 18: Distribution of annual costs for small companies

The main costs for small mechanical desludging companies are related to operating and dumping costs. The average distribution of these costs for small companies is detailed in the figure below. The distribution of operating and dumping costs shows that 67% of costs are related to fuel purchase, 20% to maintenance and 4% to communication. Free desludging services, other social works and police harassment account for 3%. The cost of maintenance and repair is high due to the age of the trucks and traffic congestion, which also partly explain the high cost of fuel consumption.

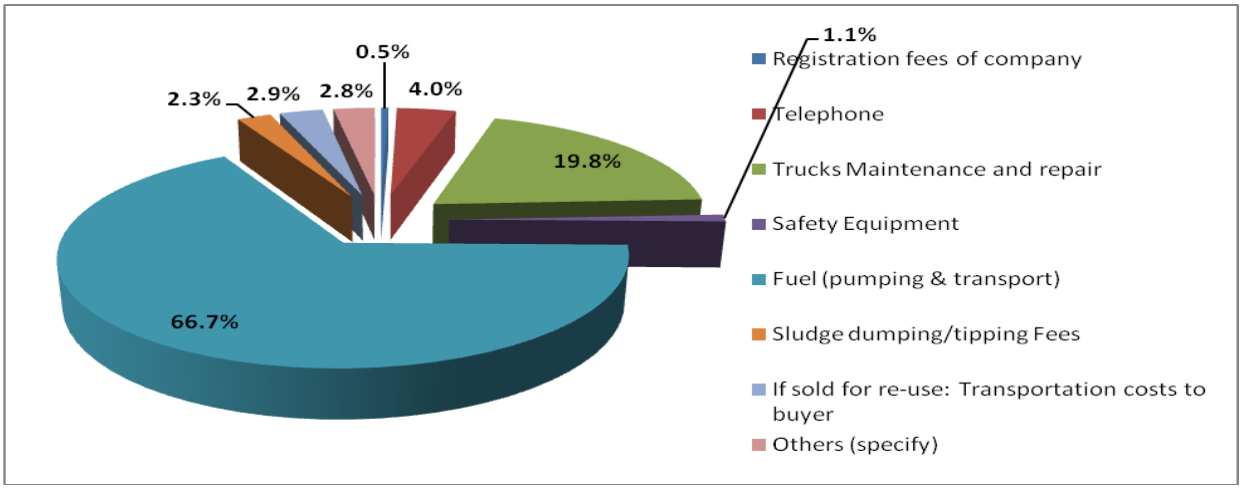


Figure 19: Distribution of operating costs for small companies

Table 25: Consolidated income statement for medium-sized companies: average of 3 companies, each having 2 trucks and an annual average of 2,496 trips per company.

Item	Units	Annual Amount	Monthly amount	Cost per trip	%charge
Personnel Costs					
Wages paid:	USD	0.00	0.00	0.00	00%
Permanent staff	USD	3822.34	318.53	1.53	4%
Daily wage workers	USD	4176.26	348.02	1.67	5%
Social Contribution to permanent staff	USD	0.00	0.00	0.00	00%
Medical expenses	USD	707.84	58.99	0.28	1%
Subtotal	**USD**	**8706.43**	**725.54**	**3.49**	**10%**
Operating and dumping costs					
Registration fees of company	USD	479.27	39.94	0.19	1%
Licensing fees for truck	USD	28.76	2.40	0.01	00%
Office building rent	USD	0.00	0.00	0.00	00%
Telephone	USD	1380.29	115.02	0.55	2%
Electricity	USD	0.00	0.00	0.00	00%
Water	USD	92.02	7.67	0.04	00%
Offices supplies, computer	USD	0.00	0.00	0.00	00%
Trucks Maintenance and repair	USD	7786.24	648.85	3.12	8%
Safety Equipment	USD	309.68	25.81	0.12	00%
Fuel (pumping & transport)	USD	44169.22	3680.77	17.70	48%
Sludge dumping/tipping Fees	USD	1327.20	110.60	0.53	1%
If sold for re-use: Transportation costs to buyer	USD	0.00	0.00	0.00	00%
Others (specify)	USD	6795.26	566.27	2.72	7%
Subtotal	**USD**	**62367.93**	**5197.33**	**24.99**	**67%**

Equipment Capital costs					
Loan Interest paid to Bank	USD	0.00	0.00	0.00	00%
Insurance costs for trucks, vehicles	USD	672.45	56.04	0.27	1%
If used, costs to refurbish truck (one time-upfront)	USD	5161.33	430.11	2.07	6%
Truck Depreciation Cost	USD	9437.87	786.49	3.78	10%
Tyres annual depreciation Cost	USD	4247.04	353.92	1.70	5%
Suction pipes depreciation Cost	USD	1592.64	132.72	0.64	2%
Office equipment depreciation costs	USD	0.00	0.00	0.00	00%
Vehical rental cost	USD	0.00	0.00	0.00	00%
Subtotal	**USD**	**21111.33**	**1759.28**	**8.46**	**23%**
Total charges		**92185.69**	**7682.14**	**36.93**	**100%**
Revenue Sources					
Emptying (Households only)	USD	99380.74	8281.73	39.82	108%
Emptying (Other*) Specify each	USD	4147.50	345.63	1.66	5%
Other uses** of the trucks (specify each)	USD	0.00	0.00	0.00	00%
If sold for re-use: Income from sale to buyer	USD	0.00	0.00	0.00	00%
Total revenue	**USD**	**103528.24**	**8627.35**	**41.48**	**113%**
Profit /Loss					
Revenue before Tax	USD	11342.55	945.21	4.54	13%
Revenue Tax	USD	0.00	0.00	0.00	00%
Profit (loss) after Tax	**USD**	**11342.55**	**945.21**	**4.54**	**13%**

The table below summarizes mechanical desludging activities in Touba.

Table 26: Income statement for mechanical desludging companies in Touba

Item Touba	Units	Small	Medium	Large
Average		1truck of 10m^3 937 trip/year HH emptying only	2 trucks of 10m^3 2,496 HH trip/year (1248 trips/truck)	0
Personnel Costs	USD	4,556.72	8,706.43	0
Operating and dumping costs	USD	28,979.71	62,367.92	0
Equipment Capital costs	USD	11,440.46	21,111.33	0
Total Charges	**USD**	**44,976.89**	**92,185.69**	**0**
Revenue Sources				
Emptying (Households only)	USD	34,507.20	99,380.736	0
Emptying (Other*) Specify each	USD	737.33	4147.5	0
Total Revenue	**USD**	**35,244.53**	**103528.236**	**0**
Profit /Loss				
Revenue before Tax	**USD/**	**-9,732.36**	**113,42.55**	0
Revenue Tax	**USD/**	**0.00**	**0**	0
Profit (loss) after Tax	**USD**	**-9,732.36**	**11,342.55**	0
Break-even point		**-27.61%**	**10.95%**	

There are no large sludge companies operating in Touba. Just like Dakar, desludging is a profitable activity for medium-sized businesses and not profitable for small businesses. In contrast to Dakar, all fecal sludge operators in Touba offer other services during the annual Magal pilgrimage to Touba. All trucks in the city are operational during this period. Companies have no contract and therefore do not pay tax on income.

It is only in Touba that a real profit is observed for medium-sized companies and this can largely be explained by three factors: the high rate of mechanical desludging, the relatively low monthly dumping tax (US$50/month) and the large number of desludging activities during the period of the the Magal (both before and after the Magal, the number of rotations can reach 7 per truck per day).

- **Thiès**

Table 27: Consolidated income statement for small companies: average of 2 companies, each having 1 truck and an annual average of 828 trips per company.

PETITE: Consolidée					
Item	**Units**	**Annual Amount**	**Monthly amount**	**Cost per trip**	**%charge**
Personnel Costs					

Wages paid:	USD	0.00	0.00	0.00	0.00%
Permanent staff	USD	2654.40	221.20	3.21	6.06%
Daily wage workers	USD	6237.84	519.82	7.53	14.24%
Social Contribution to permanent staff	USD	0.00	0.00	0.00	0.00%
Medical expenses	USD	265.44	22.12	0.32	0.61%
Subtotal 1		**9157.68**	**763.14**	**11.06**	**20.91%**
Operating and dumping costs					
Registration fees of company	USD	176.96	14.75	0.21	0.40%
Licensing fees for truck	USD	0.00	0.00	0.00	0.00%
Office building rent	USD	0.00	0.00	0.00	0.00%
Telephone	USD	1486.46	123.87	1.80	3.39%
Electricity	USD	0.00	0.00	0.00	0.00%
Water	USD	0.00	0.00	0.00	0.00%
Offices supplies, computer	USD	0.00	0.00	0.00	0.00%
Trucks Maintenance and repair	USD	5176.08	431.34	6.25	11.82%
Safety Equipment	USD	530.88	44.24	0.64	1.21%
Fuel (pumping & transport)	USD	14652.29	1221.02	17.70	33.45%
Sludge dumping/tipping Fees	USD	0.00	0.00	0.00	0.00%
If sold for re-use: Transportation costs to buyer	USD	0.00	0.00	0.00	0.00%
Others (specify)	USD	1778.45	148.20	2.15	4.06%
Subtotal 2	**USD**	**23801.12**	**1983.43**	**28.75**	**54.34%**
Equipment Capital costs					
Loan Interest paid to Bank	USD	0.00	0.00	0.00	0.00%
Insurance costs for trucks, vehicles	USD	331.80	27.65	0.40	0.76%
If used, costs to refurbish truck (one time-upfront)	USD	0.00	0.00	0.00	0.00%
Truck Depreciation Cost	USD	8405.60	700.47	10.15	19.19%
Tyres annual depreciation Cost	USD	1592.64	132.72	1.92	3.64%
Suction pipes depreciation Cost	USD	508.76	42.40	0.61	1.16%
Office equipment depreciation costs	USD	0.00	0.00	0.00	0.00%
Vehical rental cost	USD	0.00	0.00	0.00	0.00%
Subtotal 3	**USD**	**10838.80**	**903.23**	**13.09**	**24.75%**
Total charges		**43797.60**	**3649.80**	**52.90**	**100.00%**
Revenue Sources					
Emptying (Households only)	USD	36630.72	3052.56	44.24	83.64%
Emptying (Other*) Specify each	USD	0.00	0.00	0.00	0.00%
Other uses** of the trucks (specify each)	USD	0.00	0.00	0.00	0.00%
If sold for re-use: Income from sale to buyer	USD	0.00	0.00	0.00	0.00%
Total revenue	**USD**	**36630.72**	**3052.56**	**44.24**	**83.64%**
Profit /Loss					
Revenue before Tax	**USD**	**-7166.88**	**-597.24**	**-8.66**	**-16.36%**
Revenue Tax	USD	0.00	0.00	0.00	0.00%
Profit (loss) after Tax	**USD**	**-7166.88**	**-597.24**	**-8.66**	**-16.36%**

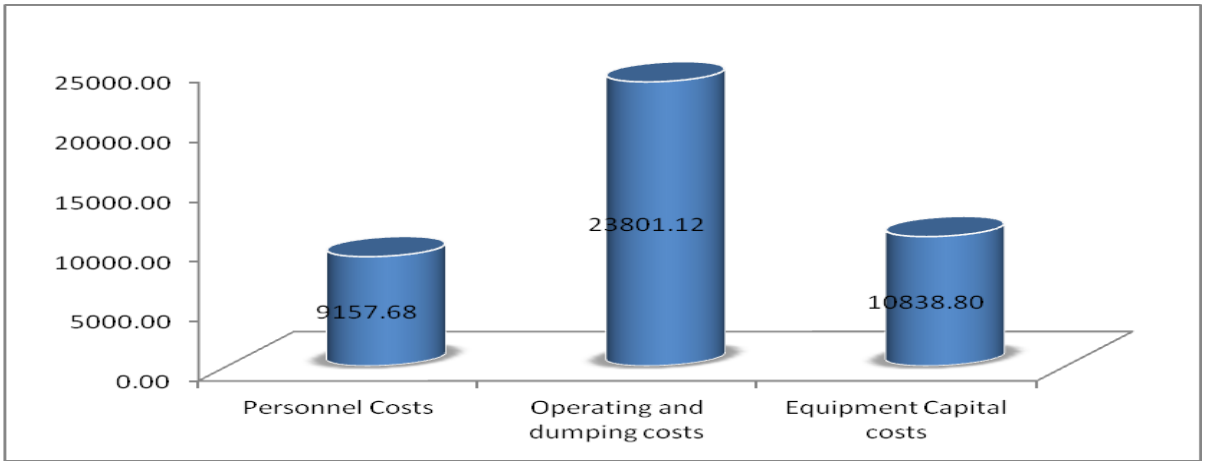


Figure 20: Distribution of annual costs for small enterprise

The main costs for small mechanical desludging companies are related to operating and dumping costs. The average distribution of these costs for small companies is detailed in the figure below. The distribution of operating and dumping costs shows that 62% of costs are related to fuel purchase and 22% to maintenance. Free desludging services, other social works and police harassment represent 8% of costs.

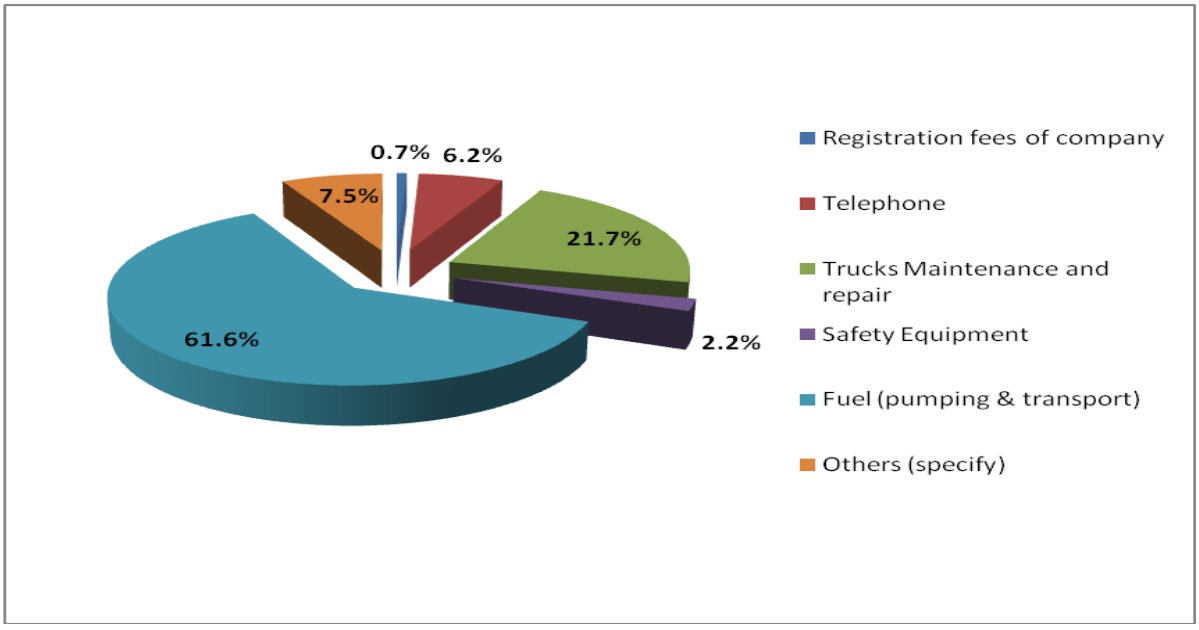


Figure 21: Distribution of operating cost for small enterprise

Table 28: Consolidated income statement for medium-sized companies: 1 company, having 2 trucks and an annual average of 1,440 trips per company.

Item	Units	Annual Amount	Monthly amount	Cost per trip	% Charges
Personnel Costs		**0.00**	**0.00**	**0.00**	**0.00%**
Wages paid:	USD	0.00	0.00	0.00	0.00%
Permanent staff	USD	3981.60	331.80	2.77	6.24%
Daily wage workers	USD	7963.20	663.60	5.53	12.48%
Social Contribution to permanent staff	USD	0.00	0.00	0.00	0.00%
Medical expenses	USD	530.88	44.24	0.37	0.83%

Subtotal 1		**12475.68**	**1039.64**	**8.66**	**19.56%**
Operating and dumping costs					
Registration fees of company	USD	265.44	22.12	0.18	0.42%
Licensing fees for truck	USD	0.00	0.00	0.00	0.00%
Office building rent	USD	0.00	0.00	0.00	0.00%
Telephone	USD	2388.96	199.08	1.66	3.74%
Electricity	USD	0.00	0.00	0.00	0.00%
Water	USD	0.00	0.00	0.00	0.00%
Offices supplies, computer	USD	0.00	0.00	0.00	0.00%
Trucks Maintenance and repair	USD	5839.68	486.64	4.06	9.15%
Safety Equipment	USD	1327.20	110.60	0.92	2.08%
Fuel (pumping & transport)	USD	23889.60	1990.80	16.59	37.45%
Sludge dumping/tipping Fees	USD	0.00	0.00	0.00	0.00%
If sold for re-use: Transportation costs to buyer	USD	0.00	0.00	0.00	0.00%
Others (specify)	USD	2388.96	199.08	1.66	3.74%
Subtotal 2	**USD**	**36099.84**	**3008.32**	**25.07**	**56.59%**
Equipment Capital costs					
Loan Interest paid to Bank	USD	0.00	0.00	0.00	0.00%
Insurance costs for trucks, vehicles	USD	530.88	44.24	0.37	0.83%
If used, costs to refurbish truck (one time- upfront)	USD	0.00	0.00	0.00	0.00%
Truck Depreciation Cost	USD	8848.00	737.33	6.14	13.87%
Tyres annual depreciation Cost	USD	4247.04	353.92	2.95	6.66%
Suction pipes depreciation Cost	USD	1592.64	132.72	1.11	2.50%
Office equipment depreciation costs	USD	0.00	0.00	0.00	0.00%
Vehical rental cost	USD	0.00	0.00	0.00	0.00%
Subtotal 3	**USD**	**15218.56**	**1268.21**	**10.57**	**23.86%**
Total charges		**63794.08**	**5316.17**	**44.30**	**100.00%**
Revenue Sources					
Emptying (Households only)	USD	63705.60	5308.80	44.24	99.86%
Emptying (Other*) Specify each	USD	0.00	0.00	0.00	0.00%
Other uses** of the trucks (specify each)	USD	0.00	0.00	0.00	0.00%
If sold for re-use: Income from sale to buyer	USD	0.00	0.00	0.00	0.00%
Total revenue	**USD**	**63705.60**	**5308.80**	**44.24**	**99.86%**
Profit /Loss					
Revenue before Tax	USD/	-88.48	-7.37	-0.06	-0.14%
Revenue Tax	USD/	0.00	0.00	0.00	0.00%
Profit (loss) after Tax	**USD/Trip**	**-88.48**	**-7.37**	**-0.06**	**-0.14%**

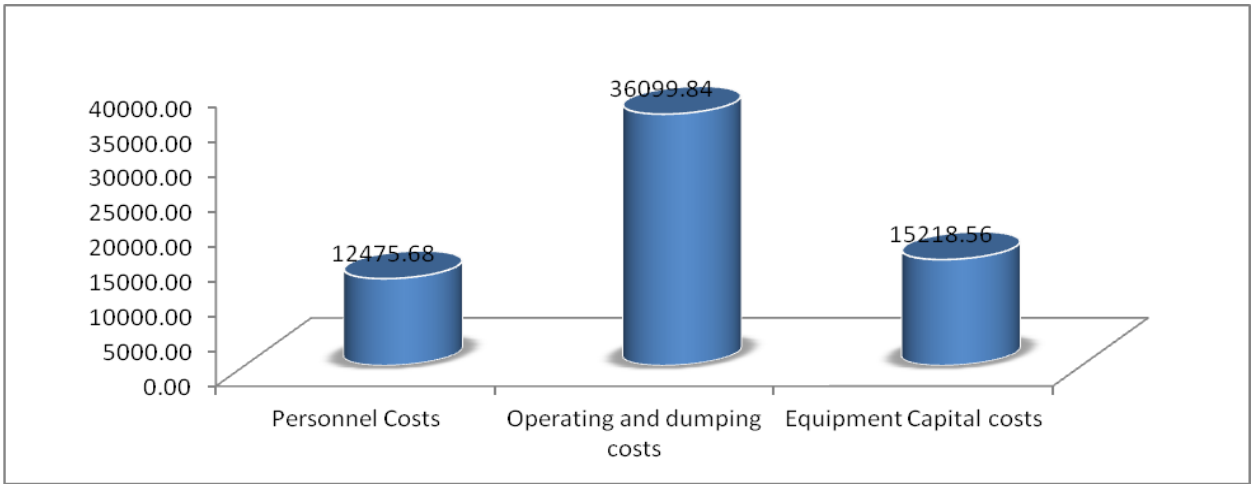


Figure 22: Distribution of annual costs for small enterprise

The main costs for medium mechanical desludging companies are related to operating and dumping costs. The average distribution of these costs for medium-sized companies is detailed in the figure below. The distribution of operating and dumping costs shows that 66.2% of costs are related to fuel purchase and 16.2% to maintenance. Free desludging services, other social works and police harassment represent 6.6% of costs equal to telephone charges.

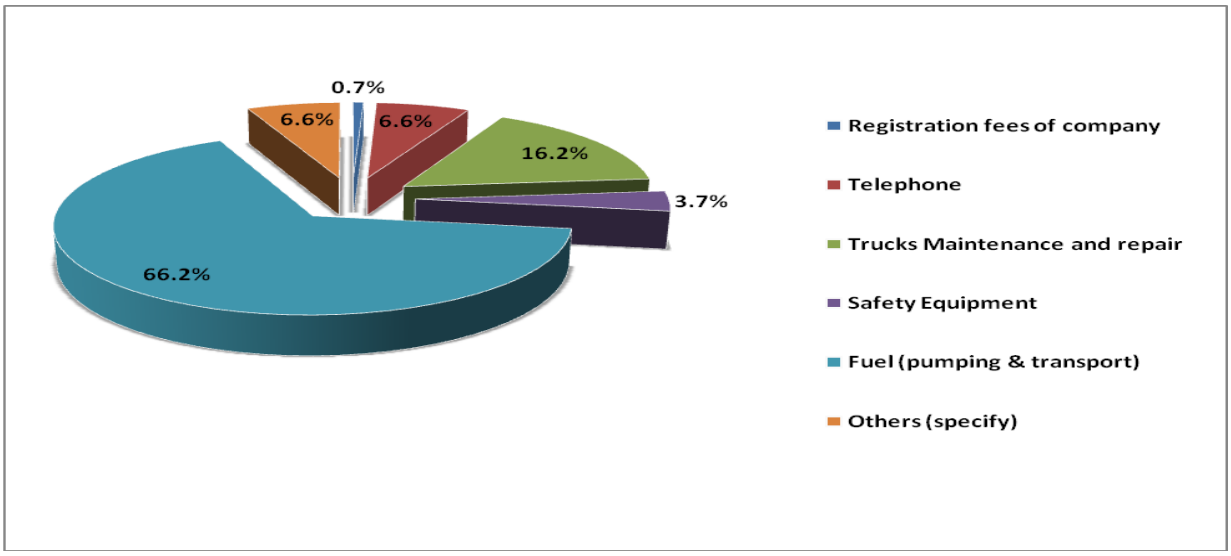


Figure 23: Distribution of operating cost for medium enterprise

The table below summarizes mechanical desludging activities in Thiès.

Table 29: Income statement for mechanical desludging in Thiès

Item Thiès	Units	Small	Medium	Large
Average		1truck of 10m^3 828 trip/year HH emptying only	2 trucks of 10m^3 1,440 HH trip/year (720 trips/truck)	0
Personnel Costs	USD	9,157.68	12,475.68	0
Operating and dumping costs	USD	23,801.12	36,099.84	0
Equipment Capital costs	USD	10,838.80	15,218.56	0
Total Charges	**USD**	**43,797.60**	**63,794.08**	**0**
Revenue Sources				
Emptying (Households only)	USD	36,630.72	63,705.60	0
Emptying (Other*) Specify each	USD	0.00	0.00	0
Total Revenue	**USD**	**36,630.72**	**63,705.60**	**0**
Profit /Loss				
Revenue before Tax	**USD/**	**-7,166.88**	**-88.48**	**0**
Revenue Tax	**USD/**	0.00	**0.00**	**0**
Profit (loss) after Tax	**USD**	**-7,166.88**	**-88.48**	**0**
Break-even point		**-19.56 %**	**- 0.14%**	

There are no large sludge businesses in Thiès. Sludge operators have no activities apart from domestic desludging, which helps to explain that both small and medium sized businesses operate at a loss.

3.4.1.2.2. Breakeven analysis

For the breakeven analysis, we assume a rate of return greater than or equal to 20% of turnover.

$$RoR = \frac{R}{S.}$$

With:

RoR: Rate of Return

R: Result(Profit or loss after Tax)

S: Sales

From which:

$$RoR = \frac{.S - T.C.}{S.}$$

With:

T.C. : Total costs

Therefore:

$$RoR = 1 - \frac{T.C.}{S.}$$

We assume that the revenue from the activity of formal desludging (Sf) is fixed and not dependent on the number of trips (informal activity). The formal activity is cyclical and is not controlled by operators. Only the formal sales is controlled by tax authorities as it is subject to regular pricing verified by invoices. The informal sales correspond to the undeclared revenue from domestic desludging.

This can be expressed in the following equation:

$$RoR = 1 - \frac{T.C.}{S_f + S_i}$$

With:

Sf: Formal sales

Si: Informal sales

$$C.A._i = PxN$$

With:

P: Price of desludging

N: Number of rotations

So:

$$1 - 0.2 = \frac{T.C.}{S_f + PxN}$$

Therefore:

$$N = \frac{T.C. - 0.8xS_f}{0.8xP}$$

$$N = \frac{T.C. - 0.8xS_f}{0.8xP}$$

If we set the average price of desludging as $50 in Dakar and $36 in Touba and Thiès :

$$N = \frac{T.C. - 0.8xS_f}{0.8xP}$$

Numerical Application:

We produced the following results on the number of rotations per year needed for each size of business and in every city to in order for it to be profitable.

The number of rotations required to break even under this hypothesis.

Table 30: Number of rotations

	SMALL	MEDIUM	LARGE
DAKAR	1383/trips/year/1 truck	4539 trips/year/2.6 trucks	10254 trips/year/7.6 trucks
TOUBA	1494 /trips/year/1 truck	3480 trips/year/2 trucks	
THIÈS	1272 /trips/year/1 truck	2212 trips/year/2 trucks	

None of the companies analyzed reached a breakeven point of **20%.**

Small companies: in all 3 cities, the average small company was running at a loss. These deficits were evaluated at - **4.17%** of sales in Dakar, **-19.57%** in Thiès et -**27.61%** in Touba.

Medium-sized companies: in Thiès, this category of company registered a loss of **-0.14%,** profits were only **de 3.14**% and in Dakar and Touba, this was **10.96%**.

Large companies: this type of company is only found in the capital, Dakar, where profit is just 8.20% of sales.

3.4.1.2.3. IRR, NPV, Cash Flow and ROE

- **DAKAR**

Small

NPV @15% discount rate: -313 151
After Tax Equity **IRR - 5 years**: #NOMBRE!
Net cash after taxes **(FCF):-**120 194
Average annual 5 year **ROE**: 59%

Medium

NPV @15% discount rate: -126 065
After Tax Equity **IRR - 5 years**: -4
Net cash after taxes (FCF):-138 387
Average annual 5 year ROE: 43%

Large

NPV @15% discount rate: 4 840 353
After Tax Equity **IRR - 5 years**: #NOMBRE!
Net cash after taxes **(FCF):** 687 126
Average annual 5 year **ROE**: 46%

- **TOUBA**

Small:

NPV @15% discount rate: -665 302

After Tax Equity **IRR - 5 years**: #NOMBRE

Net cash after taxes **(FCF)**: -240 630

Average annual 5 year **ROE**: 69%

Medium

NPV @15% discount rate:-482 416

After Tax Equity IRR - 5 years: #NOMBRE!

Net cash after taxes (FCF):-262 179

Average annual 5 year ROE: 79%

- **THIES**

Small

NPV @15% discount rate: -503 065

After Tax Equity IRR - 5 years: #NOMBRE!

Net cash after taxes (FCF):-197 794

Average annual 5 year ROE: 87%

Medium

NPV @15% discount rate: -739 725

After Tax Equity IRR - 5 years: #NOMBRE!

Net cash after taxes (FCF): -328 491

Average annual 5 year ROE: 62%

3.4.1.3. Sensitivity and risk analysis for*:*

- Trucks: Number, age, capacity

With a fleet of over 150 trucks in Dakar, 30 in Touba and 7 in Thiès, mechanical desludging in Senegal is characterized by the age of its fleet. It is difficult to determine the year of entry into service of trucks. The trucks in service are usually trucks discarded from Europe and are therefore repaired in a makeshift manner to last as long as possible. The average age is at least 30 years. However, none of the operators we met had hitherto scrapped a truck.
The mechanical desludging fleet is mainly composed of 10 m^3 trucks. However, the capacity of trucks varies between 4 and 16 m^3. There are 3 types of sludge truck: vacuum trucks, hydro-excavating trucks and slurry tankers.

Table 31: Dakar companies interview

Company name	Type of the company	Number of trucks	N° Truck	Characteristics of trucks	
				Avg Age of trucks (Year)	Capacity of trucks (m3)
C.A.K.D.F.	Small	01	1	32	10
Moustaph Ndiaye	Small	1	1	23	10
Wa keur S. Fallou	Small	1	1	35	10
Pape Djibril Mbaye	Medium	02	1	30	10
			2	32	10
Pape Cissé	Medium	3	1	26	12
			2	28	10
			3	31	10
Assane Diassé	Medium	3	1	25	8
			2	28	10
			3	30	12
Kane Assainissement	Large	08	1	30	10
			2	30	15
			3	30	11
			4	31	10
			5	31	15
			6	32	8
			7	32	10
			8	32	12
E.G.B.T.P.	Medium	03	1	25	16
			2	25	10
			3	25	10
Cayor vidange	Large	05	1	30	14
			2	30	14
			3	30	10
			4	30	10
			5	30	10
U.P.A.M.A.	Large	10	1	7	10
			2	7	10
			3	8	10
			4	8	10
			5	9	10
			6	10	13
			7	12	13
			8	13	13
			9	15	13
			10	15	16
V.I.C.A.S.	Large	10	1	19	10
			2	26	10
			3	27	10
			4	27	10
			5	27	10
			6	28	14
			7	29	14
			8	30	14
			9	30	15
			10	30	10

Table 32: Touba companies interview

Company name	Type of the company	Number of trucks	N° Truck	Characteristics of trucks	
				Age of trucks (Year)	Capacity of trucks (m3)
Aly Touré	Small	1	1	32	10
Cheikh Ndiaye	Small	1	1	25	8
M Diop	Small	1	1	?	10
Dame Sène	Medium	02	1	30	10
			2	32	10
Dame Dieng	Medium	02	1	20	8
			2	30	10

Table 33: Thiès companies interview

Company name	Type of the company	Number of trucks	N° Truck	Characteristics of trucks	
				Age of trucks (Year)	Capacity of trucks (m3)
Kan Lô	Small	01	1	27	10
Sarr	Small	1	1	29	10
Sylla &Frères	Medium	02	1	32	10
			2	30	8

- Tariffs (fees charged and dumping fees paid)

Mechanical desludging prices vary from one city to the next depending on the standard of living of the neighborhood and the distances traveled etc.
In Dakar, the price of domestic desludging varies between $30 and $100/trip but the average price and the one most frequently applied is $50/trip. Dumping at the FSTP costs $0.60/$m^3$.
In Touba, the price is between $30 and $40/trip. The average price is $34/trip. Dumping is charged at $50/truck/month.
In Thiès mechanical desludging costs between $30 and $45/trip, with the average price being $40/trip. Sludge is dumped directly into the environment and is not paid for.
These amounts are drawn from interviews conducted with desludging operators. However, there is a slight difference compared to the amounts obtained during household surveys. This can be explained by the fact that operators often tend to overestimate the rates for their services when it comes to surveys.

- Operational cost

Operating costs are the main costs for both formal and informal businesses. In all three cities they represent over 50% of total company expenses. Details are outlined in the various Income statements above.

- Maintenance costs

Vehicle maintenance and repair costs are generally very high. This is due to the dilapidated state of the sludge trucks in Dakar, the capital, and in the other two cities studied. The average age of trucks is in excess of 30 years. They are estimated at one seventh of total charges.

Hypotheses:
If we consider the construction of new sludge treatment plants in areas easily accessible to sludge trucks, as well as the replacement of the fleet with new, more fuel-efficient trucks we can envisage a 20% reduction in fuel costs. This could have considerable effects on company balance sheets and on

desludging costs.

Table 34: Dakar profit after decreasing fuel consummation by 20%

Item Dakar	Units	Small	Medium	Large
Average		1 truck of 10m^3 1000 trip/year HH emptying only	2.6 trucks of 10m^3 2970HH trip/year (1113.7 trips/truck)	7.6 truck of 10 m^3 7649.49HH trip/year (1006.5 trips/truck)
Personnel Costs	USD	13,041.95	23,756.88	82,265.16
Operating and dumping costs	USD	**30,976.82**	**129,727.90**	**224,765.74**
Equipment Capital costs	USD	9,887.64	31,679.53	65,997.23
Total Charges	**USD**	**53,906.41**	**185,164.31**	**373028.14**
Revenue Sources				
Emptying (Households only)	USD	55,300.00	175,190.40	399,327.94
Emptying (Other*)	USD	0.00	31,764.32	54,061.28
Total Revenue	**USD**	**55,300.00**	**206,954.72**	**453,389.22**
Profit /Loss				
Revenue before Tax	USD/	1,393.59	21,790.41	80,361.08
Revenue Tax	USD/	0.00	0.00	20,090.27
Profit (loss) after Tax	USD	**1,393.59**	21,790.41	**60,270.81**
Break-even point		**2.52%**	10.52%	**13.29%**

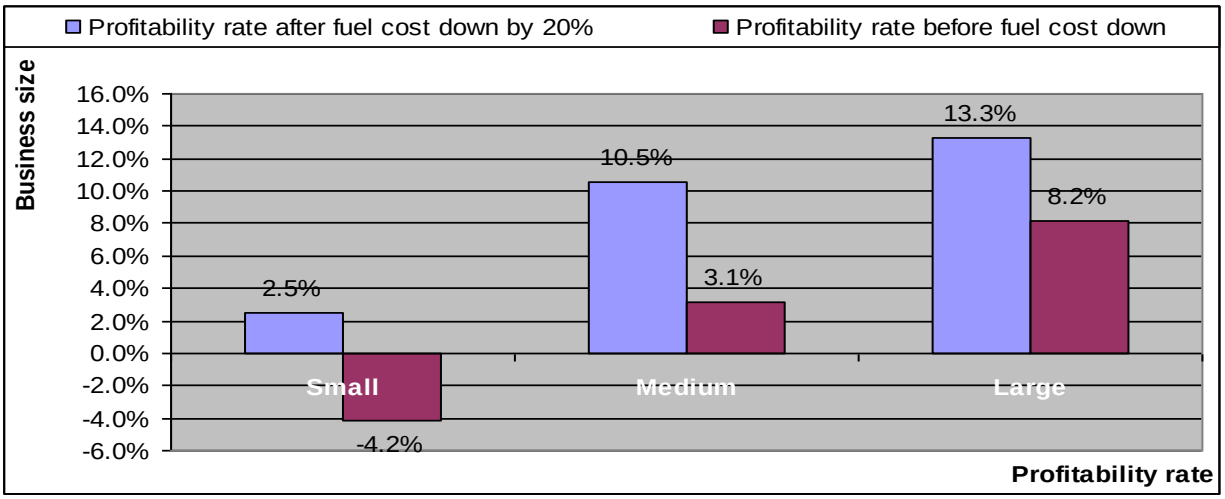


Figure 24: Comparison between profitability after and before fuel cost down

Table 35: Touba profit after decreasing fuel consummation by 20%

Item Touba	Units	Small	Medium	Large
Average		1truck of 10m^3 937 trip/year HH emptying only	2 trucks of 10m^3 2,496 HH trip/year (1248 trips/truck)	0
Personnel Costs	USD	4,556.72	8,706.43	0
Operating and dumping costs	USD	**25,114.90**	**53534.09**	0
Equipment Capital costs	USD	11,440.46	21,111.33	0
Total Charges	**USD**	**41,112.08**	**83,351.85**	**0**
Revenue Sources				
Emptying (Households only)	USD	34,507.20	99,380.736	0
Emptying (Other*) Specify each	USD	737.33	4147.5	0
Total Revenue	**USD**	**35,244.53**	**103,528.236**	**0**
Profit /Loss				
Revenue before Tax	**USD/**	**-5,867.55**	20,176.39	0
Revenue Tax	**USD/**	0.00	0.00	0
Profit (loss) after Tax	**USD**	**-5,867.55**	**20,176.39**	0
Seuil de rentabilité		**-16.65%**	**19.49%**	

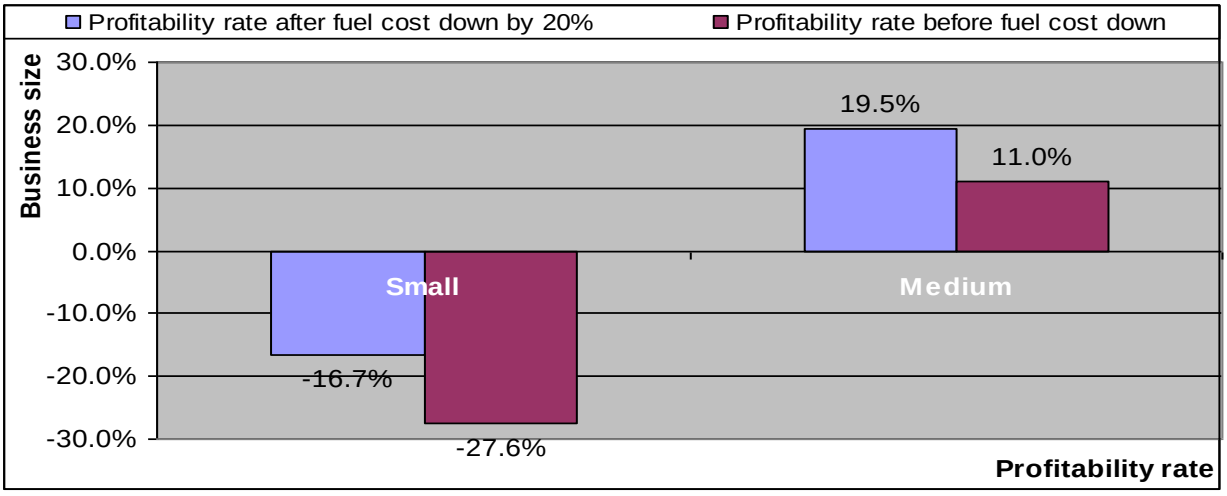


Figure 25: Comparison between profitability after and before fuel cost down

Table 36: Thiès profit after decreasing fuel consummation by 20%

Item Thiès	Units	Small	Medium	Large
Average		1truck of 10m^3 828 trip/year HH emptying only	2 trucks of 10m^3 1,440 HH trip/year (720 trips/truck)	0
Personnel Costs	USD	9,157.68	12,475.68	0
Operating and dumping costs	USD	**20,870.66**	**31,321.92**	0
Equipment Capital costs	USD	10,838.80	15,218.56	0
Total Charges	**USD**	**40867.14**	**59016.16**	**0**
Revenue Sources				
Emptying (Households only)	USD	36,630.72	63,705.60	0
Emptying (Other*) Specify each	USD	0.00	0.00	0
Total Revenue	**USD**	**36,630.72**	**63,705.60**	**0**
Profit /Loss				
Revenue before Tax	**USD/**	**-4236.42**	4689.44	**0**
Revenue Tax	**USD/**	0.00	0.00	**0**
Profit (loss) after Tax	**USD**	**-4236.42**	**4689.44**	**0**
Break-even point		**-11.56 %**	**7.36%**	

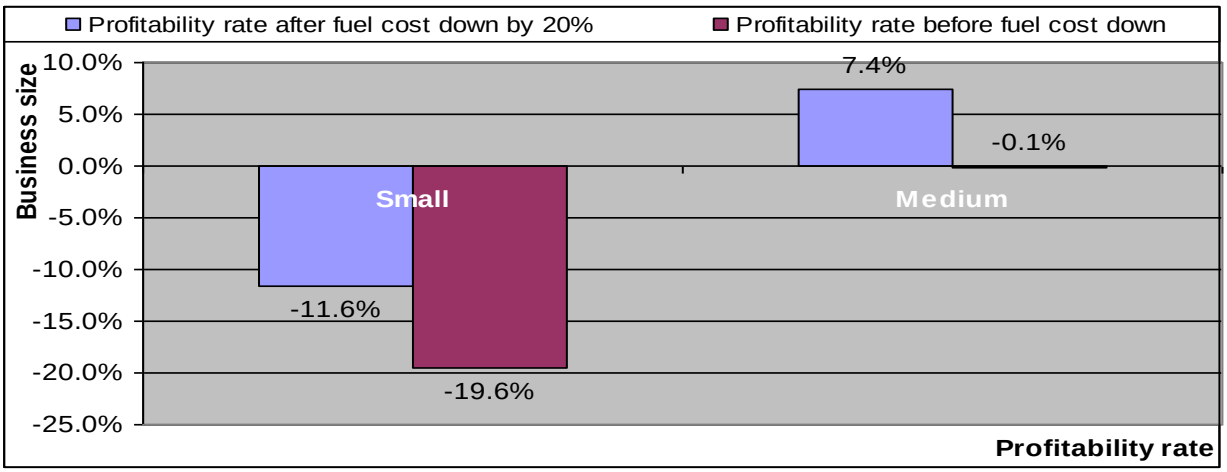


Figure 26: Comparison between profitability after and before fuel cost down

Another hypothesis relates to the reduction of telephone charges. Thus, with better organization of the network could lead to a situation where households subscribe to desludging companies' services and the latter keep records scheduling upcoming activities. Operators would therefore no longer need to

source potential customers by telephone. The impact of a reduction in telephone costs on company balance sheets would certainly be positive.

3.4.1.4. Access to finance

The fecal sludge sector is not particularly courted by financial institutions. The big banks will not offer credit to operators, even if they are solvent. Some bank officials we met confirmed that desludging sector is not targeted by them.
A few commercial banks provide credit to fecal sludge operators, but only under very difficult conditions. The first problem is that the amount of credit offered is very low. For example, these commercial banks only offer loans equivalent to a tenth of the value of their dilapidated trucks, which they offer as collateral. Interest is charged at 10% as well as a 17% tax on the interest rate. In addition, the payment periods are too short, and there is no moratorium to permit the operator to begin to pay off the debt.
All these constraints explain why mechanical sludge operators do not usually seek bank loans.

3.4.1.5. Role of public sector in business sustainability

The primary role of the public sector is the organization and regulation of the sanitation sector in general and the fecal sludge market in particular. Playing the role of regulator, the State pushes sludge companies to formalize their activities through licensing. It also falls on the State to assist the poorest households in ensuring access to sanitation, as well as making desludging rates more flexible.
The construction of dumping sites is also the responsibility of the State. The increased proliferation of dumpers could be a factor in the future reduction in desludging tariffs. In effect, the shorter the distance traveled, the lower the fuel consumption, which could lead to a drop in prices.

3.4.1.6. Business analysis of treatment plants in the three cities

Case of the Cambérène FSTP

- **Investment:**

The construction of the FSTP required an investment of $274,375, including:

- Civil engineering works = $48,894 with a lifespan of 50 years
- Electrical equipment = $9 482 with a lifespan of 10 years
- Electro-mechanical equipment = $204,677.90 with a lifespan of 10 years
- Hydraulic equipment = $7,013.17 with a lifespan of 20 years
- Office furniture and equipment = $4,307.59 with a lifespan of 5 years

- **Depreciation:**

Depreciation is calculated on a linear basis (property acquisition price multiplied by rate).

Depreciation rates are calculated thus: $\frac{100}{\text{Life Duration}}$

- **Operating revenues**

Revenues are derived mainly from dumping taxes. Records obtained at the station for the period January to December 2009 show the following:
Total quantities deposited 94,111 m^3 with a sales revenue of $41634,71 and a daily average of 392 m^3, and a of 10,161 m^3 for the month of July and a minimum of 3,369 m^3 for the month of September. Dried sludge was not sold in 2009.

- **Operating costs**

As well as recording significant revenues, the Cambérène FSTP also incurred huge expenses including:

- **FSTP staff salaries :**

The FSTP consists of a single class of officers, namely service providers who are three in number, including:
An electrical engineer: S/he is responsible for the management of all mechanical operations and ensures the correct operation and maintenance of equipment.
An operator: S/he provides technical assistance in the maintenance of equipment (e.g. cleaning, deblocking of drying bed pipes, stripping of dried sludge). The station does not record any expenses related to the maintenance of equipment as providers are responsible for this.
An executive assistant: S/he manages the commercial activities of the station, e.g. vehicle registration, cash deposits etc.
Security guards: they are responsible for the 24-hour security of staff and equipment. Two (2) teams of five (5) operate : two guards (2) during the day and three (3) at night.
An office cleaner: S/he guarantees the cleanliness of the office.
It is assumed that staff are able to maintain and repair equipment to the point that additional expenses such as the hiring of day laborers is not required.

- **Energy consumption charges:**

The total electricity consumed was 8,945 kWh, amounting to a bill of $3,733.88.

- **Water and telephone consumption charges:**

Water consumption at the dumping site could not be assessed as there is no independent meter at the FSTP. The same applies for the telephone, as there is no line directly assigned to the plant. Water and telephone charges are therefore considered negligible costs.

- **Maintenance :**

This consists of:
Disposal of dried sludge : the transportation of dried sludge cost the plant $1769.60 in 2009.
Cleaning of tanks : the office spent $331.80 per week, amounting to an annual cost of $15,926.40 (331.80 x 4 x 12)

- **Purchase of fuel and furniture :**

In total 250 liters of fuel carburant (diesel) was consumed to operate the generator, at a cost of $317.42 ($1.27 x 250). Office furniture cost 167.43 in 2009.

- **Share of fecal sludge in the operating expenses of the WWTP :**

The pretreated liquid sludge passes into the WWTP, where it is processed. In order to determine the total cost of sludge treatment, we first calculate the total volume of sludge that passes through the WWTP, i.e. the difference between the total volume of sludge deposited at the FSTP and the volume of dried sludge. We then evaluate the total operating expenses of the WWTP, formulating a prorate by multiplying the total volume of sludge passing through the WWTP by the total operating costs and dividing this by the total volume of wastewater received by the WWTP.
Total WWTP operating expenses is $10,689,585.42.
The total volume of wastewater received by the WWTP is 8,176,122 m^3 of which 1,828,524 m^3 was bypassed (i.e. discharged into the sea) and 6,347,598 m^3 of which was treated in the WWTP in 2009.

We will first calculate the volume of bypassed sludge using the formula:

$$\frac{\text{Total volume of untreated water by-passed} \times \text{Total volume of sludge routed in the WWTP}}{\text{Total volume of untreated water received}}$$

The total volume of bypassed sludge is calculated to be **20,788.6 m^3.**
The total volume of treated sludge will therefore be **72 166.2 m^3**
The share of sludge in the WWTP operating costs is **54,941,455 FCFA ($121,530.50)**
Similarly, the share of sludge in the depreciation of WWTP assets is calculated thus:

$$\frac{\text{Total amortization x Volume of sludge treated in the WWTP}}{\text{Total volume of treated wastewater}}$$

Total: 1,186,926.89 FCFA ($2,373.85)

- **Investment :**

The total cost of investment is 28,559,528.03, details of which are presented along with depreciation of assets.

Financial assessment of the Cambérène dumping site

Three (3) scenarios are considered:

- In the first, depreciation is not taken into account;
- In the second, we take account of depreciation but only on FSTP assets;
- In the third, we take sludge into account (i.e. the part that requires the treatment of sludge), into the depreciation of WWTP assets.

- **Determination of dumping price:**

The price is calculated as follows:

$$\text{Dumping price} = \frac{\sum \text{Charges}}{\text{Total volume of dumped sludge en 2009}} = \frac{77\,658\,415}{94\,111}$$

Dumping price = 825.18 F CFA = $1.65

Taking depreciation of FSTP assets into account, we have the following price:

$$\text{Dumping price} = \frac{77\,658\,415 + 10\,628\,290}{94\,111}$$

Dumping price = 938.11 F CFA = $1.88

However, if we take into account assets depreciation for the WWTP we have:

$$\text{Dumping price including depreciation} = \frac{77\,658\,415 + (10\,628\,290 + 15\,288\,397)}{94\,111}$$

Dumping price including depreciation = 1100.6 FCFA = $2.20

These prices do not indicate the real prices which ONAS must implement as they do not permit the recording of profit but only the cost of sludge treated at the FSTP.

- **Projected income statement of the Cambérène FSTP**

All operating cost data is for 2009.
The difference between lower operating revenues and operating costs (including staff charges as well as depreciation) gives the pre-tax profit. However as ONAS is an EPIC *(établissement public à caractère industriel et commercial)* it is exempt from paying tax on profits.
The operating account of the FSTP presented a deficit of $130,145.70, excluding depreciation, in 2009. If depreciation on FSTP assets is taken into account, the deficit would be around $187,473.42 and et $153,655.49 if the share of fecal sludge in the depreciation of WWTP assets is taken into account.
The cost of sludge treatment in the WWTP is very high, encompassing 70.7% of total operating costs of the FSTP.

Table 37: Projected income statement of Cambérène FSTP (in USD)

Designation	2009
Operating revenue	41634.7064
Deposit volume	208.173532
Revenue	41634.7064
Total operating expenses ex. depreciation	171780.414
Staffing expenses	28335.18912
Salaries	9555.84
Security	16586.81472
Cleaner	2192.5344
Operating expenses	21914.7264
Electricity	3733.87812
Water	0
Phone	0
Materials and supplies	167.42628
Fuel group	317.422
Cleaning (150 000 * 4 * 12)	15926.4
Evacuation excavated	1769.6
Sludge from the WWTP	121530.4985
Depreciation	23509.77748
Weight of the mud off investments in the step	33817.93416
With total operating expenses depreciation	100733.1705
Operating profit ex. depreciation	130145.7076
Operating profit with depreciation FSTP	153655.4851
Operating profit with depreciation (FSTP + WWTP)	187473.4192

3.4.1.7. Recommendations for sustainable business models per city

- **DAKAR**

The city of Dakar has the largest number of desludging companies (both formal and informal) and is therefore the site of a competition which one could refer to as the fecal sludge market. In order for a desludging company to be profitable and sustainable in Dakar, operators recommend that it be a large-sized formally operating company, with a fleet of 5 trucks, of which one is a hydro-cleaning truck[4]. The formalization of the company offers the chance to contract with public and private services (for other non-domestic and diversification activities).

Given the size of septic tanks (most commonly used), which are generally between 9 and 10 m^3, trucks with a capacity of at least 10 m^3 are strongly recommended. With a capacity of less than 10 m^3, trucks will be required to make 2 trips in order to empty a septic tank, thus entailing higher fuel consumption costs as well as a loss of time.

The team should consist of:

1 Director

1 Customer salesman

[4] A hydro-cleaning truck is a high-pressure vacuum truck capable of desludging the most compact sludge.

1 Mechanic

1 Secretary

5 Drivers

10 Operators

Let us consider an average fee of US$40 per rotation (US$10 less than the current average fee), a fixed dumping rate of US$0.60/$m^3$, and a complete improvement of the desludging operation. In this case, demand for mechanical desludging will increase, and so permit more than 4 trips per truck per day (the current average). With 7 working days per week, and an average of 5 trips per truck per day (one rotation more than the current average), the company will have 9,000 rotations per year.

This recommendation will only give the predicted outcome if the fecal sludge drainage sector is organized. This assumes that:

- Very dilapidated truck fleets are renewed
- The number of sludge trucks is known
- ONAS has an identification file for all trucks operating in the fecal sludge sector
- An operating license is established and paid for by all desludging companies
- Applications increase for neighborhoods currently not serviced (e.g. Keur Massar, Pikine, Guédiawa, Thiaroye, Ngor, Mbao etc.).
- Funding for the mechanical desludging sector is available from banks and other financial institutions

The implementation of these recommendations can guarantee that companies will break even, allowing a reduction in certain exorbitant charges such as fuel consumption, police harassment (from corruption), and truck maintenance and repair costs. We can therefore expect a reduction in the desludging fees paid by households and an increase in the demand for desludging services.

TOUBA

The city of Touba consists solely of informal desludging companies. The number of desludging trucks in this religious city is lower so we cannot talk of competition or a fecal sludge market in Touba. In order for a desludging company to be profitable and sustainable in Touba, operators recommend that it be a medium-sized company operating 2 sludge trucks, in good condition.

Given the size of septic tanks (most commonly used), which are generally between 9 and 10 m^3, trucks with a capacity of at least 10 m^3 are strongly recommended. With a capacity of less than 10 m^3, trucks will be forced to make 2 trips in order to empty a septic tank, which will entail higher fuel consumption costs as well as a loss of time.

The team should consist of:

1 Manager

1 Mechanic

2 Drivers

4 Operators

Let us consider an average fee of US$30 per rotation (US$10 less than the current average fee), a fixed dumping rate of US$50 per truck per month, and a complete improvement of the desludging operation.

In this case, demand for mechanical desludging services will increase, and so allow 5 trips per truck per day. With 6 working days per week, and an average of 5 trips per truck per day (one rotation more than the current average), the company will have 3,120 rotations per year.

This recommendation will only give the predicted outcome if the fecal sludge drainage sector is organized. This assumes that:

- Very dilapidated truck fleets are renewed
- The rural community association has an identification file for all trucks operating in the fecal sludge sector
- Planning of sanitation infrastructures
- Building and operation of sludge dumping and treatment plants
- Capacity building of the private mechanical desludging operators
- Provision of desludging and transportation services to the urban poor
- Trigger community awareness of sanitation and promote demand for services
- Funding for the mechanical desludging sector is available from banks and other financial institutions

The implementation of these recommendations can guarantee that companies will break even, allowing a reduction in certain exorbitant charges such as fuel consumption (the current dumping site is 14km from the city), truck maintenance and repair costs (vehicle breakdowns will be much less frequent with the renewal of the fleet). We can therefore expect a reduction in the desludging fees paid by households and an increase in the demand for desludging services.

THIES

In Thiès, mechanical desludging activities are less successful than in the other two cities.
The city of Thiès consists solely of informal desludging companies and there is no fecal sludge treatment plant - the dumping site is located in the wilderness. The city is served by 10 sludge trucks. A large proportion of the sludge produced in this city is not collected by the trucks. In order for a desludging company to be profitable and sustainable in Thiès, we recommend small individual companies operating one truck, in good condition.

Given the size of septic tanks (most common used), which are generally between 9 and 10 m^3, trucks with a capacity of at least 10 m^3 are strongly recommended. Indeed, with a capacity of less than 10 m^3, trucks will be forced to make 2 trips in order to empty a septic tank, which will entail higher fuel consumption costs as well as a loss of time.

The team should consist of:

1 Driver-Manager

2 Operators

Let us consider an average fee of US$30 per rotation and a complete improvement of the desludging operation. In this case, demand for mechanical desludging will increase, and so allow 5 trips per truck per day. With 7 working days per week, and an average of 5 trips per truck per day (one rotation more than the current average), the company will have 1,800 rotations per year.

This recommendation will only give the predicted result if the fecal sludge drainage sector is organized.

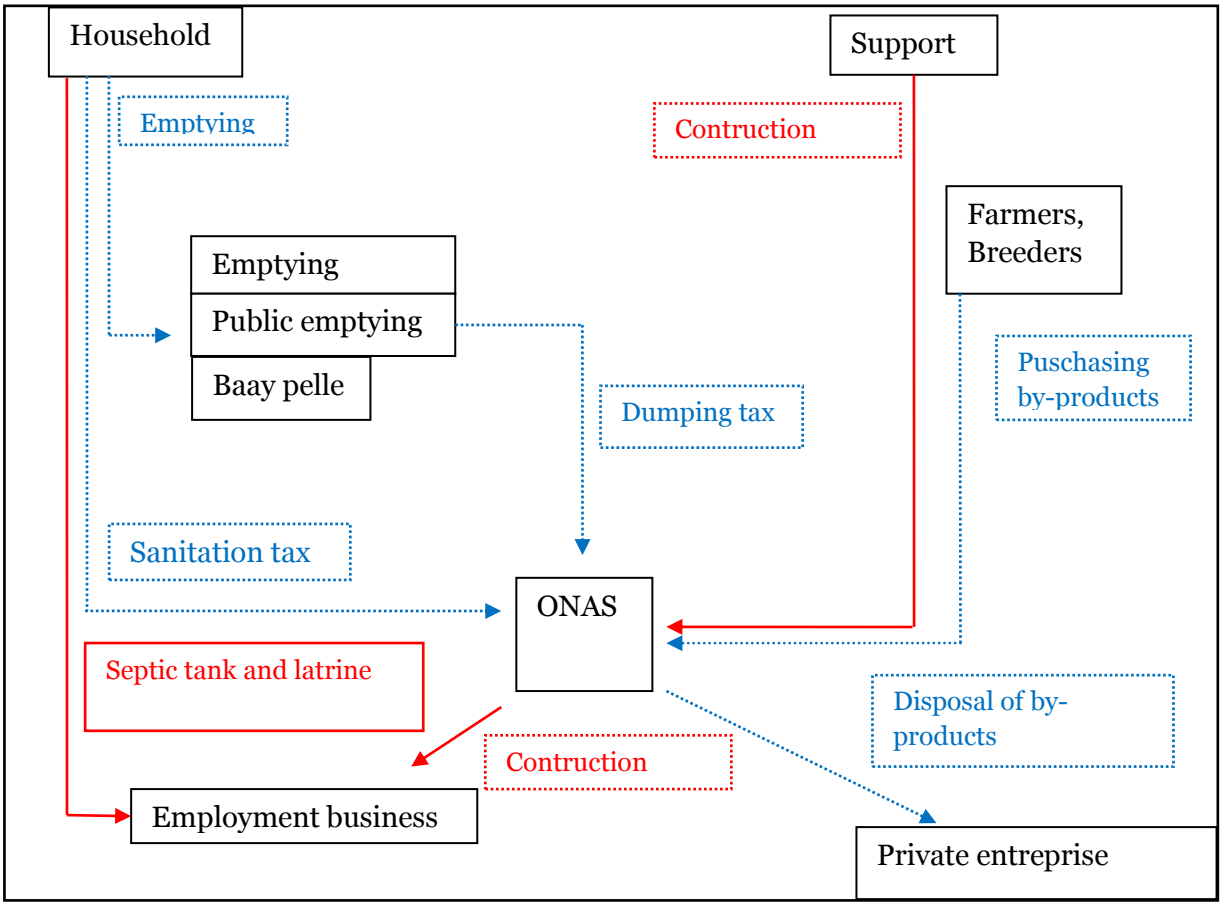
This assumes that:

- Very dilapidated truck fleets are renewed
- The commune has an identification file for all trucks operating in the fecal sludge sector
- Planning of sanitation infrastructures
- Building and operation of sludge dumping and treatment plants
- Capacity building of the private mechanical desludging operators
- Provision of desludging and transportation services to the urban poor
- Trigger community awareness of sanitation and promote demand for services
- Funding for the mechanical desludging sector is available from banks and other financial institutions

The implementation of these recommendations can guarantee that companies will break even, allowing a reduction in certain exorbitant charges such as fuel consumption (with the construction of a sludge treatment plant in the city) and truck maintenance and repair costs (vehicle breakdowns will be much less frequent with the renewal of the fleet). We can therefore expect a reduction in the desludging fees paid by households and an increase in the demand for desludging services with new customers willing to pay for such services.

3.4.2.Country level (across cities)

Figure 27: Monetary interactions between fecal sludge management stakeholders



3.4.2.1. Difference in parameters across the three cities

Similar to the national level, the research results show that for the three cities examined, the amount of sludge produced is great than the amount collected. Alongside this general observation, there is a set of parameters which differs according to each city. (See table below on the various parameters, by city).

Table 388: Difference in parameters across Dakar, Thiès and Touba

	Dakar	Thiès	Touba
HH INCOME/MONTH			
Avge income (USD/HH/month)	$541	$302	$280
DESLUDGING COST			
Current price of desludging trip	$55.30	$36	$36
Avge annual manual desludging cost/HH	$60.30	$40,9	$38.84
Avge mechanical desludging cost/HH	$116.7	$114,40	$68.88

With average monthly incomes varying between US$541 in Dakar, US$302 in Thiès and US$280 in Touba, the households surveyed empty their septic tanks on average 2.5 times per year. The unit rates and annual sludge amounts are detailed in the table above.

Table 39: The unit rates and annual sludge amounts details

	Dakar	Thiès	Touba
MECHANICAL DESLUDGING BUSINESS INFORMATION			
Number of private mechanical businesses	avg50	avg5	avg12
Number of trucks run by private businesses	avg 150	avg 7	avg 30
What is the official dumping site for city?	FSTP	Nothing	Official open land
What is the m3 capacity / treatment facility?	1of 150 m3, 2 of 60 m3	No treatment facility	No treatment facility
What are the dumping fees?	0.6$/m3	0	50$/ month
Is this payment per trip, per month or m3?	per trip	0	per month
Avge number of trips per day	4	2	3

Other, equally important, parameters of mechanical desludging are taken into account in our analysis. The average number of sludge companies is 50 in Dakar, 12 in Touba and 5in Thiès, and the truck fleet is estimated to be 150 in Dakar, 30 in Touba and 7 in Thiès. The average number of trips taken by each truck is 4 in Dakar, 3 in Touba and 2 in Thiès. The table above summarizes the information on mechanical desludging.

The household survey enabled us to get information on the frequency and method of desludging. The two parameters summarized in the following table vary considerably from one city to another.

Table 40: HH survey data: emptying frequency/method

	Dakar	Thiès	Touba
Desludging frequency			
% HH that have desludged at least once	**64%**	**67%**	**78%**
% Never desludged	**36%**	**33%**	**22%**
More than 3 times /year	16%	2%	4%
2-3 times / year	41%	11%	28%
Once per year	31%	19%	44%
Once every 2 years	8%	21%	9%
Once every 3 years	1%	3%	0.30%
Once every 4 years	1%	6%	0.30%
Once every 5 years		5%	0.80%
Once every 6-9 years		1%	
Once every 10 years	1%	1%	
Once every 10-15 years		2%	
Nsp		29%	12%
DESLUDGING METHOD			
% HH that use manual desludging	47%	34%	6
% HH that use mechanical desludging	43%	52%	87%
% HH that use both	**9%**	**13%**	**7**
Other (electric pump)	1%	1%	

3.4.2.2. Recommendations for sustainable business models across the common parameters

Currently, the fecal sludge sector is mostly informal, with only a few companies in Dakar operating on a formal basis. In the cities of Thiès and Touba, all desludging companies are completely informal. The main consequence of this phenomenon is that the desludging companies are exposed to police harassment, which engenders significant financial costs. In Dakar, a sludge truck pays corrupt police on average US$2 per trip. This practice is less common in the city of Thiès and nonexistent in Touba (a religious city with a special status).

It is possible to eliminate these costs through the organization of the sector and the formalization of desludging companies. First of all, we recommend the acquisition of new, weatherproof trucks, which comply with Senegalese environmental standards. We also suggest the identification of sludge trucks by a common color, as is the case with taxis.

Certain costs such as fuel (pumping and transportation), telephone, personnel costs, and truck maintenance and repair vary in the same way. These items are detailed in the three tables below.

Table 41: Percentage of certain expenses in relation to the overall expenses of desludging companies in Dakar

Item Dakar	Small	Medium	Large
Fuel (pumping & transportation)	32%	38%	38%
Telephone	2%	2%	3%
Personnel costs	23%	13%	19%
Truck maintenance and repair	4%	5%	6%

In Dakar, truck maintenance and repair costs are low, given the advanced age of the vehicles (on average 30 years old), explained by the fact that in this city, companies often have a mechanic on their team. Some desludging companies even have their own mechanical workshop. Thus, one part of this item is included among personnel costs, which is not the case in Thiès and Touba.

Table 42: Percentage of certain expenses in relation to the overall expenses of desludging companies in Touba

Item Touba	Small	Medium
Fuel (pumping & transportation)	42.96%	47.58%
Telephone	2.56%	1.50%
Personnel costs	10.13%	9.63%
Truck maintenance and repair	12.73%	8.45%

In Touba, personnel costs are low compared to the two other cities, due to lower labor costs, as Touba is a much more rural place than either Thiès or Dakar, the capitals of their respective regions.

Table 43: Percentage of certain expenses in relation to the overall expenses of desludging companies in Thiès

Item Thiès	Small	Medium
Fuel (pumping & transportation)	33.45%	37.45%
Telephone	3.39%	3.74%
Personnel costs	20.91%	19.56%
Truck maintenance and repair	11.82%	9.15%

In Thiès, as in the other cities, fuel consumption constitutes the most significant part of overall expenses. Fuel (pumping and transportation) is the most important factor affecting the profits of desludging companies. Even a small reduction in fuel charges would positively impact on company profits.

To encourage the development of mechanical desludging activities, we strongly recommend reducing

fuel charges. The following steps are necessary in order to achieve this:

- Increase the number of fecal sludge treatment sites in inner city Dakar in order to reduce the distance between residential areas and dumping sites
- Construct fecal sludge treatment plants in the cities of Thiès and Touba in order to avoid long journeys for operators to dumping sites in the wilderness

Regarding the high maintenance costs of trucks, we recommend the renewal of the vehicle fleet, as well as the establishment of a spare parts store. In this way, truck maintenance costs could be drastically reduced.

In addition to building treatment plants and the renewal of the vehicle fleet in order to reduce fuel and maintenance charges, we strongly recommend that financial institutions support the mechanical desludging sector. Indeed, in all three cities studied, operators sought support from donors, the State and financial institutions in order to qualify for loans with longer repayment periods (normally 60 months for bank loans), which would allow them to renew their truck fleet. In order achieve do this, the operators suggest the awarding of grants, which they could use as bank loan guarantees.

The implementation of all these recommendations will allow operators to offer lower desludging fees, making the service more accessible to households and growing the demand for mechanical desludging services, thus guaranteeing increased profitability for mechanical desludging companies.

Mechanical desludging companies, despite their significant number, cover only a portion of sludge production, so the market can certainly accommodate further businesses. However, financial investment approaches are still hazy, because of fear of the tax authorities and the taboo surrounding money in Senegal.

• Despite their efforts to compensate for the effects of illegal dumping, the management of the three dumping stations in Dakar needs to be improved.

• Illicit dumping into the environment remains a relatively common practice, especially in areas where there is no treatment plant, even if this practice is illegal. Agricultural recycling practices also exist, although the re-use of untreated sludge is also prohibited.

• To counter illicit dumping, it is necessary to increase and decentralize the number of dumping sites in relation to sludge operators, taking into account the constraints they face (proximity to customers, access times etc.)

• To improve the operation of mechanical desludging (especially in terms of its environmental impact), it is necessary to formalize relations between operators, ONAS and the local communities.

• The high cost of trucks and spare parts is a major cause of the dilapidation of the fleet and the source of significant maintenance and repair costs. It is therefore necessary that banks assist the desludging companies by offering finance on flexible terms.

• The formalization of the mechanical desludging sector, the introduction of operating licenses and the capacity-building of the technical and administrative personnel are recommended for the increased sustainability of the desludging business.

3.5. Details and recommendation of at least one business ready for investment and growth

3.5.1. Current service levels

For the establishment of a company mechanical emptying, consider a medium business in Touba with 2

trucks of 10 m3 capacity. The staff consists of a manager, an engineer, two driver and four laborers.. Given state that the market is not saturated, consider that the trucks made an average of 5 per day rotation each. The total annual average of rotations would be 3 120. The tariff of emptying is $ 36. The trucks work six days a week from 8 am to 8 pm.

3.5.2. Current profitability

The current profitability of this mechanical emptying company would be:

$$\text{Re} = \frac{R}{CA.} \qquad \text{Re} = \frac{24\,282}{116\ \ 468} \qquad \text{Re} = 20.84\,\%$$

3.5.3. Projected profitability in 3-5 years

Table 44: Projection of profitability

	Unit % / cost	Units	Year 1	Year 2	Year 3	Year 4	Year 5
Inflation index	1.2%	USD	1	1.01	1.02	1.04	1.05
Net profit		USD	92 910	101 730	111 140	121 211	132 025
Taxation	25%	USD	- 23 228	- 25 432	- 27 785	- 30 303	- 33 006
EAITDA		USD	**69 683**	**76 297**	**83 355**	**90 909**	**99 019**
Net cash after taxes (FCF)			**34 898**	**93 101**	**95 187**	**97 139**	**98 937**
Projected profitability		USD	31.02%	33.56%	36.23%	39.05%	42.03%

3.5.4. Investment required

The investment required for this project is 280 000$. It' is just the emptying truck price.

Table 45: Investment required

	Units	Year 1
Investment Cash flow	$	
Cost of the 2 vehicles	$	280 000
Net investment cash flow	$	280 000

3.5.5. Risk analysis

Internal risks: Control of all truck travel is almost impossible, and vehicle teams may not report certain informal activities, which could eventually weaken the desludging company.

External risks: In legal terms, there are no liabilities or restrictions expected to affect the fecal sludge market. Organizing the sector with new rules that does not take into account the costs borne by

companies could weaken these businesses.

Security: In light of company expansion, it is necessary to strengthen management. Meanwhile, market consolidation should be quickly achieved in order to prevent or complicate the entry of other competitors.

The nature of the desludging activity exposes operators to pollution and potential accidents. This could impede the progress of the company's business.

4. CONCLUSION

Fecal sludge management takes into account the discharge, treatment and re-use or disposal of effluent and solids (bio-solids). For now, the informal sector constitutes the entire chain apart from the treatment of sludge. This treatment, however, is the only way to remove health and environmental hazards (by eliminating pathogens, concentrating sludge in an impermeable location and the discharge of treated effluent). The re-use of biosolids can be made possible through the production of a compost which is no longer a danger to public health.

On conclusion of this study, we find that the sludge management sector is characterized by the involvement of several actors: the State (through ONAS and its bodies); private operators (sludge management business chiefs and manual and mechanical desludging operators); NGOs; research institutes; and the public. However, even if it is easy to identify the industry stakeholders, the fact remains that it is a disorganized sector.

The evolution and ongoing experience of fecal sludge management in Senegal are largely the result of work by NGOs such as ENDA and CREPA. These organizations support the population through training sessions, and awareness-raising activities. Even more importantly, they finance private and/or community initiatives for the management of fecal sludge.

Local populations are the core of the fecal sludge management system. Indeed they are the primarily producers of sludge, ensure its storage and pay for its disposal. Thus this category of stakeholder deserves to be taken into account. Despite this centrality, it is the people who suffer the high costs of desludging. 26 % of household heads surveyed chose manual desludging as they could not afford to use mechanical desludging services. Hence the need for a harmonized pricing and concerted pricing system for all stakeholders, but especially for the local populations.

The results obtained in Senegal in relation to fecal sludge management are tangible, but in order to attain the MDGs in terms of sanitation, certain recommendations should be implemented so as to strengthen these achievements.

BIBLIOGRAPHY

1. **Abdoul Aziz Ndiaye, (2007):** Characterization of fecal sludge and performance of the Cambérène dumping site, thesis.
2. **CREPA-Sénégal, (2001-2004):** Community management of fecal sludge of the commune of Sahm-Notaire, city of Guédiawaye, Dakar region. Programme de Recherche Report du Projet de démonstration (PROGEBOUE), report.
3. **CREPA-Senegal, (2002):** Fecal Sludge Management Project (PROGEBOUE/Assessment), Research Program 2001-2004, study report.
4. **CREPA-CI, (2002):** Strategy of fecal sludge management of septic tanks and latrines in a city of more than 500,000 inhabitants, case of the city of Bouake in Côte d'Ivoire, study report.
5. **CREPA-Mali, (2007):** Improvement of fecal sludge management by the strengthening of the local private sector, survey report.
6. **CREPA-Sénégal, (2004):** Commune of Sahm-Notaire, Fecal Sludge Management in sub-Saharan African cities (PROGEBOUE), Protocol agreement for the community management of fecal sludge.
7. **Djinodji Ndorem Florentin, (2007):** Study on technologies for the manual collection and transportation of fecal sludge, thesis.
8. **Doulaye Koné, Martin Strauss and Darren Seywell, (2007):** Report on the first symposium/ international workshop on fecal sludge management policy. Dakar, Senegal, May 9-12, 2006 "Towards a Better Management of Fecal Sludge" September 2007, report.
9. **EDE, (2007) :** "Reference document for the management of fecal sludge treatment plants in the peri-urban neighborhoods of Dakar, Senegal", report.
10. **Elhadji Serigne Tacko Diongue, (2006):** Optimization strategies for the fecal sludge latrine sector in Dakar, thesis.
11. **Florian Klingel, Agnès Montangero, Doulaye Koné and Martin Strauss, (2002):** "Fecal sludge management in developing countries", planning manual, first edition.
12. **Halidou Koanda, (2006):** Towards a sustainable urban sanitation in sub-Saharan Africa: an innovative approach to fecal sludge management planning, thesis.
13. **H2O Engineering, (2006)** "Sanitation strategy for the city of Guédiawaye, feasibility study for the town of Sahm Notaire", study report.
14. **Info-CREPA, (1998):** Funding for sanitation in rural Burkina Faso. CREPA quarterly n° 20, April-May-June.
15. **Info-CREPA, (2001):** "Dossier: Fecal sludge management, options, strategies and techniques in West Africa". CREPA quarterly n° 32, April-May-June.
16. **Jacques Nefussi, (2006):** "Introduction to financial analysis", textbook, page 24.
17. **Jean Birane Gning (2009):** Socio-economic assessment of the fecal sludge sector in Dakar (Senegal), thesis.
18. **Kassa Mvouvou Félicien, (2004):** Assessment of the community management of fecal sludge in the commune of Sahm Notaire, thesis.
19. **M. Steiner, A. Montangero, D. Koné, M. Strauss, (2004):** "An innovative concept for the financial sustainability of fecal sludge: analysis of financial flow options", research document.
20. **P. Blunier, (2004):** "Mechanized collection and transportation of fecal sludge in the city of Ouahigouya (Burkina Faso). Market analysis and proposal for the reorganization of financial flows", dissertation.
21. **PAQPUD, (2006):** On-site sanitation: a response to massive expansion policies related to sanitation, journal N° 1, April 2006.
22. **PAQPUD, (2007):** The semi-collective: a major innovation for urban sanitation, journal N°2 May 2007.
23. **Ministry of the Environment of Senegal, (2001):** Environment code, 2001.

24. **Republic of Senegal, Ministry of Agriculture and Hydraulics, Department of Hydraulics (2004):** "Strategy document for the realization of the Millennium Development Goals by 2015" Long-term Water Project, Senegal, December 2004, Volume 1, Assessment, Definitive Report.
25. **Republic of Senegal, (2003):** Compilation of texts on decentralization. Ministry of the Interior and Local Authorities, Department of Local Authorities.
26. **Sven Bolomey, (2003):** "Improvement of fecal sludge management through the strengthening of the local private sector: Case of the 6th Commune of the District of Bamako", research report.
27. **Sylvia Winkler, (2005):** "The experience of CREPA in the promotion of on-site sanitation in West Africa: current situation, analysis and perspectives", research thesis.
28. **Tchonda Tetouehaki, (2006):** Analysis of the mechanical desludging market in medium-sized cities and the conditions for the success of the private sector: Case study of Sokode in Togo, Master's thesis.
29. **Vidange Curage Assainissement de Sahel, (2006):** Standardized financial statements of West African accounting systems, year end 12/31/2010.

APPENDICES

APPENDIX 1: Proposal for sampling method

APPENDIX 2: Methodology for creation of wealth index

APPENDIX 3: Socio-economic report on the city of Dakar

APPENDIX 4: Socio-economic report on the city of Thiès

APPENDIX 5: Socio-economic report on the city of Touba

APPENDIX 6: Definition of existing sanitation technologies

APPENDIX 7: Role of institutional and organizational stakeholders

APPENDIX 8: Income statements and detailed financial calculations

APPENDIX 9: Production of sludge

APPENDIX 10: Financial Model of FSTP

APPENDIX 11: Cash Flows