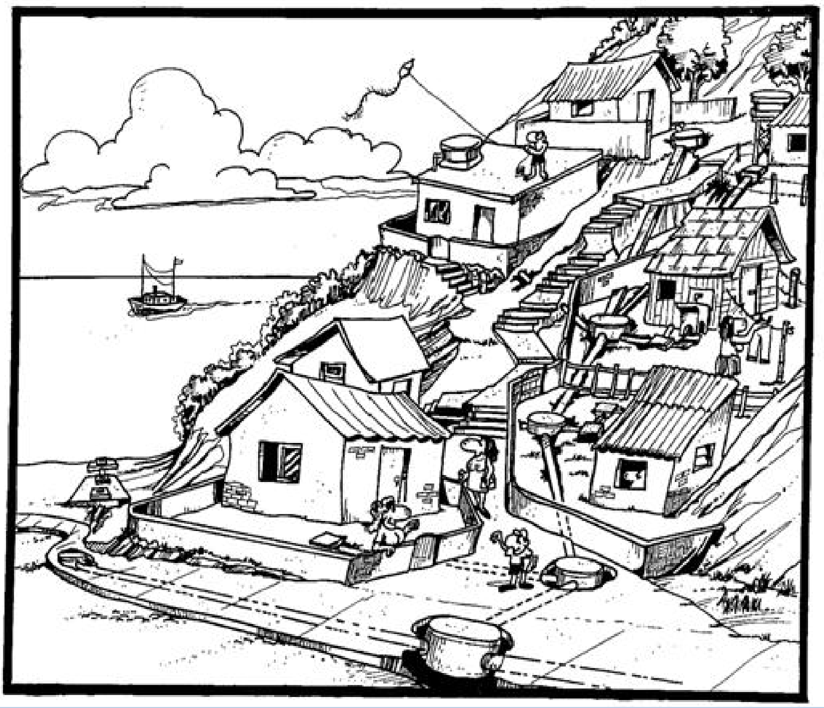
Choosing and implementing **non-conventional sewers** for the provision of sanitation services



Analysis Report

Working Document

AGENCE FRANÇAISE DE DÉVELOPPEMENT

eau seine Normandie – Agence de l'eau

SYNDICAT INTERDÉPARTEMENTAL POUR L'ASSAINISSEMENT DE L'AGGLOMÉRATION PARISIENNE – SIAAP

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We would also like to extend our thanks to those international experts who have kindly taken the time to respond to our questions, send us information and even, on occasion, review our reports.

Foreword

The findings and conclusions contained in this report and the country studies are those of the authors and do not necessarily represent the views of partners or the people interviewed.

Studying a topic as broad and complex as non-conventional sewers in just a few months is not without difficulty and a number of issues were encountered:

- **this has proven to be an extremely vast topic that includes a wide range of experiences covering a large geographical area and timeline, the outlines of which are thus not easy to define;**
- **there is a huge amount of information available, making summarizing this a complex task;**
- **due to the format of the field studies, it was not possible to examine each case in depth in the space of a few days;**
- **despite best efforts during the data collection phase, the figures available are often only partial, incorrect or out-of-date (particularly with regard to costs).**

This document is designed to be regularly updated and evolve over time. To assist with this process, please send any feedback or suggestions for improvement to the following address: ily@pseau.org

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Introduction

I. Review of urban sanitation, as understood in this report

What is sanitation?

Sanitation, as considered in this report, refers to the **management of wastewater, specifically:**

- greywater, which is the water used for washing up, handwashing, baths and showers;
- blackwater, which is wastewater that contains fecal matter and urine.

A global issue…

The lack of sanitation and hygiene has a significant impact on public health in developing countries with diarrheal diseases killing 2.5 million people each year, 1.5 million of whom are children under the age of five.

Whereas open defecation and unhygienic practices are demeaning and degrading, providing people with access to adequate sanitation enables them to rebuild their self-esteem and gain the esteem of their neighbors. Having access to sanitation facilities means women no longer have to find a place to hide to urinate or defecate; they thus feel safer and recover their right to privacy and dignity. Installing equipment to evacuate excreta also helps improve neighborly relations, which can sometimes be soured by bad smells.

A population in good health can increase a country's productivity and contribute to economic growth. Thus, according to UNDP, every dollar invested in sanitation generates an average return of eight dollars in costs averted and productivity gained.

Lastly, properly-designed sanitation facilities help protect the water resources (surface water and groundwater) used to supply people with drinking water and thus reduce the water production cost; they also prevent the pollution of natural resources, ecosystems and the soil.

One chain, three segments

Wastewater management, as understood in this report, involves a chain of actions and stakeholders that can be broken down into three segments, each with its own particular challenges that require tailored solutions:

- **the access segment,** which includes the facilities used for the collection of greywater and blackwater;
- **the evacuation segment** which involves the evacuation of wastewater;
- **the treatment segment** which covers the treatment and utilization of effluent (with the treated liquid waste used for irrigation and the treated solid waste - and the nutrients this contains – used as crop fertilizer).

Although the main focus of this report is the 'evacuation' segment, the sanitation services provided via the non-conventional sewer will thus be studied as entire sanitation chains composed of these three segments.

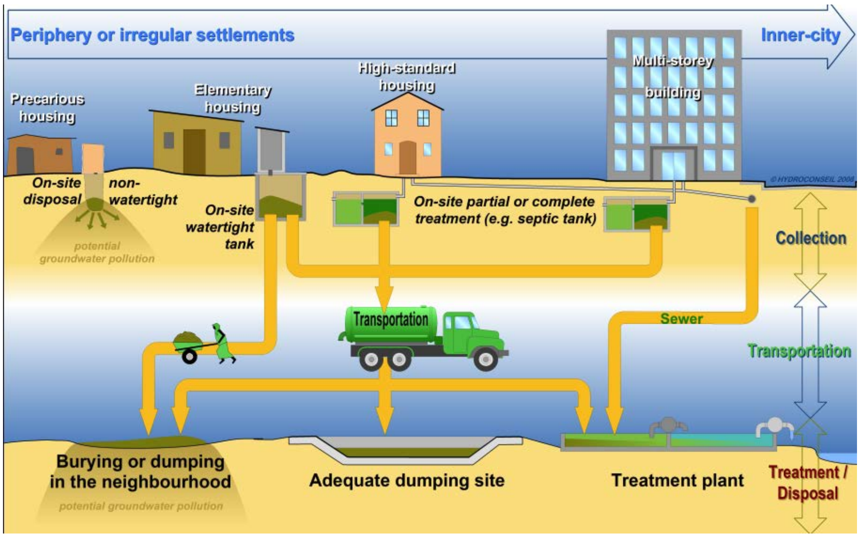


Figure 1: Diagram of the sanitation chain (source: Hydroconseil)

II. Why a study on non-conventional sewers?

A technical option under development … and under discussion

The non-conventional sewer is a **solution that has been implemented across the world over the last few decades, using diverse technological options and management methods and in a wide range of contexts and on different scales**: from rural towns in India or Egypt to built-up neighborhoods in Pakistan or Brazil, where these networks can cover several hundreds of thousands of inhabitants.

A large number of examples can also be found in sub-Saharan Africa and this solution is attracting **growing interest** from both sanitation stakeholders across Africa and their cooperation partners.

However, **the implementing conditions** required to ensure these non-conventional sewers are effective remain open to debate, as do their **real comparative advantages** over other sanitation solutions.

Although there is a wealth of literature and case studies on this topic, there is as yet no **synthesis of the solution's technical, financial, social and management aspects** available to decision-makers or field practitioners, and no **methodological support tool** for local contracting authorities.

Study objectives

The aim of the study is to provide responses to the following three questions:

- *What exactly are the **strengths and weaknesses** of non-conventional sewer systems from a technical, financial and management perspective? What have been the **factors of success – or failure – of the different non-conventional sewer systems** implemented across the globe? **In which contexts** is this solution appropriate?*
- *What recommendations for **designing, implementing and operating** these systems in African countries can be made?*
- *Is it appropriate to advocate this solution to national and local decision-makers in Africa and their development partners, and what obstacles need to be overcome to do this?*

This information will feed into the following main deliverables:

- **Five case study reports;**
- **An evidence-based study report in which all the results obtained from the case studies will be consolidated and analyzed;**
- **ujA reference guide to assist local contracting authorities and their partners.**

III. How was the study carried out?

A synthesis of existing knowledge…

A call for evidence was issued in May 2012 to a group of **2,000 qualified contacts** from around the globe (with a response rate of around 10%).

It became apparent during this initial stage that, although there was a wealth of literature available, **there was no synthesis** that covered the topic of 'alternative sewer systems in developing countries' as a whole.

Following a period of in-depth consultation and investigation, pS-Eau identified and reviewed around **500 relevant publications**. 50 of these were then selected to be studied in greater detail.

Following this literature review and consultation with international experts, an initial summary was produced that enabled us to:

- better define the purpose of the research;
- create an initial map of 'non-conventional sewers' around the world;
- establish a detailed analysis matrix for the case studies;
- select the case studies *(see the following paragraph).*

A cross-analysis of the case studies

Case study selection criteria

In agreement with the study partners and experts consulted, the following case study selection criteria were established:

- diversity of geographical contexts;
- length of time in operation (to assess sustainability);
- diversity of management methods;
- 'scale-up';
- amount of information available upfront;
- diversity of technological options: settled/simplified, decentralized/connected to conventional sewerage, etc.
- level of innovation.

In-depth case studies in six countries on three continents

In-depth case studies were undertaken in:

- India;
- Senegal;
- Ghana;
- Mali;
- Brazil.

Following pS-Eau's visits to India and Vietnam, and using information provided by Borda, GRET and their partners, a working paper was also produced on the use of DEWATS in Asia.

Also see the case study reports in the Annex.

'Second level' case studies

In addition to these field studies, desk studies of other initiatives liable to provide useful information were also carried out. These initiatives included:

- the Orangi Pilot Project in Karachi, Pakistan;

- El Alto, on the outskirts of La Paz in Bolivia;
- the septic tank effluent disposal (STED) schemes (settled sewers) in Australia;
- the few examples of settled sewers found in the United States and Canada;
- the El-Moufty El-Kobra settled sewerage project in Kafr El-Sheikh, Egypt;
- the settled sewerage pilot project in the township of eThekwini in Durban, South Africa, as well as other South African initiatives.

A study that relies on the expertise of network members

Interviews with international experts

pS-Eau conducted around **thirty semi-structured interviews with international sector experts** *(the full list is available in the Annex).* This phase provided a wealth of potential avenues for research and all those involved expressed a keen interest in learning the outcomes of the study.

A Study Monitoring Committee composed of experts from France

A Study Monitoring Committee has met three times in Paris to compare the outcomes of the different study phases from a French expert perspective *(the list of committee members is provided in the Annex).*

International consultants

The investigative and case study analysis activities were carried out by international experts, all members of the pS-Eau network:

- in India: Asit Nema, Foundation for Greentech Environmental System;
- in Ghana: Lukman Y. Salifu, WasteCare Associates;
- in Brazil: Antonio Miranda da Costa Neto, independent consultant;
- in Mali: Youssouf Cissé and Assétou Sokona, Pan-African Inter-Governmental Agency, Water and Sanitation for Africa (WSA).

IV. The aim of this report

The aim of this report is to address the questions that guided this study and produce a synthesis of the literature reviews, field research and consultations.

Although some recommendations may emerge, this report is not intended as an ‘operational’ tool.

A methodological guide is to be developed during the next phase of the study to assist contracting authorities in developing countries and their partners to meet this need for a ‘turnkey’ solution.

Part 1.
What is a ‘non-conventional sewer’?

I. Different terminology…

In the guide '*How to select appropriate technical solutions for sanitation*', pS-Eau and its partners identified two different categories of 'non-conventional sewer':

- 'simplified' sewerage
- 'settled' sewerage.

This distinction remains valid. However, there are also a number of other terms used to more or less accurately describe the option studied.

The French term, '*mini-égout*' has no direct equivalent in English; instead, a different term is used for each specific technical option (which meant a detailed explanation was required when describing our study to the non-French speaking stakeholders met).

Thus, depending on the context, different authors or experts may use the following terminology:

'*Mini-égouts*' or 'non-conventional sewers'

The English equivalents: 'small-piped sewers', 'reduced diameter sewers', 'shallow sewers' or even 'non-conventional sewers' (the term used as the translation of '*mini-égouts*' for the purposes of this study) are usually used to describe settled sewerage only (*for more information on settled sewerage, please see below).* This is therefore a 'technical' description that focuses mainly on the diameter of the pipe. However, in the French definition, '*mini'* can also refer to the 'small' size – or length – of the sewer system itself.

'*Assainissement semi-collectif'*

This term is used mainly in Francophone Africa and is often translated as 'simplified sewerage' or, less commonly, as 'semi-collective sanitation'.

Positioned between (city-wide) conventional sewerage and on-site sanitation (individual household facilities), this type of sewer is usually managed at 'district level'. As seen in Part 7. *How are non-conventional sewers managed?,* this management method has given rise to a number of issues that threaten to undermine the sustainability of these solutions.

'Condominial sewerage'

In French: '*égouts condominiaux'*; in Spanish: '*alcantarillado condominial'*; in Brazilian Portuguese: '*saneamiento condominial*' or '*esgotos condominiales*'.

This system is based on the same premise as '*assainissement semi-collectif"* as, in Spanish and Brazilian Portuguese, '*condominio*' means 'building' or, 'co-ownership'. Originally, responsibility for managing condominial sewers was to be 'shared' between the residents of the same 'block'. However, as described below (*Part 2: Non-conventional sewers around the world: where have they been implemented and using what approach?),* in most places this management method was quickly abandoned.

From a technical perspective, virtually all of the South American 'condominial' sewers are 'simplified' systems.

'Decentralized sewer systems'

In French: '*réseaux décentralisés'*.

These are sewer systems that are not connected to the larger conventional sewer system (either physically or by its management method). This term can thus be used to describe both '*semi-collectif'* and 'condominial' sewerage.

'Simplified sewerage'

In French: '*mini-égouts simplifiés'* or '*égouts simplifiés'*.

This term is most often used to describe systems with simplified route layouts and designs (of reduced length and with fewer, smaller inspection chambers, etc.) and small diameter pipes.

‘Settled sewerage’ or ‘solids-free sewers’

In French: ‘*égouts décantés*’.

This term refers to systems that evacuate both greywater and blackwater that has been pre-treated in a settling tank.

‘Alternative sewerage’

In French: ‘*égouts alternatifs*’.

This is used as an umbrella term to describe all sewer systems that fall outside conventional sewerage ‘standards’ (however, these also vary between countries and are not always precisely defined).

II. ‘Reduced diameter’ sewers?

This appears to be the common denominator linking all the different solutions identified: they are all systems that evacuate wastewater via a network of ‘reduced diameter’ pipes. As a result, investment costs are reduced; the sewer can be installed along narrower channels; and it operates using ‘tractive tension’.

According to Duncan Mara, one of the main features of non-conventional sewers is precisely that, because of their reduced diameter pipes, they operate using ‘tractive tension’ (the minimum force required to carry a particle of a specific size). This makes it possible to lay pipes at flatter gradients and with smaller minimum diameters. There is, therefore, less risk of pipes becoming clogged (self-cleansing); however, pipes are much more vulnerable to blockages from debris and other objects.

Non-conventional sewers also have fewer manholes (or these are replaced by simple inspection units), which are smaller than those in place on conventional sewerage systems.

In practice, most non-conventional sewer schemes use PVC pipes of around 100mm in diameter for the entire system. This is much smaller than the diameters specified in design standards for conventional sewerage in developed countries: 150mm for ‘tertiary’ sewer lines (connections) in France and 1.3m in diameter under each street for secondary sewer lines in Paris.

	Ramagundam, India	**Dakar, Senegal**	**Kumasi, Ghana**	**Bamako, Mali**	**Recife, Salvador de Bahia and Brasilia (Brazil)**	**Certain sewers in the USA**	**Certain sewers in South Africa**	**Malang (Indonesia)**	**GRET (Cambodia)**
Diameter	150 to 250mm (simplified)	From 110 to 200mm (settled + simplified)	100 to 300mm (simplified)	110 to 160mm (settled)	100 to 150mm (simplified)	50 mm in some cases (settled) *(according to Tayler, 2004)*	Up to 63mm (settled) *(Tayler, 2004)*	100mm (simplified)	Around 200mm (simplified)

Table 1: Diameters used on different non-conventional sewer systems

However, as with conventional sewerage, a non-conventional sewer system usually consists of different sized pipes. Thus, the ‘indoor’ (essentially, the domestic plumbing) section of the non-conventional sewer is no different to that used with conventional sewerage.

Further downstream, due to the volume of effluent passing through the sewer, larger pipes are sometimes required (over 200mm in diameter) that are very similar in size to those used on conventional sewer schemes.

III. 'Mini' sewers?

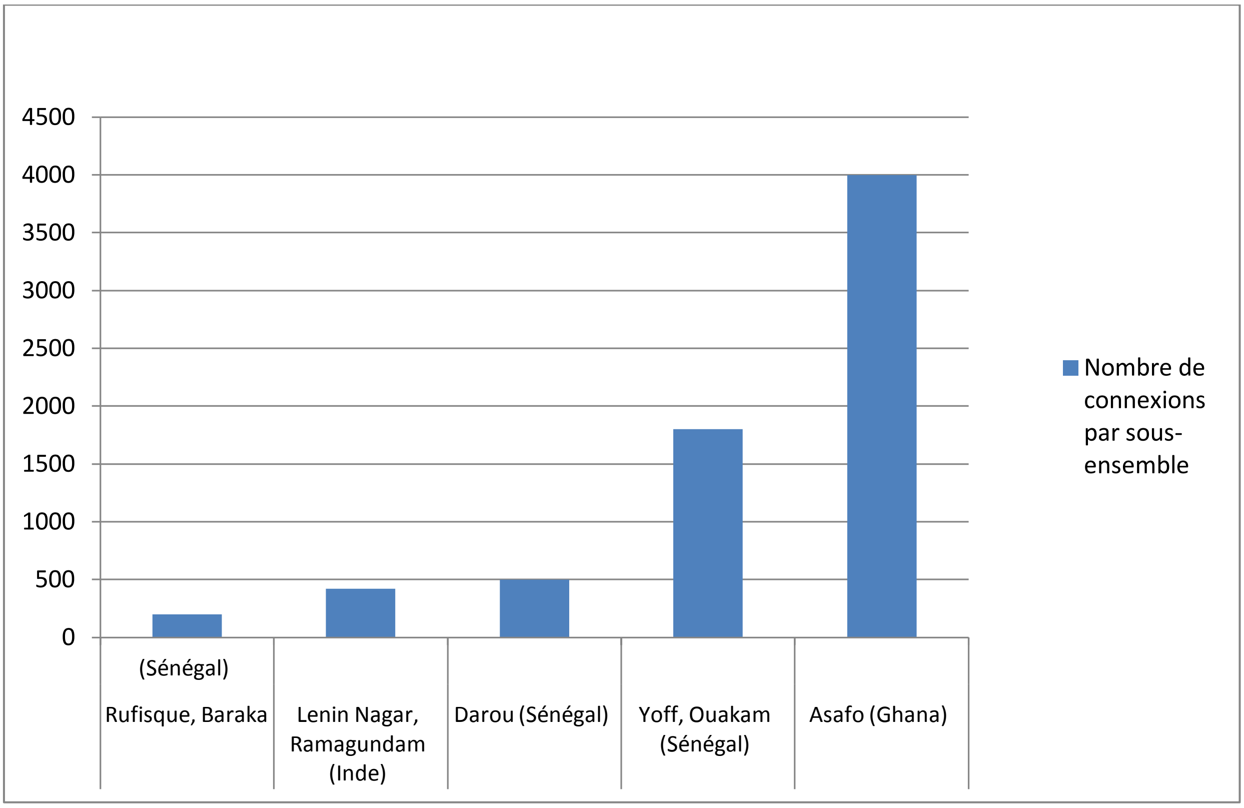


Figure 2: Examples of the number of connections per system

As can be seen in the figure above, it is difficult to define 'non-conventional sewers' by their size, as this can vary considerably from one system to the next.

Attempting to define the systems in Brazil by their size is particularly challenging due to difficulties determining what measure is to be used: the condominial block (a maximum of 25 connections) or all of a sewer system that meets 'condominial standards' (namely 80% of the city of Brasilia).

IV. Decentralized sewer systems?

This concept remains the subject of debate among the specialists interviewed. Nevertheless, there are certain criteria that can be used to help define a 'decentralized' sewer system:

- scale: each system covers only part of an area (a district within a town);
- physical separation from the main system: the decentralized sewer system is independent of conventional sewerage (this criterion does not therefore apply to those non-conventional sewers connected to the conventional sewer system);
- responsibility for the service and management method: these differ from those in place at citywide level.

Based on existing experiences (see table below), 'decentralized sewer system' is not always an accurate description of non-conventional sewer schemes as, not only are non-conventional sewers and conventional sewerage sometimes physically connected, but responsibility for the service (contracting authority) and management method (operator) are also often the same.

Contrary to popular belief, non-conventional sewers are also not always placed under 'community-based' management (i.e. managed by the users); in fact, far from it.

	Ramagundam, India	Dakar, Senegal	Kumasi, Ghana	Recife, Brasilia, Salvador de Bahia, Brazil	Bamako, Mali
Outlet	Decentralized treatment plants	Decentralized treatment plants or connection to conventional sewerage	Same treatment plant as for conventional sewerage	Connection to conventional sewerage	Decentralized treatment plants
Responsible for the conventional service	Municipality	National operator (ONAS)	Municipality	Provincial operator	Municipalities
Responsible for the non-conventional sewer	Joint municipality/users	Joint ONAS/users/municipalities	Municipality	Provincial operator	Users
Conventional sewerage operator	Municipality	National operator (ONAS)	Municipality	Provincial operator	Association-based operators or national public operator
Non-conventional sewer operator	Joint municipality/users	Joint ONAS/users/municipalities	Private operator	Provincial operator	Users

Table 2: Decentralized sewers or sewers connected to conventional sewerage and a wide range of management methods

V. ‘Settled’ sewerage?

Non-conventional sewers are sometimes understood as being ‘settled’ sewers, meaning that the solid and liquid matter from household wastewater is separated in a settling tank and only the liquids are evacuated.

However, most non-conventional sewer projects in fact implement a ‘simplified’ solution that evacuates both liquids and solids.

VI. An ‘unconventional’ route

Across private land

Non-conventional sewer systems are often routed across private land (gardens, yards, etc.). This makes it possible to:

- reach those areas without a structured road network (old historic centers, informal settlements, etc.) where the boundaries between public and private land are often unclear and where the winding road layout makes laying large diameter pipes unfeasible;
- reduce the length of pipework required compared to conventional sewerage, notably as each household can be connected to their neighbor, as in an apartment building (hence the Latin-American term ‘condominial’ used for this type of system), rather than to a secondary sewer line. (The reduction in the length of pipework alone can reduce the cost of pipes by up to 50% according to UNCHS, 1986);
- reduce exposure to the passage of heavy vehicles and erosion (which can be particularly high where there are unpaved roads). Pipes can thus be laid at a shallower depth (at only 20cm in the north-east of Brazil), which also helps further reduce the cost.

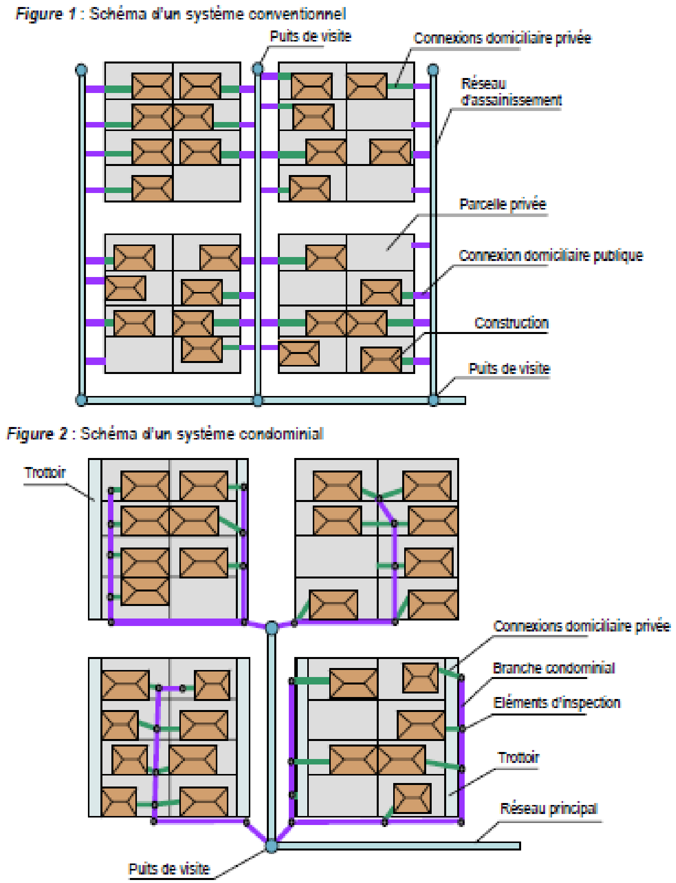
Box 1: *Sewerage and private land: not merely restricted to non-conventional sewers*

In developed countries, the ‘public’ sections of conventional sewers can also cross over private land.

The operator in charge of conventional sewerage is thus generally granted right of way to access and work on the sewer line.

Across public land, but away from roads

In other instances (notably most African non-conventional sewers, but also more and more condominial sewers in Brazil), pipes are routed across public land. However, whereas larger-diameter conventional sewer pipes are laid under the street, non-conventional sewer pipework is often laid under the sidewalk. This protects them from damage and results in cost savings in both pipe-laying and maintenance.



Comparison of conventional and condominial sewerage layouts (Source: Vincent I., 2001, Suez Environnement)

Settled and simplified vs. conventional sewerage

Item	Simplified	Conventional
Minimum pipe diameter:	Min. ∅	Min. ∅
• House connection	75 mm	120-150 mm
• Block or street collector	100 mm	200-300 mm
• Collector in solids-free sewerage	50 mm	---
Gradient of collectors:		
• For unsettled wastewater	Continuous	Continuous
• For settled wastewater	Can be inflective	---
Min. gradient		
• House connection	1 - 2 %	2 %
• Block or street collector	0.6%	1 %
Minimum velocity	0.3 - 0.5 m/s	0.7 - 0.9 m/s
Sewer layout	Usually under backyards or sidewalks	Usually underneath street
Peak : average design flow ratio	≤ 2	≤ 4
Minimum pipe cover	30 cm (no traffic load)	≥ 80 cm (traffic load)

Comparison of non-conventional and conventional sewerage technical features (source: EAWAG-SANDEC)

Figure 3: How the route layout and technical features differ from conventional sewerage

VII. Can open channels be ‘non-conventional sewers’?

In many places, notably in Asia, open channels initially designed to collect and evacuate stormwater have been converted into ‘open sewers’ into which local residents discharge their domestic grey and blackwater. These sewers are generally rectangular in shape and sometimes covered with removable slabs.

However, it would be inappropriate to refer to these as ‘non-conventional sewers’ because:

- they are not watertight, thus they fail to protect the urban environment from contamination from pathogens and do not meet minimum public health standards;
- the fact that they were designed solely to accept stormwater means that these channels are rarely able to cope with more viscous liquid. As a result, they are highly vulnerable to blockages.

VIII. Conclusion: non-conventional sewers, as understood in this study, are therefore…

A common feature of the non-conventional sewers included in this study is that they all differ from conventional sewerage in one or more ways:

Either in their technical features:

- the system uses smaller diameter pipes;
- or is shorter in length;
- the sewer is independent from conventional sewerage and connected to a decentralized outlet;
- the sewer has a settling tank;
- it follows a simplified route;
- there are fewer and smaller inspection chambers;
- etc.

(For more information on the different technical design options, please see Part 4: What does the technical design include?).

Or through the party responsible for the sewer and the management method used:

Such as when one section of the sewer line (usually also physically distinct from the conventional sewer) comes under the responsibility of a stakeholder other than the ‘traditional’ contracting authority and a different operator than that managing conventional sewerage is assigned to manage the non-conventional sewer.

(For more information on the different management methods used, please see Part 3. To which contexts are non-conventional sewers best suited? and Part 7. How are non-conventional sewers managed?).

Part 2. Non-conventional sewers around the world: where have they been implemented and using what approach?

I. 'Conventional' standards seldom attainable for Southern countries

Although the first sewer systems date back to Roman times, current sewage system standards were not developed until the 19th century, following advances in public health and urban planning know-how and in scientific knowledge. Northern countries then applied these techniques and standards in towns and cities throughout their colonies.

Since this time, in Northern countries, these technical standards have been continually improved and supplemented by increasingly stricter wastewater discharge standards.

In developing countries, however, many systems fell into disrepair following independence due to a lack of sufficient technical, financial and organizational capacities. There are a few exceptions to be found in some 'emerging' countries of Asia and Latin America; however, even here managing 'conventional' sewer systems has not been without its problems. For instance, during the field visit undertaken for this study to Raipur (India), it was established that the conventional sewer system installed several decades ago has never actually worked. Furthermore, in Recife (Brazil), the provincial operator is still struggling with its conventional sewerage service, as is the service operator in the suburb of Hanoi (Vietnam).

Overall, there is a myriad of solutions that fall outside the norms of 'conventional' sewerage, not all of which have been formally identified. However, we have excluded from this study those stormwater drainage channels and other 'empirical' solutions not originally intended or designed to be proper, closed sewers for evacuating wastewater.

Southern countries have been considering the option of using 'alternative' standards for wastewater evacuation and treatment for many years. There are records of such discussions in Brazil that date back to the first half of the 20th century (interview with Dr Patricia Campos Borja, Federal University of Bahia (UFBA), Salvador de Bahia).

According to Duncan Mara, the first real examples of non-conventional sewers were developed in Africa; more specifically, in Nigeria and Zambia in the 1960s, immediately following independence.

II. Brazil: the original 'condominial' sewerage experience

For more information on condominial sewerage in Brazil, please see the case study report in the Annex.

José Carlos Melo's 'condominial philosophy'

Although not the first Brazilian engineer to have studied the use of 'simplified' technologies as a means of expanding sanitation services, José Carlos Melo was the first to develop a complete 'doctrine' on the subject that included the technical, financial, institutional and management aspects required to provide universal access to sanitation services for the population of Brazil. He is thus rightly considered the 'father' of condominial sewerage. The condominial sewerage 'philosophy' developed by Melo is based on the following principles:

Technical

- using smaller diameter pipes and manholes;
- 'streamlining the routes' by reducing the sewer length, sizing the systems more accurately and moving away from the traditional grid-based layouts that require additional costly and unnecessary pipework;
- routing the system over private land with a view to reducing the sewer length.

Universal service

Users' acceptance of this 'simplified' condominial system (less expensive but more constraining for the user) was conditional upon condominial sewers becoming the unique standard for the entire town.

However, Brasilia is currently the only city in which this principle has been applied. Moreover, as Melo himself says, the condominial system, which was "invented to universalize access, has too often been used to discriminate" *(interview with J-C Melo).*

User participation in the decision-making process

Along with the simplified sewer route, user participation in the decision-making process is the best known and most widely adopted element of the condominial sewerage philosophy outside Brazil.

Under the condominial system, the users, as members of local community associations, are involved in all technical, financial and management decisions pertaining to their sanitation service. There are ongoing discussions with the operator and his service providers throughout both the implementation and operational phases. A number of 'social workers' or 'community workers' are employed to develop and support this dialogue and these form part of multi-disciplinary teams along with the engineers and technicians.

Box 2: User involvement and awareness-raising method used in Brazil (SARMENTO, 2001)

"A meeting with the households of the block aiming to:

- *explain the general sanitation conditions necessitating interventions;*
- *appeal for cooperation;*
- *describe the proposed solution;*
- *make the potential users conscious of their responsibilities;*
- *exchange ideas and opinions;*
- *get permission to undertake a door-to-door survey;*

and get agreements on:

- *undertaking another meeting;*
- *the responsibilities of each person;*
- *the costs of the system and tariff policy;*
- *the allowance of members of the community to observe the system."*

Management: the condominial 'pact'

It is often incorrectly assumed that the condominial sewerage philosophy involves passing full responsibility for the sewer system onto the users only (which could thus potentially be discriminatory).

However, Melo stresses the need for cooperation between the users, local authority and the operator. The condominial 'pact' negotiated and signed by all parties is intended to ensure the rules of this cooperation and the technical and financial obligations of each party are established in a democratic manner.

Thus, the users are initially asked to decide whether they want to undertake routine sewer maintenance themselves and thus receive a 50% reduction on their sanitation fee (which is a substantial reduction for low-income families as the sanitation fee in Brazil generally equates to 100% of the water bill).

Although Melo considers that the operators and public authorities have often been too 'cowardly' in ensuring this pact is upheld *(see the following paragraph)*, he also believes that public operators taking over control of the systems is a natural development given the advances in technical understanding and economic growth (interview in March 2013).

A first step towards universal service in Brazil

Condominial sewerage was initially developed for the *favelas,* unplanned settlements with narrow, winding lanes in which neither conventional sewers nor on-site sanitation were an option and the inhabitants had long been excluded from sanitation services.

The aim of simplifying the sewer systems was to reduce their investment cost (by 25 to 50%) and thus "do more with the same resources", namely progressively install condominial sewers in all towns rather than only directing investment towards building conventional sewers with high capital costs in well-off areas.

Thus, in Parapuebas, rather than constructing a conventional system for the town center only, condominial sewerage was put in place for the whole town for the same budget (Melo).

The first condominial sewer was installed in the district of Rocas, in the city of Natal, an area with rocky soil and high population density.

Box 3: The weak capacities of the users' associations

The difficulties experienced when assigning responsibilities for the 'original' condominial sewers were due not only to disagreements between the states' public operators and municipalities, but also to the fact that 'participatory' democracy was often very new, ad hoc and highly localized (virtually non-existent in Salvador, poor in Recife, etc.).

In those places where a users' association has been set up (which is not always the case), this bears more resemblance to a general community discussion forum than to a body with set resources, rules and procedures.

In Salvador de Bahia, condominial sewerage now serves 50% of the population, or over 1 million people; this also corresponds to the proportion of informal settlements constructed on the sand dunes, known as '*moros*'.

In Brasilia, 80% of the population is connected to condominial sewers, which, since 1991, have become the standard solution in rich and poor areas alike.

Provincial public operators taking over control of condominial sewerage

Condominial sewerage soon generated considerable interest, particularly from municipalities. However, its development was often hampered by initial misunderstandings over the respective roles of the users and public operators.

Thus, in Recife, the municipality financed the construction of several condominial sewers; however, for a long time, neither the users nor the provincial public operators were willing to accept responsibility for managing these systems.

In some instances, these issues even led to sewers being abandoned (in Recife, as well as in small rural towns in the north-east of the country, according to an interview with a manager from CISAR).

Despite having signed condominial 'pacts', users that had undertaken to carry out routine sewer maintenance never actually did so. As a result, the operators were frequently called upon to help out. Thus, they gradually took over control of the systems, sometimes under pressure from the municipalities or the courts or following television reports showing the poor state of 'condominial' sewerage services. In return, they charged the same sanitation tariffs as for conventional sewerage (as, according to CAESB, condominial sewers are no cheaper to maintain).

There are number of reasons for the low levels of user involvement in managing the sewers:

- the users' organizations lack both structure and capacities *(see the box above);*
- the resources and know-how required to carry out some of the maintenance tasks often exceed the capabilities of the 'amateur sewer worker' (also see the section on operation and maintenance);
- 'condominial' management has often given rise to neighborhood disputes: when a user fails to follow good practice and blocks the sewer, it inconveniences the entire block. (In areas with social issues and where violence is rife, there are numerous of anecdotes of disputes gone bad…);
- poor maintenance has led to leaks and seepage of wastewater into the subsoil, which in turn has resulted in subsidence, causing houses to collapse: the courts have ordered the operators to compensate the affected households (Salvador de Bahia, interviews with the senior management of EMPASA). This has cost them a lot of money and spurred them into taking over management of the sewers themselves…
- low-income users are poorly educated and have low levels of awareness (in Salvador de Bahia, it has been noted that the sewers in middle-class areas are better maintained);
- neighborhoods experience high residential turnover: tenants or homeowners move out and the new arrivals are not trained;
- ongoing awareness-raising and support mechanisms are often lacking;
- whenever there is an operator working in the area, users automatically turn to this operator each time there is a problem, even if they signed the initial 'pact'.

Box 4: Is condominial sewerage an 'ultra-liberal' philosophy?

Yes, according to certain Latin-American researchers and practitioners as it affirms an inequality in service between rich and poor.

No, according to the philosophy of JC Melo; he advocates an average service for all rather than a high level of service for the rich alone, as well as the empowerment of the poorest and community participation.

The introduction of condominial sewerage also has to be seen in the context of post-dictatorship democratization; the aim being to empower the people, thus enabling them to assert their rights to water and sanitation and "take services out of state-owned companies' hands" as part of an anti-bureaucratic approach. This was also a time of low investment capacity, which meant that, over the short-term, it was impossible to provide universal access to the service through 'conventional' methods.

Melo, a man of the left, also had a brief career as a politician, serving first as deputy mayor of Recife in charge of water and sanitation, then as deputy governor of the State of Pernambuco. He notably campaigned for transparency and accountability in water supply, requiring engineers to hold meetings with users, a situation with which the engineers were extremely uncomfortable.

- as both the standard of living and demand for comfort increase, so the willingness to carry out maintenance tasks decreases.

Condominial sewerage today

Condominial sewerage is still the focus of passionate debate in Brazil (see *Box 5: Is condominial sewerage an 'ultra-liberal' philosophy?*).

However, there is no question that condominial sewerage has provided universal access to sanitation services in urban areas and had a recognized impact on public health (interviews with the sanitary engineering team at the UFBA Polytechnic School in Salvador de Bahia and impact assessments from the Bahia Azul program). In addition, it has raised the self-esteem of the poor, who are now being increasingly recognized in public policies.

Practitioners and scientists in Brazil nearly all consider condominial sewerage to be an 'appropriate technology'. There have been a few technological improvements made: in many cases, the original diameter of the pipes used on condominial sewer lines has been increased from 100mm to 150mm due to density and increases (or potential increases) in consumption and to prevent blockages caused by solid waste. However, according to the experts (interview with Ivan Paiva, Salvador de Bahia), the basic design has remained the same.

Lastly, although not the only approach in use, the condominial doctrine has also played an important role in helping develop a concerted planning and social mediation culture, etc. In the words of JC Melo: "No other program has ever led to over 30,000 meetings being held across the globe; meetings which have always ended peacefully!". This doctrine has progressively developed into one of '*saneamiento integral',* namely an integrated approach that involves working across sectors such as stormwater management, solid waste management, water and electricity services and road surfacing and in close alignment with land use and housing improvement or social development and security policies.

Condominial sewerage outside Brazil

Condominial sewerage is widely used in the central and Andean regions of Latin America. It is included in national standards in Colombia, Paraguay, Peru, El Salvador and Bolivia and has also been piloted in the Dominican Republic. Furthermore, the Brazilian operator, CAESB, is providing technical assistance to the cities of Saint-Marc and Port-au-Prince in Haiti.

Brazilian technical experts had also been working on adapting the solution (the technical aspects only) for use in Benghazi in Libya prior to the fall of the Gaddafi regime.

There have also been numerous attempts to replicate the Latin American condominial sewerage model in Africa, for example:

- visits were undertaken by ONEP Morocco to Brazil, organized by the World Bank (which, however, did not lead to adoption of the standard);
- visits were also made by Luis Lobo for WSP to West Africa (Ghana, Senegal, Côte d'Ivoire) at the beginning of the years 2000;
- in addition, support was provided to the PAQPUD program in Dakar by the expert Fernando Inchauste (Peru).

III. Non-conventional sewers in Africa: 20 years of experimentation (20 years of failure?)

How have systems developed in southern Africa?

The fate of the first non-conventional sewer initiatives in southern Africa is unknown. However, Robert Reed and M Vines, WEDC, assessed several small settled sewer systems in Zambia in 1991, all of which had serious maintenance issues attributable to a lack of clear responsibility for management (VINES M, REED R., 1991).

Initiatives in South Africa

Numerous small settled sewers have been constructed over the last two decades in middle and upper class peri-urban residential areas in South Africa. They are run by highly competent operators and are economically competitive (PISANI, 1997). However, these schemes are set in contexts comparable to those of 'developed' countries and are very similar to the STED schemes found in Australia (*see above).*

Other initiatives have been implemented to install sewers in the townships. One examples of this was the settled sewerage pilot project in eThekwini, Durban, which was unsuccessful as the users were reluctant to pay for and manage the sewer schemes.

Attempts to introduce 'condominial sewerage' into West Africa during the 1990s

In Kumasi, Ghana

This initiative, that dates back to the beginning of the 1990s, was implemented as part of a municipal sanitation strategy with support from UNDP and the World Bank (who provided 50% of the financing) and extensive high-level international and African expertise. Although supposedly based on the condominial system, a more conventional route was adopted and, from the outset, responsibility for the sewers was given to the local authority, who then delegated operation of the system to a local private operator (the constructor). This non-conventional sewer initiative has proven to be sustainable and has been providing a high level of service for over 20 years (although there have been some changes to the operator and contracting authority contract, periods of conflict between the operator and the contracting authority and an ongoing lack of regulation). However, this initiative remains relatively unknown and, due to lack of investment capacities, has never been replicated, not even locally.

(Please see the Ghana case study report in the Annex.)

The ENDA initiative in Dakar, Senegal

At the beginning of the 1990s, the NGO ENDA drew on the initiatives undertaken in Pakistan and Brazil to implement non-conventional sewers. The first was installed in the extremely poor district of Baraka ('barracks'), whose residents were being threatened with eviction, then in Rufisque, a low-income district of Dakar, and in Yoff, an informal settlement in Dakar. The 'settled sewerage' option was selected as being most suitable for the low gradients and low water consumption. However, there have been major management issues on all these systems and thus they have not been extended. Attempts to replicate the initiative in Burkina Faso, Cameroon, Mali and other towns in Senegal have all encountered the same problems.

(Please see the Senegal case study report in the Annex.)

CREPA: in Mali, Togo, Côte d'Ivoire, Burkina Faso

CREPA, now known as the Pan-African Inter-Governmental Agency, Water and Sanitation for Africa or WSA, initiated pilot projects in a number of countries: Burkina Faso, Mali *(see the case study in the Annex),* Côte d'Ivoire, Togo, etc. These initiatives involved constructing sewers to evacuate household greywater only. Although much technical know-how has undoubtedly been gained (also from previous condominial sewerage initiatives), there were difficulties developing effective management systems and some of the sewer schemes have since been abandoned (Togo, Bobo-Dioulasso, etc.).

(Please see the Mali case study report in the Annex.)

The PAQPUD and GPOBA programs in Dakar: an attempt to scale-up non-conventional sewers across Dakar

Under the sanitation program for the peri-urban areas of Dakar (PAQPUD: *Dakar Programme d'Assainissement des Quartiers PériUrbains de Dakar*) **10 'settled' sewerage schemes** were to be constructed, the design of which was based on both the lessons learned from the experiences of **ENDA in Senegal** and the methods used to develop **condominial sewerage in Brazil** (government management staff and representatives from consultancy firms in Senegal received training in Brazil and Latin-American consultants were brought in). Services were to be run by community-based economic interest groups (EIG), with the users and local authorities sharing responsibility as part of a 'management committee' and receiving technical assistance from ONAS.

However, there were **significant technical issues** encountered during PAQPUD's implementation of this non-conventional sewer option, as well as difficulties in ensuring those involved, namely ONAS, the users and local authorities, effectively assumed their responsibilities. Only two management committees are actually active.

In order to address the shortcomings of the PAQPUD program, the World Bank launched an Output-Based Aid program at the end of 2010 known as **GPOBA.** The GPOBA program provided **support not only to enable completion of the construction work and during the final acceptance of work phase** (particularly of the pumping stations), but also to **increase the number of connections**. ONAS then undertook to 'reclaim responsibility' for the systems and the **national operator is now actually operating the non-conventional sewer schemes**, albeit with extremely limited resources.

Lastly, the World Bank has recently issued a call for tenders in which teams of international consultants have been invited to propose **a sustainable management model for the ONAS non-conventional sewers** and also **compile an inventory** of all systems constructed in the country 'outside PAQPUD' so that these can be **incorporated into ONAS's assets.**

Development which is being continued by ODA partners

In spite of the difficulties encountered with past non-conventional sewer initiatives in Africa, implementation of this option remains ongoing due notably to the efforts of development partners.

Thus, around thirty non-conventional sewer schemes have so far been implemented in Senegal, along with a similar figure in Mali and there are also many other projects in the pipeline. Non-conventional sewers have been incorporated into the national standards of both countries and use of this option is also gaining traction in Cameroon.

In Anglophone Africa, WSUP is developing projects to connect public toilets to non-conventional sewers, notably in Kibera in Kenya. In addition, Borda is in the process of developing a number of pilot schemes in southern Africa (particularly Tanzania) in which non-conventional sewers are connected up to DEWATS applications.

IV. The Maghreb and the Middle East

In Morocco, there were a number of non-conventional sewer projects implemented in the rural villages of the Atlas region in partnership with Hydraulique Sans Frontières and the City of Paris.

At one point, use of the 'condominial sewerage' option was also being considered for the informal settlements of Casablanca (studies by Hydroconseil undertaken for Lydec, a subsidiary of Suez); however, it would appear that this standard was never adopted.

Despite a visit from a Brazilian expert organized by WSP, the non-conventional sewer option has not been particularly warmly received by the national decision-makers.

In Egypt, management issues have hampered the El-Moufty El-Kobra settled sewerage project in Kafr El-Sheikh, a small, densely populated, rural village in the Nile Delta; however, other projects are currently underway in this region that are being funded by GIZ and supported by EAWAG-SANDEC.

There have also been a few isolated and ad hoc initiatives undertaken in Libya and Palestine.

V. Asia

OPP and initiatives in Pakistan

Since 1981, the NGO Orangi Pilot Project has been working in the Orangi slum in Karachi to help over 112,000 households, or over 90% of the population, connect to tertiary and secondary sewer lines that discharge to the 'nalas', small urban ravines that have streams running through them. In an area of very strong social cohesion (immigrants originally from the same region) and where the inhabitants' standard of living has considerably improved over the last few decades (HASAN A., 2006 and interviews with B. Evans and K. Tayler), OPP implementation, financing and management is entirely 'community-based'. The extremely low costs (between 50 and 100 euros per connection, including the 'soft' components) are due to the particularly strict process used *(see the box below).* According to OPP, the (total or partial) failure of the numerous attempts to replicate the OPP initiative in Pakistan has been caused by failure to adhere to this process.

Although experts visiting Orangi have slightly qualified the extremely positive results published by OPP, notably highlighting certain shortcomings in implementation and management issues, this remains a seminal initiative that has served as a model for many other projects around the world. Along with the Brazilian condominial sewerage system, it is also cited as a benchmark in virtually all non-conventional sewer methodological documentation (although it would appear that neither of these two initiatives has ever been analyzed in detail).

Box 5: The social preparation process implemented by OPP

- Dialogue is initiated through the social organizers (OPP employees). **OPP identifies and contacts an influential /active individual with good reputation**, who in turn contacts the lane residents (= area containing a few dozen households).
- **OPP holds a public meeting** to explain the salient features of the low-cost sanitation program.
- **If residents show willingness and submit a written request** to OPP, OPP surveys the lane and prepares a map and cost estimates of the sewer line. These documents are handed over to the representative of the lane, who is confirmed by the lane residents as their representative/lane manager.
- **This lane manager then collects money from each household** in accordance with the prescribed contribution levels set out in OPP recommendations.
- **OPP establishes physical levels** and demarcates the position of the sewer line.
- **The work begins: OPP provides tools and supervises the entire execution**. The lane manager manages the overall process and facilitates the maintenance of accounts.
- With time, **many of the OPP inputs are taken over by local masons and contractors** and by the community itself.

DEWATS in Indonesia and the rest of Asia

The term DEWATS, as used by the German NGO Borda, stands for 'Decentralized Water Treatment Systems'. It covers a **wide range of 'intensive' technical wastewater treatment solutions with low initial investment costs that are cheap and simple to operate.** Initially, Borda implemented DEWATS in low-income peri-urban settlements in South-East Asia, before expanding the approach to southern and central Asia. These DEWATS applications generally consist of a set of technical treatment options (modules), which can include Anaerobic Baffled Reactors, gravel filters, planted drying beds, biogas reactors, Imhoff tanks, etc. The DEWATS approach advocated by Borda and its partners has often been combined with solid waste projects.

In Indonesia, where several hundred DEWATS have been implemented (and, according to Borda, now serve more users than the country's 'conventional' systems), DEWATS **construction was standardized to cope with growing demand**: they are made of fiber-glass reinforced plastic and can be constructed in a matter of days. This helps guarantee the construction quality and reduces the technical supervision required. A manufacturing plant has also recently been created in Afghanistan and Borda is currently rolling out the approach in southern Africa.

(For more information on DEWATS in Asia, please see the case study in the Annex).

In India

In Ramagundam (Andhra Pradesh), which is a town of around 200,000 inhabitants, 13 low and middle income communities, part of an initial phase of 6,600 households, have been connected to a 'simplified' (not settled) **sewer for around 15 years**. Responsibility for the sewer is shared between the local authority and the users, who also jointly operate the system. This solution has remained sustainable since its implementation, even though it is not at all well-known in India. *(For more information on the simplified sewer system in Ramagundam and the situation in India, please see the case study in the Annex).*

In **the Punjab, a World Bank funded program** (Punjab Rural Water and Sanitation Project) is currently underway to construct non-conventional sewers in 100 rural villages.

A substantial number of projects to construct non-conventional sewers connected to DEWATS have also been implemented in India (see the case study on DEWATS in Nagpur).Furthermore, 'non-conventional sewers' are included in the national standards in India.

Lastly, although these do not strictly fit with our definition of 'non-conventional sewers', it is also important to note the numerous examples of '**improved stormwater drainage**' that have spontaneously been developed in rural and urban areas.

VI. An option also being considered in developed countries?

New types of decentralized systems are also being developed in rural and peri-urban areas of developing countries such as the USA, Australia, Europe, wealthy residential areas of South Africa, etc., particularly where on-site sanitation is not an option (bedrock, wetlands, etc.) or to lower investment costs.

The literature mentions examples of long-established non-conventional sewers in the United States (Mt. Andrew) and Australia (Pinaroo) (OTIS R. J., MARA D., 1985): 4,000 connections to a *sewered network tank system* (SITS) (settled sewer) in southern Australia installed between 1962 and 1986 and 200 small systems constructed in the USA between the middle of the 1970s and 1990 (according to OTIS, 1996).

There are no reported examples of 'non-conventional sewers' as such in France; however, there are small conventional sewers (with 150mm diameter pipes) connected to decentralized treatment plants in some rural and semi-urban areas and a number of 'vacuum' and 'pressure' settled sewers have also been constructed in areas with particular physical constraints (interview with J. Lesavre, AESN).

Figure 4: Countries in which non-conventional sewers have been implemented

Part 3. To which contexts are non-conventional sewers best suited?

I. Why were non-conventional sewers chosen?

	Ramagundam, India	Rufisque, Baraka & Yoff (ENDA), Senegal	PAQPUD ONAS, Senegal	Darou/Saint Louis, Senegal	Cayar, Senegal	Asafo Kumasi, Ghana	Salvador de Bahia, Brazil	Recife, Brazil	Brasilia, Brazil	Bamako, Mali	Mopti, Mali
Reason behind the choice	To provide universal access to the service	On-site sanitation options limited due to near-surface water tables or bedrock and highly built-up residential areas (Baraka)	On-site sanitation options limited due to near-surface water tables or bedrock	To provide universal access to the service	On-site sanitation options limited due to near-surface water tables and highly built-up residential areas	On-site sanitation options limited due to low rate of percolation, highly built-up residential areas	To protect the environment and public health To develop tourism potential To provide universal access to the service	To protect the environment and public health To develop tourism potential To provide universal access to the service	To provide universal access to the service To protect the environment and public health	Extremely built-up residential areas and winding lanes, greywater discharged into the streets	Extremely built-up residential areas and winding lanes, greywater discharged into the street Near-surface water table

Table 3: Reasons non-conventional sewers were chosen

The main reasons given by promoters for selecting the non-conventional sewer option include:

- on-site sanitation options are impossible or too problematic to install, particularly in **highly built-up urban areas** or areas where there are **physical constraints** (very steep gradients, near-surface water tables or impermeable soil);
- **conventional sewerage is too expensive, too complex to manage and/or difficult to install in unplanned urban areas** (lack of space, narrow winding streets).

Other reasons also mentioned include:

- the 'on-site + pit emptying' sanitation chain is too expensive, there are no treatment sites and it is difficult to manage due to the number of stakeholders involved;
- without infrastructure networks there can be no 'real' service or modernity. (This was one of the drivers behind development of condominial sewerage in Brazil and probably also on other continents);
- to provide a solution that is 'by the poor for the poor' and to empower users in order to counter the lack of interest shown by the authorities and/or the traditional operator;
- to improve the town's tourist image (in Salvador de Bahia this was more important to the municipality than developing access for the poor);
- a willingness to try out an innovative solution;
- to "produce biogas";
- the parties involved have a (real or supposed) in-depth understanding of the technology;
- major infrastructure projects mean large amounts of funding;
- etc.

II. What process was used to select the non-conventional sewer option?

Here, the term 'selection process' covers all discussions held among stakeholders to weigh up the advantages of non-conventional sewers against other options and to reach a decision.

	Ramagundam, India	Rufisque, Baraka & Yoff (ENDA), Senegal	PAQPUD ONAS, Senegal	Darou/Saint Louis, Senegal	Cayar, Senegal	Asafo Kumasi, Ghana	Salvador de Bahia, Brazil	Recife, Brazil	Brasilia, Brazil	Bamako, Mali	Mopti, Mali
Process that led to the option being selected	Sanitation development strategy for low-income areas	Pilot projects to develop sanitation services in these areas	Sanitation development strategy for the city's peri-urban areas	A neighborhood sanitation development project	City center sanitation development project	Citywide sanitation development strategy	Citywide sanitation development strategy			A neighborhood sanitation development project	A neighborhood sanitation development project
Actors behind the choice	The local authority, with support from an Indian consultant	The NGO, ENDA	International experts	International experts	The NGO ENDA and the development cooperation partner	The local authority and international experts	The local authority, the provincial operator and Brazilian experts			National public decision-makers	National public decision-makers
Were non-conventional sewers included in national standards?	No (they were added subsequently)	No (they were added subsequently)	Adopted at around the same time	Yes	Yes	No (they were added subsequently)	Yes			No (they were added subsequently)	No (they were added subsequently)

Table 4: The processes that led to the non-conventional sewer option being selected

There are two main types of selection process used:

The sanitation strategic planning approach

Developed for the whole town or sometimes only low-income outlying areas with no sanitation service, this approach consists of **considering all areas, profiling their physical, socio-economic and urban characteristics, then usually proposing a variety of service options.**

Service development is planned in **phases:** immediate, priority needs; short to medium-term needs; and development over the longer term, etc.

This approach sometimes forms part of a **wider slum improvement scheme**: Fondation Droit à la Ville in Senegal, *saneamiento integral* in Brazil, etc.

The 'project' approach

The 'project' approach focuses on one particular area (neighborhood). The project runs for a specific period of time (usually two to three years) that generally covers the design and implementation phases only. At the end of the project, responsibility for the non-conventional sewer is transferred to the relevant local stakeholder.

However, these two approaches are not mutually exclusive as most 'projects' are designed to conform to local sanitation master plans.

Who are the decision-makers?

It can be seen from the table above that the decision to select the non-conventional sewer option is often made by '**technicians' or even foreign experts attached to local institutions**.

The future managers of the service – primarily local authorities – have no or little involvement in the decision-making process, despite the considerable urban planning, financial and social challenges, etc. that the selection of a non-conventional sewer presents. Although the majority of service development approaches advocate the need for 'consultation', discussions with supply and demand stakeholders (not only local authorities, but also the users, the public operator where relevant, and the private sanitation sector, etc.) to select the service option are rare. This no doubt partially explains the frequent misunderstandings about roles and responsibilities and the lack of ownership often seen during the subsequent management phase *(see Part 7. How are non-conventional sewers managed?).*

In contrast, for some approaches, 'participation' in the decision-making process – particularly by future users of the service – is a prerequisite for the development of any type of sanitation service *(see Part 5. What user-focused activities have been developed?).*

How much consultation takes places with all parties?

- **sanitation is a public policy**: as the party responsible for the service 'framework' (contracting authority), local decision-makers ensure consistency with other policies and sustainability of the service;
- the role of **users** is also key as, in addition to being beneficiaries, they also provide part of the funding (mainly for operating the service) and often also carry out maintenance;
- the **private sanitation sector** (which is often informal) has a sound understanding of sector issues and could ultimately be appointed to operate the system;
- there are **national, provincial or municipal public operators** in a number of countries in Africa (ONEA, ONAS), as well as in Brazil. These operators can either act as contracting authority or operate the service. Thus, their full involvement in the selection process is vital. It is imperative that operators contribute their technical knowledge and understanding of sector issues.

However, most 'projects' fail to include any stakeholder involvement in the selection process (consultation), resulting in a **serious lack of ownership or outright rejection of the project by these same stakeholders during subsequent phases.**

Were non-conventional sewers included in national standards?

The response to this question enables us to determine whether the 'non-conventional sewer' option was chosen as a one-off local pilot initiative or as part of a wider strategy.

Non-conventional sewers are now included in most of the countries' national sector standards. In many cases, they were adopted in the standards after the initial pilot initiatives, during attempts made to scale-up use of the option with support from international donors (who fund and drive the national strategies): Senegal, Mali, Ghana, etc. *(please see the case studies in the Annex).*

It is interesting to note that, despite the Ramagundam pilot initiative being largely unknown or forgotten in India, non-conventional sewers are included in the country's national standards. The 'non-conventional sewer' option has, however, been included in large-scale projects funded by the World Bank or bilateral development cooperation (GIZ with the NGO Borda) *(please see the case studies in the Annex).*

The situation in Brazil is unique in that each federal state sets its own standards. **The state in which condominial sewerage has been deemed a success (the Federal District that includes the capital, Brasilia, and its region) has adopted this option as the 'single standard'.** In the two other states studied, Bahia (Salvador) and Pernambuco (Recife), condominial sewerage is also included in the standards, but as one of several options. According to specialists in Brasilia, this is one of the challenges facing the condominial option in these two states: presented as a 'low-cost' standard for the *favelas,* condominial sewerage is mostly overlooked by engineers and often considered to be a 'third-rate' service by users *(please see the case studies in the Annex).*

III. User demand

	Ramagundam, India	Rufisque, Baraka & Yoff (ENDA), Senegal	PAQPUD ONAS, Senegal	Darou/Saint Louis, Senegal	Cayar, Senegal	Asafo Kumasi, Ghana	Salvador de Bahia, Brazil	Recife, Brazil	Brasilia, Brazil	Bamako, Mali	Mopti, Mali
Users' level of income/socio-economic category and capacity-to-pay	Low to middle-income	Very low to middle-income	Low to high-income	Low to lower-middle income	Low-income	Low to middle-income	Low to middle-income	Low-income	Low to high-income	Low to middle-income	Low to middle-income
Housing occupancy status: tenant or homeowner	Homeowners	Homeowners and tenants	Homeowners and tenants	Homeowners	Homeowners	Homeowners and tenants	Homeowners and tenants	Homeowners and tenants	Homeowners and tenants	Mostly homeowners	Mostly homeowners
Water consumption/ inhab/day and projected trends	60 to 100l	20 to 50l	30 to 150l	?	20l	60-100l	Approx. 100l on average	Approx. 100l on average	Approx. 100l on average	Approx. 20l on average	Approx. 40l on average
What type of sanitation service was previously in place?	Open defecation	On-site In Baraka: open defecation	On-site	On-site	On-site	Bucket toilets, on-site, evacuation through stormwater channels	Evacuation through water pipes	On-site with manual pit emptying	On-site	On-site (soakaways)	On-site (soakaways)
Was a demand assessment carried out?	?	Yes, but users don't seem to have been given the opportunity to choose the option	Yes, but did not include opportunity to choose the option	Yes, but did not include opportunity to choose the option	Yes, but did not include opportunity to choose the option	Yes, but did not include opportunity to choose the option	Yes, but did not include opportunity to choose the option	Yes, but did not include opportunity to choose the option	Yes, but did not include opportunity to choose the option	Yes	Yes
What were the outcomes of demand indicators during the operating phase?	Inhabitants very satisfied, 100% connected High willingness-to-pay	Inhabitants claim to be satisfied Sluggish connection rate (due to lack of resources only?) Moderate willingness-to-pay	GPOBA program enabled 100% connection rate to be achieved Moderate willingness-to-pay	Connection rate steadily increasing Users satisfied Moderate willingness-to-pay	Not yet in service	Users satisfied 100% connection rate took time to achieve Moderate willingness-to-pay	Users fairly satisfied 100% connection rate (mandatory) Moderate willingness-to-pay	Users fairly satisfied 100% connection rate (mandatory) Moderate willingness-to-pay	Users very satisfied 100% connection rate (mandatory) High willingness-to-pay	?	

Table 5: Profile of local sanitation demand

How to assess user demand

For more information on demand and demand assessments, please see the guide: How to analyze the demand of current and future users for water and sanitation services in towns and cities in Africa, pS-Eau - MDP, 2011.

(Also see Part 5. What user-focused activities are developed?).

Box 6: What is meant by 'user demand' in relation to sanitation?

"The concept of demand refers to need, but results from an expression of willingness by the population to cover its own needs. The population's expression of need is inevitably subjective as each population has its own priorities in terms of both consumption and solvency (budget priorities)".

Preference for one particular type of service thus depends on the variables specific to each option, notably as regards **availability, reliability, cost and comfort** for the user. It is through this preference that user demand is assessed.

(Source: How to analyze the demand of current and future users for water and sanitation services in towns and cities in Africa, pS-Eau - MDP, 2011)

A set of objective criteria

A set of 'objective' criteria is used to ascertain the users' standard of living and practices and thus undertake an initial analysis of the 'demand for sanitation', which remains entirely theoretical at this stage. A variety of different criteria may be used; however, some of the main criteria include:

- the users' **level of income**/socio-economic category and thus the capacity-to-pay for any future service;
- the housing occupancy status**: tenants or homeowners;**
- **water consumption per inhabitant per day** and projected trends;
- **the type of service previously in place** and satisfaction with this service.

In Africa and Latin America, non-conventional sewers can be used by both **very poor and upper middle-class households** alike**.** The level of comfort offered is considered equal (or very nearly equal) to that provided by conventional sewerage. However, this is only on the condition that the fee and operating fee (sanitation tax) are set at levels that the poorest households can afford (meaning they are often subsidized).

The housing occupancy status can influence demand as, in theory, a homeowner will be more inclined to invest in a connection. However, in Rufisque (Dakar) in particular, a number of **landlord-tenant arrangements** have been made in which the connection fee is paid through rent adjustments. In Dakar and Brazil, local stakeholders also acknowledge that a sewer connection can increase property values, leading to gentrification of the areas covered.

Consumption levels vary considerably according to the type of social category involved: from 20l/c/d in the low-income areas of Dakar to 200l/c/d in certain high-income districts of Latin America. However, given the (frequent) lack of household meters, consumption levels are based on figures provided by the operators, who often calculate an average volume per inhabitant 'injected' into the system. These figures rarely include losses, which can be as high as 50 to 70%. The volume consumed, and thus the volume of wastewater discharged, is therefore significantly lower than stated.

It is clear that user demand for an improved service is higher in areas where users have previously never had access to a sanitation service (for instance Ramagundam, India, or Baraka, Dakar) or where this service has presented significant challenges (notably in terms of costs, as in Rufisque, Senegal).

User consultation

In addition to an analysis using 'objective' criteria, a demand assessment may also include a user consultation phase during which users are presented with a 'catalog' of the types of sanitation service available. This consultation thus involves:

- an information phase to present the various options along with the advantages and disadvantages of each;
- **collecting the stated preferences** and stated willingness to pay and undertake maintenance (which will then be formally included in the user contract).

(Please also see Part 5. What user-focused activities are developed?)

Box 7. Can connection be made mandatory?

There are two possible options with regard to connections:

Making connection mandatory, as in Ramagundam, India, where there was very high demand and consensual support for the sewer system within the community. Connection is also mandatory in areas with a sewer system in France and in Vietnam.

Making connection optional and relying on and stimulating growing demand. This is the most commonly used option.

Indicators of long-term demand

In order to assess whether the selected option is continuing to satisfy user demand after several years of operation, there are a number of indicators that can be used. For example:

- user satisfaction (or, conversely, the number of disconnections);
- connection rate trends;
- the number of illegal connections (which indicates an interest in the service);
- sanitation fee recovery rate (willingness-to-pay).

The majority of users interviewed are satisfied with the service, in which wastewater is nearly always appropriately transported away from the property, and there have been no reported cases of mass disconnections. The (frequent) service malfunctions (leaks, clogging, lack of suitable treatment) mainly affect public areas (pollution, flooding) and thus impinge on users less than if problems were to occur inside the home.

If the connection rate starts to stagnate or is slow to take off, this is most likely because the connection rate is too high or there is no operator managing these connections.

Illegal connections, of which there are many in Dakar and Salvador de Bahia, are a common complaint; although these can endanger the financial and technical viability of the sewer, they also reflect a high demand for connections.

Sanitation fees seem to have been widely accepted by people in Africa as they are substantially lower than the cost of pit emptying (however, these fees are rarely able to ensure the financial sustainability of the service as they are hardly ever collected).

In Brazil, sanitation fees equate to 80% of the water bill and are frequently cited as being too high for lower-income households to afford. In many cases, even where the operator has directly taken over management of the sewer to remedy the lack of user maintenance, the initial 'condominial' fee of 45% has been retained (Salvador de Bahia) - often for political reasons.

Box 8: Do non-conventional sewers always help improve public health?

Yes, in areas with no previous sanitation solution (India) and where they replace open defecation.

Yes, when they are well-designed and replace poor quality on-site facilities (Ghana). This has been demonstrated in epidemiological impact assessments carried out in Pakistan and Brazil (Bahia Azul program, Salvador).

No, when the service level is very poor. Thus, on some non-conventional sewers in Africa, clogged sinks and grease traps near living spaces have become breeding grounds for parasites, as have poorly positioned greywater collection facilities (inside narrow compartments rather than outside). Further downstream, if there are no or only inefficient treatment solutions, the build-up of wastewater at the outlet poses just as great – if not greater – a hazard as the previous method of greywater discharge and sludge disposal used.

In areas where inhabitants previously used open channels (Brazil), users can be reluctant to pay for a service that they don't necessarily feel they need. However, **demand for the service increases in line** not only **with population growth** and thus the additional inconvenience of bad smells, but also with regeneration of the area and improvements in standards of living/education, which leads to heightened awareness of public health and hygiene issues.

IV. Physical context

	Ramagun-dam, India	Rufisque, Baraka & Yoff (ENDA), Senegal	PAQPUD ONAS, Senegal	Darou/Saint Louis, Senegal	Cayar, Senegal	Asafo Kumasi, Ghana	Salvador de Bahia, Brazil	Recife, Brazil	Brasilia, Brazil	Bamako, Mali	Mopti, Mali
Gradient	Moderate	Moderate to low	Moderate to low	Moderate	Low to moderate	Moderate to high	High	Low to moderate	Low to moderate	Moderate to low	Low
Soil type	?	Rocky in Baraka	Rocky, Low permeability in certain cases	?	Sandy	Poor percolation	Sandy	?	?	?	Sandy, sandy clay
Hydraulic environment	River, monsoon	Near-surface water tables, coastal area	Near-surface water tables	?	Near-surface water tables Coastal area	?	?	?	?	Near-surface water tables Nearby river	Near-surface water tables Nearby river

Table 6: The different physical contexts in which the non-conventional sewer has been implemented

Gradient

According to the literature, the minimum gradient required is:

- 1% for simplified sewerage;
- 0.5% for settled sewerage (which transports less viscous liquids).

However, these are theoretical gradients estimated using fluid flow calculations that do not appear to take into account the inevitable intrusion of solid matter, such as sediment, solid waste, or sludge overflow from non-emptied settling tanks.

Thus, in the field studies, **those systems with fewest clogging problems are often also those with the highest gradient (Kumasi, Ramagundam)**. In contrast, settled sewers in Africa, although designed to ensure proper flow over land with low gradients, are prone to frequent clogging (further aggravated by more restrictive urban environments: lack of solid waste and stormwater management services, unpaved roads, etc).

Geological context

Non-conventional sewers are the preferred option for certain geological and hydrological conditions where on-site sanitation is not possible due to:

- the **poor infiltration of effluent from septic tanks** (rocky or impermeable soil);
- the **presence of a water table**, nearby sea or river that can flood the pits, meaning these require emptying more frequently.

Type de Sols	Taux d'infiltration l/m²j	Bac à Laver Puisard	VIP	TCM	Fosse Septique	Fosse Etanche	Réseau petit diamètre
Type 1 : ***sols argileux à engorgement temporaire*** ;	<10					XX	XX
Type 2 : ***sols lessivés à capacité d'infiltration faible*** ;	10 à 15	x	x	x	x	XX	XX
Type 3 : ***sols très filtrants*** ;	> 50	XX	X	XX	XX		
Type 4 : ***sols filtrants à risque de pollution de la nappe faible***	30 à 45	XX	X	XX	XX		
Type 5 : ***sols ferrugineux non lessivés à bonne capacité d'infiltration***	25 à 35	XX	X	XX	XX		
Type 6 : ***sols rocheux***	< 15					XX	XX
Type 7 : ***sols hydromorphes des NIAYES***	0						X
Type 8 : Sols calcaires et vertisols	< 20	x	x	x	x	X	X
Type 9 : sols caillouteux et sols ferrugineux de Diass	20 à 25	x	x	X	X	XX	XX

Table 7: Matrix used to select technological options based on soil type in Dakar as part of the PAQPUD program *(Source: service assainissement autonome, ONAS, in Toubkiss, 2007)*

Category	Percolation		Loading (liters/m2/day)	Localities
	Description	Rate (mm/hr)		
A	Very High	50	40	Kwadaso, Fanti New Town, Zongo, Akrom, Oforikrom (Part)
B	High	36-50	22-35	Oforikrom (Part), Bomso, Anloga, Dichemso, New Tafo, Ashanti Newtown
C	Moderate	21 and 35	8-22	**Asafo (part)**, Anou (Prempeh College Area), Subin Valley (Adum)
D	Low	20	8	Asokore Mampong, Nima

NB: The percolation rates were used to categorize (and map) housing areas and the type of feasible sanitation technologies

Table 8: Soil percolation tests in different areas of Kumasi, Ghana *(source: TREND Group, 2001)*

Does the non-conventional sewer enable preservation of the water resource?

A further argument often used in support of sewer systems is that **pit effluent can pollute the sub-soil and water table** in highly built-up areas. In both Dakar and Dar-es-Salaam, Tanzania, the high density of on-site sanitation facilities has led to pollution of the water table *(see the following page).*

However, the extent to which these sewer systems are 'watertight' is often relative. Although no reliable impact assessments have ever been carried out (due to complexity and cost), both water infiltration into the sewers and wastewater seepage into the water table is highly likely. This sealing of the sewers is also an issue in Northern countries (interview with Stéphane Clayette). Furthermore, the presence of near-surface water tables generates both problems and additional costs during implementation.

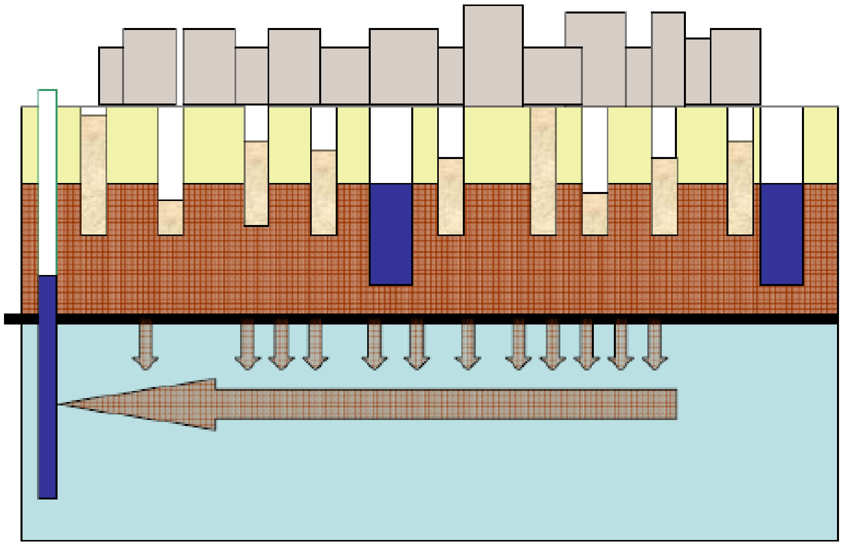


Figure 5: Pollution of the water resource by septic tank effluent in urban areas *(Source: Steve Sugden - London School of Hygiene and Tropical Medicine)*

V. Urban context

	Ramagundam, India	Rufisque, Baraka & Yoff (ENDA), Senegal	PAQPUD ONAS, Senegal	Darou/Saint Louis, Senegal	Cayar, Senegal	Asafo Kumasi, Ghana	Salvador de Bahia, Brazil	Recife, Brazil	Brasilia, Brazil	Bamako, Mali	Mopti, Mali
Building and population density	Moderate to high	Moderate to high	Moderate to high	Moderate to high	Moderate to high	High	High	High to moderate	Low to moderate	Moderate to high	High
Type of housing	Single-family houses; max. 1 storey	Single-family houses; max. 1 storey	Single-family houses, some shared housing blocks	Single-family houses; max. 1 storey	Single-family houses; max. 1 storey	Shared housing blocks, up to 4 floors	Single-family houses, small shared housing	Single-family houses, small shared housing	Single-family houses, small shared housing	Single-family houses, small shared housing	High proportion of multi-storey housing
Land tenure status	Legalized	Informal (Baraka) or legalized	Legalized	Legalized	Legalized	Legalized	Legalized	Legalized	Legalized	Legalized	Legalized
Urban morphology	Somewhat winding streets	Somewhat winding streets	Somewhat winding streets	Regular streets	Somewhat winding streets	Regular streets	Very narrow, winding streets	Somewhat winding streets	Regular streets	Somewhat winding streets	Regular streets
Population growth and area development process	High growth at time decision was made	High growth	High growth	High growth	High growth	High growth at time decision was made	High growth	High growth	High growth	High	High (3.24%/year)
Is there conventional sewerage?	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes
Solid waste collection service?	Yes	No (or very poor)	Very poor	No (or very poor)	No	Yes	Yes	Yes	Yes	Yes	Yes
Road surfacing?	Yes	No	Rarely	No	No	Yes	Yes	Yes	Yes	Yes	Yes
Stormwater drainage?	Yes	No	No (or very poor)	No	No	Yes	Yes	Yes	Yes	Yes	Yes

Table 9: Urban contexts in which non-conventional sewers have been implemented

The type of urban context is not an absolute determining factor as non-conventional sewers have been adopted in **extremely densely populated and built-up areas** (the *favelas* of Brazil or informal settlements of Dakar), as well as high quality residential areas on the outskirts of Brasilia and in rural villages in India. However, **an area's population density does tend to increase the number of connections to sewer length ratio, thus reducing overall unit costs.**

In **extremely built-up areas** (such as the *favelas* of Brazil or Baraka slum in Dakar), it is difficult for households to install a septic tank due to lack of space. As a result, sewers are the preferred option (although, in Baraka, these are connected to shared septic tanks).

Districts with multi-storey housing (a maximum of 3 to 4 floors) are connected to non-conventional sewers in Brazil, Ghana and Senegal.

The sewers are generally designed to last **20-30 years** (which is also the widely accepted lifespan of small-scale schemes) and sized in accordance with the demographic trends contained in urban development plans (where these exist). In terms of hydraulic capacity, Brazilian experts consider that their pipe diameters of 110mm to 150mm are suitable for the majority of schemes and never get overloaded. Increasing the pipe diameter helps prevent clogging by solid waste.

In towns with **conventional sewerage**, some non-conventional sewers are able to connect to this sewer outlet, which is a less costly option than building a decentralized treatment plant. In addition, there is often already a 'culture' of sewer operation within the system operator's organization *(see also paragraph VII of this section: What operating capacities are required?).*

Except in those rare cases where a non-conventional sewer project is initiated by an NGO independently of the local authorities (Baraka in Dakar), all **land tenure issues** need to be resolved – even temporarily – and the district officially recognized by the authorities prior to any non-conventional sewer development taking place.

Lastly, non-conventional sewers are extremely vulnerable to external forces *(see also the section on managing non-conventional sewers*):

- damage from vehicles (unpaved roads);
- exposure through stormwater erosion (unpaved roads);
- stormwater intrusion;
- sediment intrusion (notably through manholes, with or without stormwater);
- clogging caused by solid waste.

As a result, the most technically sustainable initiatives have proven to be those which included not only sanitation, but also work on road, stormwater management and solid waste collection services: Kumasi (Ghana), Ramagundam (India) and cities in Brazil. In contrast, projects that failed to adopt a 'holistic' approach to urban development (such as those in cities in Senegal and Mali) have encountered serious operational issues.

VI. What are the actual costs compared to those of other options?

	Ramagundam India	Rufisque, Baraka & Yoff (ENDA), Senegal	PAQPUD ONAS, Senegal	Darou/Saint Louis, Senegal	Cayar, Senegal	Asafo Kumasi, Ghana	Salvador de Bahia, Brazil	Recife, Brazil	Brasilia, Brazil	Bamako, Mali	Mopti, Mali
Cost of the hard components	**166**	**625**	**762**	**?**	**1,000**	**Approx. 96 euros (cost in 1990)**	**?**	**685 to 4,000**	**120 to 170**	Between 200 and 300 euros	**?**
Cost of the soft components	**?**	**?**	**Around 250**	**29% of the total**	**163**	**?**	**?**	**?**	**?**	**?**	**?**
Method of financing	**Local authority + ODA + users**	**ODA**	**State + users**	**ODA + state + users**	**ODA + local authority**	**Local authority + ODA**	**State + local authorities**	**State + local authorities**	**State + local authorities**	**State + users**	**State + users + local authority + ODA**
Cost per connection to conventional sewerage	**?**	**50 to 100% more expensive**	**50 to 100% more expensive**	**50 to 100% more expensive**	**50 to 100% more expensive**	**50% more expensive**	**50 to 100% more expensive**			**?**	**?**
Cost per connection to on-site sanitation facilities	**?**	**50 to 70% less expensive than non-conventional sewer**	**50 to 70% less expensive than non-conventional sewer**	**50 to 70% less expensive than non-conventional sewer**	**50 to 70% less expensive than non-conventional sewer**	**?**	**?**	**?**	**?**	**?**	**Around 175 euros for a soakaway**

Table 10: Summary of comparative investment costs for each sanitation chain. All costs are in euros.

What is the average investment cost per connection?

What are the actual reported costs?

It is extremely difficult to conduct comparative studies of investment costs as:

- there are **very few** (or no) good quality and **in-depth ex-post evaluations** available and very little detailed information on actual project costs;
- estimated costs often only include the '**hard'** component (infrastructure).**Costs for the 'soft' component**: IEC, capacity-building, project management and contracting authority activities **are rarely available**. In the few instances where these costs are available, they vary considerably in accordance with the methods used and the efficiency of the project/project stakeholders;
- **these costs often only include the 'sewer system' element (evacuation segment)** or simply the 'cost of the connection' and fail to take the 'access' or 'treatment' segments into account;
- costs vary in accordance with the **design methods used, any site constraints and the materials selected, etc**. (for example, lift pumps can increase costs by around 100%);
- **the low connection rates** seen on certain systems can distort the unit costs;
- the costs studied are those that were valid at the time (over the last two decades) the system was installed and thus relate to **very different periods.** Furthermore, they do not include variations in the exchange rate or capital costs (interest rates), etc.
- lastly, the use of **international funding** (ODA) automatically inflates project costs;
- etc.

Thus, the cost per connection can range from **under 100 euros** (OPP in Pakistan, DEWATS in Indonesia, etc.) to **over 1,000 euros** (certain projects in Senegal), with an average of around 500 euros per connection 'all inclusive' (hard + soft, access + evacuation + treatment).

In Africa, these costs are particularly high (as they are for on-site sanitation facilities). However, experience in Latin America and Asia suggests that it would be possible to progressively reduce these costs by developing the technical engineering and project management capacities of African stakeholders.

Non-conventional sewer investment costs compared to conventional sewerage

Due to the fact that it has been 'simplified', **in terms of cost per connection, the non-conventional sewer is always cheaper than conventional sewerage.** In nearly all cases, costs are recognized as being **between 30 and 50% lower**.

However, the lifespan of each system is not the same. When correctly designed and implemented, the lifespan of a non-conventional sewer is considered to be around 25-30 years, which is consistent with that of the systems in Ghana and Brazil, the oldest sewers studied here. Yet, it is also acknowledged that the lifespan of conventional sewerage is at least twice that (there are even some in Europe and Latin America that are over a hundred years old).

Thus, spread over its lifetime, the non-conventional sewer is not necessarily 'cheaper' than conventional sewerage, but instead is more of a shorter term investment. This medium-term investment tends to be made in areas with substantial and pressing needs and where there is less 'visibility' with regard to population growth and urban development.

It is also an investment made in areas where capital costs (interest rates) are likely to increase, as was notably the case in Brazil in the 1990s, a period during which condominial sewerage was developed on a large-scale.

Compared to on-site sanitation

The 'actual' costs of on-site sanitation are also rarely available or only very roughly estimated (often including only the cost of latrine construction, disregarding both the evacuation and treatment segments and the 'soft' components) and vary widely according to the context.

In Africa, it would appear that the investment cost per household for a non-conventional sewer is still around 50 to 100% more expensive than that for on-site sanitation.

However, in certain contexts, such as in highly built-up areas that enable a good sewer length to connection ratio and where project stakeholders have sound technical knowledge, **it is possible for non-conventional sewers to compete with**

the cost of on-site sanitation. This was the case in Brazil, for example *(see the figure below. However, it is likely that the 'evacuation' and 'treatment' segments costs of on-site sanitation were not included).*

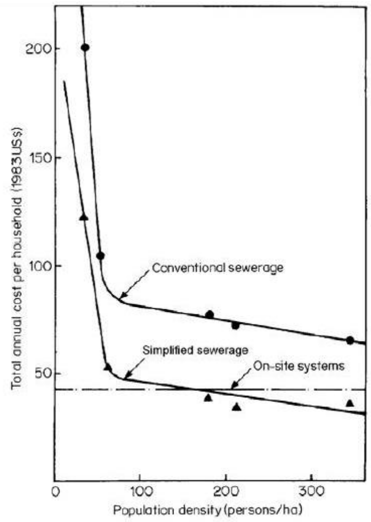


Figure 6: Total annual costs per household sewerage, simplified sewerage and on-site sanitation in the city of Natal, Northeast, Brazil in 1983. (Source: EVANS B., MARA D., 2011)

Simplified sewerage became cheaper than on-site systems at the relatively low population density of ~160 people per ha. (EVANS B., MARA D., 2011)

How are they financed?

In contrast to on-site sanitation, for which households are largely responsible for financing both the 'access' and 'evacuation' segments (evacuation by paying for pit emptying where this service exists), **sewerage systems are mainly financed by the public authorities.**

In Africa, and in contrast to Asia and Latin America, local authorities very rarely have the financial capacities required to invest in sewerage systems (low fiscal resources, virtually no access to loans, very low budget allocations from the state). The main source of funding is thus the **state** (through a World Bank loan as in Senegal) or **official development assistance** (a number of non-conventional sewers in Senegal and Mali and 50% of the Kumasi non-conventional sewer in Ghana).

Alternatives to non-conventional sewer investment, such as subsidizing all or part of the 'on-site pit emptying' sector, are rarely considered. Yet, by way of comparison, in Senegal, public investment in a non-conventional sewer of 1,000 euros per household would equate to around:

- 16 years of free pit emptying with a 100% subsidy;
- 32 years of pit emptying with a 50% subsidy.

(Based on a median of 2 pit emptying operations per year (above average frequency), at 30 euros per mechanical emptying.)

Box 9 . What mechanisms can be used to finance user connections?

Poor users are rarely able to pay the connection cost in one lump sum. Thus, a number of different mechanisms can be used:

- Payment by installment via the sanitation tax (spread over 36 months in Brazil);
- Revolving fund type microcredit mechanisms, such as that used in Nala, Nepal, where 48% of investment for the sewer was funded by users;
- The connection cost is fully or partially subsidized by the public authorities and/or a development partner.

An 'equitable' investment?

In contrast to the principle of 'universal access' that underpinned the development of the condominial sewerage philosophy in Brazil, **selection of the non-conventional sewer option is often discriminatory** (both in Africa and in Brazil).

For instance, this option, which has high capital costs, is commonly developed as an improved service 'project' that, **instead of developing strategic sanitation planning at city level for all inhabitants, focuses only upon a given area (the 'project approach')**.

Alternatively, this option is selected '**by default**' for unplanned settlements outside the scope of the conventional sewerage development area, such as in Darou Saint-Louis, Senegal and Recife, Brazil, etc. Thus, those users connected to the non-conventional sewer, who are often among the poorest inhabitants, not only have to take on responsibility for (contracting authority), and in places even operate, their sewer, but also sometimes have to pay an additional fee (to which the wealthier inhabitants connected to conventional sewerage are not subjected) and suffer the disadvantages inherent in such a less robust technical solution. This type of situation understandably results in a reduced sense of ownership on the part of the users.

What are the operating costs?

NB: It is important to distinguish here between the fee set by the operator (often substantially lower than the cost borne by the operator) and the actual maintenance costs. Using what little information was available to us, we have endeavored to break down the different maintenance items in the table below.

	Ramagundam, India	Rufisque, Baraka & Yoff (ENDA), Senegal	PAQPUD ONAS, Senegal	Darou/Saint Louis, Senegal	Cayar, Senegal	Asafo Kumasi, Ghana	Salvador de Bahia, Recife, Brasilia, Brazil	Denpasar, Indonesia	Hin Heup Laos	Bamako, Mali	Mopti, Mali
Total/month/connection	?	According to ENDA, 3 euros/month would cover all costs	According to ONAS studies, between 2.5 and 3 euros would cover all these costs	Estimated at 2.6 euros	Estimated at 2.5 euros	1.17 (operator's estimated cost to cover all expenses)	?	0.25 euros (actually covers all costs)	1 euro (actually covers all costs)	?	?
First and second level maintenance	0.5 euros equates to the amount paid by users on a piecemeal basis	?	?	?	?	?	?	?	?	0.25 euros (equates to the amount paid by users for maintenance)	Ad hoc, piecemeal contributions of around 3 euros requested by the operator in the event of problems
Third level maintenance	?	?	?	?	?	?	?	?	?	?	?
Lift pump and station maintenance	?	?	Estimated to be 50% of sewer system operating costs			?	?	?	?	?	?
User relations	?	?	?	?	?	?	?	?	?	?	?
Monitoring & regulation	**?**	**?**	**?**	**?**	**?**	**?**	**?**	**?**	**?**	**?**	**?**

Table 11: Comparison of operating costs

Operating costs

Analyzing and comparing operating costs is extremely complex as:

- operators rarely have a clear picture of these costs (which are often buried within an overall sanitation budget) or are reluctant to release them;
- there are virtually no correctly operated non-conventional sewers (or conventional sewers or pit emptying and sludge treatment sector) in sub-Saharan Africa.

However, at this stage, there is no evidence to confirm that non-conventional sewers are actually cheaper to operate than conventional sewerage.

In Brazil, the costs are considered to be roughly the same, just broken down differently: non-conventional sewers require fewer major interventions (such as cleansing), but more ‘small’ interventions (clogging), as well as social mediation/user relations activities and a stronger presence in the field.

(Please also see Part 7. How are non-conventional sewers managed?).

How to finance operating costs

Users’ socio-economic status does not intrinsically limit the financial sustainability of the service as, like investment, service operation is often subsidized. **The sanitation fees charged are nearly always aligned to the inhabitants’ willingness-to-pay.**

However, in order to ensure their sustainability over the long-term, these funding sources should always be incorporated into adapted mechanisms, through a contractual agreement between all parties, and accompanied by a monitoring and penalty mechanism *(see the final section of this report on non-conventional sewer management).* Yet, in sub-Saharan Africa, this is hardly ever the case as responsibilities are not clearly established and the stakeholders in charge of the system lack the relevant capacities. The exception to this is Kumasi, where the operator sets the tariffs himself, both in accordance with the rules of supply and demand and taking into account an expected recovery rate of around 50%.

VII. What operating capacities are required?

We have identified four levels of operation and maintenance (O&M) *(see Part 7. How are non-conventional sewers managed?):*

- users systematically carry out 1st level maintenance of household equipment (or pay a contractor to do it for them);
- **small, informal private or community-based operators, or even the users themselves, can undertake 2nd level technical O&M,** for which hand tools and technical and management capacities available to small community-based organizations are required (as long as these organizations' capacities are developed accordingly);
- 3rd and 4th level O&M require the skills and resources of **a professional specialist operator with the equipment and permanent staff required for the effective technical and financial operation of the service**.

Therefore, the same (public or private) operator can be put in charge of the entire system (Brazil, Ghana). Alternatively, management responsibilities can be shared among different operators, as in Ramagundam, India, and the ONAS sewers in Senegal.

Clearly, operation becomes more difficult as the size of the system increases (number of connections, sewer length) and as more complex technical options are used (notably the treatment method and where lift pumps are required).

What financial capacities are required?

As far as cost recovery and operating account management (where this exists) is concerned:

- **management is shared**: inhabitants either pay a sanitation fee to a small 2nd level operator or pay on a case-by-case basis whenever there is a breakdown. A 'large' operator covers the cost of 3rd and 4th level O&M through a separate operating account;
- or there is a **joint operating budget for these 3 levels** that is managed by the same operator.

Regardless which of these methods is used, it is vital that there are **accounting knowledge and tools (account books, receipts, user contracts, etc.)** and sound management procedures in place; however, apart from Kumasi and, to a lesser extent, Darou-Saint Louis (Senegal), for the majority of systems in Africa, this is not the case.

What monitoring and regulation capacities are required?

Regardless of the context, assigning the tasks of monitoring and regulation, and thus responsibility for the service, to the users alone on the basis of their goodwill has almost always resulted in failure *(also see the following section: Is it possible to assign all or part of non-conventional sewer management to users?).* As for operating the service, **if responsibility (contracting authority) for the service is to be assigned to the 'community' of inhabitants connected to the system, this community needs to be properly organized** (into a formal association in which the managers are compensated for the time spent on ensuring reliability of the service) and its monitoring capacities improved.

This **responsibility can also be shared with the municipal technical department (or other legitimate and qualified public entity**, such as the national sanitation operator) as is the case in Darou/Saint-Louis (Senegal). Alternatively, this department/operator can take over full responsibility (as in Brazil or Kumasi, Ghana).

VIII. Is it possible to assign all or part of non-conventional sewer management to users?

A common feature of all approaches: "ensure communities are at the heart of the project"

The aims of this user involvement are to:

- **foster user ownership of the systems** and, thus, their use of 'good practice' with regard to maintenance and fee payment;
- **compensate for local authority shortcomings** in urban services management;
- **empower** (notably poor) 'communities' to take charge of 'their own' problems.

In fact, the **'community-based' non-conventional sewer management methods implemented in Senegal, Mali, Brazil and Indonesia have all shown signs of weakness**, resulting in unsustainable sanitation services that tend to deteriorate rapidly.

> **Box 9: What is 'community-based management'?**
>
> 'Community-based management' is a term often used in relation to both small rural and urban water schemes and non-conventional sewers.
>
> It is first necessary to define what is meant by 'community': do the inhabitants of an area necessarily constitute a homogeneous, consistent and organized community? Experience in both Brazil and Pakistan has shown that there is high residential turnover even in low-income areas and that community representatives often disappear after a few years. This is where urban centers differ from rural areas.
>
> Secondly, does 'community-based management' mean:
>
> - 'community-based contracting authority', as in Indonesia (DEWATS), Senegal (in theory), Colombia, etc.?
> - Or 'community-based operation'? This means that the users themselves are responsible for maintaining the system, as in Darou Saint-Louis (Senegal) and as was initially the case in Brazil (guides and tools were even handed out to users), etc.

Is 'community-based management' unsuitable or merely 'poorly implemented'?

After having reviewed project documents, methodological guides and field work, it has become apparent that there are very few detailed 'community participation' methodologies available. Thus, there are also no answers to the following questions:

- does '**community-based management**' mean '**contracting authority**' (purely community-based or shared with the local authority and potentially another stakeholder) or '**operation**'? Or both? (*See box opposite).*
- what tasks are users actually able (or unable) to carry out?
- how is **a non-conventional sewer users' association set up**? How are roles allocated internally? What procedures and resources are required and how can capacities be developed?
- **what type of contract** should be put in place between the association and the users and between the association and its other partners?
- etc.

This is one of the reasons why operators took over responsibility for condominial sewerage in Brazil. Management of these systems was initially assigned to poorly organized inhabitants' groups, with a little 'social' monitoring. However, these groups were unable to properly manage the systems and were constantly requesting assistance from the provincial operator.

This lack of organization and capacity-building also largely explains the major recurring difficulties encountered on non-conventional sewers in Senegal and Mali, and on DEWATS in Indonesia (although efforts are now being made to organize the users' associations managing DEWATS into a national federation and provide them with a back-up support and capacity-building program), etc.

There are thus two options:

1. Conclude that community involvement is inadequate and dismiss it.

Yet, what happens when **local authorities have extremely low capacities and there is no sanitation operator**, as in Indonesia or Nepal? Or when the national operator is in financial difficulty and refuses to taken on management of the systems (as in Senegal)?

In order to delegate management to the private sector, there needs to be a pool of qualified professional operators, as well as supervision by a contracting authority capable of monitoring and regulating the contract. However, in most cases, it is not possible to meet all these conditions locally.

2. Continue to seek user involvement in the operational phase

Thus, also helping users to **organize themselves into groups and to clarify not only their roles but also those of the local authority and other stakeholders, as well as providing them with capacity-building, tools and procedures and improving their effectiveness and transparency.**

This is the approach most commonly used for managing small drinking water schemes in rural and some peri-urban areas. It is also the approach advocated by SANDEC in Nepal and Tanzania and by Cinara Cali in Colombia for small-scale sanitation services (apparently with success). In addition, it is being considered by the Darou non-conventional sewer management committee in Saint-Louis (Senegal) and by increasing numbers of DEWATS users' associations in Indonesia.

XI. Conclusion: to which contexts are non-conventional sewers best suited?

The non-conventional sewer is probably never the only possible sanitation option. Instead, its use stems from a desire to offer an improved sanitation service in areas where conventional sewerage is not possible.

There is no one single determining factor for selecting the non-conventional sewer, but rather a range of factors that combine to support this option:

Opportunity:

- ***when on-site sanitation is no longer an option…;***
- ***when conventional sewerage remains impossible…;***

Conditions of equity:

- ***when a local sanitation strategy facilitates the equitable development of appropriate services for the entire population of the town;***

Conditions of success:

- ***when stakeholder consultation has resulted in each stakeholder committing to the project in full awareness of the advantages and disadvantages of the option;***
- ***when the option forms part of an approach that includes land regularization, stormwater management, road paving and solid waste collection programs;***
- ***when the service comes under the responsibility of a contracting authority that has a specialized department able to carry out technical and financial monitoring and implement corrective action (including penalties for both the operator and users);***
- ***when responsibility for the service can be allocated to a specialized operator with financial and technical management skills and user relations experience.***

Is the non-conventional sewer a suitable option for sub-Saharan Africa?

Given both the required conditions outlined above and the frequently low technical, financial and organizational capacities of the majority of contracting authorities in sub-Saharan Africa, **the window of opportunity for non-conventional sewers in Africa would appear to be extremely small.**

However, the 'success stories' reported to date, such as that of Kumasi, not only give us cause for optimism and but also provide us with examples of different possible approaches. Indeed, a water and sanitation practitioner's level of expertise is not fixed. **The capacities of the contracting authority, technical supervisory body and operator can and should be improved.** To achieve this, it is necessary to commit sizeable resources, use methodologies that are precisely tailored to the needs of the target organization and **recognize that this capacity-building is required over the long-term, over timescales that far exceed the infrastructure construction phase.**

Part 4. What does the technical design include?

I. What technical options were used for the 'access' segment (wastewater collection)?

	Ramagundam, India	Rufisque, Baraka & Yoff (ENDA), Senegal	PAQPUD ONAS, Senegal	Darou/Saint Louis, Senegal	Cayar, Senegal	Asafo Kumasi, Ghana	Salvador de Bahia, Brazil	Recife, Brazil	Brasilia, Brazil	Bamako, Mali	Mopti, Mali
Wastewater collection facilities	Showers, toilets and domestic utility sinks	Showers, toilets and shared or domestic utility sinks	Showers, toilets and domestic utility sinks	Showers, toilets and domestic utility sinks	Showers, toilets and domestic utility sinks	Showers, toilets and domestic utility sinks	Domestic showers and toilets	Domestic showers and toilets	Domestic showers and toilets	Domestic utility sinks	Domestic utility sinks
Settling system?	No	Yes, individual household or shared settling tanks	Yes, individual household settling tanks	Yes, individual household settling tanks	Yes, individual household settling tanks	No	No	No	No	Yes, shared settling tanks	?
Grease trap?	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Table 12: The different wastewater collection facilities used

Wastewater collection facilities

These facilities include pour-flush or flush toilets (for wealthier households) for blackwater, showers and utility sinks or sinks (with a screen to trap solids) for greywater.

In some areas (of very high population density and/or in the poorest settlements), the access segment consists of **shared facilities, such as communal utility sinks and laundry tubs** (in Yoff and Baraka) or toilet blocks that contain both toilets and showers (in Baraka and in pilot projects currently being implemented in Nairobi, Kenya).

These facilities need to be fitted with a U-bend that acts as a seal against odors and prevents the back up of drain matter. The experts interviewed also stressed the importance of ventilation to reduce smells ('chimney').

Internal pipework consists of PVC, lead or aluminum pipes. The outlet diameters used range from 4 to 7cm.

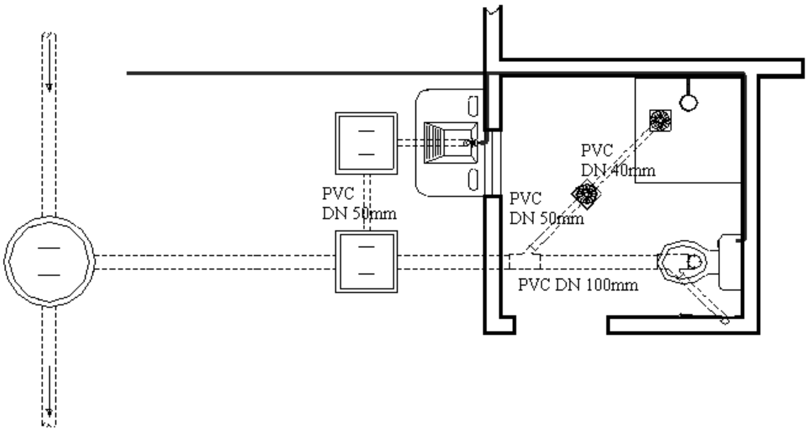


Figure 7. Plan of the 'basic sanitation module' used in El Alto, Bolivia *(source: VINCENT I, Suez Environnement, 2001)*

Grease trap

In both Brazil and Africa (particularly those countries where dietary habits mean the cooking water is full of fat), a **grease trap** (or a set of two grease traps) is placed before the settling tank to prevent fat and oil clogging the sewers. (This is also the recommended option used in France for restaurants.)

In Brasilia, it is compulsory for each household to purchase and install a grease trap; however, only around 50% households have done so to date. According to CAESB, fat and grease do not particularly pose a problem for the sewers, but do create issues during **treatment**.

However, some experts (notably the consultancy firms SEMIS, H2O who worked on designing the ONAS sewers in Senegal) consider **this grease trap to be unnecessary as the grease does not solidify in such a hot climate (no blockages) and floats on the surface of the pit above the outlet**. Some of this grease is then digested and the remainder removed when the pit is emptied.

If not properly maintained by households (as is very common), grease traps can become particularly **vulnerable elements of the sewer system** (blockages that become breeding grounds for infection).

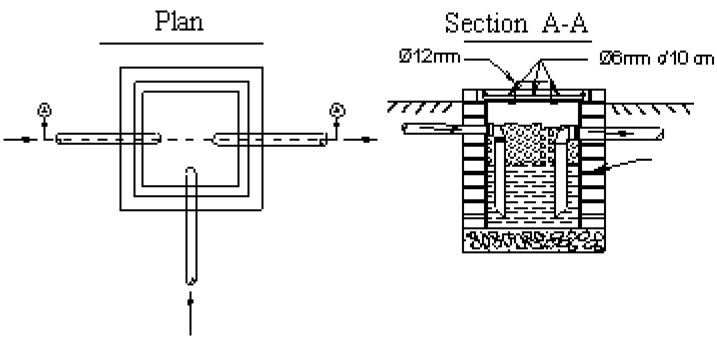


Figure 8: Plan and cross-section of a grease trap. (Source: VINCENT I., Suez Environnement, 2001)

For settled sewerage: settling tanks

Also known as 'septic tanks' (even though there is no system to enable infiltration of effluent into the soil), these tanks are used to separate the solid sludge from the wastewater on settled sewer systems. There are two types of tank: household or shared (common) settling tanks.

The use of a T-pipe at the tank entrance and exit is recommended to prevent solids entering the settling tank.

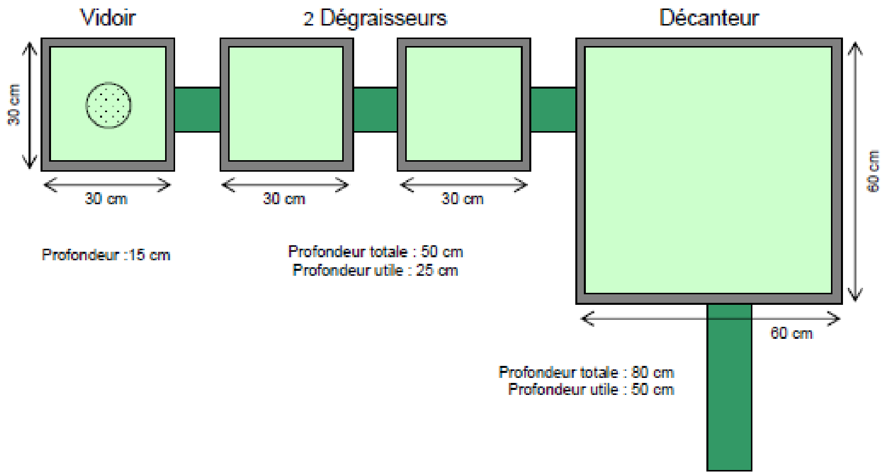


Figure 9: Plan view of household facilities used on settled sewer systems in Senegal (source: ENDA RUP)

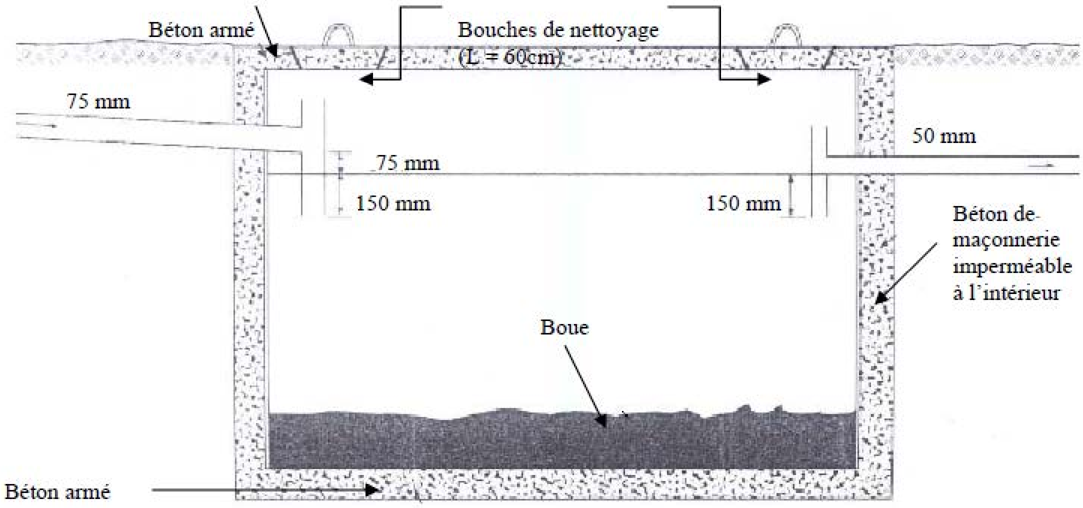


Figure 10. Cross-section of a settling tank used in Senegal (source: ONAS)

Some observations indicate that settling tanks may be **over-sized**, as is the case on the ONAS settled sewerage systems in Dakar where the settling tank in Ngor has not needed emptying in eight years. However, there is likely to be a large amount of anaerobic digestion taking place in the tank (as seen in Pakistan by K. Tayler). Whilst this is a good thing, it can also lead to complacency with the necessary checks and budgeting being overlooked, ultimately increasing investment.

'Condominial' (shared) settling tanks

The use of these tanks has been piloted in Brazil, Mali (Bamako) and the Yoff and Baraka districts of Dakar (Senegal). According to ENDA, these settling tanks require little maintenance and only infrequent emptying (the tanks in Yoff have not been emptied in 10 years; however, there are only around thirty households connected).

In fact, they are very similar to the settling tanks used at the end of the sewer line as the sole treatment option in Ramagundam (India), or as a pre-treatment stage for DEWATS and other intensive anaerobic treatment plants (Dakar ONAS, etc.).

Although it is not possible to conduct a price comparison, it is highly likely that the **investment cost of condominial settling tanks is lower than that of individual tanks (economies of scale).** Furthermore, they are located on public land, which is an advantage in densely populated neighborhoods/small plots. There have been no reports of either bad smells or opposition from local residents.

SANDEC also considered using these condominial settling tanks in Egypt. The option proved to be technically feasible; however, for management purposes, they opted instead to use a single, centralized reactor for the final treatment process. Indeed, they decided that it would be easier to clearly define responsibility for and monitor treatment if all treatment options were concentrated in one place, rather than dispersed across different neighborhoods.

Conversely, by locating the condominial settling tanks on public land, it is possible **to assign responsibility for these tanks to the operator, thus eliminating problems caused by households allowing their tanks to overflow**.

Connections

These connect household facilities, which are the user's responsibility, to the public sewer. Facilities are connected to the sewer system either by a simple connection (see the diagram below) or through a small inspection chamber, also known as a connection box (which can contain several household connections).

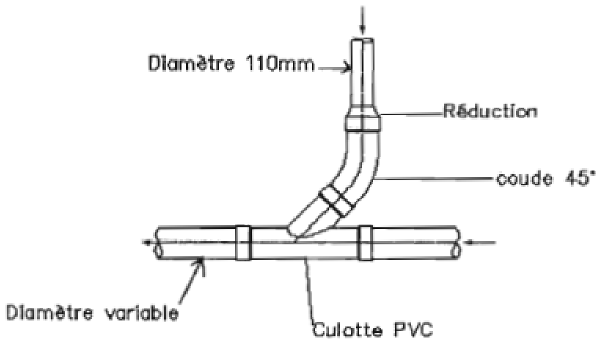


Figure 11: 'Y-shaped' connection used on the ONAS sewer systems in Dakar and Saint-Louis/Darou *(source: ONAS).*

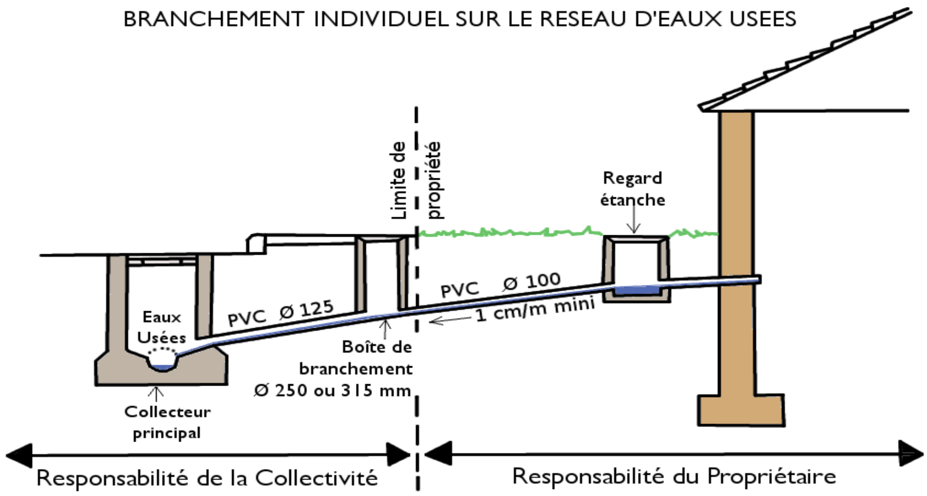


Figure 12: Diagram of a connection used in France. This is the layout that is most commonly used for non-conventional sewers in developing countries (source: Communauté de Communes du Thouarsais)

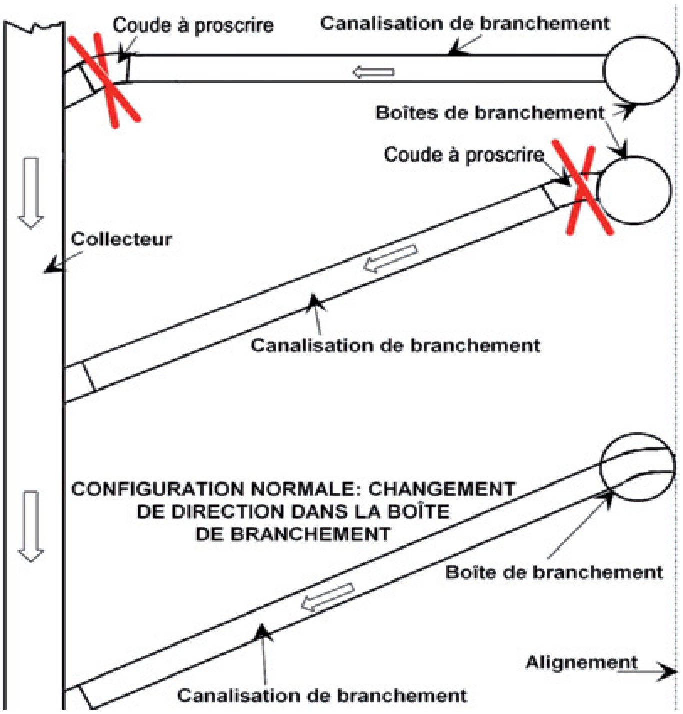


Figure 13. Plan view of different types of household connections to the sewer. Source: VINCENT I., 2001, Suez Environnement

II. What technical options were used for the ‘evacuation’ segment?

	Ramagundam, India	Senegal ENDA Rufisque, Baraka & Yoff	Senegal PAQPUD ONAS	Senegal Darou/Saint Louis	Senegal Cayar	Asafo Kumasi Ghana	Salvador de Bahia de Bahia, Brazil	Recife, Brazil	Brasilia, Brazil	Bamako, Mali	Mopti, Mali
Sewer type	Simplified	Settled	Settled and simplified	Settled	Settled	Simplified	Simplified	Simplified	Simplified	Settled	Settled
Pipe diameter (in mm)	150 to 250	110	From 110 to 200	63 to 100	110 to 215	100 to 300	100 to 150			110 to 160	160 to 300
Pipe materials	Clay	PVC	PVC	PVC	PVC and HDPE	PVC	PVC	PVC	PVC	PVC	PVC
Depth of pipes (in m)	Laid above ground (oldest sewers) 50-60cm elsewhere	Laid above ground (Baraka) 50-60cm elsewhere	minimum 0.5	0.8 7 downstream	?	0.5 under sidewalks 0.9 under roads 2.38 downstream				?	?
Sewer protection	Concrete casing over exposed areas	Concrete casing over exposed areas	Concrete casing over exposed areas	Concrete casing over exposed areas	Concrete casing over exposed areas	Paving, concrete casing over exposed areas	Paving, concrete casing over exposed areas	Paving, concrete casing over exposed areas	Paving, concrete casing over exposed areas	?	Paving
Sewer length	?	?	?	?	?	?	?	?	?	7,000 and 35,000 meters long	3,000m long
Type of manhole	Simplified, too small to enable access by technician, concrete covers	Simplified, too small to enable access by technician, concrete covers	Simplified, too small to enable access by technician, concrete or cast iron covers	Simplified, too small to enable access by technician, concrete covers	Simplified, too small to enable access by technician, concrete covers	Simplified, too small to enable access by technician, concrete covers	Simplified (40 to 60cm in diameter, too small to enable access by technician)			Simplified, too small to enable access by technician, concrete covers	Simplified, too small for access by technician, concrete covers

Table 13: The different technical options used for the ‘evacuation’ segment

The different sections of the route

It is important to differentiate between:

- ‘tertiary’ pipework that passes over private land and runs from the household wastewater collection facilities to the sewer line;
- secondary pipework that has a diameter of between 75 and 150mm, depending on the option used, the size of the sewer system and sizing, and which crosses mainly over public land;
- primary pipework that consists of the main sewer line leading to the treatment plant, the diameter of which can range from 100mm (on the shortest systems) to sizes similar to those found on conventional sewerage.

Diagram of a non-conventional sewer with four levels

The choice of route: public or private land?

In Brazil, condominial sewerage was often initially routed **over private land** in order to **reduce costs**, which meant either users were made responsible for this section of the sewer or an operator-user agreement was required to guarantee the operator right of access *(also see Part 2. Where have they been implemented and using what approach?).* However, as the public operators have since taken over responsibility for these sewers, **the preferred option is now to route the system over public land** whenever possible. In areas where this is not an option (hillside *favelas* with a maze of narrow lanes), the sewer is routed 'wherever it will go'. Users no longer object to visits by the operator as they now understand the purpose of these inspections.

However, **as far as we are aware, the non-conventional sewers in Africa and India are virtually all routed over public land** (although, in unplanned settlements, the distinction between 'public' and 'private' land can sometimes be unclear). As a result, **agreements between landowners are not required.** The sewers do not, however, follow 'conventional' routes as they adapt to the often winding layout of the roads in unplanned settlements.

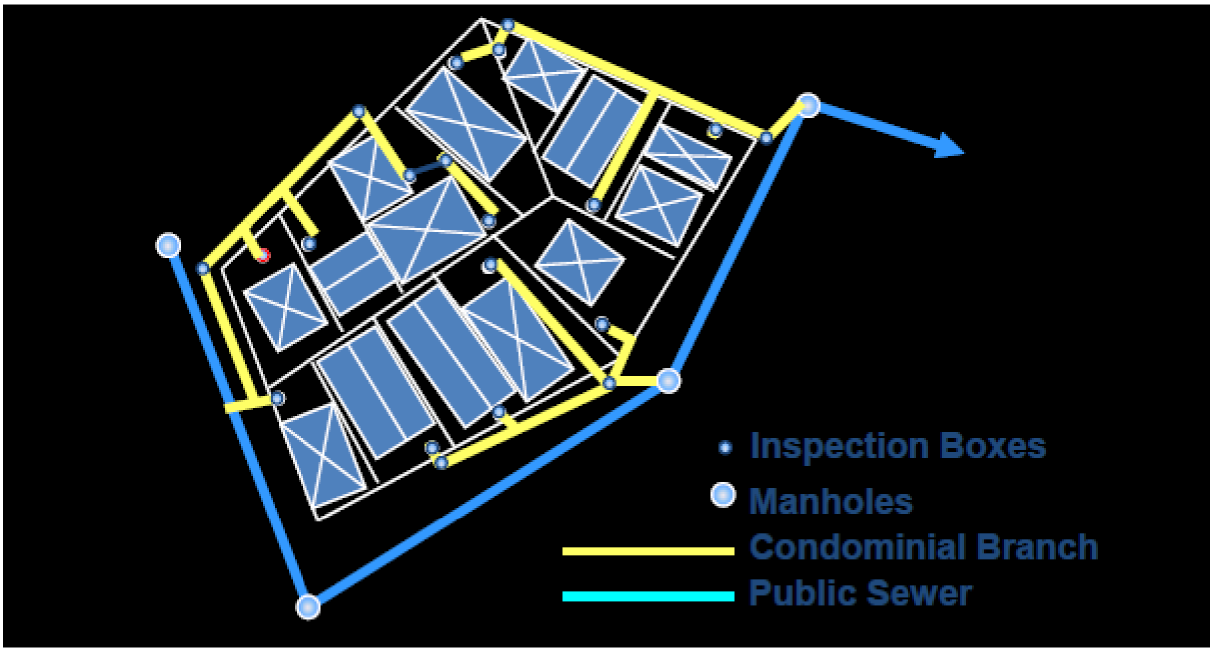


Figure 14: Plan of a sewer system in a *favela* in Brasilia (Source: CAESB)

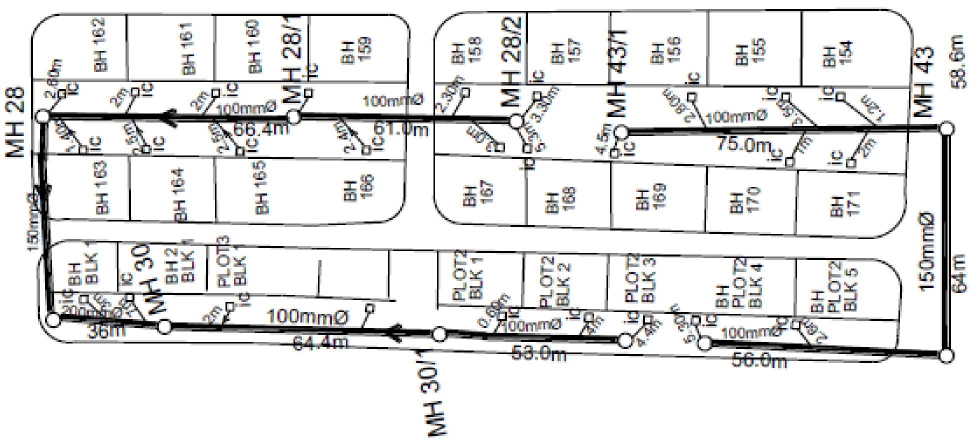


Figure 15: Route of a sewer system in Asafo, Kumasi, Ghana

What type of sewer?

There are three main types of 'non-conventional sewer' that are predominantly defined by the type of wastewater evacuated:

Combined sewers

These are usually **'open' channels, often rectangular in shape and sometimes covered with removable slabs. Originally designed to collect only surface run-off, local residents subsequently started to connect up their household sanitation facilities to run into these channels.** This situation is very common in highly populated urban areas where this type of channel exists.

The main advantage of these sewers is that they are **easily accessible, thus easy to clean**. In contrast, they pose a significant **public health risk**, as people regularly come into contact with pathogens, particularly when the channels overflow. This risk is exacerbated by the fact that the removable slabs are often damaged, broken or missing, thus enabling solid matter to enter the sewer.

There are also a number of closed sewers specifically designed to collect both household wastewater and stormwater, particularly in Rio de Janeiro, Brazil (EVANS B., MARA D., 2011). However, in tropical regions, sizing this option is difficult due the fact that rain events are very short yet intense.

In order to treat both stormwater and domestic wastewater, **treatment systems need to be adapted to handle discharge of different qualities and in higher volumes than on separate sewers**.

Settled sewers

These are sewers that are connected to either individual household or shared **settling tanks** (see the previous chapter on the technical options used in the 'access' segment) that separate out the solids and liquid matter. Only the liquid matter is evacuated by the sewer (surface run-off is prevented from entering the sewer and requires its own infrastructure).

Settled sewers are particularly suited to areas where both **low water consumption (and thus discharge) and, in particular, low gradients** mean that overly viscous wastewater cannot be properly evacuated (without creating slopes 'artificially' by digging deep trenches).

Settled sewers often have smaller diameter pipes than 'simplified' sewerage; however, according to those experts interviewed, this equates to only a small saving on investment costs. In contrast, **settling tanks significantly increase costs.**

As (when used properly) they only contain liquid matter, settled sewer design manuals often state that the route of these sewers can follow reverse slopes. However, the study of settled sewerage practices in sub-Saharan Africa shows that these sewers nearly always contain some form of solid matter (waste, sediment, sludge from unemptied pits or illegal connections). Therefore, there is already a **high risk of clogging** and this is only exacerbated in areas with reverse slopes and reduced diameter pipes.

In addition, a **system needs to be put in place to empty and treat the effluent (sludge) from the settling tank.** It is also necessary to ensure that the users empty their tanks regularly to prevent sludge overflowing into the sewer.

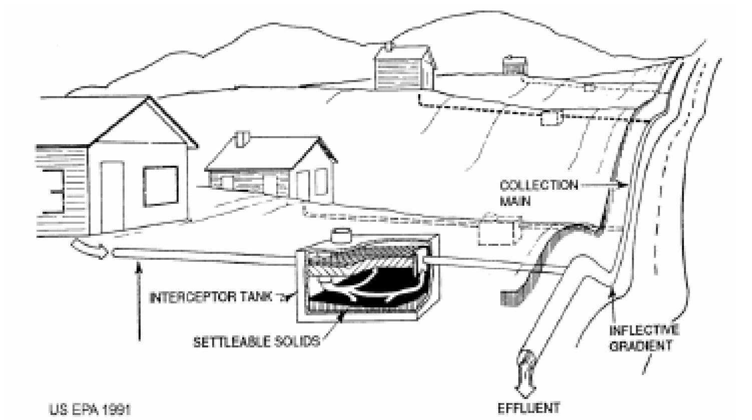


Figure 16: Diagram of a settled sewer. ***(Source: EAWAG-SANDEC)***

'Simplified' sewers

This is the most commonly used non-conventional sewer option. As with conventional combined sewers, they evacuate domestic wastewater (black and grey water, solid and liquid matter), but (in theory) not surface run-off.

To ensure proper drainage, simplified sewers require a minimum gradient (from 0,5 to1% depending on the level of water consumption) and cannot be used on reverse slopes. **They usually use smaller diameter pipes (of around 100mm) than conventional sewerage both to reduce investment costs and enable 'self-cleansing' through flushing.**

However, in Brazil – where simplified sewers have been widely adopted – the diameter of the pipes used for the section of the sewer routed over public land is often very similar to that used on conventional sewerage (150mm, which is exactly the same as the Brazilian and European standard diameter for pipes used on 'conventional' tertiary sewer lines). The additional investment costs incurred by this increase in diameter are considered negligible. In contrast, **increasing the diameter significantly reduces clogging caused by solid waste** and does not appear to affect the flow of liquid matter.

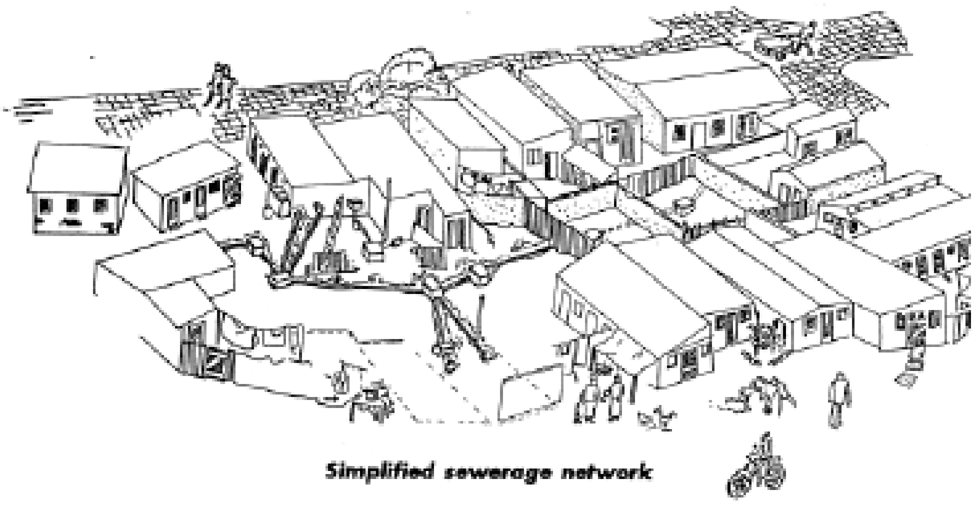


Figure 17: Diagram of a simplified sewer in an informal settlement. ***(Source: EAWAG-SANDEC)***

Sizing methods

Design and sizing methods have most notably been produced by **Duncan Mara and his team at the University of Leeds** and are available on their extremely well-illustrated website[1]. Mara and his team have also developed 'simplified sewerage' design software.

Contracting authorities tend to use specialist engineers (internal resources or consultants) to produce **detailed topographical surveys, sizing calculations and accurate estimates of the volume and quality of the wastewater to be evacuated.**

However, in some cases, **a more 'empirical' design method is used, which involves roughly estimating the gradient and outflow, then drawing up the plan of the sewer.** This is the method used by OPP in Karachi and, to a lesser extent, by ENDA in Senegal. In theory, this reduces the design costs; however, it can also sometimes undermine the quality of the infrastructure.

In practice, the majority of stakeholders use 'hybrid' methods that include **sizing calculations, as well as estimates and empirical observations** (thus, in Brasilia, it was initially thought that, for the hydraulic design, a diameter of 100mm or less would be more than sufficient for 'condominial' sewer pipes; however, this has since been increased to 150mm to prevent clogging by solid waste).

The equations used in **sewer design calculations** take into account:

- the **type of effluent:** wastewater only or wastewater + solids, and the viscosity of this effluent;
- the **effluent discharge volume** per connection (calculation based on household water consumption and a discharge coefficient of between 0.5 and 0.8), to which a specific coefficient is applied;
- the **number of connections**;
- the **gradient of the slope;**
- the **roughness coefficient of materials** (Manning's coefficient);
- **projected increases** in water consumption (and thus wastewater volume), housing construction and connections.

Equation utilisée

$$\tau = \delta * R_h * I$$

- τ est la force tractive moyenne en Pascals
- δ est le poids spécifique de l'eau
- R_h est le rayon hydraulique
- I est la pente de lacanalisation

L'utilsation de cette formule permet de calculer la pente minimum à respecter pour un débit donné:

$$I_{\min} = 0{,}0062 * Q^{-\frac{6}{13}}$$

$$I_{\max} = 2{,}66 * Q^{-\frac{2}{3}}$$

- assumant n = 0,01
- utilisant τ = 1 Pa
- utilisant une vitesse maximale de 0,5 m/s

[1] http://www.personal.leeds.ac.uk/~cen6ddm/simpsew.html

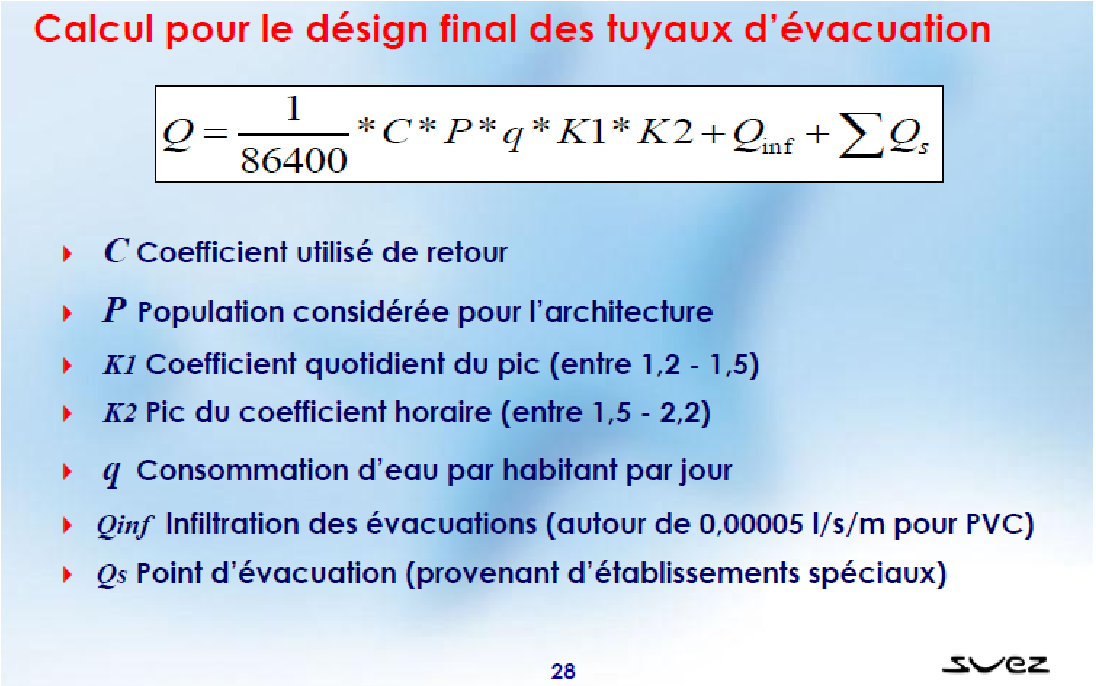


Figure 18: Non-conventional sewer design formulas used in El Alto, Bolivia. ***(Source: I. VINCENT 2001, Suez Environnement)***

Maximum number of connections

The largest non-conventional sewers have up to **4,000 household connections** (Asafo district of shared housing blocks in Kumasi, Ghana). However, as for the 'large' non-conventional sewers in Dakar, this includes numerous subsets connected to secondary sewer lines.

J-C Melo considers that a maximum of 25 households can be connected 'in series' to the same tertiary sewer line.

(Also see Part 1. What is a non-conventional sewer?).

Incorporate stormwater – or not?

In theory, the sewers are designed to **'prohibit' stormwater intrusion**. Households and the operator are required to ensure that wastewater and stormwater are kept separate. This is notably because stormwater contains sediment that can clog up manholes and damage lift stations.

In reality, however, stormwater always gets into the sewers, predominantly through the manholes as these are never completely watertight and, moreover, **the covers are often damaged or stolen**. In addition, local residents themselves also regularly open the manholes and pour stormwater into the sewers.

Sizing methods thus often (Reed, Melo) recommend applying a stormwater run-off coefficient (although, this is difficult to define as run-off enters the sewer 'by accident').

In India, where the monsoons can be very heavy, sewers have been backed up in homes in some areas. However, sizing the sewers based on these peak flow rates is impossible as it would result in absolutely huge pipe diameters.

An additional yet necessary solution to stormwater-related issues involves adopting an integrated approach that includes road paving, constructing stormwater drainage and other options (such as the 'drainage staircases' on the steep slopes of the *favelas* in Brazil, etc.).

Ventilation

Ventilation points are recommended for settled sewerage at the highest points of reverse slopes.

Materials

PVC pipes are the most common as they are resistant (due to their flexibility), light and low-cost.

Some pipes, notably those used for secondary sewer lines laid under roadways, are made of **HDPE** (high-density polyethylene), which are even more resistant but also more expensive.

Local materials, such as ceramics, can also be used (Ramagundam, India and Karachi, Pakistan). The advantage of these is that they can be made locally at a very low cost. However, they are more fragile and thus more vulnerable to damage.

Sewer protection

Pipes laid under sidewalks

In areas where sidewalks exist, laying pipes under these pathways (at depths shallower than that used for conventional sewerage) protects them from damage from vehicles. This option is made possible by the use of smaller diameter pipes than found on conventional sewer lines, which are laid under roadways.

Road paving

This has become systematic in Brazil since implementation of the '*saneamiento integral*' programs and is also common in India (Ramagundam) and Kumasi (Ghana). Road paving not only helps to protect the sewers (against damage, sediment intrusion, water drainage), but also helps ensure inhabitants treat their living environment with greater respect and use the sewers properly.

Casings, slabs, cages or underground boxes

The sections of the sewer system that pass under road and pathways are often protected by **concrete slabs or casing.**

At changes of direction or slope, inspection chambers, **cages or underground boxes** (inaccessible chambers) are also used.

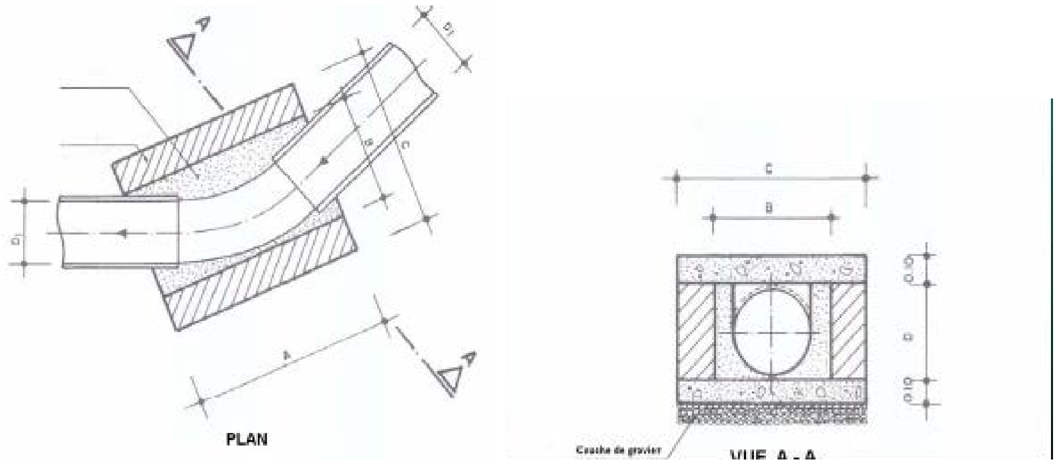


Figure 19. Underground boxes *(source: ONAS)*

Inspection chambers

The manholes are often '**simplified**', in that they are smaller than those usually seen on conventional sewerage systems: large enough to enable a cleaning system to be inserted into the sewer but too small to enable access by technicians.

In places, such as Saint-Louis/Darou and probably Dakar (recommended in the ONAS technical guides), these chambers are alternated with **inspection 'tubes'**, which are essentially bypass outlets with a cap (this solution is also used in South America).

These are placed not only at sufficient intervals to enable cleaning, but also at changes in direction and slope and/or at connection junctions.

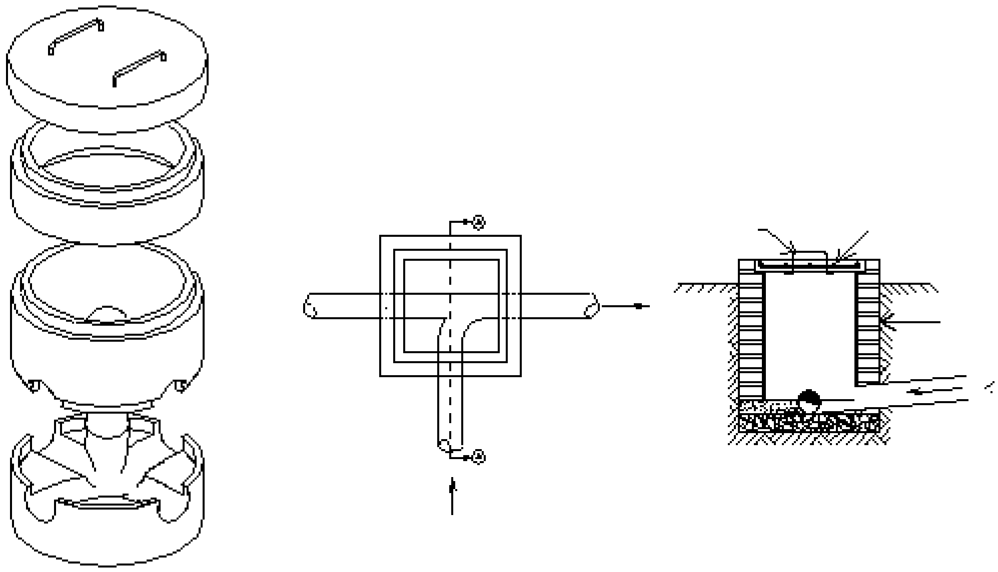


Figure 20: Different types of manhole used in El Alto, Bolivia. Left: molded plastic manhole; right: brick manhole *(Source: I. VINCENT, 2001, Suez Environnement)*

Figure 21: Left: Replacement inspection tube (*source: ONAS).* Right: mass production of simplified manholes in Brasilia *(source: CAESB).*

There are often problems with the manhole covers as **concrete** covers are **vulnerable** to damage (from general handling and the passage of vehicles) and **cast iron covers are extremely vulnerable to theft**.

Users lift off the manhole covers to throw solid waste or stormwater (that contains solids) into the sewer. However, attempting to prevent this by sealing (concrete) or bolting down the covers would only make it more difficult for the operator to inspect the sewer line.

The depth of the pipes

Depths range from **0cm** (pipes laid on top of the bedrock in Baraka, Dakar) **to several meters** for the downstream sections of certain systems. However, the 'normal' depth is **between 30cm and 1m** (whereas conventional sewer systems are usually laid at a depth of at least 1m50cm).

III. The treatment segment

	Ramagundam, India	Rufisque, Baraka & Yoff (ENDA), Senegal	PAQPUD ONAS, Senegal	Darou/Saint Louis, Senegal	Cayar, Senegal	Asafo Kumasi, Ghana	Salvador de Bahia, Brazil	Recife, Brazil	Brasilia, Brazil	Bamako, Mali	Mopti, Mali
Treatment method	Anaerobic reactors (primary treatment)	Connection to conventional sewerage (Baraka) Waste Stabilization Pond (Rufisque) Anaerobic reactor + gravel filters (Yoff)	Connection to conventional sewerage or anaerobic reactor + gravel filters	Waste Stabilization Pond	Waste Stabilization Pond	Waste Stabilization Pond	Connection to conventional sewerage	Connection to conventional sewerage	Connection to conventional sewerage	No treatment other than pre-treatment in the shared settling tanks	Waste Stabilization Pond
Lift station?	No	Yes (Yoff, not operational)	Yes on some systems (often not operational)	Yes	Yes	No	Yes, on some systems	Yes, on some systems	Yes, on some systems	No	Yes

Lift station pumps: a major weakness of the system

Lift stations often contain **two electromechanical pumps** (that operate alternately, thus ensuring there is always a back-up to cover breakdowns and maintenance). These pumps are powered by mains electricity and there is a generator on stand-by in case of power cuts.

These pumps are a **major capital expense** that account for around 15-20% of a project's overall investment costs and at least **50% of O&M costs: fuel, caretaking, maintenance.**

They suffer from poor design, poor implementation and **poor maintenance**. Furthermore, they are highly vulnerable both to the (frequent) infiltration of mud, sand and solid waste and to flooding.

Photo 1: Lift station in Saint-Louis, Senegal (large capacity as it also receives effluent from the conventional sewer system).

Type of outlet/treatment method

Wastewater is discharged into the environment without treatment

This option, which relies on the natural purification capacity of the environment (a waterway or ocean, etc.), is often used by default (in Mali, for example) because either the treatment plant is not working properly or there are no resources available for investment.

This method has little impact on public health and the environment if the volumes of wastewater discharge are low and the outfall is in **a sparsely developed area**. However, this is rarely the case in urban and peri-urban areas.

Construction of a wastewater treatment plant on the downstream section of the sewer is, therefore, strongly recommended.

Connection to the conventional sewer line

In areas where the conventional sewer route passes near to the non-conventional sewer, the simplest solution is to connect to the conventional sewer line.

Extensive treatment methods

Waste Stabilization Ponds are relatively simple and effective; however, they require **a large footprint (between 1 and 20m2** per population equivalent, depending on the technique used, level of treatment required…and the source), which renders them unsuitable for many urban areas.

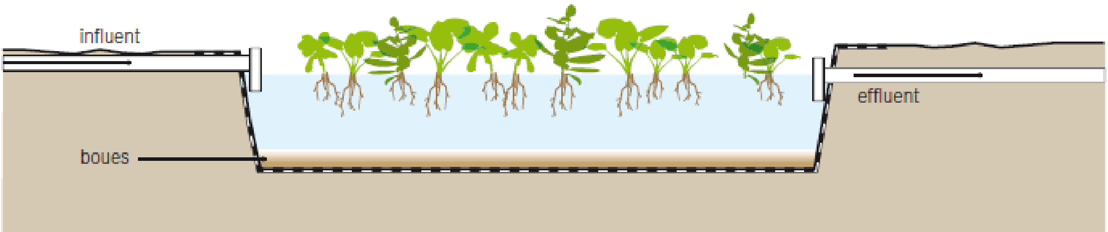


Figure 22: Constructed wetland extensive treatment plant with macrophytes ***(source: EAWAG SANDEC)***

Intensive treatment methods

Intensive treatment methods require a far smaller surface area and provide perfectly satisfactory treatment, as long as they are properly designed and implemented. They include a wide range of different solutions and are collectively known as DEWATS (Decentralized Wastewater Treatment Systems).

(Please also see the technical note on the use of DEWATS in Asia in the Annex).

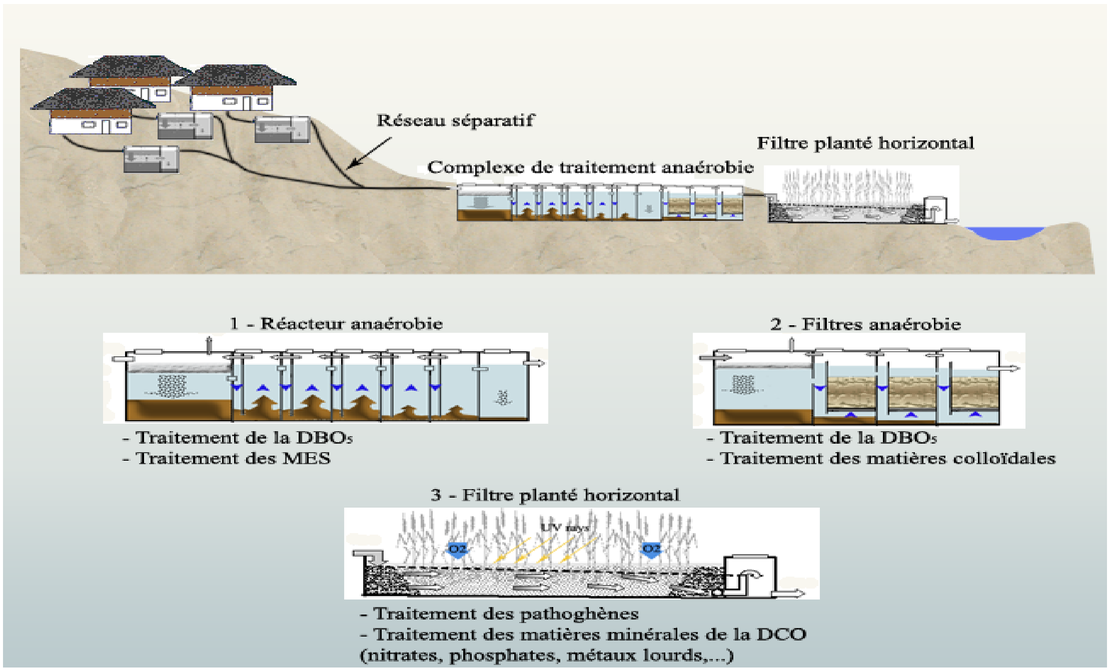


Figure 23: Examples of three types of modules that make up a DEWATS-type wastewater treatment plant. ***(Source: East Vietnam)***

The advantages and disadvantages of reutilizing the treated wastewater and sludge

Although often cited as the way forward, very few of the cases studied have implemented a mechanism to reutilize treated wastewater and sludge. In the rare instances where this does take place, the financial benefits by no means offset treatment plant investment and operating costs and have **no impact on the operating balance of the service.**

Part 5.
What user-focused activities are developed?

I. What are and what is the aim of ‘user-focused activities’?

This term encompasses all ‘social engineering’ methods, such as awareness-raising and user consultation.

The aims of these activities are listed below in an order that is *more or less* consistent with the main stages of a non-conventional sewer development project:

1. **Raise user awareness of good hygiene practices and the importance of sanitation and stimulate demand** for an improved sanitation service;
2. Improve the way in which the technical and organizational solutions are aligned to the actual demand of these same users by adhering as closely as possible to their practices and expectations: this is the aim of the **demand assessment;**
3. Involve users in defining the route and prevent problems arising from disruption caused by the construction work: this is the aim of the regular consultation that takes place during the **design and implementation phases**;
4. Ensure users assimilate ‘good practice’ with regard to maintenance and regularly paying for the service: this is the aim of the **awareness-raising activities conducted during the launch phase;**
5. Promote the service in order to develop the number of connections: the “service marketing”;
6. Listen to user expectations, respond to their needs as regards interventions and provide regular reminders of ‘good practice’: this is the aim of **user relations** during the operational phase;
7. If required, build user capacities to enable them to help ensure operation of the service by **assigning them some of the responsibility for the service (contracting authority) and/or involving them in its operational management**.

All of these activities have a **profound impact on the future sustainability of the service.** However, in practice, few non-conventional sewer projects pay sufficient attention to these aims or allocate sizeable resources to each stage.

Nevertheless, there are some examples that focus on these activities from selection of the option through to the operational phase. These include:

- the ‘**condominial’ methodology implemented in Brazil** and by CAESB in Brasilia, in particular *(see the box on the following page and the Brazil case study report in the Annex);*
- **the CLUES approach developed by EAWAG-SANDEC** and implemented in Nepal and Tanzania and, with some minor variations, in many of the DEWATS projects in Asia now too *(see the box on the following page).*

Photo 2: Users’ association meeting in Recife

II. What user-focused activities are undertaken in each case?

	Ramagundam India	Rufisque, Baraka & Yoff (ENDA), Senegal	PAQPUD ONAS, Senegal	Darou/Saint Louis, Senegal	Cayar, Senegal	Asafo Kumasi, Ghana	Salvador, Recife, Brasilia, Brazil	Bamako, Mali	Mopti, Mali
Demand stimulation	Community meetings	PHAST-SARAR community meetings	PHAST-SARAR community meetings	PHAST-SARAR community meetings	Currently being defined	Yes (but no information available on the method)	Community meetings + marketing	Home visits, radio, town criers	Door-to-door, radio
Consultation during the design and implementation phases	?	?	No	Community meetings	No	Poor	Community meetings + staff working in the field	Weekly meetings	Weekly meetings
Good practice awareness-raising during the launch phase	?	Yes (door-to-door, marketing)	Yes (door-to-door)	Yes (door-to-door, marketing, meetings)	Planned	Community meetings	Door-to-door by field staff during the connection phase	?	?
User relations during the operational phase	?	Poor (due to the operator), except in Baraka	Poor (due to lack of capacities on the part of the operator)	Poor (due to lack of capacities on the part of the operator)	- -	Yes (kiosk in the area, door-to-door visits)	Call centers + community field staff	No	No
User service responsibility/management capacity-building	?	Poor	Poor	Yes	Planned	Yes	Poor	Poor	Poor

Table 14: User-focused activities

Stage 1. Raise user awareness of good hygiene practices and the importance of sanitation and stimulate demand for an improved sanitation service

(For more information on the concept of 'user demand', please also see Part 3. To which contexts are non-conventional sewers best suited?).

This stage often involves **'laying the groundwork' for a demand assessment. Thus, no decision has yet been made as to the type of sanitation option that will be proposed**. However, some approaches prefer to select the technical option first (with or without a demand assessment) and then stimulate demand for this specific solution.

Some of the typical methods for stimulating demand for sanitation in urban areas are defined below; however, in most cases, **a 'combination' of these methods will be used,** selected in accordance with the length of the project and the issues that need to be addressed.

The PHAST-SARAR approach

The local community communication method used in the **PHAST** approach is an adaptation of the SARAR **methodology of participatory learning,** which builds on people's innate ability to address and resolve their own problems (Toubkiss, 2007, see box on the following page).

To select the service type, this 'demand stimulation' method can be combined with a 'demand assessment' approach (*see the following point*). The PHAST-SARAR meetings thus take the form of 'focus group' discussions in which the proposed solution and willingness-to-pay are debated (see the following 'demand assessment' stage).

The main stumbling block of these so-called 'participatory' methods is **low attendance at meetings**. Thus, in Brazil, social workers set an attendance rate target of 50% (interview with JC Melo, Cesar Rissoli, CAESB and Hermelinda Rocha, COMPESA).

Community-led total sanitation (CLTS) in urban areas

Similar to the PHAST approach, this also includes some of the methods used in CLTS in rural areas:

- **transect walks;**
- **mapping open defecation areas;**
- **analyzing contamination 'routes';**
- **calculating excreta and medical expenses;**
- Etc.

This approach has most notably been piloted by WSSC in India (Calcutta) and in Nairobi (ICLEI and Plan Access program), etc.

Although, as far as we are aware, this approach has never yet been used in a 'non-conventional sewer' project, it would appear to be perfectly suitable for such an initiative, provided that the '0% subsidy' and self-build 'principles' are omitted.

'Door-to-door' visits

Although **resource and time intensive, door-to-door visits enable a more 'personalized' relationship to be built with each household** and are used in areas where overly frequent meetings lead to signs of meeting fatigue *(see the box below on the National Sanitation Office of Senegal (ONAS) review of its PAQPUD program IEC campaigns).*

However, they are most commonly used during the following stages: demand assessment; consultation during the design and implementation phases; and good practice awareness-raising.

"The local community communication method used in the ***PHAST*** *approach is an adaptation of the SARAR methodology of participatory learning, which builds on people's innate ability to address and resolve their own problems. PHAST sessions in the form of home visits, group meetings and guided tours are held for specific groups (women's groups, local youth association members, community groups, etc.). Extension workers use a variety of participatory tools to carry out community awareness-raising:*

- *Community mapping in which people draw a map of their local water supply and sanitation facilities; this tool is used to help communities identify and locate all their sanitation-related issues.*
- *Three-pile sorting and the pocket chart are used to help communities review their current hygiene and sanitation practices and sort them into good and bad.*
- *Contamination routes and barriers are used to help people identify the main transmission routes of fecal-oral disease and their barriers. Upon completion of this exercise, the community should have a better understanding of how some of their current daily hygiene and sanitation practices can contribute to the transmission of fecal-oral disease. Using this knowledge, they will then be able to identify the most effective barriers for preventing these diseases.*
- *Gender role analysis involves identifying which tasks are generally carried out by men and women within the community. This tool is used to determine whether it is necessary and possible to reallocate any of these tasks.*
- *Gender role analysis involves identifying which tasks are generally carried out by men and women within the community. This tool is used to determine whether it is necessary and possible to reallocate any of these tasks.*
- *Planning posters are used to help the community develop a plan to implement water and sanitation and hygiene behavior changes. This exercise consists of setting out the current and future situations with regard to water and sanitation facilities and asking the community to identify the strengths and weaknesses of both.*

Once they feel at ease with the approach, extension workers assist with implementing this participatory method. Prior to this, they should receive regular visits from their supervisors".

Box 10: Description of the PHAST-SARAR methodology used in Dakar as part of the PAQPUD program. ***(Extract from TOUBKISS, 2007)***

Stage 2. The actual demand assessment

(See Part 3. To which contexts are non-conventional sewers best suited?).

Stage 3. Consultation during the design and implementation phases

Consultation during the design phase

This consultation is conducted once the demand assessment has been completed and the service type has been selected. Such consultation makes it possible to 'refine':

- **the chosen route**;
- the choice of **management method/division of responsibilities/related tariffs**;
- also at this stage, users can be invited to help with the trench **excavation and grading work** as a contribution 'in kind' to the cost of their connection.

This is the original 'Brazilian' condominial method. In practice, operators now prescribe a route across public land and directly operate the service through tariffs only. **However, inhabitants are always provided with an opportunity to approve the route**, particularly in the highly-built-up *favelas* where the sewer has to weave through 'private' land.

Furthermore, this consultation is required not only in all areas where the sewer crosses private land, but also in order to eliminate 'unwelcome surprises' during the implementation phase (for instance, discovering that there is a religious taboo, land tenure issue or official development ban in place for a certain area).

User relations during the implementation phase

User relations involves handling **any user complaints relating to damage/disruption caused by the construction work, communicating in a clear and concise manner to prevent conflict and compensating users if required**.

In Brasilia, specialist 'condominial' teams comprising engineers, technicians and social mediation experts are involved in the project from beginning to end. They all undertake field visits and the social workers are also particularly useful during the construction phase.

Stage 4. Good practice awareness-raising during the launch phase

This stage is generally carried out during a visit to the household **at the time the property is connected**. Thus, in Brasilia, this visit makes it possible to:

- **verify that the household facilities have been correctly installed**;
- **connect** these household facilities to the sewer line;
- depending on the payment method selected, **collect all or part of the connection fee from the household;**
- **ensure the household is aware of how to correctly use the facilities** (not dispose of solid waste in the sewer, clean the grease trap, regularly check the connection box, etc.) and of the need to pay the sanitation fee;
- answer any questions the user may have.

This is thus both a 'technical' and 'social' stage, hence the reason why, in Brasilia, this visit is conducted by a multi-disciplinary team (technician and social worker).

Figure 24: Illustration used to raise user awareness of the type of toxic materials that must not be thrown into the sewer (*source: CC du Thousarnais)*

Summary of the 7 planning steps

Step 1 Process Ignition and Demand Creation

The planning process begins with ignition and promotional activities. This step aims to sensitise the community to environmental sanitation and hygiene issues and to create momentum and a solid platform for community participation. After a participative community mapping exercise and the discussion of key concerns with the residents in a first community meeting, an agreement on action is formulated and a community task force is formed by previously identified community champions. (page 19)

Step 2 Launch of the Planning Process

In step 2 all key stakeholders formally come together to develop a common understanding of the environmental sanitation problems in the intervention area and agree on the process of how to address them. The launching workshop must be inclusive, well-structured and attract public attention. In step 2 stakeholders generate a protocol agreement, an agreement on the project boundaries and an agreement on the overall planning methodology and process. (page 23)

Step 3 Detailed Assessment of the Current Situation

In step 3 stakeholders compile information about the physical and socio-economic environment of the intervention area. This step is important because it provides necessary background information for all future planning steps. Outputs include a refined stakeholder analysis, baseline data, and a thorough assessment of the enabling environment and current levels of service provision. The main outcome of step 3 is a detailed status assessment report for the intervention area. (page 27)

Step 4 Prioritisation of the Community Problems and Validation

In step 4 stakeholders deliberate the findings and implications of the assessment report, and identify and prioritise the leading general and environmental sanitation problems in the community. The main outcomes of step 4 are the validated assessment report and an agreed-upon list of priority problems in the community. (page 31)

Step 5 Identification of Service Options

In step 5 the planning team, in consultation with environmental sanitation experts and key stakeholders, uses an informed choice approach to identify one or two environmental sanitation system options that are feasible for the intervention area and can be studied in greater detail. The community and the local authorities reach agreement based on an understanding of the management and financial implications of the selected systems. (page 33)

Step 6 Development of an Action Plan

In step 6 stakeholders develop local area action plans for the implementation of the environmental sanitation options selected in step 5. The action plans must be implementable by the community, the local authorities and the private sector. The main output of step 6 is a costed and funded action plan that follows time sensitive, output-based targets. Every action plan must contain an operation and maintenance management plan to ensure the correct functioning of the sanitation system.
(page 39)

Step 7 Implementation of the Action Plan

As the goal of step 7 is to implement the CLUES action plan developed in step 6, this last step is not strictly speaking part of the planning process. Stakeholders translate the action plan into work packages which ultimately become contracts for implementing the service improvements. The final stage of step 7 is the implementation of the O&M management plan. (page 43)

Box 11: The CLUES approach developed by SANDEC: an example of the participatory sanitation planning process used at community level, based on a user demand assessment

Review of the PAQPUD awareness-raising activities undertaken by ONAS in Senegal

"Appointments are generally scheduled for weekday mornings and afternoons. The target groups are mainly young people, community groups composed predominantly of women, children or schoolchildren. However, as the main decision-maker and the person who provides for the family, the primary target should be the head of the household. This means that the appointment days and times need to be changed as, on weekdays, the head of the household is at work (ONAS recommendation – PHAST tools technical note n°4, May 2004).

Lastly, the PHAST approach should not have merely an educational role, but should also generate interest among the community and foster their involvement in the project. Emphasis should therefore be placed on the last stage of the PHAST approach: encouraging people to want to invest in sanitation facilities. This type of 'commercial marketing' is often lacking (ONAS recommendation – PHAST tools technical note, May 2004).

Door-to-door marketing is the activity that generates most demand for sanitation facilities. With 45% of the population visited, this activity generated 84% of all requests".

Box 12: Findings from the IEC campaign undertaken as part of the PAQPUD program in Dakar. (Source: TOUBKISS, 2007)

Activités IEC du programme GPOBA, Dakar

- 23 cérémonies de lancement officielles-communautaires
- 72 spots télévisés et 51 spots radios
- 96000 visites de porte-à-porte
- 51 camions itinérants sur 20 zones
- 8 « concours »
- 116 réunions communautaires
- 15 réunions des comités de gestion
- 1000 t-shirts, 200 posters
- 16 500 visites de suivi

Information sources	Percentage
Radio	8%
Newspaper	9%
Word of mouth	60%
Meeting	3%
Posters	4%
Other	16%
Don't know	1%
Total	**100%**

Is the choice of facility made by men or women?	Total
By women only	25.10%
Primarily by women	11.50%
Joint decision (man and woman)	24.50%
Primarily by men	3.80%
By men only	18.70%
One facility only available	16.20%
Don't know	0.20%
Total	**100.00%**

Figure 25: Sanitation marketing activities undertaken as part of the GPOBA program in Dakar and their impact on the target groups (Source: World Bank)

Stage 5. User/operator relations during the operational phase

See Part 7. How are non-conventional sewers managed?

Stage 6. User involvement in sewer management: always recommended, but rarely correctly organized

See Part 3. To which contexts are non-conventional sewers best suited? and Part 7. How are non-conventional sewers managed?

Part 6.
How are non-conventional sewers constructed and implemented?

I. What does the ‘implementation’ phase include?

This implementation phase includes ‘technical’ construction, as well as ‘social’ and ‘capacity-building’ activities.

Construction

This consists of constructing the different elements of the system:

- the **treatment plant** and any lift pumps;
- **the sewer** (starting with the downstream section and working upstream);
- the **household facilities** (these can be installed either by the users or by the same contractor responsible for the sewer line and connections);
- the actual **connections**.

User-focused activities

See the previous section.

Capacity-building

This involves training all service stakeholders:

- the users (see the previous section);
- the contracting authority to manage both the implementation phase and, in particular, the non-conventional sewer itself (see the following chapter and Parts *3.VII What operating capacities are required?* and *7. How are non-conventional sewers managed?)*;
- the supervisor responsible for monitoring the work *(see the following chapter);*
- the works contractors *(see the following chapter);*
- the IEC providers *(see the previous section).*

II. What are the main problems encountered during the implementation phase?

Main reported defects and shortcomings in the construction process

- **gradients were incorrectly calculated:** in Rufisque (Senegal) a second sewer system had to be constructed parallel to the first as the initial gradient calculation was incorrect and in Ngor (Senegal), when transcribing the results of the topographical survey, a ridge and a valley were inverted, leaving part of the area with no service. In Kieu Ky (Vietnam), gradients were incorrectly measured and they had to revert to connecting households to the original combined sewer.

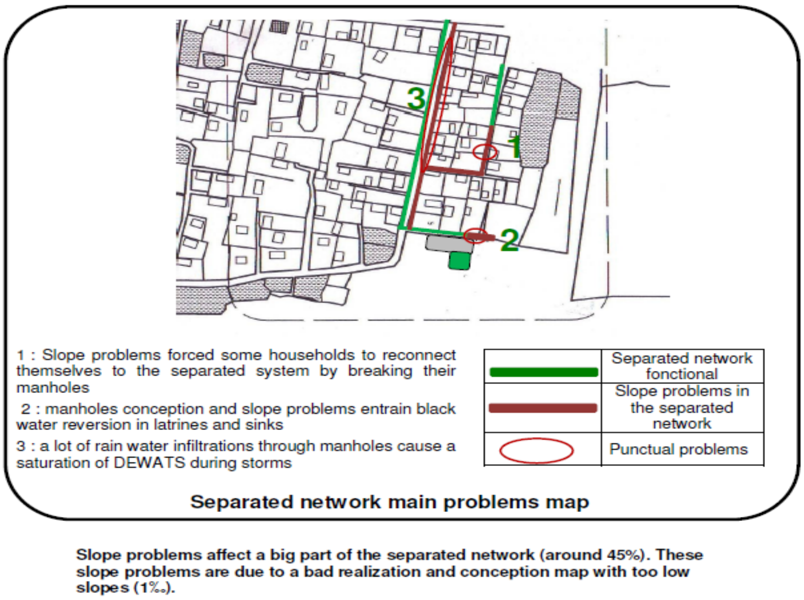


Figure 26: Gradient problems affecting the non-conventional sewer system in Kieu Ky, Vietnam. *(Source: ADB – Borda).*

- **the sewer was laid at too shallow a depth** meaning that many household facility outlets were beneath the level of the sewer line and thus could not be connected. This issue was encountered in both Kieu Ky, Vietnam (see diagram above) and Recife, Brazil.
- **work was not finished**, not delivered or defective (ONAS sewers in Dakar). This was particularly the case with lift pumps;
- **systems were not properly sealed** (where the non-conventional sewer joins the conventional sewerage system; household connections were not watertight).

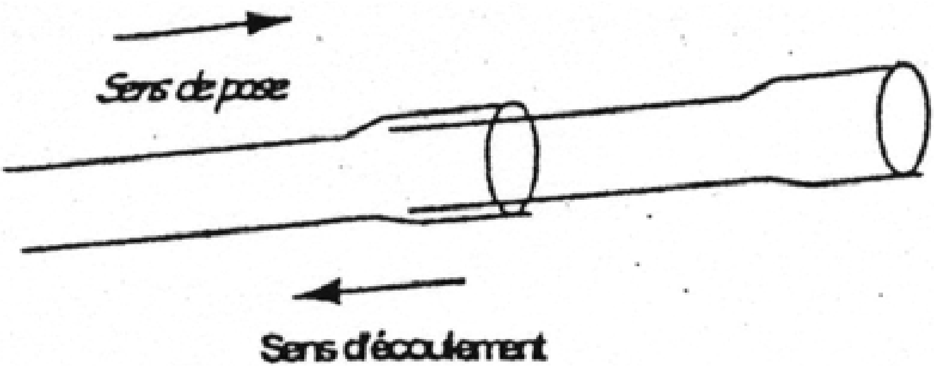


Figure 27: Direction in which to lay the sewer. ***(Source: S. Clayette, Conseil Général de Seine Saint-Denis)***

Site-related issues

If site-related constraints are not anticipated from the outset, these can either lead to spiraling costs and long delays or significantly affect the service quality. Thus, major work is required in areas with **near-surface water tables** (lowering the water table, pumping, casings as in Darou). **Land disputes** (between the site owners, local residents, etc.) during construction work are common.

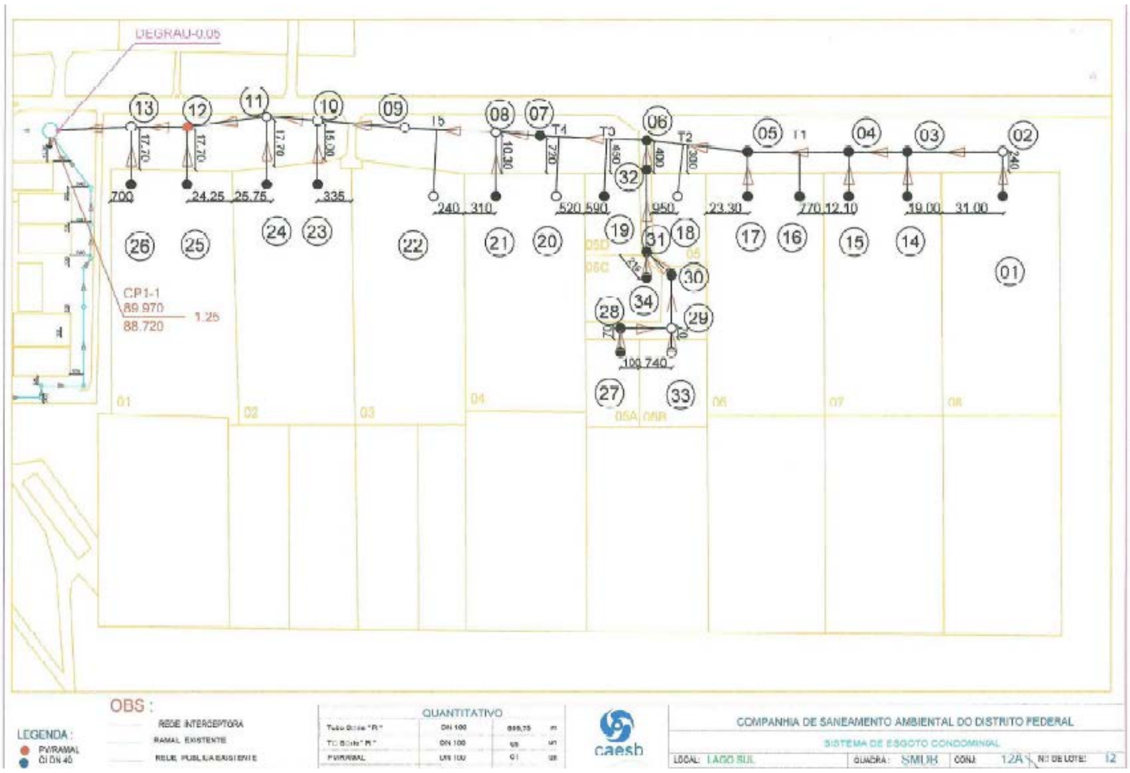


Figure 28. Condominial sewer construction plan used during the implementation phase in Brasilia (source: CAESB).

III. How should roles be divided during the implementation phase?

The importance of involving all stakeholders in each phase

In many cases, the future contracting authorities or service operators have been insufficiently or not at all involved in designing and constructing the sewer. As a result, **although subsequently responsible for monitoring and operating the scheme, their knowledge of the system is very poor.**

This was the situation in Dakar, where the role of contracting authority was delegated to an implementing agency that found it difficult to get the national operator, users' committees and local authorities involved.

In contrast, **in Brasilia, responsibility for designing, managing the construction and operating the condominial sewers is designated to the same department within CAESB, which thus has a thorough understanding of the systems.**

Technical supervision: monitoring the construction work and contractors

For most of the stakeholders involved, the non-conventional sewer is still a relatively new technology. In addition, there has been a **failure to develop a proper results-based culture and local public works contractors/professionals often fail to uphold their contractual commitments.** Thus, in order to ensure facilities are built to the required quality standards, all contractors require close supervision.

This aspect is seldom fully taken into account, which results in **sometimes poor quality** construction and **significant budget overspends and delays**. As a knock-on effect of this, there are then **fewer resources available for 'soft component' activities and monitoring in the post-investment phase**.

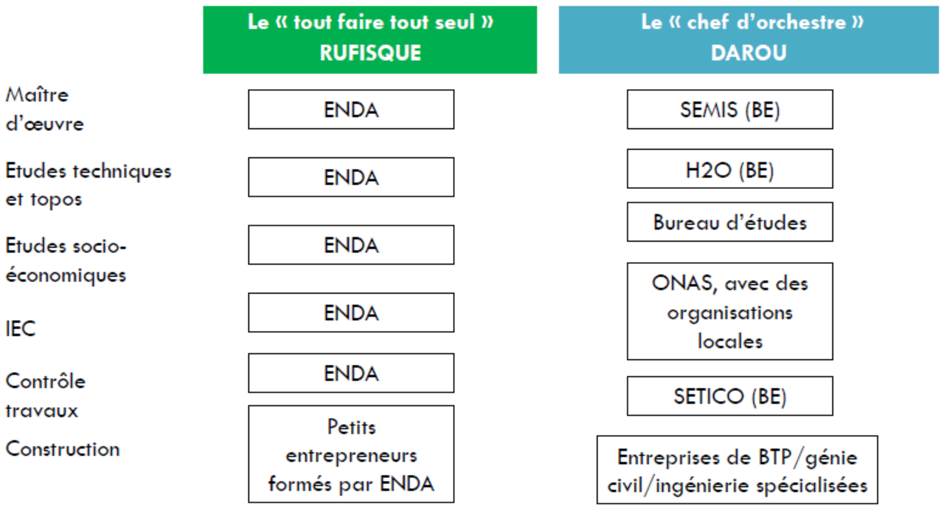


Figure 29: Division of roles: examples of two very different approaches used during the implementation phase in Senegal

Sewer system mapping

In Dakar (ONAS sewer systems), Cayar and Saint-Louis/Darou (Senegal), as in Brazil, a detailed map of the sewer line and associated connections was produced by taking **GPS readings** of all system installations.

However, not all management committees (Rufisque, Senegal) or contracting authorities (Dakar PAQPUD, Rufisque, Yoff, Baraka in Dakar) have a full copy of this map available for consultation. This complicates the task of the operator and increases the risk of damage being caused to the sewer during work on other networks or by road works.

User involvement in construction?

This has been piloted in Baraka and Saint-Louis/Darou, Senegal, and on a large scale in Brazil, with a view to:

- reducing costs;
- creating local revenue-generating activities;
- instilling ownership.

In the initiatives studied, user involvement was restricted to helping with excavation work and the outcome of the pilots was positive in that **users' sense of ownership was improved.**

In Orangi, Pakistan, a 'community-based' approach was adopted for the entire implementation phase. According to the experts interviewed, this resulted in extremely low unit costs, but also in relatively low quality construction.

	Mois						
	1	2	3	4	5	6	7
1. Faisabilité technique	■						
2. Evaluation de la demande	■						
3. Caractérisation technique et socio-économique		■					
4. Avant projet			■				
5. Evaluation participative			■				
6. Discussion tracé condominial				■			
7. Signature des accords				■	■		
8. Formation construction branches condominiales					■		
Construction principal réseau				■	■		
9. Construction branches condominiales, formation construction de modules sanitaires					■	■	
10. Formation exploitation et entretien							■
11. Integration du projet dans la compagnie							■
12. Evaluation du projet							■

Figure 30: Project timetable used in El Alto, Bolivia *(Source: VINCENT I, 2001, SUEZ*

Part 7.
How are non-conventional sewers managed?

I. Technical risks during the operational phase

	Ramagundam, India	Rufisque, Baraka & Yoff (ENDA), Senegal	PAQPUD ONAS, Senegal	Darou/Saint Louis, Senegal	Asafo Kumasi, Ghana	Salvador, Recife, Brasilia, Brazil	Bamako, Mali	Mopti , Mali
At household level	-	Households fail to maintain grease traps Failure to empty household and shared settling tanks	Households fail to maintain grease traps Failure to empty household settling tanks	-	Households fail to maintain grease traps	Households fail to maintain grease traps	Households fail to maintain grease traps	Households fail to maintain grease traps
On public land (sewer)	Manholes broken/raised by inhabitants to enable stormwater drainage Broken manhole covers Inundated with water (monsoons) and backed up into homes Presence of solid waste Sludge cleaned out of the manholes and deposited in the street	Broken manholes Not properly cleaned Stormwater Sediment Solid waste Construction work Damaged by heavy vehicles (unpaved roads)	Illegal connections Settling tanks not emptied=sludge overflows Stormwater and sediment Solid waste Broke/stolen manholes Damage (trucks) Not properly cleaned	Stormwater Sediment Solid waste Construction work	Stormwater Sediment Solid waste Construction work	Housing extends above the sewers Stormwater Sediment Solid waste Construction work	Solid waste Broke/stolen manholes Damage (trucks) Not properly cleaned	Solid waste Broke/stolen manholes Damage (trucks) Not properly cleaned
At lift pumps	-	-	Delivery/implementation shortcomings Under-sized, electrical and mechanical breakdowns Sludge and sediment degradation No or inadequately trained caretakers Lack of funds for purchasing fuel	No problems reported after 1 year of operation	-	All pump-related problems are generally well-managed and anticipated by the public provincial operators	-	-
At the wastewater treatment plant (WWTP)	No decision taken to bypass stormwater in the event of saturation	Lack of routine WWTP care and maintenance (Yoff WWTP out of service) Responsibility for WWTP management poorly defined (ENDA? Local authority?)	No major problems reported at the decentralized WWTP managed by ONAS	The sewer is connected to a conventional centralized WWTP that is currently being rehabilitated	Waste Stabilization Pond not properly cleaned due to lack of equipment	All condominial sewers are now connected to conventional WWTP that are being properly managed by the provincial public operators	-	-

Table 15: Technical risks

Photo 4: Broken manhole blocked by solid waste that is overflowing into the street in Rufisque (Senegal).

Photos 3 and 5: Sludge from the manhole emptied into the street, manhole opened to enable stormwater drainage and broken pipes in Ramagundam, India

II. A vulnerable and maintenance-intensive solution

An option that is vulnerable to external risks

The small diameter pipes used on non-conventional sewers render them vulnerable to external risks: physical damage; intrusion of solid waste, sediment, stormwater, sludge (see also *Part 3. To which contexts are non-conventional sewers best suited?*).

A maintenance-intensive option

To ensure the non-conventional sewer continues to function effectively over time, regular repair and maintenance is required at all levels. Lack of monitoring and supervision leads to rapid deterioration of the service.

All operators interviewed agreed that non-conventional sewers don't need to be cleaned out as often as conventional sewerage ('self-cleansing'), but smaller tasks to remove blockages are more frequent.

III. Four levels of repair and maintenance

Four levels of repair and maintenance, often carried out by different operators

There are a number of different stakeholders that can identify/initiate (responsibility) and carry out maintenance tasks, each of whom has varying levels of resources and capacities. The stakeholder involved largely depends on both the **maintenance type (routine or heavy maintenance)** and **location** (household facilities/upstream section of the sewer/main sewer lines/pumping station and treatment plant). **The resources and capacities required increase the further downstream on the sewer the maintenance task is to be carried out**.

We have thus identified **four levels of repair and maintenance**, each of which comes not only with its own technical risks and repair and maintenance requirements, but also often **under the responsibility of a different type of stakeholder.** However, in practice, these tasks are rarely structured and coordinated…

(It is to be noted that, those countries in which O&M is carried out most effectively – India, Brazil, and Ghana - already had a 'conventional' culture that now exists in tandem with that of the non-conventional sewer).

'Main sewer lines and '3rd level' repair and maintenance

Not all 'non-conventional sewers' have larger diameter sewer lines on the downstream section of the system (especially not the smaller systems with only a few dozen/hundred connections).

However, even on the upstream sections (of a small diameter sewer), it is important to be prepared for heavy maintenance tasks (pipe or manhole replacement) that require specific resources and which fall under '3rd level' maintenance.

1st level: household sewer equipment maintenance

Photo 5: Grease trap in Kumasi, Ghana

Task description	Who is responsible for the task?	Who carries out the task (provider)?	Equipment and tools required
Deal with blockages and leaks (plumbing)	The users	The users themselves or a small informal private provider (plumber)	Picks, brushes
Clean the grease trap and connection boxes	The users	The users themselves or a small informal private provider (plumber)	Picks, brushes, trowels, shovels
Settled sewerage: check the level of the settling tank and have this emptied if necessary	The users	Informal private sector (manual or mechanical pit emptier)	Vacutug or vacuum truck
Settled sewerage: check the level of the condominial settling tank and have the domestic tank emptied when necessary	The users or Sewer operator under contract: Private operator or Community-based operator or National public or local public operator	Operator under contract or one of their contractors (Private pit emptying companies)	Vacuum truck

2nd level: routine non-conventional sewer maintenance

Task description	Who is responsible for the task?	Who carries out the task (provider)?	Equipment and tools required
Clean the sewer and manholes and remove (frequent) minor blockages *(except main sewer lines)*	The users themselves or Sewer operator under contract: Private operator under contract or Community-based operator or National public or local public operator	The users themselves or a small informal private provider (plumber, pit emptier, garbage) or sewer operator under contract: Private operator or Community-based operator or Public operator	Hand tools: Picks, brushes, flexible rods, spades, cleaning balls Mechanical equipment: High-pressure ewer cleaning equipment (Brazil)
Carry out corrective maintenance on the upstream section of the sewer: illegal connections, cracks, breakages	Sewer operator under contract: Private operator under contract or Community-based operator or National public or local public operator	Sewer operator	Visual (surface) inspection Inspection camera (Brazil)

Photo 6: Small informal provider responsible for routine sewer maintenance and household sewer equipment maintenance in Ramagundam (India)

3rd level: heavy maintenance, maintenance of the entire system and routine maintenance of the main sewer lines

Photo 7: High-pressure sewer cleaning truck, sewer cleaning nozzle and CAESB robots with video cameras in Brasilia

Task description	Who is responsible for the task?	Who carries out the task (provider)?	Equipment and tools required
Remove major blockages on the upstream section of the sewer (small diameter pipes)	Users or Sewer operator under contract: Private operator under contract or Community-based operator or National public or local public operator	Sewer operator or A service provider (pit emptying company, for instance, as in Brazil)	Sewer cleaning pump (truck or pick-up)
Clean out the main sewer lines and their manholes and remove blockages	Sewer operator under contract: Private operator or Community-based operator or National public or local public operator	Sewer operator or A service provider (pit emptying company, for instance, as in Brazil)	Sewer cleaning pump (truck or pick-up)
Carry out corrective maintenance on the upstream section of the sewer: illegal connections, cracks, breakages	Sewer operator under contract: Private operator under contract or Community-based operator or National public or local public operator	Sewer operator	Visual (surface) inspection Inspection camera (Brazil) Other inspection tools Internal inspection by technicians on sewers with access
Undertake maintenance: replace damaged pipework, manholes and covers	Sewer operator under contract: Private operator under contract or National public or local public operator	Sewer operator or A service provider contracted by the sewer operator (public works company, for example)	Hand or mechanical digging tools Transport truck Lifting equipment, if required

4th level: lift pump and wastewater treatment plant repair and maintenance

This pertains to instances where the sewer is connected to a 'small' decentralized treatment plant that treats the wastewater from one or two non-conventional sewers, rather than to a 'large' conventional wastewater treatment plant that treats the wastewater from a citywide conventional sewerage system.

Task description	Who is responsible for the task?	Who carries out the task (provider)?	Equipment and tools required
Routine operation and maintenance of the pumping station: mechanical, electrical and hydraulic equipment, fuel supply, etc.	Sewer operator: under contract Private operator or National public or local public operator	Sewer operator	Possibly a permanent on-site technician (both caretaker and electromechanic)
Heavy maintenance of the pumping station **Emptying the lift station (removing sludge and sediment) (about once a year)**	Sewer operator: under contract Private operator or National public or local public operator	Sewer operator or specialist electromechanical or hydraulic contractor	Engineer or high-level technician specializing in electromechanics Lifting equipment, if required (if no gantry above the station) Pump
Routine operation and maintenance of the decentralized treatment plant **Monitor the quality of wastewater discharges** **Bypass in the event of heavy rains**	Sewer operator: under contract Private operator or National public or local public operator	Sewer operator (or conventional sewerage operator if different)	Possibly a permanent caretaker-technician Dedicated engineer for overall monitoring of the WWTP
Heavy maintenance of the treatment plant **Empty or clean the treatment plant (every 1 to 5 years, depending on the type of WWTP)**	Sewer operator: under contract Private operator or National public or local public operator	Sewer operator (or conventional sewerage operator if different) or specialist contractor (WWTP emptying company)	Specialist technicians Cleaning and pumping equipment

Photo 8: Emptying a lift station using a booster pump (Dakar)

IV. The financial sustainability of non-conventional sewer systems

For information on operating costs, please refer to Part 3. To which contexts are non-conventional sewers best suited?

Chronic operating deficits

According to the business model, non-conventional sewers are often to be **financed in part by the users,** expected to finance routine maintenance on the upstream section of the sewer (or even the whole sewer in certain cases) through their payment of the 'non-conventional sewer' sanitation fee, and **the public authorities**, who are generally expected to **cover the cost of both lift pump and treatment plant maintenance and 'supporting' activities** (capacity-building, regulation).

However, nearly all **non-conventional sewers are plagued by chronic operating deficits** due to a range of factors, the combination and importance of which differ in accordance with the system being considered:

- **low collection rate of the sanitation fee** from users (see below);
- **too few connections** to finance all equipment;
- **planned subsidies (particularly local authorities) not disbursed** (see below);
- **recurring operating costs under-estimated**, which thus means they are under-funded;
- **technical problems** (due to the design or to lack of maintenance) resulting in large one-off maintenance costs.

Difficulties encountered by the public authorities to finance operation

The funding they are required to provide is often disproportionate to their financial capacities and unrelated to their priorities

There are two main reasons for this:

- **local authorities lack fiscal resources:** either because the power to levy and collect taxes has not been devolved to them or because local tax collection capacities are too poor;
- **public authorities are reluctant to spend any of their meager resources either on sanitation in general or on non-conventional sewers in particular**. This is notably the case of those authorities who had very little involvement in the non-conventional sewer selection and design phase and with whom this financial commitment has not been formalized through a contractual agreement.

It is a source of finance that is often unpredictable and offers few performance-based incentives

For many years in Kumasi (Ghana), the local authority paid the private operator in charge of running the non-conventional sewer system directly. The funds came out of the overall local authority budget and were raised through local taxes and an allocation from the state. However, this arrangement was terminated at the request of the operator as he was not receiving payments on a sufficiently regular basis.

This is also the approach being used in Ramagundam, India, where the local authority provides funds from its operating budget (largely financed by the state) to cover the cost of 3rd and 4th level O&M, which it also carries out (2nd level is the responsibility of the users).

Furthermore, this is also the system now in use in Dakar, as the national public operator has (under duress) taken over management of the majority of non-conventional sewers at its own expense and out of its own budget (partially financed by the state).

Nevertheless, there are a number of **major disadvantages** to local authorities 'directly' financing the service**:**

- the operating subsidies available are often too low to cover all costs, resulting in a low quality service;
- it is dependent on the resources available and allocations from the municipal budget, which remain unpredictable over the medium to long term;
- it does not provide clarity of costs and expenditure and thus offers little incentive to the operator to improve his performance.

Different methods of collecting the sanitation fee from the users

On a 'case-by-case' basis:

Whenever there is a problem with the sewer (clogging), the users (usually those residents directly affected) **club together** to raise the funds required to fix it**.** This is notably the system used not only on most of the sewers in Dakar (Senegal) and Bamako (Mali) where there is no operator actually able to collect the sanitation fee, but also in Ramagundam (India) to cover the cost of routine maintenance on the upstream pipework.

At best, this system enables enough funds to be collected to cover the cost of routine maintenance on the upstream section of the sewer ('2nd level' maintenance). On its own, it cannot therefore be used to ensure the financial sustainability of the service, as users' willingness to contribute can fluctuate wildly.

Regular payment of the sanitation fee through 'door-to-door' collection:

This is the system in place on most **'community-based management' services: a collection agent (a volunteer from the community or small operator remunerated by the management committee)** is responsible for regularly collecting a 'contribution' from the users to ensure the smooth running of the service.

To encourage users to pay, it is often necessary to rely on their willingness, common sense and 'community peer pressure'.

In practice, **in sub-Saharan Africa, this system almost always collapses and has often proven to be very fragile in other countries too** (Indonesia, in particular). The reasons for this are as follows:

- **there is no way of forcing the users to pay,** as, technically (unlike with water supply), it is almost impossible to 'cut off' the service to a user who defaults on payment;
- **the collection agent is either a volunteer or paid in accordance with a fixed cost schedule**. The agent therefore has no personal incentive to improve the collection rate;
- **users are reluctant to pay for a service that is often of poor quality.** Thus, the operator cannot afford to properly maintain the sewer and the service quality deteriorates even further, etc. This 'vicious circle' has been observed on many sewer schemes.

However, this system appears to work better when the sanitation **fee is collected at the same time as the fee for solid waste collection** (such as in Nagpur, India, or Kieu Ky, Vietnam), as this is a service that can be cut off and for which there seems to be a higher spontaneous demand.

Door-to-door collection has also been implemented in Kumasi, where the private operator collects the sanitation fees he is owed from each building. There are still a high number of users who default on payment; however, the operator is now increasingly taking these users to court *(see below: What penalty mechanisms are in place for non-payment?).*

The fee amount is never given as a reason by users for 'non-payment' (except in instances where the fee is higher than that paid by users of conventional sewerage in neighboring areas and consequently considered discriminatory: Darou, Saint-Louis, Senegal).

However, responsibility for cost recovery and operating account management is often assigned to a stakeholder that lacks the relevant capacities. This is particularly the case of sewer systems under so-called 'community-based' management. Only the management committees (that bring together the users, public operator and the local authority) of Darou in Saint-Louis (Senegal) and, to a lesser extent, Cité Ousmane Fall (Dakar, Senegal) have been provided with the 'basic' tools required to recover costs and financially manage operations, namely:

- **customer records;**
- **account ledger;**
- **sanitation fee receipt of payment;**
- **cash book;**
- **customer contract and service regulations to be issued to users;**
- etc.

Levied on the water (or electricity) bill:

In theory, this is the most effective system as it ensures regular payment and makes it easier to impose penalties on users who default; however, in order to work, a certain level of coordination between the different operators is required (alternatively, there needs to be a single operator put in charge of the different services).

This was the system implemented through the GRET-supported projects in Laos and Cambodia (payment of the sanitation fee through the water bill in one instance and through the electricity bill in the other).

This system is also used in Brazil. In Kumasi, the initial intention was to adopt this same system to remunerate the operator; however, this was never implemented due to a breakdown in communications between the local authority and public water operator.

What penalty mechanisms are in place for non-payment?

It is vital for the financial sustainability of the sewer system - and particularly for the often fragile financial stability of those operators of the smallest systems - that operators are able to impose penalties on users who default on payment.

'Community-based' management tends to rely on 'peer pressure' between users as a type of self-regulation. **This system rarely works** as the 'communities' are not made up of homogenous, consistent and organized groups. Furthermore, **when the collection agent is from the community, he often finds it difficult to influence members of his family or neighborhood (Mali).**

In Ghana, the private operator has taken users who default on payment to court; however, so far, these users have only been made to pay the monies owed, with no additional penalty imposed.

In Brazil, operators emphasized the fact that **the process to cut off a user's water supply for non-payment is long and rarely successful due notably to a lack of political will**. This outstanding debt can easily be absorbed by Brazil's public operators, whose financial capacities far exceed those of sanitation stakeholders in Africa or less developed countries in Asia.

What financial management tasks are involved and to whom should these be assigned?

Tasks include:

- **monitoring revenue collection**: the sanitation fee collection rate and possible penalties for users who default, as well as the collection of other types of financial resources (particularly subsidies);
- **disbursing expenses:** for routine expenses, this is the responsibility of the operator's accountant upon request from the technicians. Larger expenditure items require approval from the president and treasurer of the users' association.

These tasks can be carried out directly by either the operator (particularly where there is a private operator) or the entity responsible for the service (contracting authority). This is notably the process followed on sewers under 'community-based' management, such as Saint-Louis Darou (Senegal) and Denpasar (Indonesia).

However, there can also be **two levels of financial management, particularly in instances where the technical operation of the sewer is divided among several stakeholders**. Thus in Darou-Saint-Louis (Senegal), users club together to pay for routine non-conventional sewer maintenance (2^{nd} level) and the national operator is responsible for the (financial) operation of the main sewer line, pumping stations and treatment plants. This is also the approach initially devised for 'condominial' sewerage in Brazil; however, it was very rarely actually adopted.

	Ramagundam, India	Rufisque, Baraka & Yoff (ENDA), Senegal	PAQPUD ONAS, Senegal	Darou/Saint Louis, Senegal	Asafo Kumasi, Ghana	Salvador de Bahia, Brazil	Recife, Brazil	Brasilia, Brazil
Who finances operation?	Users for routine maintenance on the upstream section of the sewer Municipality for maintenance of the main sewer line, lift stations and WWTP	Users Occasionally ad hoc support from the municipality (Rufisque). ENDA would like this to become more widespread	Users State	Users State	Users Local authority	Users	Users	Users
How are user contributions collected?	On a 'case-by-case' basis in accordance with user demand in the event of a blockage	In theory, a monthly fee In reality, on a 'case-by-case' basis as required	'Non-conventional sewer' fee +sanitation tax levied on the water bill	'Non-conventional sewer' fee +sanitation tax levied on the water bill	'Non-conventional sewer' fee for the operator collected door-to-door	'Non-conventional sewer' fee for the operator levied on the water bill	'Non-conventional sewer' fee for the operator levied on the water bill	'Non-conventional sewer' fee for the operator levied on the water bill
Who sets the fee?	Informal private operator, based on the cost of the intervention	ENDA, in conjunction with the local authority (Rufisque and Yoff) Users' association (contribution)	Management committee (in theory)	Management committee	Private operator	Public operator	Public operator	Public operator
Who is responsible for cost recovery?	Small informal private operator responsible for maintenance charges on a 'case-by-case' basis The municipality funds maintenance and major repairs through the municipal budget (local taxes and, particularly, allocation from the state)	Users' association in theory, but this is only the case in Baraka	Management committee (in theory) and ONAS	Management committee and ONAS	Private operator	Public operator	Public operator	Public operator
Who is in charge of managing the operating account?	No operating account	No operating account	No operating account except in Ngor (local authority) and Cité OF (users' association)	Management committee that includes the users, ONAS and the local authority	Private operator	Provincial public operator	Provincial public operator	Provincial public operator
Operational stability	Stable (adequate repairs and maintenance)	Loss-making (does not enable sufficient repairs & maintenance)	Loss-making (does not enable sufficient repairs & maintenance)	Loss-making (does not enable sufficient repairs & maintenance)	Stable, albeit precarious	Stable	Stable	Stable

Table 16: Different methods of financing operation

V. The user – operator relationship

During the operational phase, the operator needs to ensure they have a **trained member of staff available in the field on a daily basis to manage user relations**. However, this is often not the case.

The 'commercial' relationship between the operator/manager and the user (client)

The role of the user relations officer is to **deal with complaints, handle minor problems and escalate any major issues** (requests for a technician), etc. These tasks can be combined with that of fee and outstanding debt collection and/or routine sewer maintenance. Thus, in Kumasi, the local operator has a kiosk in the center of the area covered by the sewer, which is manned by a multi-skilled technician who handles users' requests and may also carry out inspection visits.

Photo 9: Operator's user information kiosk in the Asafo district, Ghana

Having a member of staff 'on the ground' also provides the operator with a means of technically monitoring the sewer. The employee will be able to spot a general drop in the service level or in user satisfaction and can pinpoint areas of frequent clogging that may indicate a more serious underlying technical problem, etc.

Reminders of good practice and 'ongoing' awareness-raising

Even when users initially appear very keen to participate in a non-conventional sewer project, their **involvement soon drops off if there is a lack of follow-up**. Users stop employing good practices, the number of connection requests falls and cost recovery becomes more and more difficult, etc. This phenomenon has been observed on all sewer schemes; however, it is all the more pronounced on those systems where the service quality is low (the management body is not clearly identified or incapable of fulfilling its responsibilities, technical faults, etc.).

Thus, all stakeholders agree on the need for '**ongoing' user awareness-raising.**

To this end, and in order to avoid overly frequent and time-consuming meetings and prevent 'meeting fatigue' (feedback from users in Rufisque), priority has been given to **door-to-door and site visits**. In addition, the operator has further opportunities to raise user awareness during visits to carry out repairs or collect the sanitation fee.

These all too rare 'follow-up reminders' have had an immediate impact in both Rufisque and Saint-Louis-Darou (Senegal). Similar visits have also been carried out in Brasilia, Recife and Salvador de Bahia, as well as by the private operator in Kumasi with the support of the local authority's 'social' specialist.

VI. Monitoring and regulation mechanisms

There is very little attention paid to monitoring and regulation on any of the non-conventional sewer schemes involved in this study, which explains their low levels of sustainability. Neither is monitoring and regulation covered in any great detail in non-conventional sewer literature.

For an introduction to water and sanitation service regulation, please refer to TREMOLET, BINDER, 2010 and DESILLE, FAGIANNELLI, 2013.

What is meant by 'regulation'?

Regulation involves:

1. **defining the service operating framework:** fee structure, stakeholder duties and responsibilities, service quality and performance objectives, etc.;
2. **checking that the service is operating within this previously defined framework** by collecting and analyzing data to inform a series of user satisfaction, financial and technical indicators;
3. **ensuring this framework is respected by implementing corrective measures when necessary**: technical interventions, penalties for failure by stakeholders to uphold their commitments, conflict resolution.

The aim of regulation is to **ensure and maintain the quality and sustainability of the service.**

How to conduct financial and technical monitoring and using which indicators?

Monitoring the service involves:

- **collecting data to inform technical, financial and 'social' (user satisfaction) indicators**;
- analyzing and comparing these indicators against the **quality and performance objectives** outlined in the service framework to produce an accurate and real-time diagnostic of the 'health' of the service.

The monitoring tool is thus an essential prerequisite for all regulation.

Indicators

Some of the main indicators used on the non-conventional sewer schemes studied are provided below:

Financial indicators

- balance sheet;
- fee and subsidy collection rates;
- level of savings built up for renewal;
- ongoing maintenance costs;
- etc.

Technical indicators

- number of interventions per sewer line per year for each area (when multiple interventions have to be carried out on the same section of the sewer, this usually means there is a technical problem that needs to be identified and resolved);
- average response time to reported problems / user complaints;
- quality of the wastewater being discharged from the treatment plants;
- visual inspection of the sewer;
- etc.

User satisfaction

- complaint trends;
- complaint handling times;
- sanitation fee collection rate trends;
- etc.

Who is responsible for collecting data and analyzing monitoring indicators?

In theory, data to inform **monitoring indicators should be collected and analyzed by a suitably qualified and independent body**. This could either be a specialist government department, for instance the national regulatory authority or regional directorate of water, health or the environment, or one of its service providers (consultancy firm).

In practice, there are very few properly organized non-conventional sewer monitoring systems in place. Thus, in Senegal, Mali and India for example, there is very little monitoring data available.

Who is responsible for regulation?

Each service stakeholder contributes to regulation:

The contracting authority

The contracting authority establishes the service operating framework, ensures the operator honors its contract and, to this end, often monitors the operator's performance and introduces corrective measures, such as penalties against the operator for failure to honor the contract or, conversely, fee increases to guarantee the operator a certain level of profitability.

Thus, there need to be **sanitation service specialists with a sound understanding of the technical, economic and financial, legal and social aspects of the service** working within the contracting authority**.**

Whilst this is the case in Brazil and, to a lesser extent, in Ramagundam (India) and Kumasi (Ghana), other contracting authorities, notably in Africa, lack the necessary resources. The situation is not helped by the fact that actual responsibility for the service has frequently been transferred between stakeholders (users, local authority, national operator), meaning that the service operating framework was initially incorrectly defined.

The regulatory bodies

As, in some instances, the contracting authority is both regulator and the party being regulated, an additional level of regulation is required to avoid a conflict of interest and, for example, to settle disputes between the contracting authority and operator or compensate for any weaknesses in the contracting authority's regulation.

This additional regulation can be carried out by a **specialist government department**, for instance the national regulatory authority or regional directorate of water, health or the environment.

Lastly, **the local or national courts** also contribute to regulation in that they can impose penalties on any of the parties involved for failure to honor commitments (ruling in favor of the operator and against users having defaulted on payment in Kumasi, Ghana), or rule on disputes between the contracting authority and the operator.

The users

The users contribute to monitoring by reporting issues encountered in their daily use of the service and technical problems (leaks, bad smells) in public areas to the operator and/or contracting authority or by reporting any issues with the service provided by the operator**.**

By requiring that the service framework is upheld and putting pressure on the operator, contracting authority and government departments (if relevant) to provide an efficient, available and accessible service, the **users are also a key contributor to regulation.** Thus, in Brazil, the national operator took over management of the condominial sewers at the demand of the users (who even organized demonstrations and television programs to protest against the local operators).

The operator

The operator forms a key part of the monitoring and regulatory system as he identifies and deals with technical problems on 'his' sewer scheme every day, has to resolve the service issues reported by users and ensure he maintains a satisfactory fee collection rate. Thus, **it is the operator who, on a daily basis, is responsible for the initial level of regulation that is vital for ensuring the viability of the service.**

This 'self-regulation' works relatively well in Kumasi (Ghana) where the private operator ensures the financial stability of the service on the basis of user satisfaction (through the principle of supply and demand). Although the municipal technical departments undertake only very remote monitoring and regulation, following a number of modifications made at the request of the operator (freedom to set fee levels), this system has been financially stable for the last 20 years.

On many other non-conventional sewers in Africa, the (often community-based) operators lack the resources to either undertake adequate technical monitoring and regulation or ensure users uphold their commitments to pay the sanitation fee and utilize good maintenance practices. Furthermore, they often find themselves with no support from the contracting authority or higher regulation authority and incapable of requesting such assistance.

The need to establish monitoring and regulation indicator reporting frameworks

In order to ensure service operation is transparent and render the public authorities and operator accountable to the users, **a consultation framework can be put in place**. The aim of this consultation is to share and jointly approve the monitoring results and carry out 'concerted regulation' by discussing potential corrective measures and settling any disputes.

Thus, on the GRET-supported projects in Laos and Cambodia, **a service monitoring meeting attended by the operator, user representatives, district authorities (contracting authority) and state departments is held every six months.**

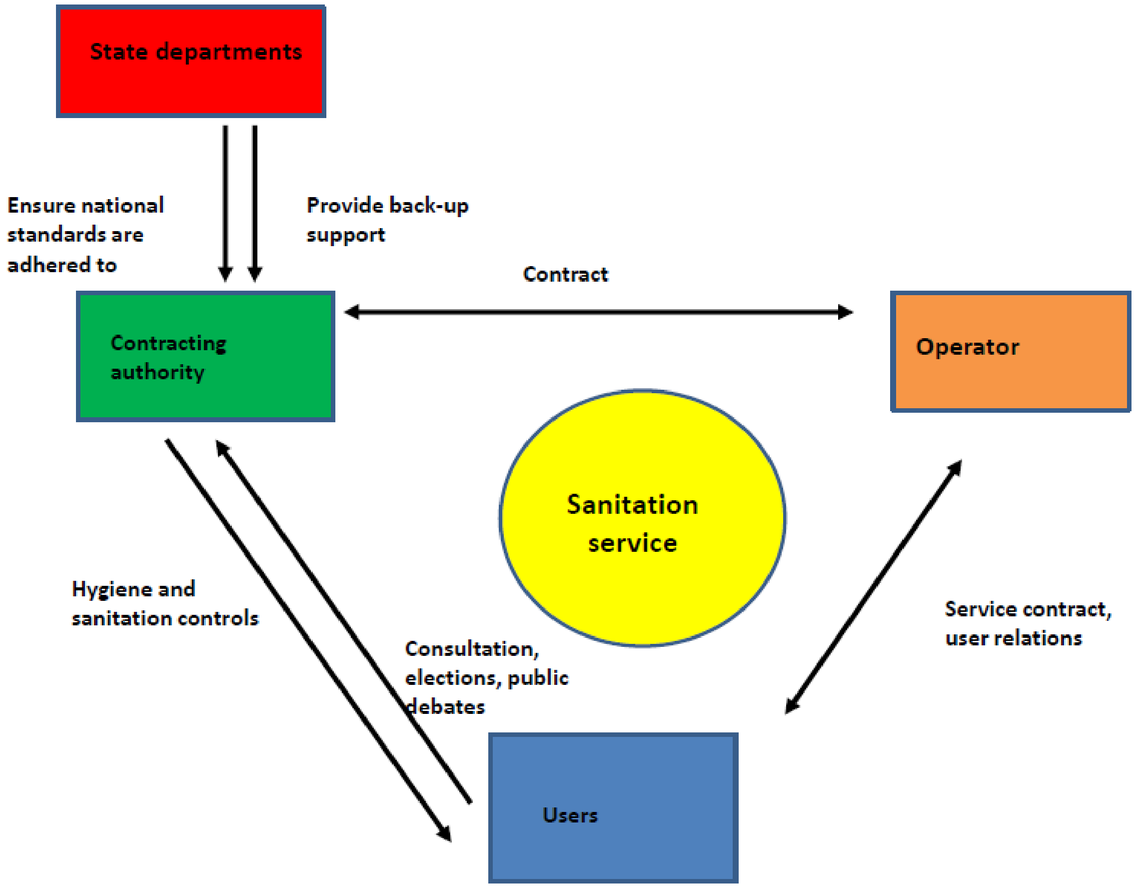


Figure 31. Service stakeholders and the regulation mechanism

Annexes

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II. List of international experts interviewed

For details of the interviews conducted for the country studies, please refer to the relevant country study report in the Annex.

- Kevin Tayler, WEDC;
- Bob REED, WEDC;
- Barbara EVANS, University of Leeds;
- François Brikké, GWP;
- Pierre-Marie Grondin, pS-Eau;
- Tha Thu Thuy, pS-Eau;
- Dominique Hautebergue, AFD;
- Christian Zurbruegg, Roland Scherteinleb, Christophe Luthi, Philippe Reymond, Lukas Ulrich and Augustin Tchonda, EAWAG - SANDEC;
- Stephan Reuter, Nicolas Reynaud and Mareen Heuvels, BORDA;
- Jérémie Toubkiss, UNICEF Mali;
- Martin Kouamé, EAA;
- Antoine Huart, Fondation SADEV;
- Patrick Godard, Periferia;
- Martin Kouamé, EAA;
- Emmanuel Ngikam, ERA Cameroun;
- Annie Savina, Consultant;
- Mbaye Mbéguéré, ONAS;
- Eve Karleskind, Conseil Général du Val de Marne;
- Stéphane Clayette, Conseil Général de Seine Saint-Denis;
- Jonathan Parkinson, IWA.

III. Country Report: India

Author: Asit NEMA, consultant

See attached document

IV. Country Report: Ghana

Author: Lukman Y. SALIFU, consultant

See attached document

V. Country Report: Senegal

Author: Jean-Marie ILY

See attached document

VI. Country Report: Mali

Author: WSA MALI

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VII. Country Report: Brazil

Authors: Antonio DA COSTA MIRANDA NETO, consultant, and Jean-Marie ILY

See attached document

VIII. Technical Note: DEWATS

Author: Jean-Marie ILY

See attached document