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Fecal Sludge Management: Diagnostics for Service Delivery in Urban Areas

Case study in Lima, Peru

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Supporting document

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Executive summary

Introduction

This report summarises the main findings of a case study on faecal sludge management in Lima, Peru. It is part of the project entitled 'Fecal Sludge Management: Diagnostics for Service Delivery in Poor Urban Areas', funded by the World Bank Water and Sanitation Programme (WSP). There are five city case studies as part of this project (Balikpapan, Dhaka, Freetown, Lima and Santa Cruz). The specific objectives of the Lima study were:

- To provide quantitative and qualitative data on the sanitation situation in Lima from a socio-economic perspective, specifically as it relates to FSM.
- To do the above in such a way that the data is representative of poor non-sewered areas of the city.
- To provide initial recommendations to guide discussions around future interventions in the sanitation sector in Lima, by contributing credible data and analysis.
- To inform the development of analytical tools and guidelines for using them, by "road-testing" draft tools using primary data collection.

Methodology

The study followed an overall research framework developed as part of the inception period, which set out research questions and sub-questions. Data collection instruments were then developed so as to answer these questions. Six data collection instruments were used in Lima, four quantitative and two qualitative. The quantitative instruments were a household survey, transect walks, observation of service provider practices, and tests of fecal sludge characteristics. The qualitative instruments were key informant interviews and focus group discussions.

The lead consultant team led on methodology design and data analysis, while data collection was undertaken by separately-contracted consultants under the leadership of WSP. All data collection was undertaken by Akut Peru, with the exception of key informant interviews which were undertaken by a WSP short-term consultant.

The household survey primarily aimed to collect data from households using on-site sanitation regarding their current use and preferences for future FSM services. The sampling was carefully planned so as to allow conclusions to be drawn about non-sewered areas of the city as a whole and lowest-income non-sewered areas in particular. The transect walks aimed to enable participants to make a subjective and qualitative assessment of physical and environmental conditions within a community. The observation protocol for service providers involved making visual inspections about fecal sludge (FS) from pits or tanks to final disposal. The tests of fecal sludge characteristics were carried out at three stages: (i) in containment, (ii) during removal, and (iii) after treatment. The key informant interviews aimed to address key questions about how both the 'enabling environment' and the 'operating environment' affects FSM services (past, current and future). Finally, the focus group discussions aimed to gather qualitative data that complements, validates, or challenges the conclusions drawn from the household survey data.

Sampling for most quantitative instruments was derived from the sampling for the household survey, for which there were two sub-samples. For sub-sample A, the Primary Sampling Units (PSUs) were *Unidades Administrativas Locales* (*UALs*), an administrative unit akin to "urban neighbourhoods", which were selected so as to allow estimates which were representative of non-sewered areas of Lima as a whole. For sub-sample B, the PSUs were lowest-income neighbourhoods, purposively selected among the 33 low-income and priority areas for SEDAPAL (i.e. areas that are unlikely to get access to sewerage in the next 4 years). There are 720 households overall, equally divided between the two sub-samples.

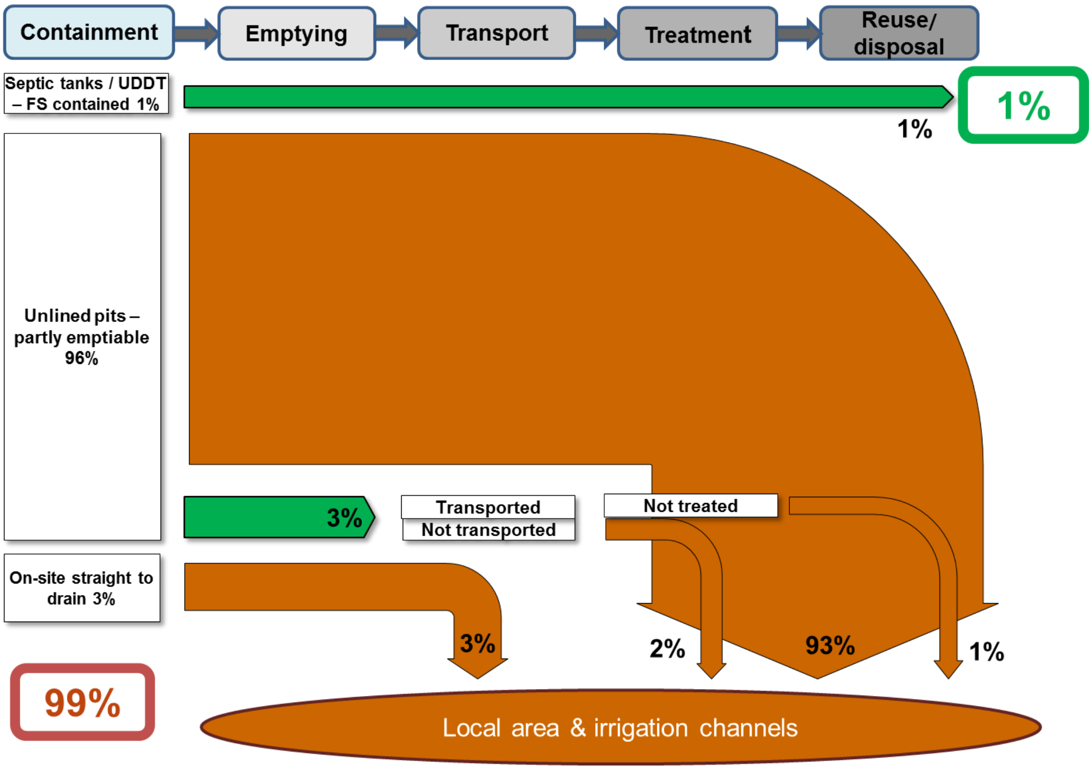
Results

The table below summarises some key indicators from the household survey.

Indicator	Non-sewered areas
Use of sanitation	
Households using improved sanitation (excluding 'shared improved')	76%
Households using improved sanitation (including 'shared improved')	84%
Type of containment	
Households using a toilet discharging directly to an unlined pit	96%
Households using a toilet discharging directly to a drain or ditch	3%
Emptying	
Households who have abandoned (sealed and unsealed) their previous pit after it filled up	99%
Households who experienced their current pit / tank filling up	3%
Households who have emptied their current pit / tanks after it filled up	90%

The data in the table above paints a picture of almost all fecal sludge ending up in unlined pits, of which all are usually abandoned after they fill up. It is therefore not surprising that a market for FSM services does not exist. These key data are reflected in the fecal waste flow diagrams (FWFDs) in the body of the report. The non-sewered areas FWFD is reproduced below.

Faecal Waste Flow Diagram for Lima – non-sewered areas



Analysis of demand and supply for FSM services finds that there is basically no demand and no supply for the urban poor in Lima. That is not surprising in the context of the SFD above, and particularly the household survey finding that only 3% of households in non-sewered areas who had a toilet with a pit or septic tank have experienced it filling up. Households in non-sewered areas generally cover and abandon their pit once it fills up, digging a new one nearby. However, there have been several reports (both in the media and also in the focus group discussions) about people running out of space in their plots to dig new pits, which may be encouraging the demand for FSM services. Nonetheless, current prices remain too high and unaffordable for the majority of households in poor non-sewered areas. On the supply side, there are currently no large-scale FSM services for poor households, with private service providers mainly serving only public facilities (e.g. hospitals, schools) or households in wealthy areas of Lima. Given the lack of knowledge about the potential market for FSM services as well as the lack of ability and / or willingness to pay of households in poor peri-urban areas, private service providers have had little incentive so far to offer services in these areas.

Findings from the transect walks show that there are very few instances where blackwater was visible in irrigation channels. Although open defecation (OD) is not a major problem in Lima, OD was reported in 10% of the non-sewered areas sampled, mainly practiced by a few children or elderly people. Fecal sludge was also reported to be dumped alongside solid waste – focus group discussions revealed that this was primarily carried out by households whose pit had filled up and were unable to dig a new pit, or by people who use potties (as opposed to a toilet) in the evenings. The main issue in the majority of locations was the accumulation of solid waste on a daily basis. Overall, the combination of instances likely introducing risks to public health occurred in a total of 17 locations in non-sewered areas and 3 locations within lowest-income areas.

The City Service Delivery Assessment shows that public policy is deficient, while there is a severe shortage of capital investment and operational oversight of FSM services throughout Lima. Although for the city as a whole, the lack of FSM services may not seem to be a priority (given the high level of sewerage coverage), there are around 800,000 people in poor areas without a real and sustainable solution to their daily sanitation needs. Sustainable solutions will only come about when an FSM Framework translates into clearly defined, capacitated and financed action. This requires recognition of the scale of the problem, dialogue and engagement of public, private and civil society bodies to ensure appropriate infrastructure and services can be systematically developed and adapted to respond to the various contextual challenges of the city. Segmentation and lack of coordination is already a key constraint in the provision of basic services, so bringing all key stakeholders together and aiming at reaching a consensus on a course of action, is an imperative. A clear definition and agreement of the roles of different stakeholders along the sanitation service chain is also required, with a particular focus on developing adequate containment and treatment frameworks, and strengthening both emptying and transport components of the FSM chain.

Finally, a Prognosis for Change shows that the current incentives discourage actions from both public and private stakeholders. On one hand, responsibilities for FSM at both national and local levels have not been clearly designated, and thus both planning and financing for FSM are unlikely to happen if no stakeholder can be held accountable for investments and results. Evidence from KIIs also suggests that, although there seems to be no political opposition to the development of FSM services, there is no political will either to carry this forwards. On the other hand, without a clear demand (current and future) for FSM services, private service providers are unwilling to develop a market that may be unprofitable. Moreover, households may be reluctant to invest in upgrading their containment facilities, partly because many regard sewerage as the only long-term option, but also because the lack of land tenure and ownership generally discourages investment. Change is achievable, but interventions will not be successful unless they address the incentives which deliver the current *status quo*.

Table of contents

List of tables and figures

List of abbreviations

ATP	Ability to Pay
CSDA	City Service Delivery Assessment
DHS	Demographic and Health Survey
DESA	Dirección Ejecutiva de Salud Ambiental (Executive Directorate of Environmental Health)
DIGESA	Dirección General de Salud Ambiental (General Directorate of Environmental Health)
ENAHO	Encuesta Nacional de Hogares (National Household Survey)
ESI	Economics of Sanitation Initiative
FGD	Focus Group Discussion
FS	Fecal Sludge
FSM	Fecal Sludge Management
FWFD	Fecal Waste Flow Diagram
JMP	WHO / UNICEF Joint Monitoring Programme
KII	Key Informant Interview
MoE	Ministry of Environment
MoHCS	Ministry of Housing, Construction and Sanitation
NGO	Non-Governmental Organisation
ODI	Overseas Development Institute
OPM	Oxford Policy Management
OSS	On-Site Sanitation
PFC	Prognosis for Change
PHRA	Public Health Risk Assessment
PSU	Primary Sampling Unit
RF	Research Framework
SEDAPAL	Servicio de Alcantarillado y Agua Potable de Lima (Lima Sewerage and Water Supply Service)
SFD	Shit-Flow Diagram
SSU	Secondary Sampling Unit
SUNASS	Superintendencia Nacional de Servicios de Saneamiento (National Superintendence of Sanitation Services)
SWM	Soild Waste Management
TOR	Terms of Reference
TW	Transect Walk
UAL	Unidad Administrativa Local
UASB	Up-flow Anaerobic Sludge Blanket
UDDT	Urine-Diverting Dry Toilet
UNICEF	United Nations Children's Fund

WB	World Bank
WEDC	Water, Engineering and Development Centre, Loughborough University
WHO	World Health Organisation
WSP	Water and Sanitation Programme
WTP	Willingness to Pay

1 Introduction and Research Framework

1.1 About this report

This report summarises the findings of a case study on fecal sludge management in Lima, Peru. It is part of the project entitled 'Fecal Sludge Management: Diagnostics for Service Delivery in Poor Urban Areas', hereafter "the FSM research project". This work is funded by the World Bank Water and Sanitation Programme (WSP). There are five city case studies as part of this project (Balikpapan, Dhaka, Hawassa, Lima and Santa Cruz).

The project is led by Oxford Policy Management (OPM) in partnership with the Water, Engineering and Development Centre (WEDC) at Loughborough University. The full TOR for the project can be found here. The overall objective of this assignment is to "work with the WSP urban sanitation team to develop the methodology, design and survey instruments, undertake analysis of data collected from five field case studies (linked to World Bank operations projects), refine the diagnostic tools, and develop decision-making tools and guidelines for the development of improved FSM services." Specific objectives of the Lima case study are listed in the next section.

This document is part of a project deliverable designed to be internal at this stage. Therefore, it does not contain much background information, and the assumed audience is the WSP project team and other stakeholders familiar with the Lima FSM context. The inception report is available here for other readers, which contains more background information on the project and the methodology.

The report's structure is detailed below. It begins with a background to the research and the city, moving into several sections analysing the urban sanitation context, which are not specific to FSM. Thereafter, the report's focus is on FSM services in particular.

1.2 Study rationale and objectives

It is very common for poor people living in urban areas of most low-income countries to either use on-site sanitation facilities or defecate in the open. Even when improved on-site options are used to contain feces, there generally exist few services for collection, transport and disposal or treatment of the resulting fecal sludge. Fewer opportunities for resource recovery through end-use of fecal sludge exist. The service delivery gaps within and between stages of the sanitation service chain become more apparent as sanitation coverage increases in poor urban areas. Failure to ensure strong links throughout the fecal sludge management (FSM) service chain results in untreated fecal sludge (FS) contaminating the environment, with serious implications for human health.

Despite increasing demands for FSM services, there are few tools and guidelines to help city planners navigate complex FSM situations. This study aims to build on existing frameworks and tools, in particular the City Service Delivery Assessment (CSDA) scorecard, Fecal Waste Flow Diagram (FWFD), and the Economics of Sanitation Initiative (ESI) toolkit. The aim is to produce diagnostic and decision-making tools that are based in tried-and-tested strategic planning approaches and frameworks, with a focus on practicality. Critically, updates to the tools and guidelines will be based on primary data collection in five cities. In most of the cities, this is supported by interaction with city stakeholders involved in ongoing World Bank lending. Acknowledging the difficulty of reforming FSM services in cities, the political economy questions around FSM are explicitly included as part of the overall analysis.

The specific objectives of the study are:

- To provide quantitative and qualitative data on the sanitation situation in Lima from a socio-economic perspective, specifically as it relates to FSM;
- To do the above in such a way that the data is representative of the non-sewered areas of the city as a whole but also provides a separate picture of the situation in lowest-income non-sewered areas;
- To provide initial recommendations to guide discussions around future interventions in the sanitation sector in Lima, by contributing credible data and analysis; and
- To inform the development of analytical tools and guidelines, by "road-testing" draft tools using primary data collection.

The study was therefore primarily socio-economic rather than technical. It did not aim to carry out technical inspections of infrastructure or produce detailed maps with neighbourhood-level analysis and recommendations. For those who have previously worked in the sanitation sector in Lima, there may be few surprises, but the report does offer representative data to back-up what has previously been reported in smaller or more general studies.

1.3 Research framework

During the inception stage, the OPM/WEDC team developed a Research Framework (RF), based on the overarching research questions implicit in the TOR and draft research protocol. From these questions, a logical set of project components was developed. These became the basis for the design of data collection instruments that would enable information to be collected for the indicators making up each component.

The approach is to place all components – as well as ensuing results – of the study within the context of the FSM service chain, to optimise its relevance and effectiveness. This is clear from the full version of the RF in the Inception Report, with all components and questions arranged along the service chain. There is not enough space here to go through the research questions, but the Research Framework can be downloaded from a link available in Annex F.

The initial structure of components from the Inception Report is reflected in Table 1 below. The study methodology is described in Annex B.

Table 1 FSM project components

	Assessment	Objective		Component
1	Service delivery assessment	To understand the status of service delivery building blocks, and the political economy of FSM services overall	**1a**	CSDA scorecard
			1b	Stakeholder analysis
2	fecal sludge situation assessment	To understand current FECAL SLUDGE management patterns, risks and future scenarios	**2a**	Fecal Waste Flow Diagram
			2b	fecal sludge characteristics and end-use potential
			2c	Public health risk analysis
3	Existing demand & supply assessment	To understand customer demand for FSM services and the current status of service providers	**3a**	Demand – mapping customer demand and preferences
			3b	Supply – mapping service provider supply and capacity
4	Intervention assessment	To identify a hierarchy of FSM intervention options and models for implementing and financing them	**4a**	Intervention options
			4b	Implementation and financing models
5	Appraisal	To appraise different interventions against the "business as usual" scenario	**5a**	Economic appraisal of intervention options

1.4 Report structure

This report is sub-divided into three groups of chapters. The initial chapter describes the city background and there are three chapters that cover the urban sanitation context without a specific focus on FSM. The rest of the report considers FSM services and service delivery.

- **Background**
  - Section 2 provides a background to the city
- **Urban sanitation context**
  - Section 3 shows a Fecal Waste Flow Diagram
  - Section 4 contains a Public Health Risk Assessment
- **Analysis of FSM services**
  - Section 5 contains the potential FSM service demand and supply assessment
  - Section 6 discusses reuse options
  - Section 7 contains a Service Delivery Assessment
  - Section 8 provides a Prognosis for Change based on the current situation

- Section 9 discusses intervention options
- Section 10 provides an economic analysis of the intervention options
- Section 11 concludes

- **Annexes**
  - Annex A shows a map of the sampled areas
  - Annex B summarises the study methodology
  - Annex C contains the detailed Fecal Waste Flow matrices
  - Annex D provides the full CSDA scoring table
  - Annex E provides more information on the public health risk assessment
  - Annex F contains further tables on the economic analysis

2 Background to Lima City

2.1 Lima overview

Lima is located in the central Peruvian coast, within the valleys of three main rivers: Rímac, Chillón and Lurín, which serve as the city's main drinking-water resources. The city is characterised by a mild and warm climate, with mean annual temperature ranging between 18.6°C and 19.8°C, and a high humidity, which fluctuates between 81% and 85%.

In this study, we are considering the whole of Lima Metropolitan Area (hereon after referred to as Lima), which encompasses the municipalities of Lima and Callao. Lima is the third largest city in Latin America, with a population of almost 10 million distributed across 49 districts, the majority of which are entirely urban. Indeed, like other Latin American countries, urbanisation has been one of the main drivers of population growth, with around 60% of Lima's citizens coming from other regions of the country.

However, lack of long-term planning has led to a highly disorganised urbanisation process, with many 'human settlements' in peri-urban areas having limited or inadequate access to basic public services, i.e. electricity, water and sewerage. For example, while coverage of piped water supply for households in the highest quintile was 100% in 2013, coverage was only 50% among households in the lowest quintile. This is compounded by the fact that human settlements are both formal and informal in nature, which increases the difficulty in the provision of adequate services, not only due to land titling issues but also to the type of terrain that is inhabited, e.g. some communities are located in remote arid areas, where building any type of infrastructure is very expensive. Figure 1 below depicts the usual conditions in many of these low-income peri-urban settlements.

Figure 1 Human settlements in San Juan de Lurigancho

a. La Campiña

b. Los Leones

The main provider of both drinking water and sanitation services is SEDAPAL, which has been in operation since 1981. SEDAPAL mandates the operation, maintenance, control and development of water and sanitation services, also undertaking tasks related to planning, programming and financing, among others. SEDAPAL provides services to both Lima and Callao, as well as to other districts or areas within the Lima Department that have received approval from the Ministry of Housing, Construction and Sanitation (MoHCS). Other relevant stakeholders for the provision of water and sanitation services are presented in Table 3.

2.2 Lima's sanitation context

According to the 2013 National Household Survey (ENAHO), around 92% of Lima's population has access to sewerage (both inside and outside the dwelling). However, only 43% of the population in the lowest quintile, as compared to 100% in the highest quintile, has access to the sewer network (Table 2). Indeed, around 800,000 people in peri-urban areas of Lima do not have access to sewerage. Households in the lowest quintile rely mainly on septic tanks (17%) and unlined pits for containment (19%), with 12% of them having no sanitation service at all (i.e. open defecation).

Table 2 Type of sanitation service by wealth quintiles (%)[1]

	Lowest	Second	Middle	Fourth	Highest	Total
Sewerage (inside the dwelling)	36.3	79.8	96.4	99.0	99.7	87.4
Sewerage (outside the dwelling but inside the building)	6.4	9.9	1.7	0.6	0.3	4.3
Latrine	5.8	2.1	0.5	0.1	0.0	1.3
Septic tank	16.8	3.2	0.9	0.3	0.0	2.7
Unlined pit	19.4	3.5	0.3	0.0	0.0	2.7
River / channel	2.6	0.5	0.0	0.0	0.0	0.4
No service	12.1	1.1	0.1	0.0	0.0	1.3

Source: APEIM, based on ENAHO 2013.

Although it would be ideal to have more information on the type of user-interface (i.e. the type of sanitation facility used), the focus of this study is primarily the management of fecal sludge from latrines (i.e. the containment stage) and, to an extent, all forms of fecal waste flows, including sewerage, through to end-use/disposal (see Figure 2 below).

Figure 2 The sanitation service chain

This study is not focusing on the structural conditions or the latrine itself, so much as the extent to which it contains/does not contain fecal sludge and what happens to the fecal sludge from this stage onwards. For this reason, the household survey and later sections of this report refer to different categories for household sanitation facilities and assess fecal sludge management in relation to the service chain above.

2.3 Lima's FSM context

Later sections of this report will identify the scale of FSM services and its implications, based on extensive qualitative and quantitative data collected through this study. Here, the roles legally assigned to the key actors that currently are and could be involved in FSM are briefly presented, based on key informant interviews and field experience gathered by the World Bank consultant. The list is not exhaustive. How this plays out in reality is covered in Section 8.

[1] For Lima, there is an overlap in the data between the type of sanitation facility and the type of blackwater containment/disposal for all major national and international surveys (e.g. ENAHO, DHS). It is thus not possible to accurately classify sanitation facilities.

Table 3 Roles assigned to key FSM stakeholders

Categories	Stakeholder	Assigned roles
National government	Ministry of Housing, Construction and Sanitation (MoHCS)	• Improve sanitation management • Improve access and quality of services and ensure their sustainability • Ensure the financial sustainability of service providers
	National Superintendence of Sanitation Services (SUNASS)	• Regulate and supervise the provision of sanitation services • Enhance the sustainability, quality and access to drinking water and sewerage
	Ministry of Environment (MoE)	• Reduce socio-environmental conflicts • Improve quality of life through a better environment (e.g. reduce pollution of water resources) • Develop the New Law for Solid Waste Management, which includes emptying, transport, treatment and reuse of bio-solids.
	Technical Organism for the Management of Sanitation Services (OTASS)	• Ensure the adequate management of service providers to guarantee their efficiency, autonomy and social integration • Regulate, promote, supervise, audit and restructure the administration and management of service providers
	Lima Directorate of Environmental Health (DESA)	• Enforcement of sanitation regulations • Health promotion and monitoring of possible risks related to poor sanitation
Local government	Lima Metropolitan Municipality	• Support the formalisation of human settlements and subsequent requests for access to basic public services • Provide permits to solid waste collection service providers • Health promotion
	SEDAPAL (Lima Water Supply and Sewerage Service)	• Mandate the operation, maintenance, control and development of water and sanitation services • Undertake tasks related to planning, programming and financing, among others
Private sector & NGOs	Households	• Dig pits/build sanitation facilities • Request water and sewerage services • Demand fecal sludge emptying services
	NGOs (X-Runner, etc.)	• Provision of urine-diverting dry sanitation facilities (UDDTs) and collection of fecal sludge for treatment and reuse (i.e. compost)
	Tertiary service providers (Mega Pack Trading, DISAL, etc.)	• Provision of FSM services for public facilities (schools, universities, hospitals and social clubs) and medium- to high-income households

3 Fecal Waste Flow Diagrams

3.1 Introduction

Fecal Waste Flow Diagrams (also known as 'shit flow' diagrams or SFDs) are an innovation arising from WSP's 12-city study of FSM (Peal & Evans, 2013). In short, an SFD is a visualisation of how fecal waste (fecal sludge or wastewater) flows along the sanitation service chain. At each stage of the chain, the proportion of fecal waste that is or is not effectively managed to the next stage of the chain is indicated.[2]

This means that where fecal waste is deemed to be:

- Effectively managed from one stage of the chain to the next (for example, where wastewater from cistern flush toilets is effectively transported through sewers to a designated treatment site, or fecal sludge is transported by a tanker to a designated disposal site), the SFD shows the flow of fecal waste continuing along the chain – and the arrow representing that flow of fecal waste to the next stage remains green;

- Not effectively managed from one stage of the chain to the next (for example, where wastewater leaks from sewers before reaching a designated treatment site, or fecal sludge is dumped into the environment or drainage channels), then the SFD shows the fecal waste "dropping out" of the service chain – and the arrow representing that flow of fecal waste turns brown.

The proportion of fecal waste that is effectively managed all the way to the end of the service chain is indicated as "safely managed", with the remaining proportion that has dropped-out of the chain deemed "unsafely managed". The primary destination of that "unsafe" fecal waste is indicated (e.g. receiving waters, general environment, drains, etc.).[3] Thus far, SFDs in different cities have been undertaken using different methodologies, as is often necessary in the context of poor data availability. Furthermore, most SFDs so far (including those in the 12-city study) were undertaken using secondary data and expert estimates. This study is amongst the first to use primary household survey data and field-based observations to construct SFDs. A group of urban sanitation experts is currently discussing the 'roll-out' of the use of SFDs, for which other methodologies will be developed.[4]

For this study, SFDs are being developed which are indicative of (i) the city-wide situation, and (ii) the situation in low-income settlements (see Annex B for more information). For Lima, the former is based on secondary data, whereas the latter is based on primary data collection in non-sewered settlements (which are generally low-income areas), as part of sub-sample A.

[2] Previous iterations of SFDs distinguished between safe and unsafe practices, but here we refer to effective / ineffective management. This progression has been made because it is difficult be sure of the safety of the process, but if the fecal waste is managed to the next stage of the sanitation service chain, we can say it is considered an effective process.

[3] It is acknowledged that fecal sludge may pass from irrigation channels into other water bodies, e.g. rivers, but the diagram focuses on the *primary* destination. It was beyond the scope of this study to be able to track the pathways of sludge beyond the household, e.g. which canals did it pass through and where was its eventual destination.

[4] See website for the SFD promotion initiative here.

3.2 Methodology

As noted above, the city-wide SFD is based on secondary data, because neither sub-sample in the household survey was representative of Lima as a whole.[5] Secondary data used includes other household surveys (e.g. ENAHO 2013 for the type of sanitation system used) and utility records (i.e. SEDAPAL's data related to the proportion of wastewater which is transported and treated).

For the SFD in non-sewered areas, data from the household survey questions was used.[6]

A. *What kind of toilet facility do members of your household usually use?*

B. *Where do the contents of this toilet empty to?*

Of these, question 'B' is the most crucial for the SFD. The household's response is taken as given, as it was not possible to confirm responses by observation. Enumerators could however observe 'above-ground' components (i.e. slab, water seal, superstructure, etc.), and this was carried out in all households where permission was granted.[7]

To analyse this data, an SFD matrix was created – a blank matrix is shown in Figure 3 below. It shows which data sources are used and how they are analysed into categories of effective and ineffective management of fecal waste through the stages of the service chain. Results for Lima are shown in the next section.

Firstly, household survey data on use of infrastructure (questions A and B above) is used to allocate households to five categories shown in the column marked (1) in the figure below:

- **(i)** **Sewered (off-site centralised or decentralised):** toilets connected to sewers (not on-site sanitation).
- **(ii)** **On-site storage – emptiable:** on-site sanitation (on-site sanitation) toilets (involving pits or septic tanks) that can be emptied. However, they can also be connected to drains through an overflow, to avoid the need for emptying. These toilets are emptiable but may or may not be emptied.
- **(iii)** **On-site storage – single-use / pit covered:** on-site sanitation toilets where pits or tanks are covered and / or abandoned once full. These toilets are emptiable but never emptied.
- **(iv)** **On-site non-storage – straight to drain / similar:** on-site sanitation toilets which connect directly to drains, water bodies or open ground. These toilets are therefore non-emptiable.
- **(v)** **Open defecation (OD):** self-explanatory.

The question of emptiability is key. Category (ii) above is denoted as emptiable, meaning that this containment option involves a pit or tank which fills with fecal sludge. Between the two extremes of a closed system and a system which never fills up, there is a spectrum of scenarios. For example, some pits / tanks may have an overflow to the drain but may still require emptying if they become

[5] In other cities in this five-city study, sub-sample A was designed to be representative of the whole city. However, given the very high sewerage coverage in Lima, sub-sample A is largely representative of non-sewered areas of the city. For more information on sampling, please refer to Annex B.

[6] Full response categories for these questions are included in the survey questionnaire, to which there is a web link in Annex F. In particular, the response categories to question B above were: (i) Piped sewer system, (ii) Lined septic tank, (iii) Unlined pit (single or twin), (iv) directly to open drain, (v) directly to sea, lake or river, (vi) open ground/street

[7] Given that 'B' is based on household response, possible sources of bias include the household not knowing the true answer or knowing it but answering differently for fear of being identified as practicing illegal behaviour. The former is certainly likely, the latter does not seem to be an issue given that households willingly disclosed illegal behaviour where applicable.

blocked. These categories were designed to be applicable around the world. As it happens, the vast majority of households in Lima fall into category (i), as there is 92% sewerage. In non-sewered areas, most households fall into category (iii).

Data from questions A and B at the beginning of this section are allocated in column (2) below (a key shows the meaning of the colour-coding of cells by data source). Next, the proportions for each of the stages of the chain are allocated. As can be seen from the emptying column, marked (3), a certain proportion of the population's fecal sludge which is collected is emptied by a service provider, with the remaining fecal sludge not emptied (e.g. overflows to drains).

The rest of the matrix follows a similar logic. Full SFD matrices for the Lima Metropolitan Area (city-wide) and non-sewered areas (sub-sample A) are presented in Annex C, along with further methodological notes. This section has given a brief overview of where the data underlying the SFDs comes from. The SFDs themselves are more intuitively appealing and are presented in the next section.

As the data comes from household surveys (i.e. the Peru National Household Survey – ENAHO – and this study's household survey), the proportions in the matrix are proportions of households, not proportions of people or fecal sludge volumes.[8]

[8] The impression given by the SFD therefore involves assumptions that (i) each person produces the same amount of FS, and (ii) pit accumulation rates are constant across the city. This is an approximation but the most pragmatic approach in the context of uncertainty around fecal sludge volumes. Fecal sludge volume only really becomes an issue when considering the extent of change in service levels needed to deal with the amounts. This study is primarily about identifying the broader picture of *where* the management of fecal sludge is or is not effective, not what volumes are being managed or mismanaged.

Figure 3 Fecal Waste Flow Matrix template

1	2			3						4
		Containment		**Emptying**		**Transport**		**Treatment**		**Overall**
Type of system	*Population using: (%)*	*Of which: (%)*		*Of which: (%)*		*Of which: (%)*		*Of which: (%)*		**Safe**
		Contained	*Not contained*	*Emptied*	*Not emptied*	*Transported*	*Not transported*	*Treated*	*Not treated*	**0%**
Sewered (off site centralised or decentralised)		100%	0%	100%	0%		100%		100%	
		0%	0%	0%	0%	0%	0%	0%	0%	**0%**
On-site storage – emptiable		100%	0%		100%		100%		100%	
		0%	0%	0%	0%	0%	0%	0%	0%	**0%**
On-site storage – single-use / pit sealed		100%	0%							
		0%	0%							
On-site non-storage – straight to drain/similar		0%	100%							
		0%	0%							
Open defecation		0%	100%							
		0%	0%							
		Containment	0%	Emptying	0%	Transport	0%	Treatment	0%	
Unsafe	**0%**		**0%**		**0%**		**0%**		**0%**	
Affected zones (you can adapt the terms to suit the context)		*Local area and beyond via drains (amount direct to groundwater not identified)*		*Local area (via overflowing latrines or dumped FS)*		*Neighbourhood (via leakage / overflow from sewers or drains)*		*Receiving waters (via sewer outfall/discharge)*		

- From household survey
- From secondary data
- De facto value

3.3 Results

Firstly, the secondary data and household survey results, which are inputs to the SFD, are shown in the tables below. They are reported separately for Lima Metropolitan Area and non-sewered areas (sub-sample A). After that, a separate SFD matrix and diagram for each area are presented.

3.3.1 Household survey results as an input to the SFD

In most countries, national household surveys usually collect data on the toilet type (e.g. cistern flush, pour / manual flush, pit latrine, hanging toilet, etc.). However, in Peru only the type of blackwater disposal is inquired about in Demographic and Health Surveys (DHS) and other similar surveys. Therefore, it is not possible to know what type of toilets are most prevalent in Lima from secondary data, though anecdotally it is mostly cistern flush or pour flush, with a raised seat in all cases.

For non-sewered areas however, primary data (sub-sample A) is available. Although data is also available for sub-sample B, the situation is fairly similar to that of non-sewered areas – conceptually, it is best to think of sub-sample B as a subset of sub-sample A, i.e. all the lowest-income neighbourhoods are in non-sewered areas. Since sub-sample A is more representative of the situation in non-sewered areas as compared to sub-sample B, we have decided to use data from the former to populate the SFD.

As can be seen in Table 4 below, the majority of households in non-sewered areas (57%) used pour/manual flush toilets Pit latrines without a slab and cistern flush were the next popular, at 16%, followed by pit latrines with slab (8%) and urine diversion toilets (1%).

Table 4 Sanitation facility used, by technology type – non-sewered areas

	%	No. of households
Cistern flush	15.6	56
Pour / manual flush	56.9	205
VIP latrine	2.8	10
Pit latrine (with slab)	8.1	29
Pit latrine (without slab)	16.1	58
Urine diversion toilet	0.6	2
Bucket	0.0	0
No toilet	0.0	0
Total	**100.0**	**360**

The table above shows the basic categories, but it is also important to consider the proportion of these which are shared. This is relevant, not just in terms of developing the standardised indicators of the WHO/UNICEF JMP, but also because the FSM arrangements for shared latrines are likely to be different from those of 'private' latrines from a management perspective. This is because accountability for dealing with full or blocked pits, as well as payment for FSM services, may be less clear-cut in a 'shared' situation, recognising that this label could refer to a large number of scenarios. The technology and service used would be as for private facilities, while noting that shared pits/tanks would be likely to fill more quickly, depending on the number of users.

As can be seen from Table 5 below, 76% of households in non-sewered areas used a facility considered improved under JMP definitions (see footnotes below). However, this value should be read with some caution as, even if the facility is classified as improved by standard definitions, its quality and maintenance may not always be adequate. Figure 4 shows some of the typical facilities and superstructures that are observed in non-sewered peri-urban areas of Lima – superstructures tend to be made of non-durable materials that can easily collapse while the facility itself may be partially broken and unclean. The type of soil and landscape is also a concern in Lima, with households in rocky and hilly areas (as shown below in Puente Piedra) being more likely to have poorly constructed facilities.

Sharing was not that common, with only 11% of households sharing an improved or unimproved latrine. Data on sharing was not available for Lima city-wide.[9]

Table 5 Sanitation facility use, by JMP category – non-sewered areas

	%	No. of households
Improved	75.6	272
Improved – shared[10]	8.3	30
Unimproved	13.6	49
Unimproved – shared[11]	2.5	9
Total	100.0	360

Figure 4 Sanitation facilities in non-sewered areas of Lima

a. Puente Piedra **b. San Juan de Miraflores**

As noted above, the most important question in the survey is where the contents of toilets go after flushing or similar. The standard DHS question incorporates this into the overall sanitation question (see WHO/UNICEF core questions available at www.wssinfo.org). However, for this study, it was necessary to ask a separate question in order to get better quality data.[12] Household-reported data is relied upon for this indicator, while noting that households may not always know the full detail, especially if they are renting, or may answer untruthfully. Furthermore, with a socio-economic survey rather than a technical survey, it was not always possible to physically verify household's answers to this question. Nonetheless, a large proportion of the enumerator training was spent ensuring that the enumerators fully understood the distinction between the response categories. In the event, most interviewed households in non-sewered areas of Lima fall into one category.

[9] ENAHO does collect data on this question but it is not readily available.
[10] The JMP definition of a shared facility is one which is used by 2 or more households (including a public facility).
[11] "Unimproved shared" is not a category usually reported by the JMP, but it is useful to report for our purposes so we can see the full proportion of households sharing latrines.
[12] As stated above, the question asked was "Where do the contents of this toilet empty to?" The question is answered by all households, regardless of whether they owned a private facility, or managed / used a shared facility.

For completeness and consistency with other case study reports, it is important to explain that results were grouped into risk categories based on the relative risk to public health from a combination of the type of containment arrangement and where the fecal sludge and effluent empty to:

- **Low-risk** categories are those where the fecal sludge can be considered to be contained (in JMP terms), at least in relation to the first stage of the service chain.
- **High-risk** categories are those where the fecal sludge goes directly into the environment and so potentially poses a risk of exposure to the public, whether via drainage systems or water bodies with which people interact (especially children).
- **Medium-risk** categories are those where there is at least some containment in a pit or septic tank, but those pits/tanks either: (a) have outlets connected to drains that allow only partially digested effluent to flow through, or (b) are unlined, allowing fecal sludge to leach into the surrounding soil and groundwater that may be used for domestic purposes (e.g. washing clothes). These scenarios still represent a risk, but it is somewhat lower than contact with fresh fecal sludge as in the high-risk category above.

The results are shown in Table 6 below. Only 3% of non-sewered households have high-risk blackwater management practices, all of which goes “directly to drain”. The most common category was medium-risk (96%), with all these being unlined pits. Comparison to the city-wide situation can be done with reference to Table 2, noting that 92% of Lima’s population are connected to a sewer and only 2% have high-risk blackwater management practices (connected to river or open defecation).

Cutting the data another way, it is important to note that only 7% of households city-wide use what is considered as an on-site sanitation system, whereas 100% of households in lowest-income areas do so. However, in practice, the majority of these on-site systems consist of lined / unlined pits which are covered when full and abandoned. This covering of the raw fecal sludge is usually done with lime and soil (and in some instances with wood and cement), and cannot generally be considered effective management.

Table 6 Management of blackwater, where toilets discharge to – non-sewered areas

	%	No. of households
Low risk	**0.9**	**3**
Septic tank with no outlet	0.3	1
Urine-diverting toilet – contractor collects waste	0.6	2
Medium risk	**95.8**	**345**
Unlined pit	95.8	345
High risk	**3.3**	**14**
Directly to an open drain/ditch	3.3	12
Directly to an open ground (street/ field)	0.0	0
Buried	0.0	0
Total	**100.0**	**360**

With 7% of households using on-site sanitation city-wide, the majority of which belong to low income wealth quintiles and thus have a low ability to pay, it is not hard to see why there is such a limited market for FSM services. However, in order to assess the potential demand, households were asked whether both their previous and current pit / tank ever filled up. For pits that were previously in use, 77% of responding households in non-sewered areas (n = 155) noted that the pit had filled up. With regards to pits / tanks currently in use, only 3% households in non-sewered areas reported the pit ever filling up (n = 342).

Finally, it is worth considering the reported household behaviour in the context of pits filling up. This was assessed by asking about the action taken by the household when their pit last filled up. As can be seen in Table 7, the majority of households either left the pit unsealed or sealed and abandoned it, which is consistent with the common practice of digging a new pit every time the one in use fills up. However, when referring to the last time the current pit/tank filled up, 90% households in non-sewered areas responded that the tank had been emptied (n = 10). This may be related to the lack of space for building a new pit, and suggests there is some scope for future FSM services, although there are too few observations to draw accurate conclusions.

Table 7 Action after previous pit/tank used filled up – non-sewered areas

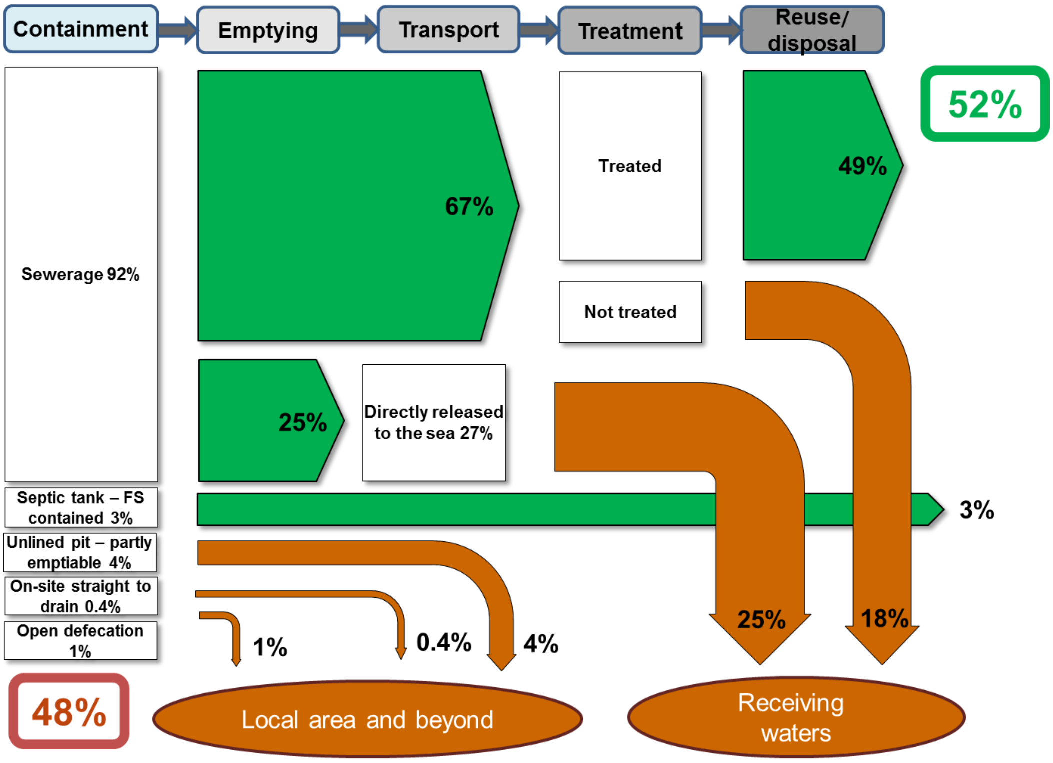
	%	No. of households
Abandoned unsealed	47.1	56
Sealed and abandoned	52.1	62
Other	0.8	1
Total	**100.0**	**119**

3.3.2 Presentation of SFDs

Using all these results, two sets of SFD matrices and diagrams were constructed: one giving a city-wide picture based on secondary data and one based on sub-sample A of the household survey. These are presented as **¡Error! No se encuentra el origen de la referencia.** and **¡Error! No se encuentra el origen de la referencia.** below. SFDs work on the same principle as the matrix shown above. Household's toilet technology and associated containment method is shown on the left, with intermediate steps and primary destination of the fecal sludge shown along the sanitation service chain.

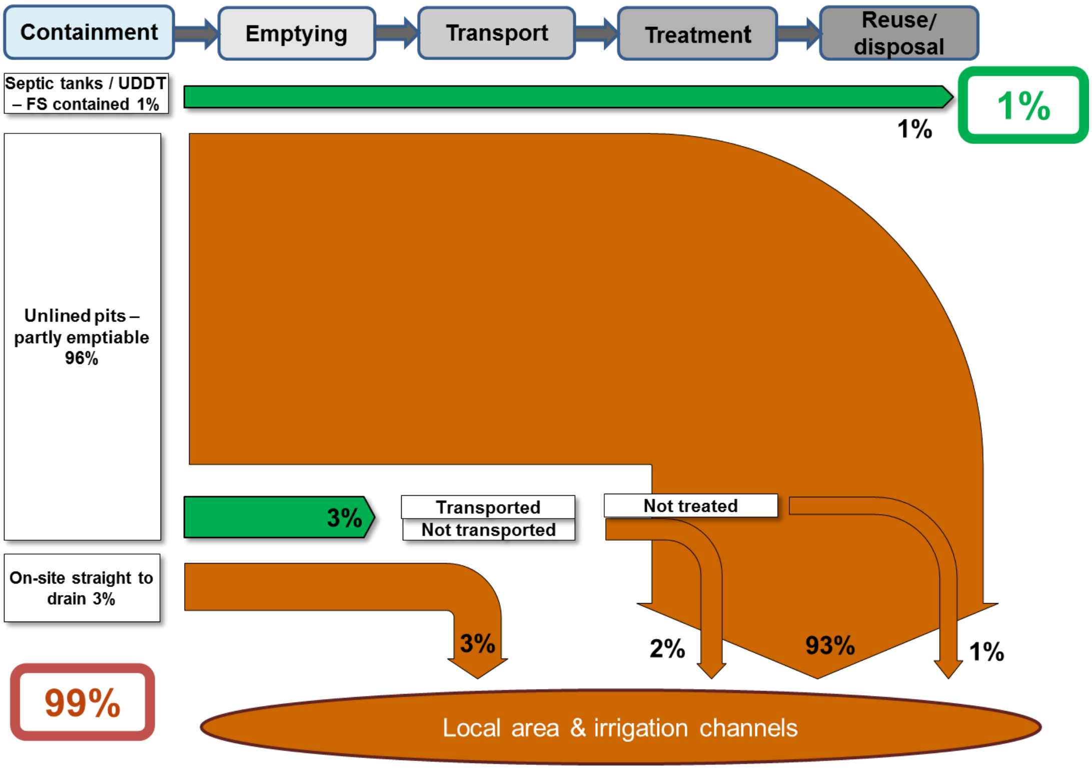
What is clear from the city-wide SFD is that almost half (48%) of fecal sludge in Lima is not effectively managed. While 92% of households have a sewer connection, 27% of wastewater is released directly into the sea without treatment. Furthermore, around 73% of the wastewater which makes it to the treatment plant is effectively treated. These weaknesses in the sewerage system are the main reason for the city-wide SFD looking as it does. The proportion of households that practice open defecation or use toilets that empty straight to drains is very small, jointly encompassing 1.4% of households. The only remaining point of note is that septic tanks are assumed to be adequately managed while unlined pits (except when emptied) are considered to be ineffectively managed. Overall, around 7% of households in Lima use an on-site sanitation system, 3% of which are deemed to be effectively managed (i.e. septic tanks).

Figure 5 Fecal Waste Flow Diagram for Lima - city-wide based on secondary data



Considering next the SFD for the non-sewered sample (**¡Error! No se encuentra el origen de la referencia.**), the picture is completely different because there are no sewers in these areas. The vast majority of households (96%) have an unlined pit, of which around 3% were deemed to adequately contain FS (i.e. households reported the pit filling up). The remaining 93% of unlined pits are deemed to be ineffectively managed, with FS leaching into the surrounding environment. Households further reported that 90% of pits that fill up are emptied, for which only 44% of FS seems to be transported (i.e. FS is discharged into a tanker truck). However, given that there are no treatment plants specifically designed for the reception of FS, none of the FS emptied and transported is likely to be given adequate treatment. A further 3% of households have toilets which discharge straight to drains, and finally 1% have a septic tank or a urine-diverting dry toilet (UDDT), in which fecal sludge is safely contained and, for UDDTs, emptied, transported and treated by NGOs. Overall then, only 1% of fecal sludge in non-sewered areas in Lima is effectively managed.

Figure 6 Fecal Waste Flow Diagram for Lima – non-sewered areas, based on household survey



3.4 Implications of the SFDs for FSM in Lima

The city-wide SFD shows that the city is doing relatively well at extending sewerage coverage, but the capacity for treatment needs to be improved. By the end of 2016, both La Chira and La Taboada wastewater treatment plants will be fully operational, increasing the capacity of treatment to almost 100%. The great majority of households that do not have access to sewerage rely on on-site sanitation facilities that discharge to an unlined pit (96%). Only 3% of these households empty their pits while the remaining ones generally cover and abandon their pits when full. These abandoned unlined pits are a public health hazard, as FS leaches into the surrounding environment, potentially contaminating nearby water sources. Some reports and media headlines also suggest that people in poor areas are running out of space to dig new pits, while many of the covered pits collapse.

Having large amounts of fecal sludge in the environment, via unlined pits, is a hazard which primarily affects people in poorer areas but the discharge of untreated wastewater represents a broader externality affecting everyone. Both the SFDs are necessarily vague about the destination of the untreated fecal sludge (i.e. "local area and beyond"). Lima has a very dry climate and much of the fecal sludge may not contaminate the groundwater easily, but this is still possible.

Further implications of the SFDs above for FSM in Lima are discussed in Section 9 of this report, which focuses on implementation options. In short, however, it is clear that the key challenges in Lima are: (i) improving wastewater treatment capacity; (ii) developing and extending FSM services to non-sewered areas where people are currently abandoning full pits in a potentially unsafe manner – adequate containment and facility maintenance needs to be encouraged, and FS reuse needs to be developed to increase the profitability of FSM markets; and (iii) progressively extending alternative services, including forms of sewerage coverage to 100% (e.g. condominial sewerage) or UDDTs with centralised emptying and treatment.

4 Public health risk assessment

4.1 Introduction and methodology

A component of the diagnostic study is to assess the extent of public health risk resulting from poor FSM services within Lima, representing risks for non-sewered areas. The study also seeks to identify the approximate level and location along the sanitation service chain of adverse public health risks.

Methods adopted within the data collection instruments to do this include:

- Identifying types of household facility and emptying services used (supported by direct observation of the cleanliness and functionality of the facility), during the household survey;
- Observing emptying service providers to identify how their practices may introduce risk to the household specifically (containment and emptying stages) and to the wider public at large (emptying, transport and disposal stages);
- Scoring hazards and vulnerability factors observed during transect walks (see explanation below), along with information about local practices that could result in fecal contamination in the environment (see Annex E for information on the scoring system used);
- Measuring fecal contamination levels in local drains and water supplies, to identify potential levels of exposure to risks; and
- Asking for perceptions of risk related to emptying services, during focus group discussions.

Collating and analysing results from the data collection instruments provides information about sources of risk through the service chain. This includes: how clean and operational toilets are kept within the household; how effectively and safely service providers empty, transport and dispose of fecal sludge; and the extent to which infrastructure provides effective handling of fecal sludge and wastewater through the city.

Given the limited extent of data collected for this part of the study, it can only provide a general indication of risk level at positions along the service chain. The study is not intended to report on specific locations or flow paths of fecal sludge movement within the sampled UALs.[13]

For more information about sanitation-related diseases and the significance of safe management of fecal sludge to protect environmental and public health, see Cairncross & Feachem (1993, pp.11-25), and Strande *et al* (2014, pp.1-4).

4.2 Results: risks through stages of the FSM service chain

4.2.1 Containment: household facilities, levels of sharing and practices

From the survey, **reported levels of sharing** of facilities shows that 8% of households in non-sewered areas use an *improved* shared latrine and 3% use an *unimproved* shared latrine (see Table 5). For shared latrines in non-sewered areas, 73% of households report sharing the latrine with up to 5 people, and 26% share with up to 10 people. Around 1% of households reported sharing the latrine with 11 people or more. Ownership of private household toilets is high in non-

[13] Original datasets contain GPS locations of observed risks in the UALs that can be examined further.

sewered areas, with 89% of households reporting owning a private latrine (on plot) – either an improved (76%) or unimproved (14%) facility.

Standards of **cleanliness** for household facilities, observed during the household survey, indicate that in non-sewered areas, 68% of observed latrines were found to have a cleanable slab and 53% had no fecal or urine contamination on the floor or slab (20% had either feces, or feces plus urine, visible).

Practices around the **disposal of child faeces** also introduce risks to both households and potentially the wider public. In non-sewered areas, 75% of households who reported their practices (n=109) identified unsafe methods when disposing of feces of children under 5 years old (72% throwing the feces out with solid waste, while the remaining households either buried or burned the feces). In addition, 55% of households reported storing solid waste within the household before collection and 24% reported throwing solid waste out into the street. All of these practices have serious implications for contamination of the immediate household and neighbourhood environment, as shown in Figure 7.

Figure 7 Solid waste disposal areas in San Juan de Miraflores

Self-reported diarrhoea prevalence stated by the respondent (person answering the questions) during the household survey are shown in Table 8 below. Prevalence is relatively low, with 9% of households reporting having at least one diarrhoea episode in the past 2 weeks.

Table 8 Prevalence of diarrhoea among respondents in the last 2 weeks – non-sewered areas

	%	No. of households
None	91.4	329
One	5.0	18
Two	1.9	7
Three	0.6	2
Four	1.1	4
Total	**100.0**	**360**

Focussing exclusively on children under 5, household survey data suggests that 18% of all children under 5 in non-sewered areas (n = 190). This is significantly higher than the prevalence reported in the 2013 ENDES (or DHS) for Lima, with 7% of children under 5 having an episode of diarrhoea. This suggests that households in non-sewered areas of the city have a greater risk of diarrhoeal disease as compared to the city overall, which is likely to be linked to poor access to water and sanitation services. Indeed, at a national level, 2013 ENDES estimates indicate that the prevalence of diarrhoea among children under 5 was higher among those who used an unimproved water source (14%) as compared to those who used an improved water source (11%). Similarly, the prevalence of diarrhoea was higher for children with an unimproved shared toilet (12%) as compared to children with an improved and private facility (10%).

Diarrhoea prevalence is only one indicator of a contaminated environment. It is increasingly understood that nutrition outcomes, especially stunting (height-for-age) are strongly linked to sanitation through multiple transmission pathways, although stunting has numerous determinants, including living in contaminated environments.

Wider risks to public health, beyond risks to families and individuals from poorly-managed containment facilities and practices, as is the use of unlined pits that are poorly covered and abandoned, arise from poor access to fecal waste management during discharge, emptying, transport and disposal practices.

4.2.2 Emptying: household practices around emptying services

As seen in the results from the household survey in non-sewered areas, the majority of households rely on using some form of simple latrine discharging to an unlined pit (96%) that is covered and abandoned when full (93%) and in very few cases, emptied (3%). Others have latrines discharging directly to an open drain, ditch or ground (3%), while the remaining 1% have a septic tank or an UDDT facility. In 16% of cases, greywater is also discharged into the unlined pits, but the majority of greywater is discharged directly to the open (69%) and only 3% to a soakaway.

What is clear is that very few households in non-sewered areas make use of emptying service providers, as people traditionally cover and abandon the pit when it becomes full and dig a new one. This is borne-out by the reported average age of pits in non-sewered areas being less than 4 years old (median is 3 years old, n = 358 households).[14]

4.2.3 Emptying, transport and disposal: observed practices and risks

Planned observations were carried out at six latrines. Of these, three latrines (two pits and one septic tank) were emptied using mechanised tankers, while two were UDDTs relying on manual removal of dried feces from a vault or a mobile container and urine separately handled. The other was an abandoned pit latrine. The use of urine diversion latrines (permanent and mobile) is currently at a small scale in Lima – but of growing interest as a service option in the non-sewered areas.

Using a structured observation format, likely sources of immediate risk from exposure to fecal sludge at each step of the process were identified for the containment, emptying, transport, disposal, treatment, and end-use stages. Transportation, treatment and end-use of fecal material is only practiced on a very small scale in non-sewered areas of Lima; in this instance, for the urine diversion latrines with urine diversion and potential for re-use of dried feces.

Risk levels were taken to be based on exposure as follows:

- At containment stage, to the family members / households who use the facility;

[14] Similarly, for the overall non-sewered sample, less than 3% of households reported their pit / tank ever filling up.

- At emptying stage, to those in the compound (site) where the facility is located, plus the neighbourhood along the emptying route from the compound to transport / disposal point, and
- At transport, treatment and disposal stages, affecting a wider geographical area and population.

Based on the scoring system developed for the structured observation, exposure to risk were recorded using high / medium / low categories. A summary of the results is shown in Annex E, while the following sections discuss the broader findings and their implications. It should be kept in mind that, as the immediate risk was being noted down at each stage in the process, the risk level can vary between stages, depending on the actions taken.

Containment and emptying: mechanical

Containment facilities where mechanical emptying was observed (three cases) were considered to introduce low risk to two of the households, while in one case the pit latrine was full and at risk of overflowing, with evidence of flies or insects inside the superstructure, which increased the overall risk to the household to a medium level.

The emptying procedure in each case was observed to pose low risk to the household, as the removal and transfer of fecal sludge was contained in the pipework running directly from the pit / tank to the tanker, with only small amounts of fecal sludge becoming exposed close to the emptying point.

Containment and emptying: manual

In the instances of manual emptying, the content was separated from urine and washing water in UD latrines. Different types of solid waste were found in the abandoned pit, while the contents of the urine-diversion latrines contained no solid waste.

The containment facilities themselves were found to pose low risk to households, based either on the abandoned nature of the pit, or on the way in which feces is stored in closed containers. For one UD latrine, the use of twin vaults allows the feces to be stored in one vault for a year before removal, making it safe to handle. For the other UD latrine, feces are stored in a portable bucket fitted with a lid, which is removed on a weekly basis (see Figure 8 below). Careful handling of the content of the UD bucket results in a low risk during the emptying stage, with a low risk level also identified for emptying the dried feces after a year of storage.

Figure 8 Urine diversion toilets in San Juan de Miraflores

Transport and disposal: mechanical

The mechanical emptying tankers take the fecal sludge to Huaycoloro landfill site. The observed process did not introduce any risks to the environment or population along the route and the fecal sludge was considered to be “taken to a secure site”, although the landfill site itself was not observed during the process.

Transport and disposal: manual

The content in the abandoned latrine was considered to introduce medium risk in terms of long-term disposal arrangement, as people, animals or insects could come into contact with the abandoned FS. In the majority of cases, when pits are abandoned, the pit is sealed (i.e. filled up with soil and lime on top of the fecal sludge content before being abandoned). However, some cases of land subsidence or pits being poorly covered were reported in FGDs.

For the UD latrines, the twin-vault facility with feces correctly stored before removal was considered to introduce low or no risk during the final stages of disposal / reuse on site (no transport necessary). The mobile facility was considered to introduce low risk during transport – using the sealed bucket – or during the treatment process (in sealed bags), but the disposal and reuse arrangements were considered to introduce medium risk due to the process exposing only partially-treated feces back into the environment as it is mixed with sawdust and bacteria for the final processing stages. These risks should be confined to the processing plant (in Villa El Salvador) and can therefore be better managed through correct operating procedures. The partially-processed product (fecal material plus additives) needs further storage before being sold on to a final destination.

4.3 Results: risks from wider environmental contamination

The 40 transect walks (30 conducted in non-sewered areas and 10 in lowest-income non-sewered areas) highlighted that in a few instances (6 locations in non-sewered areas and 2 in lowest-income non-sewered areas), blackwater was visible in the local environment in irrigation channels. Where this occurred, it was reported as being a daily occurrence, although little information is available about the source of the blackwater.

Open defecation and dumped fecal sludge

Open defecation, while not a significant problem in Lima, was reported to be observed in 4 non-sewered UALs. Consultation with community members identified open defecation as practiced in 3 locations: either by “a few” mainly children, or elderly people and children most of the time, or by “many” people from households without latrines on a daily basis. In a further 3 locations, a few unspecified people were suspected to be practicing open defecation, but with no further details provided.

Other unsafe practices were reported during community consultations as:

- fecal sludge dumped by dwellings or the roadside on a monthly basis, in 1 location, which may come from the use of potties in the evening or among children and the elderly;
- Uncontrolled latrine emptying near to roads and paths every couple of months, in 1 location;
- Overflowing latrines occurring in 4 locations, either on an uncommon basis (3 locations in non-sewered areas and 1 location in lowest-income areas) or most of the time (1 location).

The combination of instances likely introducing risks to public health occurred in a total of 17 locations in non-sewered areas and 3 locations within lowest-income non-sewered areas.

Water supply and irrigation channels

Tests were carried out to identify levels of fecal contamination of samples of drinking water supplies and water in drainage/irrigation channels in 10 non-sewered UALs and 7 lowest-income non-sewered areas. The level of *E. coli* in the drinking water measured above 3 FCU/100ml in 3 of the 10 non-sewered area samples and 2 of the 7 samples in lowest-income non-sewered areas. Samples from drains/irrigation channels were shown to have levels of up to 100 FCU/100ml in 5 of the 10 non-sewered UALs and 4 of the 7 samples in lowest-income non-sewered areas. In addition, 2 of the non-sewered samples were found to have over 1,000 FCU/100 ml.

In all locations with fecal contamination of drinking water sources, solid waste contamination of the environment was recorded as being problematic (scoring 3 or above during the transect walk observations). Contamination of water supplies was not found to correlate with locations where blackwater was observed flowing in the drains/irrigation channels. In only one of the non-sewered locations and 2 of the lowest-income non-sewered areas, contamination of water supplies was found where community members were reported to discharge latrine contents into open water bodies (ponds, rivers, streams or irrigation channels) on a daily basis.

Evidence thus suggests no direct link between behaviours and practices around the disposal of fecal waste and resulting contamination of water supplies and water bodies, but rather a stronger association between the mismanagement of fecally-contaminated solid waste and resulting contamination.

Health and environmental risks

In 6 non-sewered locations, a diarrhoeal outbreak was identified by community members as having occurred in the last year. Of these 6 locations, 5 took place where either blackwater was observed in drains (2 instances), where household latrines were reported to be overflowing (2 instances), or where a few suspected people were considered to be practicing open defecation. In all 6 locations, solid waste was observed to be accumulating in a number of locations on a daily basis (scoring 4 in the risk matrix) and the coverage of household latrines was considered to be between 25-75%, with over 50% well maintained (3 locations) or 50% poorly maintained (3 locations).

4.4 Implications: assessing the public health risk from poor FSM

Risk to public health, as a result of poor FSM services, comes when there is human exposure (i.e. some form of contact) to the hazard (i.e. feces that contains pathogens), through an event (such as walking barefoot over fresh feces, playing in drains that carry discharges from latrines, drinking water or via hands contaminated with feces). The study has identified that some areas of Lima are prone to fecal contamination, resulting from (i) children's feces being thrown out with solid waste that is a common sight in the locations studied; (ii) latrine effluent connecting into irrigation channels that run through the localities; and (iii) a few instances of reported open defecation or latrines being emptied in an uncontrolled manner, resulting in fecal sludge being dumped by the roadside. In some areas of Lima, exposure to fecal sludge may be more direct and hazardous than others – where fresh fecal matter gets into living areas. In other situations, the cause and level of exposure may be more difficult to measure, such as the extent to which contamination in water supplies is a result of poor FSM.

The problem of exposed fecal contamination is perhaps not that widespread in non-sewered areas overall, given the extremely limited levels of latrine emptying that takes place. What is undoubtedly occurring is contamination of the soil, and possibly groundwater sources, due to leaching from unlined pit latrines. Further investigation into the public health risks and implications of this are needed, before any conclusions can be drawn.

Further analysis is therefore needed if results of where, how and to what level risk is occurring are to be clearly identified. In collaboration with the Centre for Global Safe Water at the Rollins School of Public Health, Emory University, we hope that results from Lima can be analysed using an adapted version of the SaniPATH tool.[15]

At this stage, the study is not able to present an analysis of public health risk from poor FSM services in Lima. However, the collaboration with Emory University is informing ongoing development of a SaniPATH tool for FSM services by identifying minimum data requirements to conduct a credible public health risk assessment, the need for preliminary assessment of the main pathways of risk, and the reporting requirements for target audiences, such as municipal managers or World Bank staff. Further collaboration will work towards developing a more effective tool that addresses an appropriate level of data collection and analysis, with improved visual presentation of the results.

[15] SaniPATH is a Rapid Assessment Tool to assess exposure to fecal contamination in urban, low-income settings. Details available at http://www.sanipath.com

5 FSM services: potential demand and supply management

5.1 Introduction

In economic theory, markets for goods and services operate on the basis of demand and supply. This chapter provides a brief assessment of demand and supply for FSM services in Lima. At this stage, it is important to note the difference between potential (or notional) demand and effective demand. The *potential demand* for FSM services is the quantity (and type) of services which would be demanded in the absence of any market failures or distortions. This is different from *effective demand*, which is the quantity (and type) of services actually purchased in the context of current supply and prices.

A simple way of illustrating this is to note that 7% of households city-wide use on-site sanitation (i.e. potential demand), of which only 3% report experiencing a pit or tank filling up, suggesting a very low effective demand (around 0.2% of Lima's population).[16,17] Reasons for a gap between potential demand and effective demand in Lima include, among others: (i) common practice among poor households to dig a new pit after the one in use fills up; (ii) lack of knowledge about the existence and safety of FSM emptying services; (iii) service providers not being able to physically access households, which affects the type of services demanded, and (iii) market prices for services being higher than consumers' willingness and/or ability to pay.[18]

There can be different definitions of potential demand in the context of FSM, with varying layers of complexity. The simplest definition is as per the above, i.e. services that would be demanded if all households using on-site sanitation requested emptying services and were willing and able to pay. Qualifications could be added for different scenarios, for example given (i) emptying of pits/tanks every 10 years on average, (ii) regularly desludging once a year, (iii) 30% of households are unable to pay the market price and a further 20% are unwilling, and so on. For this study, we have kept things simple.

Both FGDs and KIIs reveal that there are basically no formal FSM services provided to poor urban households – FSM services are only available for public establishments (schools, universities, social clubs, etc.), which are out of the scope of this study, and for wealthier households who own private residences near the beach. There are a few households in non-sewered areas that were reported to have used emptying services, but this is very rare and generally unaffordable. Thus, a detailed study of the supply side of FSM services was not possible. However, information provided through FGDs in non-sewered areas is referenced where appropriate.

This section will argue that the main problem in Lima is on the demand side. No FSM services are demanded partly because people are unaware of the existence of these services, but also because the most common practice is to dig a new pit once the one in use fills up. FSM services are exclusively demanded by wealthier households, while poor people are not able to pay for services, or do not even consider on-site sanitation and FSM as a medium- to long-term solution. Moreover, the potential costs associated with reaching households in low-income areas (e.g. time and fuel) as well as accessing the pits, may not make FSM services a profitable business for current providers of sanitation services.

[16] As reported by APEIM, based on ENAHO 2013.
[17] Based on household survey data for non-sewered areas.
[18] For example, in one of the FGDs carried out in the Santa Rosa district, one of the participants mentioned that emptying services may actually lead to increased pollution as the pit would have to be opened, allowing odours and contents to leak to the surrounding environment.

5.2 Methodology

This sub-section sets out key dimensions of demand and supply, and the data collected that is related to these aspects. It was not intended to collect comprehensive data on demand and supply, given the broad scope of the research and the limitations of some of the instruments used.

5.2.1 Demand

The research framework (see Section 1.3) poses the following question: *What is the existing customer demand and preferences for FSM services?* i. e. the current effective demand. This is discussed in three parts: (a) physical and economic determinants of household demand, (b) household satisfaction with current services, and (c) barriers faced by households in obtaining FSM services.[19] This list is not meant to be exhaustive, but rather considers key elements for answering the questions in the research framework.

Physical and economic determinants of household demand

It is useful to separate the physical and economic determinants of household demand because the differences between them have implications for any potential interventions, either in stimulating or responding to demand. Physical determinants are related to geography and infrastructure, whereas economic determinants are more to do with markets and finance.

The main determinants are set out in Table 9 and Table 10 below, describing its relevance and the way they have been measured by the research instruments (if data is available).

Table 9 Physical determinants of demand for FSM services

Dimension	Relevance	Instrument used to collect quantitative data
1. Accessibility of location		
Equipment access	Likelihood of equipment of different sizes (manual emptier, tanker truck, etc.) being able to access the facility to empty it	Household survey questions about equipment access and emptying point. Also, transect walk questions around conditions of roads / paths in the area
Type of building	Whether single-storey or multi-storey, and privately owned or in shared ownership	Household survey question
2. Fill rate		
Volume of containment	The nature of the containment method (e.g. whether a pit, tank, or no real containment) and its volume	Household survey question on type of containment; but not volume (as household estimates are thought to be unreliable)
Number of users	The number of household members (i.e. the owner household plus any sharing households) determines the volume entering the pit	Household survey questions around household size and numbers of households sharing the sanitation facility
Climate, soil type	Ambient temperature, soil type and	Qualitative data collected through key

[19] Given our focus on household demand, the primary concern is demand for emptying services rather than for the remaining components of the sanitation service chain. The research framework also asks about levels of satisfaction by providers of emptying services with current transport, treatment and disposal/end-use arrangements. As there are no formal fecal sludge emptying services, and there is no effective treatment or end-use for fecal sludge in Lima, this aspect does not form a significant part of the study.

and groundwater	groundwater table can all strongly influence the rate of filling and digestion of fecal sludge	informant interviews, plus available secondary data

Table 10 Economic determinants of demand for FSM services

Dimension	Relevance	Instrument used to collect quantitative data
1. Financial		
Ability to pay (ATP)	Poor people do not always have the financial resources to pay for FSM services	No formal assessment of ability and/or willingness to pay, as this was to be added at the request of the World Bank in each city. However, data were collected on capital expenditure on latrine construction and the price paid the last time the pit or tank was emptied (if relevant)
Willingness to pay (WTP)	People may have access to financial resources but are not willing to pay for the service at the market price for any number of reasons	
2. Fill rate		
Tenancy status	Households who rent property from a landlord may not have authority to deal with sanitation matters. Landlords may not want to pay for tenants' ongoing services. Tenancy status therefore influences the incentives and decision-making role of the likely service purchaser	Household survey question
Alternative sanitation options	If there is space, then households can dig a new pit and cover the old one. If there is not, the household may still abandon the latrine and use an alternative option (shared / public latrine or open defecation) rather than pay for an FSM service	No data, since it is hard to gauge what options are open to households. The household survey did however ask what households planned to do next time their pit or tank filled up

Household satisfaction with existing services

Household satisfaction with the performance of service providers will be a determinant of demand. This was addressed in two ways through household survey questions based on a four-point Likert scale.[20] Firstly, households were asked to rate their satisfaction level with various aspects of the sanitation facilities used, including quality of construction, ease of access, privacy and cleanliness. Secondly, households which had used an emptying service the last time their pit or tank filled up were asked to rate the service provider on price, overall service quality, safety and ease of obtaining service.[21]

Other barriers which households face in obtaining FSM services

[20] Categories included "very satisfied", "satisfied", "dissatisfied" and "very dissatisfied".
[21] A very the low proportion of households reported their pit/tank ever filling up (i.e. 10 out of 360), so there are very few observations for these indicators.

Some reasons for a gap between potential and effective demand for FSM services in Lima are already listed above (e.g. physical access to households and willingness to pay). However, there are many other potential barriers which households may face in securing FSM services.

Some of the barriers to accessing services have not been possible to predict *ex ante*. These were therefore explored in the qualitative research, particularly through FGDs with community members in lowest-income areas. Several of the discussion questions focused around perceptions and opinions of existing services, and what participants would like to see in terms of improved services in the future. Discussions were semi-structured, with participants able to discuss questions more openly, so allowing for the identification of further determinants of demand not otherwise addressed in the household survey. The full list of topics and questions addressed can be found via a link in Annex F.

5.2.2 Supply

On the supply side, the research questions were around the current status and quality of FSM service delivery, with a focus on assessing current technical and institutional capacity (i.e. the scope and quality of services). This was assessed mainly through the household survey and the report submitted by the WSP consultant.

5.3 Findings: household demand for services

The results in each key area are presented below, with an overall assessment provided in the concluding section, alongside implications for FSM in Lima.

5.3.1 Determinants of household demand

Accessibility of location

Whether a service provider can actually get to the facility requiring emptying (as well as the household's perception of this) will be a key determinant of demand for services. Data to assess accessibility were collected from several angles and analysed starting from road/path systems in the UAL, before focusing down to the household level and, ultimately, the facility itself.

Some of the transect walk data sheds light on the kinds of housing density, paths and roads observed in the studied areas. Table 11 provides scoring data for non-sewered areas.[22] The main issue seems to be housing density rather than the quality of paths and roads. In terms of implications for FSM services, what can be concluded from this table is that while mechanised emptying equipment may find it relatively easy to access non-sewered UALs, reaching individual households may prove to be difficult given steep hillsides in some cases, housing density and the poor quality of paths. Indeed, paths in 8 out of 30 TWs in non-sewered areas were either poorly maintained or very narrow.

[22] Scores of 1-5 have been used in each city study to represent a qualitative assessment of the relative impact from each physical aspect of the UAL on being able to achieve effective and safe FSM services in that locality, with 1 representing the lowest impact and 5 the highest impact. Annex E includes further explanation of the scoring mechanism.

Table 11 Scoring for housing density, paths and roads from transect walks – non-sewered areas

TW score	Housing density	Paths	Roads
1 = lowest	1/30	None	None
2	10/30	13/30	13/30
3	6/30	9/30	9/30
4	12/30	7/30	6/30
5 = highest	1/30	1/30	2/30

Nb. Scores indicate the relative impact on effective FSM, while values per parameter show the proportion of transect walks for which this score was given, e.g. in 1 out of 30 TWs in non-sewered areas was housing density scored with 1. Note that 30 TWs were carried out in non-sewered areas.

The type of building also influences the extent and nature of the emptying required. Table 12 below shows that the majority of households live in private residences (94%), with the remaining 6% living in shared residences. Based on photographs from the sampled areas, most of these residences (either private or shared) are single storey houses, although the management of the containment is likely to be different between private and shared residences. However, accessibility to the pit/tank will only be tangentially related to this, especially in cases where the sanitation facility is outside of the dwelling.

Table 12 Type of residence occupied – non-sewered areas

	%	No. of households
Private residence	93.6	337
Shared residence	6.4	23
Total	**100.0**	**360**

Focusing on the facility itself, Table 13 below shows the accessibility of the main pit/tank structure, followed by the presence of a purpose-built hatch (as one would expect with a correctly-constructed septic tank). Following the theme from the TW data, 16% of households in non-sewered areas were reported to have “poor access”, while 11% of households reported to have an access point or hatch to facilitate emptying of their containment facility. [23]

[23] This data comes from observations by our enumerators during the household survey. There were three categories: (1) “Poor access, only accessible to hand-carried emptying equipment”, (2) “Reasonable access for small (manual or mechanised) emptying equipment”, and (3) “Good access for medium/large size (mechanised) emptying equipment”.

Table 13 Accessibility of toilet for emptying equipment – non-sewered areas[24]

	%	No. of households
Access for emptying equipment		
Poor access (only manual is possible)	15.8	57
Reasonable access (small machines)	35.6	128
Good access (large machines)	46.5	161
Total	**100.0**	**346**
Access point for emptying		
Yes, purpose-built hatch	11.0	38
Yes, squatting plate must be removed	7.8	27
No, slab must be broken	81.2	281
Total	**100.0**	**346**

Overall, from the perspective of accessibility it is clear that while 'geographic accessibility' may not be an issue (as indicated through both TWs and household survey data), there is limited access to the pits for emptying. The latter should be a key concern in any interventions to stimulate demand for FSM services, e.g. by providing simple workshops on adequate pit/sanitation facility infrastructure to household members, as they usually dig the pits and build the facility superstructure themselves.

Filling rate

Data on the type of containment was already shown in Table 6. As noted earlier, data were not collected on the volume of pits/tanks, since household estimates were thought to be unreliable. However, households were asked how long it usually took for their pit to fill up, which was considered more relevant, and a more reliable indicator for households to estimate. The results are shown in Table 14 below. There are very few observations since so few households have experienced their *current* pits filling up (i.e. around 3% of the 7% of households that use on-site sanitation across Lima). The data shows that among households using on-site sanitation, the majority of pits take between 2 to 5 years to fill up (75%).

Table 14 Average time taken for pit or tank to fill up – non-sewered areas

	%	No. of households
Less than 1 year	12.5	1
About 1 year	12.5	1
About 2 years	37.5	3
About 5 years	37.5	3
Total	**100.0**	**8**

Moving to the data on shared latrines, the mean number of households sharing each latrine was 1.1.[25] Where toilets are shared, it is worth considering the number of *people* which were sharing in

[24] Households that have urine-diverting facilities, a latrine connected to a drain or no sanitation facility were excluded.

more detail, as is shown in Table 15 below.[26] This comes directly from data reported by households, as opposed to estimations based on secondary data. The majority of latrines were shared with fewer than 6 people (73%). This is consistent with perceptions about sharing a sanitation facility: one of the FGDs revealed that some people prefer to use public facilities at their workplace or local market rather than asking a neighbour.

Table 15 Number of people using the same sanitation facility – non-sewered areas

	%	No. of households
1 to 5	72.8	262
6 to 10	25.8	93
11 to 15	1.4	5
Total	**100.0**	**359**

Given that the majority of households do not share their facility, the rate for pits to fill up is likely to be mainly determined by characteristics of the pit itself (e.g. depth, material used, etc.) and the type of soil. Although there is no accurate data for the physical characteristics of the pit, participants from FGDs mentioned that the average depth of a pit for a household with 5 members is 3 metres, which is expected to take about 5 years to fill up. However, more rapid filling has been observed in larger households: one of the FGD participants in Pachacamac district, whose household is composed of 10 people, mentioned that in the past 3 years his pit has already filled up once, with the second pit already filling up. The time taken for the pit to fill up is also likely to be shorter in rocky areas, where digging deep pits is both physically difficult and costly.

Financial aspects

As noted above, collecting data on willingness to pay (WTP) and ability to pay (ATP) was beyond the scope of this study. However, data were collected on the price paid the last time an FSM service was used, and whether households thought that price was fair.

First though, it is worth briefly considering finance for containment. Households were asked how much they spent (in cash, including materials and labour) to build their toilet at the time when it was built, if they spent cash at all. For non-sewered areas overall, the average cost of an improved facility was US $283 (n = 256), while the cost for an unimproved facility was US $48 (n = 55).[27] Regarding repairs/maintenance to toilets in the past 12 months (including repairs to mechanism, superstructure or drainage), the average expenditure for non-sewered areas overall was US $110 (n = 34).[28] Although only 9% of households have spent money in maintaining their sanitation facilities, these amount to 65% of the original investment for their construction.

With regards to payment for FSM services the last time emptying took place (Table 16), the average amount paid was US $137 (n = 9) for non-sewered areas overall. All households paid the full amount on delivery, and most of them paid a flat rate (56%) rather than a volumetric charge. These costs are consistent with those reported by local leaders in Pachacamac district, who

[25] For these estimates, households with private latrines (not sharing with any other households) are included and coded as 1. If those households are excluded, the mean rises to 2.2.

[26] This data are directly drawn from the following survey question: “How many people use this toilet regularly?” Categories are the same as those used in the survey. Average household size was 4.4.

[27] Nb. we did not ask how long ago this was, so are unable to account for inflation and exchange rates, so the results are indicative only. We used the rate 1 Peruvian Nuevo Sol = US $0.32.

[28] Most households reported that this expenditure was mainly for repairs to the bowl / slab and for the superstructure (84% in non-sewered areas and 78% in lowest-income areas). Only 2 households (5%) in non-sewered areas incurred costs for emptying their pits in the last 12 months.

suggested that the cost of emptying ranges between US $224 and US $256, depending on the depth of the pit. For the great majority of households, these costs were perceived to be too high.

Table 16 Average amount paid for emptying services – non-sewered areas

	US dollars	No. of households
Amount paid	$136.5	9

1 Peruvian Nuevo Sol = US $0.32

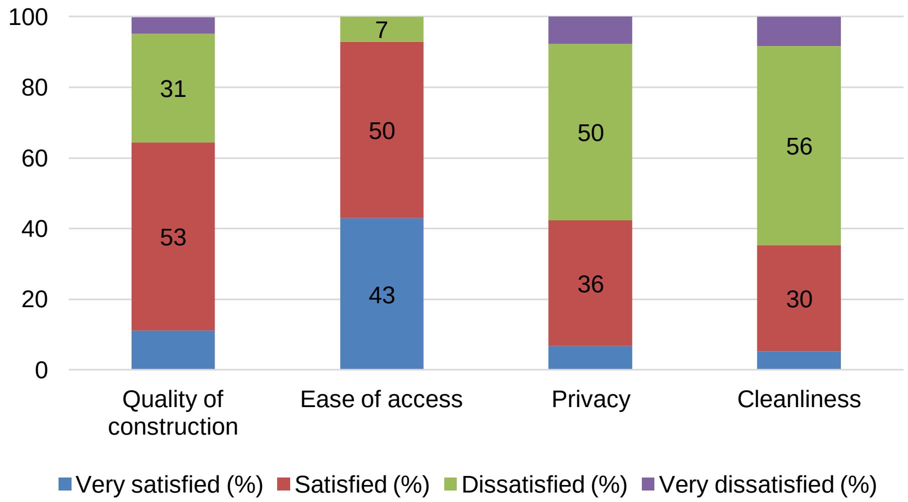
Incentives

The incentives that drive demand for improved FSM services are mainly influenced by ownership (of both the facility and the plot/dwelling itself), previous investments in constructing and maintaining the sanitation facility (as described above), and the current quality of the facility.

Around 90% of households own and have financed their sanitation facilities. Regarding their quality, 41% of households in non-sewered areas have a non-durable superstructure with a cleanable slab (with or without a water seal).[29]

Households were also asked to express their satisfaction with their current sanitation facility across a range of factors, as shown in Figure 9 below. The level of satisfaction with the sanitation facility is a driver of the incentives people have to invest in the improvement and maintenance of their facilities, which includes emptying of the pit/tank. Data shows that there are no major differences between non-sewered and lowest-income areas, with the exception of 'ease of access', for which households in lowest-income areas conveyed more dissatisfaction (56% vs 7% in non-sewered areas)[30]. Overall, households are generally satisfied with the quality of the construction, but are dissatisfied with privacy, and especially the cleanliness of their sanitation facility (over 60% for both samples).

Figure 9 Satisfaction with characteristics of the sanitation facility



No. of households: 360.

[29] Definitions used are (1) *very basic* = non-durable superstructure without water seal / cleanable slab; (2) *basic* = durable superstructure without water seal / cleanable slab; (3) *weak improved* = non-durable superstructure with cleanable slab / cleanable slab and water seal; and (4) *strong improved* = durable superstructure with cleanable slab, roof & privacy / same plus a water seal.
[30] Nb. This question was only answered by households which had a disabled member.

Households also identified their *intended* action once their pit/tank fills up (whether it had filled up previously or not) as per Table 17 below. Less weight was placed on this data than the action after the pit last filled up, as it may not be carried out and the number of observations is not large enough to draw reliable conclusions. [31] Nonetheless, it does signal market intention in some sense, with 100% of households mentioning that they intend to hire a professional service. This may be partly driven by the fact that households relying on on-site sanitation are concerned (as manifested in FGDs) with not having any space left on their plots to dig a new pit if the one currently in use fills up. Indeed, participants from FGDs in PROFAM and Las Lomas mentioned that households had dug their pits on a public road/path. Moreover, another participant in La Rinconada mentioned that one of the community members had now resorted to throwing fecal sludge along with solid waste because his pit has filled up and he has no space to dig a new one on his plot.

Table 17 Intended action after current pit / tank fills up – non-sewered areas

	%	No. of households
Hire a professional service / operator	100.0	9
Total	**100.0**	**9**

5.3.2 Barriers faced by households in lowest-income areas to obtain FSM services

Focus group discussions held in lowest-income areas identified that the key barriers faced by households relate to (1) costs / affordability and (2) lack of information or knowledge about FSM emptying services (besides those offered by NGOs with UDDTs) and containment requirements.

First, and as mentioned earlier, participants from FGDs stated that emptying services are very expensive, with an average cost of between US $224 and $256, depending on the depth of the pit. Similarly, participants from the FGD in San Juan de Miraflores, of which some use urine-diverting dry toilets (UDDTs), mentioned that a private NGO offered to collect their fecal waste on a monthly basis at a cost of US $13 per month, which is unaffordable to them. However, some of them suggested they would be willing to pay between US $5 and US $6 on a monthly basis for this service.

Another issue is that households in are also relatively unaware of what FSM services are. In the pilot FGD carried out in San Juan de Miraflores, none of the participants had ever emptied their pits/tanks nor did they have any idea of what an emptying service entailed. One of the participants in Santa Rosa district also believed that emptying pits may lead to more contamination, and thus pose a risk to the community. Moreover, although some NGOs have offered some training regarding how sanitation facilities should be built and maintained, the majority of households in lowest-income non-sewered areas rely on family and friends to build their facilities, most of whom have learned through their relatives/friends as well. FGDs also revealed that some of the pits are poorly covered – a participant in PROFAM even reported that one of their community members has not covered his pit, leaving all the fecal sludge exposed –, and as mentioned above, very few households have access points or hatches in their pits to facilitate emptying. In terms of maintenance, women usually use lime and hydrochloric acid to prevent their facilities from overflowing.

Finally, regarding household incentives, the majority of participants in all FGDs (with the exception of people who use UDDTs) expressed their dissatisfaction with current on-site sanitation facilities, as most of the pits/latrines have a very bad smell (especially in the summer), which attracts rats,

[31] This question was not answered by households whose current pit / tank has not filled up in the past 5 years.

flies and cockroaches. Some households have also experienced pit overflow, while others are very concerned with the lack of space to build new pits in the near future. These experiences, coupled with high prices and lack of knowledge of FSM emptying services, has skewed households towards regarding sewerage as the only medium- to long-term alternative to their current situation, which reinforces the lack of demand for FSM services.

5.4 Findings: supply of FSM services

As set out in Section 5.2.2, the supply side assessment is mainly related to the current status and quality of FSM service delivery as described by KIIs with service providers.

5.4.1 Services effectively supplied

The first stage of the supply analysis should be to consider what services are supplied in the market, where effective supply intersects with effective demand. Some relevant context was already provided in Section 3.3.1 by the SFDs, especially in Table 6 and Table 7. These tables show that when pits have previously filled up, people generally abandon them, although recent behaviour suggests there may be some scope for FSM emptying services – 9 out of the 10 households in non-sewered areas for which the pit/tank currently in use filled up claimed to have emptied it. In all instances, services were provided by a formal service provider (an NGO or a private firm) using a vacuum tanker. These households were also asked about where the fecal sludge was discharged during emptying, with the majority responding that contents were discharged into a drum/container (33%) or a tanker truck (44%).[32] The remaining households did not know where the fecal sludge was finally discharged.

5.4.2 Service provider capacity

Given that there are currently no formal FSM services directed at low-income households that rely on on-site sanitation, there is limited information about the capacity of potential service providers to cope with demand.[33] Based on KIIs and information provided by the World Bank consultant, there are two types of service providers: independent NGOs, such as X-Runner or PEBAL, and current providers servicing public establishments or dealing with solid waste management, e.g. Megapack Trading S.A.C or Disal.

On one hand, X-Runner targets poor urban households and provides fecal sludge services across the whole chain. The NGO provides a UDDT to each household, emptying its contents once a week or every two weeks, treating and re-using the fecal sludge to create compost. The compost is sometimes given to back to households or as a gift to future clients, but currently the majority of it is stored at their treatment area in Villa El Salvador. FS is treated as toxic waste by national and local legislation, which does not allow FS compost to be commercialised. There are three different types of packages: (i) for two people: 1 UDDT emptied every two weeks at a cost of US $9 per month; (ii) for three or more people: 2 UDDTs emptied every week at a cost of US $12 per month; and (iii) for six people or more: 3 to 5 UDDTs emptied every week at a cost of US $16 per month. X-Runner is currently serving 480 households, the majority of which have 2 UDDTs (74%).

On the other hand, Megapack Trading S.A.C is a large and well-established firm that primarily serves the municipality (i.e. public establishments) and large industries (including in the mining

[32] Households were only asked about the initial discharge point, as they would not always be in a position to know where service providers eventually discharged to. This indicator was only answered by 10 households in non-sewered areas.
[33] Although some richer households in wealthy neighbourhoods are serviced by vacuum tankers to empty their septic tanks, these services are usually directed at public establishments, which households can use if they are willing and able to pay the cost.

sector). In particular, for FSM services in schools, hospitals and social clubs, the service is provided using mechanical emptying with tanker trucks, which have a capacity of 6, 10 and 30 m^3. Services are reported to be very efficient, with delivery upon request, but costs and limited physical accessibility have been highlighted as some of the potential deterrents for providing services to poor peri-urban households. Indeed, KIIs with NGOs and service providers have suggested that it may be difficult for current service providers (mostly specialised in solid waste management) to extend their services to cover domestic FSM: decentralisation of treatment and improved regulation and monitoring will be needed. From a purely business perspective, service providers all mentioned the need for a demand/situation assessment to determine if FSM services for the urban poor are a profitable endeavour. In addition, during the workshop held in Lima, Disal mentioned that they face two risks: (i) households not paying and (ii) breaking the law, as legislation regarding FSM is very unclear.

6 Fecal sludge reuse options

6.1 Fecal sludge characteristics

Samples of fecal sludge were collected from six different types of sanitation containment facilities:

- an offset unlined pit connected to a pour-flush toilet
- a pit receiving wastes directly from a pour-flush toilet
- a septic tank
- a dry pit, receiving only feces and urine
- a twin-vault urine-diversion latrine
- a movable urine-diverting latrine.

The six different types of sanitation facilities from which samples of fecal waste were taken, and the types of wastes from each facility, are summarised in Table 18, below.

Table 18 Fecal sludge samples from on-site sanitation facilities in Lima

Type of sanitation containment	Sanitation description	Wastes requiring treatment	Nature of FS (wet or dry)
Offset unlined pit connected to a pour flush toilet	Pour flush	Blackwater (toilet wastes) and / or greywater	Wet
Pit receiving wastes directly from a pour flush toilet		Blackwater	Wet
Septic tank		Blackwater and greywater	Wet
Dry pit	Dry latrine (with drop-hole)	Feces and urine	Dry
Twin-vault urine-diversion latrine	Urine-diversion	Feces	Dry
Movable urine-diversion latrine			Dry

The offset unlined pit is the most popular sanitation option in Lima, and there are few septic tanks in low income peri-urban areas, this option being suitable only where piped water is available and sewers are not. The twin-vault urine-diversion latrine is the most common sanitation facility for feces alone, although X-Runner provides a service for movable urine-diversion latrines on a small scale in a few peri-urban districts of Lima.

Results of the laboratory analyses on FS samples from different sanitation facilities are summarised in Table 19 below. The analyses indicate high numbers of bacteria in the FS, but with few helminth eggs. The wet fecal sludge samples showed very high water contents, and all samples showed low nutrient (nitrogen and phosphorus) contents.

The samples of fecal sludge from urine-diversion latrines did not include urine. Urine from twin-vault latrines could either be collected and used as a fertiliser, or allowed to drain into the surrounding soil. Urine from the movable urine-diversion latrines also drains into the surrounding soil.

Table 19 Characteristics of fecal sludge from on-site sanitation facilities in Lima

Parameter	Range of values	
	Wet Fecal sludge	Dry Fecal sludge
Total coliforms	-	<3 – 500 cfu/gram (MPN)*
Thermotolerant coliforms	1.7×10^5 – 1.7×10^7 cfu/100 mL (MPN) *	<3 – 500 cfu/gram (MPN)*
E. coli	-	<3 – 15 cfu/gram (MPN)*
Total helminth eggs	0 – 3 eggs/L	< 1 – 3 eggs/2 grams of Total Solids
Total solids	200 – 69,850 mg/L	322 – 822 g/kg
Suspended solids	20 – 700 mg/L	
Volatile solids	150 – 47,450 mg/L	664.6 – 943.5 g/kg of Total Solids
Water content (%)	93.0 – 100.0	17.8 – 67.8
COD (mg/L)	1,361 – 3,748	
BOD (mg/L)	789 – 1,917	
COD:BOD ratio	1.72 – 1.96	
NH4 – nitrogen	460 – 761 mg/L	1.1 – 2.4 g/kg of Total Solids
Total nitrogen	1,095 – 1,255 mg/L	13.4 – 42.7 g/kg of Total Solids
Total Phosphorus	3.2 – 6.7 mg/L	6.4 – 66.7 g/kg of Total Solids

* MPN = Most Probable Number.

Note that the dry fecal sludge values also include results from samples of feces taken directly from urine-diversion latrines. Table 20 compares analyses of feces taken from movable urine diversion toilets before and after treatment.

6.2 Availability and access to fecal sludge services

Relatively few sanitation facilities in Lima are emptied when pits or tanks become full. Few people know about suction tanker services, which also tend to be expensive. Large tankers may also be unable to gain access to some of the pits and tanks, given the quality of paths and roads, as well as the hilly nature of the areas occupied by low-income peri-urban households. In addition, the majority of households choose to abandon and cover their latrines when they are full, and build new ones. However, given increasing concerns with the lack of space to dig new pits, as well as delays in getting access to sewerage, there is some interest in alternative FSM services, potentially including emptying with tanker trucks.

During sample collection some residents were previously unaware that an emptying service was available. Collecting some samples proved to be difficult and the suction tanker was only used for three sanitation facilities:

- For the offset unlined pit connected to a flush toilet, a pipe from the suction tanker was inserted through a manhole, but part of the pit wall collapsed and blocked the suction pipe.
- For the pit receiving wastes directly from a pour-flush toilet, use of the suction tanker was very difficult because the soil was very sandy. Emptying was halted because the pit contents were too dry to be pumped as a liquid.
- Emptying the septic tank was relatively simple, and no stones or silt were encountered.
- Non-liquid samples were collected manually from the dry pit.
- Non-liquid samples were collected manually from the twin-vault urine-diversion latrine.
- Non-liquid samples were collected manually from the movable urine-diversion latrine.

6.2.1 Treatment

There are currently no treatment facilities in Lima for FS, and no organised systems for collection, except in some rich coastal areas of the city where dwellings usually have a flush latrine with a septic tank. When septic tanks are emptied, it is reported that the fecal sludge is illegally dumped in SEDAPAL sewers, landfill sites or in open spaces in nearby peri-urban areas, as there are no treatment plants designed specifically for fecal sludge.

X-Runner provides emptying, transport, treatment and reuse services in Villa El Salvador, Pamplona Alta and Villa María del Triunfo for mobile urine-diversion latrines. Feces from these latrines are taken to a small treatment plant where they are mixed with sawdust, and bacteria are added to encourage composting. The material is left to compost in plastic bags, before being mixed and stored for future sale as compost.

6.2.2 Re-use

In the absence of services for collection and treatment of fecal sludge in Lima, there is currently little, if any, re-use, and very little prospect of significant re-use in the foreseeable future. Most pits are abandoned when full, and emptying pits may damage the walls of pits, especially those that are unlined.

Permanent twin-vault latrines have been constructed in a few districts. One vault is used at any time and, when it is full, it is allowed to ‘rest’ while the second vault is used. By the time that the second vault is almost full, the contents of the first vault should be dry and inoffensive, and could be applied to agricultural land. Between 2000 and 2006, some 225 twin-vault latrines were constructed in Lima, but it is reported that only 62% (140) of these are currently in use. A further 145 were constructed between 2010 and 2014, of which more than 90% are in use. It is not clear how the urine and dried feces are used or disposed of.

As mentioned above, X-Runner (based in the Villa El Salvador district) has supplied mobile urine-diversion latrines to residents in 3 different areas. X-Runner services these toilets, providing an emptying, transport, and treatment service. Feces are collected on a weekly basis from the containers and transported to a private treatment facility, where compost is produced for possible future reuse. The treatment process and final product have not been accredited as yet, and the company is currently seeking a licence to sell the treated compost commercially. The final product is currently being stored in plastic sacks until it can be sold.

Table 20 below, shows analyses of fresh and treated samples of feces from urine-diversion latrines supplied and serviced by X-Runner. Few conclusions can be drawn from the analyses. The samples of fresh and treated feces are independent of one another, but some results are surprising. They appear to show an increase in the number of Total coliforms during treatment, while numbers of Thermotolerant coliforms remain unchanged. The overwhelming majority of any sample of Thermotolerant coliforms are *E. coli*, yet the results show very few Thermotolerant coliforms being *E. coli*. Helminth eggs were detected after, but not before, treatment, and the moisture content of the material remained constant. It is difficult to account for these anomalies. The increase in Total coliforms may be associated with the composting process, and most other anomalies may be attributed to samples being taken from different process streams. The most surprising result is the very low percentages of Thermotolerant coliforms identified as *E. coli*, suggesting errors in the bacterial analysis. The treated feces have limited value as a natural fertilizer, but could be used as a soil improver if the numbers of bacteria and helminth eggs are reduced.

Table 20 Characteristics of fresh and treated feces from movable urine-diversion latrines in Lima

Parameter	Values	
	Fresh Feces	Treated Feces
Total coliforms – cfu/gram (MPN)*	500	> 1,100
Thermotolerant coliforms – cfu/gram (MPN)*	500	500
E. coli – cfu/gram (MPN)*	15	4
Total helminth eggs (eggs/2 grams of Total Solids)	-	5
Total solids (g/kg)	322.2	312.5
Volatile solids (g/kg of Total Solids)	943.5	711.9
Water content (%)	67.8	68.8
NH4 – nitrogen (g/kg of Total Solids)	1.2	1.1
Total nitrogen (g/kg of Total Solids)	24.7	25.2
Total Phosphorus (g/kg of Total Solids)	15.5	18.4

* MPN = Most Probable Number.

6.2.3 Possible future reuse options

Some of the possible reuse options for fecal sludge include: (1) using treated fecal sludge as a soil conditioner or organic fertiliser; (2) using dried fecal sludge as a fuel; (3) generating biogas from anaerobic digestion of FS; (4) producing protein for use as animal feed, and (5) including fecal sludge in building materials. In the absence of any centralised services for emptying pits and septic tanks, or for treating FS, the only current potential reuse option is localised use of dried feces as a soil conditioner or organic fertiliser. Management of this, albeit on a small scale, may improve if X-Runner obtains a licence to sell their treated compost commercially and generate a profit. Future reuse opportunities in Lima are therefore limited, unless centralised fecal sludge collection and treatment services are introduced and managed.

KIIs suggest that SEDAPAL and private service providers are generally keen on creating a reuse market but are deterred by the lack of adequate treatment facilities for fecal sludge and/or a clear institutional framework to support its development. However, wastewater reuse was legalised in 2010 and is currently being used in urban and peri-urban green areas.[34] These guidelines may thus provide an entry point for fecal sludge end-products to be used for similar purposes, as well as in peri-urban small-scale agriculture.

[34] The Ministry of Housing, Construction and Sanitation approved the “Policy Guidelines for the Promotion of Treatment for Domestic and Municipal Wastewater Reuse for Irrigation of Urban and Peri-Urban Green Areas” in November 2010.

7 City Service Delivery Assessment

7.1 Introduction

The City Service Delivery Assessment (CSDA) is a crucial part of the analysis of FSM services. It answers an overarching question around the quality of the FSM enabling environment, the level of FSM service development and the level of commitment to FSM service sustainability. The aim of the CSDA is to allow an objective assessment of FSM service performance through all stages of the service chain, so as to identify priorities for reform. The Prognosis for Change (in the next section) then attempts to explain *why* the CSDA looks like it does.

The CSDA format builds on an approach developed under the 12-city study (Peal & Evans, 2013). In turn, the 12-city method was based on similar exercises in water and sanitation (e.g. Country Status Overviews produced by WSP).

The CSDA is arranged around three broad areas: (1) enabling services, (2) developing services, and (3) sustaining services. This is illustrated in Table 21 below, alongside the key question associated with each area, and the indicators used.

Table 21 CSDA framework for FSM

Area	Question in research framework	Indicator
Enabling	What are current policies, planning issues and budgetary arrangements?	Policy
		Planning
		Budget
Developing	What is the level of expenditure, degree of equity and level of output?	Expenditure
		Equity
		Output
Sustaining	What is the status of operation and maintenance, what provisions are made for service expansion and what are the current service outcomes?	Maintenance
		Expansion
		Service Outcomes

7.2 Methodology

The CSDA aims to be fully objective and transparent, so the analysis is clear and stakeholders can engage with it and update it over time as the situation improves. It is primarily a qualitative analysis, based on a review of key documents and interviews with stakeholders at the city level. WSP's overall study design was that the OPM/WEDC team designed the methodology, but did not do primary data collection (for more information, please refer to Annex B). For analyses such as the CSDA and PFC, it is hard to separate data collection from analysis. Therefore, the collection and preliminary analysis was conducted by a short-term consultant contracted by WSP, Eng. Ruddy Noriega.

There are several questions beneath each of the nine overall indicators in Table 21 above, with 20 questions in total. For each question, there are objective criteria to enable a score to be given for the city, with 0 (poor), 0.5 (developing) or 1 (good) on that question. Each question is scored along the whole service chain from containment to disposal. An example is given in Table 22 below, for the first question under the "policy" indicator.

Table 22 Example of an CSDA question, criteria and scoring

Question	Containment	Emptying	Conveyance	Treatment	End-use/ disposal	Indicator/ Score
Policy: Is FSM included in an appropriate, acknowledged and available policy document (national / local or both)?	0.5	0	0	0	0	• **1:** policy is appropriate, approved (or in draft form), acknowledged and available • **0.5:** policy is appropriate, approved (or in draft form), but not clearly acknowledged / available • **0:** policy not available, or inappropriate to the context

Once all 20 questions are scored, the next step is to aggregate those scores into a city scorecard, by summing together the scores for each indicator (policy, planning, etc.). Because there are different numbers of questions for each indicator, a final step is required, which is to normalise the scores to a total out of 3 for each indicator. This is achieved by dividing the city score for that indicator by the maximum possible city score, multiplying by 3, and finally rounding to the nearest 0.5. This process delivers the overall CSDA scorecard. The output for Lima is shown in Figure 10 below.

Figure 10 CSDA scorecard for Lima

	Containment	Emptying	Conveyance	Treatment	End-use/ Disposal
Enabling					
Policy	0.5	1	1	0	0
Planning	0	0	0	0	0
Budget	0	0	0	0	0
Developing					
Expenditure	0	0	0	0	0
Equity	0	0	0	0	0
Output	0	0	0	0	0
Sustaining					
O&M	0	0	0	0	0
Expansion	0	0	0	0	0
Service	0.5	0	0	0	0

	Enabling	Developing	Sustaining
City typology			

Poor
Developing
Good

7.3 Findings

The overall CSDA scorecard for Lima is shown above as Figure 10. An explanation for each score allocated to the full set of 20 questions is shown in Annex D, while the following sub-sections summarise the implications of those results.[35]

7.3.1 Enabling

Domestic FSM services in Lima have not been developed, with the current ones exclusively serving public establishments, such as schools, universities and health facilities, or private dwellings in wealthier areas (e.g. beach houses). Although most KIIs recognised the importance of FSM to address the needs of the 800,000 people that have no access to sewerage, there are no planning and/or budgetary arrangements to address these issues. Like other Latin American cities, sewerage is regarded as the 'first best' for urban areas, especially with current coverage at above 90%. Thus, the target for Lima is to achieve universal coverage by 2017, with no medium-term solutions until sewerage infrastructure is put in place. Similarly, the National Urban Sanitation Programme (*Programa Nacional de Saneamiento Urbano*) does not seem to be making any investments on on-site sanitation or FSM.

Nonetheless, legislation for FSM is slightly more developed, with both Law No. 26338 (General Law for Sanitation Services) and Law No. 30045 (Law for the Modernisation of Sanitation Services) encompassing the disposal of feces from latrines and septic tanks within the purview of sanitation services. In particular, Law No. 30045 defines the competencies across sector stakeholders (e.g. Ministry of Housing, Construction and Sanitation is sanctioned as the main governing body), and introduces support mechanisms to ensure the quality and sustainability (including financial) of the sanitation services provided, among others. Although service providers (i.e. EPSs) are mainly dealing with sewerage, treatment and solid waste management, fecal sludge service providers would likely fit under the same policy framework.

7.3.2 Developing

There is currently no identifiable public expenditure in fecal sludge urban infrastructure or services, with the result that the availability of appropriate, affordable and safe services to the non-sewered population in Lima is non-existent. In terms of equity, KIIs mentioned that FSM services are too costly for the urban poor, which may be party explained by difficulty of access (to both the dwelling and the pit/tank) and the lack of a recurrent demand for these services. Despite the principles of universal access and social inclusion for the provision of sanitation services, both national and local governments have failed to develop plans and ensure adequate funding is allocated for this purpose.

Given the lack of FSM services, there are no measurable outputs. Besides the provision of UDDTs by NGOs, and previous government efforts to provide latrines, there is nothing in place besides some partial fecal sludge containment (in septic tanks, pit latrines and unlined pits).[36]

7.3.3 Sustaining

Operation and maintenance costs for fecal sludge services are primarily carried out by households through their investment in self-financed sanitation infrastructure – the common practice for poor

[35] Since FSM is relatively under-developed in Lima, the original CSDA questions were adapted by the World Bank consultant to fit the Lima context. We have however been able to populate the original CSDA based on secondary information, KIIs and data collected through transect walks.

[36] Unlined pits refer to *pozo ciego/negro* as recorded in national surveys.

urban households is to dig a new pit once the one in use is filled up. It is not possible to determine with certainty how many of the pits are properly covered or sealed. Given the high level of sewerage coverage overall, the risk to public health is often deemed to be quite low – although there could be a high risk of environmental pollution in poorer areas where the use of unlined pits is common, resulting in pit collapse or abandoned pits not being covered safely.

One of the main issues is the lack of demand from households for services, as this reinforces the government's inaction with regards to FSM development and strengthening. The majority of KIIs confirmed that there are no government programmes or support for service providers, and no formal systems that serve the urban poor, with the exception of small NGO initiatives that provide alternative sanitation systems, mainly in the form of urine-diverting dry toilets.

7.3.4 Implications of the CSDA scorecard

The resulting CSDA scorecard of the FSM service delivery assessment in Figure 10 reveals a complete absence of public policy, capital investment and operational oversight of FSM. Although for the city as a whole, the lack of FSM services may not seem to be a priority (given the high level of sewerage coverage), there are 800,000 people in poor areas without a real and sustainable solution to their daily sanitation needs.

In a way, policy and regulatory frameworks already allow for the provision of emptying and transport services to households, as feces disposal is encompassed within the national definition of sanitation services. Current service providers of treatment and solid waste management are also likely to be able to cope and adapt to an increase in demand, assuming that the legal provisions to ensure their financial sustainability (Law No. 30045) are guaranteed. Through KIIs, SEDAPAL and other stakeholders also agreed on the need to fill this gap for the urban poor, and some manifested their willingness to get involved in the provision of adequate FSM services, as long as both national and local governments show commitment and provide the necessary support.

This suggests that what is needed is a space for open dialogue and engagement of public, private and civil society bodies to ensure that the appropriate infrastructure and services are systematically developed and adapted to respond to the various contextual challenges of the city (space, tenancy, poverty, etc.). Segmentation and lack of coordination is already a key constraint in the provision of basic services, so bringing all key stakeholders together and aiming at reaching a consensus on a course of action, is an imperative. A clear definition and agreement of the roles of different stakeholders along the sanitation service chain is also required, with a particular focus on developing adequate containment and treatment frameworks, and strengthening both emptying and transport components.

8 Prognosis for Change

8.1 Introduction

This chapter provides a Prognosis for Change (PFC), by considering the positions of various stakeholders, in particular the institutions and incentives at play. In the sanitation sector, key studies considering these questions include a multi-country study carried out by WSP with OPM (WSP, 2010) and a series of papers by the Overseas Development Institute (ODI, 2013). In addition, SANDEC's recent FSM book includes a chapter on stakeholder analysis, which is a key methodology for this kind of analysis (Strande *et al*, 2014). Through this prognosis for change, it is intended to understand three elements, which are briefly outlined below and in Figure 11.

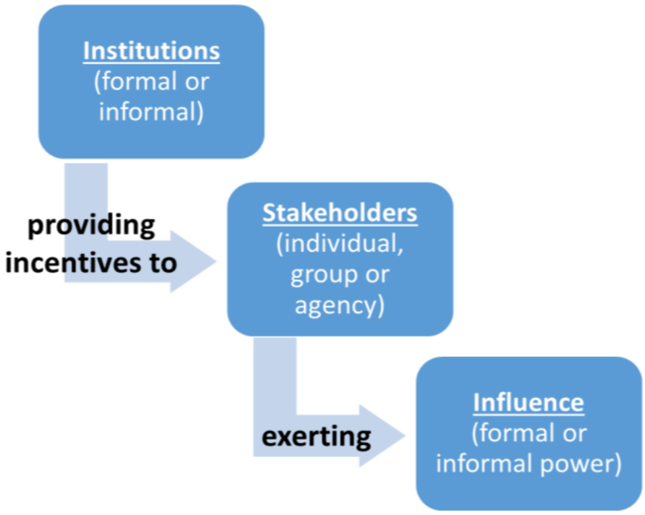
Firstly, a PFC considers *how institutions function*. Here, institutions are defined as "the rules and norms governing human interaction", rather than a narrower definition of organisations. Institutions can be formal – such as codified laws, e.g. a by-law about where fecal sludge can be legally dumped – and informal, as is the case of social norms, such as prevailing attitudes towards reusing fecal sludge in agriculture.

Secondly, a PFC considers the *incentives* which institutions provide to different stakeholders. A stakeholder is any individual or group with an interest in the outcomes of a policy. In FSM, stakeholders may include sludge truck companies, the municipality, or poor households. Stakeholders can be defined broadly or narrowly as required by the breadth and depth of the analysis. For example, the former stakeholders could be narrowed to recent entrants to the sludge truck market, the planning department of the municipality, or poor female dwellers. This allows for a more nuanced analysis rather than taking all organisations as homogeneous.

Third, a PFC considers how stakeholders exert *influence*. Here, influence is defined as the formal or informal power to cause something or to prevent it from occurring. In FSM, it might be worth considering municipality by-laws on FS. A municipality may have formal legal power, but if all their by-laws are openly flouted by service providers without fear of punishment, then their influence is very low by that measure. They may however have informal power to influence the FSM market in other ways, such as the actions undertaken by employees when they identify a blocked sewer pipe.

Finally, for a PFC to be practically useful, it should also consider the implications of the findings for effective engagement in a reform or change process. This involves the assessment of the options for engagement, and weighing them up in the context of the prevalent power dynamics and likely response of stakeholders.

Figure 11 Key concepts in PFC assessment



8.2 Methodology

In this study, developing a PFC was only one concern alongside a large number of other research components, as set out in Table 1 at the beginning of the report. There was therefore a balance to be struck. The approach was to link a focussed PFC closely to the service delivery assessment, presented in the previous section (Section 7). The aim is therefore to explain *why* the CSDA is as it is – in other words, to explore why service delivery blockages exist and what entry points are available to stakeholders to try and resolve them.

Undertaking a PFC is primarily a qualitative exercise. It relies mainly on Key Informant Interviews (KIIs) with relevant stakeholders and focus group discussions, alongside secondary data in the form of key sector documents, reports and studies. As noted in Section 7.2 for the CSDA methodology, the OPM/WEDC team did not conduct the primary data collection and preliminary analysis, which were carried out by other consultants contracted by the World Bank. Interview notes and reports from these consultants were the primary inputs for the construction of this PFC. In order to keep the length of this report manageable, only a brief summary of the full analysis conducted by the team is provided in this section.

Developing a PFC requires a structure in order to be clearly analysed and communicated. There are several tools available, which can be applied to particular questions as to explore some of the issues described in the CSDA. Many tools which are commonly used, including in this study, are contained in a sourcebook which OPM produced for the World Bank (Holland, 2007). The main tools used include institutional responsibility analysis, stakeholder analysis and process mapping.

8.3 Findings

8.3.1 Lima's FSM context

As noted above, the main objective is to explore why the CSDA results are as they are. For Lima, the CSDA is almost entirely red (i.e. "poor" scores), albeit with some yellow ("developing") scores for policy in the emptying and transport stages of the chain. Scores for the rest of the chain, and across the enabling, developing and sustaining environments are universally zero except for policy around containment, where a score of 0.5 was given due to X-Runner's provision of onsite sanitation facilities in poor urban areas, and service outcomes for containment (also given a score of 0.5) as the risks to public health at this stage are deemed to be at medium-level, given the uncertainty about the risk posed by abandoned and covered unlined pits. Overall then, the job of the PFC in the Lima context is to try and explain "why has nothing happened on FSM" and what the prognosis for change is.

At this stage, it is worth reconsidering Lima's context and the responsibility of key actors, which were briefly set out in Section 2. As many other Latin American countries, rural-urban migration is a major trend in Peru, with Lima Metropolitan Area (encompassing Lima and Callao) being the main urban and economic centre of the country. High rates of migration have led to a rapid horizontal expansion of the city, with many migrants illegally occupying small plots of land in poor peri-urban areas, which have very limited access to basic public services, mainly drinking water, sewerage and electricity. Indeed, while current sewerage coverage in Lima is estimated to be around 92%, only 43% of households in the lowest wealth quintile have access (APEIM, 2013).

Households without sewerage (8% of the city as a whole) rely either on some sort of on-site sanitation (7%) or practice open defecation (1%). Given the lack of both formal and informal FSM services, the most common practice among poor peri-urban households is to dig a new pit once the one in use fills up – although there is an increasing usage of UDDTs that are being provided by NGOs (e.g. X-Runner and PEBAL). Evidence from focus group discussions (FGDs) suggests that, while some of the pits have been lined with concrete rings or bricks, most of them are unlined and built by the household head (usually male) or other close relatives, who have learnt by observation or through a neighbour, and more unfrequently, through training by an NGO or SEDAPAL. An example of this is shown in Figure 12 below.

Figure 12 A woman digging an unlined pit in Puente Piedra

Both the superstructures and the pits are usually located within the plot but outside of the household, with the majority of pits connected with a pipe to the facility.[37] However, FGD participants mentioned that some of their neighbours have built their pits in public spaces, such as nearby green areas or even in public dirt roads, either because they have limited space (e.g. dwelling is located in a hilly area) or in anticipation of being connected to the sewerage network in the near future.[38] Properly-built pits are covered with a concrete layer or lid, with the more unstable and cheaper ones being covered with wood and soil, which tends to subside and is clearly a

[37] The distance of the pit to the facility varies, with a range of between 2 and 8 metres.
[38] According to some FGDs, people believe that if their facility is connected to a pipe that leads to the road, it will be easier for SEDAPAL to provide the sewerage connection.

hazard, especially for children. FGD participants even commented on a pit being used but left open, regardless of complaints by neighbours related to bad smell, flies and other environmental and hygiene concerns. Once full, pits are sealed with lime, rocks, wood and soil, and a new pit is built nearby or any nearby available space. The lack of space to dig new pits is an increasing concern for poor non-sewered households, with many not knowing what they will do once the pit in use fills up. There have even been reports during FGDs of people using buckets or potty chairs and throwing their contents in a refuse bag along with all other solid waste due to the pit having filled up and no space left for digging a new one. Poor FSM is coupled with poor solid waste management (SWM), increasing health risks and environmental hazards in these neighbourhoods.

On the supply side, SEDAPAL faces high costs for the provision of both water and sanitation services to peri-urban areas, partly explained by the type of terrain occupied by poor households (e.g. rocky and hilly areas, land intended for agricultural use, etc.), but also by the lack of land ownership and titling. Private or tertiary service providers are mainly reported to serve wealthier areas of the city or public institutions (e.g. schools and health facilities), where people have the ability to pay for emptying and transport of FS, and FSM is thus a profitable business. FGD participants referred to one or two cases where emptying services were provided to a poor peri-urban dweller, but this is extremely occasional and unaffordable for the majority of households in these areas. Other barriers for the provision of services in poor peri-urban areas include access to dwellings, given the hilly landscape of some of these neighbourhoods and the lack of adequate roads, as well as access to the pits and methods for emptying, given that the quality of their construction (and the terrain itself) is precarious. NGOs, such as X-Runner, provide FSM services across the whole chain, but these initiatives are still at ‘pilot-level’, serving few households and, in some cases, remaining unaffordable.

On the demand side, there is a very low level of demand for FSM services due to a lack of knowledge of the possibility of FSM services (or high prices for vacuum truck services, when people knew of their existence). Indeed, the majority of FGD participants did not know that emptying services exist or that their private pits could potentially be emptied. With regard to cost, discussions also suggest that in some neighbourhoods people are simply not willing to pay for FSM services (regardless of the cost), expecting to receive services for ‘free’ or being comfortable with the *status quo*. Moreover, on-site sanitation is generally conceived as a temporary solution with the expectation that both piped water and sewerage will be provided in the short- to medium-term (this is true even for current users of UDDTs). Many households have not observed any improvement in the past 5 to10 years, with lack of progress being primarily linked to costs and the lack of land titling and formalisation of the human settlement, which is a pre-requisite of SEDAPAL. Most FGD participants claimed that they have already submitted their documents (i.e. land titles or *plano visado*) and are waiting for a response in upcoming months. It must be noted as well that, contrary to service provision in rural areas, SEDAPAL is not able to intervene at the intra-domiciliary level in urban or peri-urban areas, limiting its ability to provide alternative sanitation services to households in non-sewered areas.

Overall, there is no formal FSM market for poor non-sewered households in Lima – while vacuum truck services are demanded and supplied in some parts of the city, there is no such market in poor peri-urban areas. On one hand, the problem has relatively low visibility given the high level of sewerage coverage and the concentration of on-site sanitation among the urban poor. On the other hand, given the low ability and willingness to pay of poor households, FSM services are not demanded and hence, private or tertiary stakeholders have limited incentives to develop a market that is likely to be financially unprofitable and unsustainable. However, SEDAPAL is currently designing a pilot for the provision of decentralised water supply and sanitation services, including FSM, in poor peri-urban areas. FSM services may be coupled with ‘sanitation marketing’ to offer poor households different on-site sanitation options at affordable prices (an alternative that is currently being explored through initiatives like "*Mi Baño*", which offers different types of prefabricated sanitation facilities). It is envisaged that SEDAPAL will have full responsibility for the development and sustainability of the FSM market, with private/tertiary service providers being sub-contracted to provide mainly emptying and transport services. Regulatory agencies (e.g. SUNASS and DIGESA) will also play a key role in fixing the maximum prices or tariffs to be charged for these services.

A preliminary overview of the situation in the language of incentives is as follows. It is clear that the prevalent FSM service providers (vacuum truck companies serving wealthier areas of the city, e.g. beach houses) have no incentives to provide services in poor non-sewered areas because there seems to be no demand and no potential profit. Poor households have no incentive to properly line their pits and empty them because the contamination is an externality that primarily affects the general public rather than the household itself. They also have little incentive to invest in safer (and more expensive) containment options, while their expectation is that SEDAPAL will eventually extend the sewer network to their area. SEDAPAL has little incentive to extend the sewer network in this way mainly because it is very costly (especially in hilly and rocky areas), but also because there are legal impediments (i.e. lack of formal land rights) for the expansion of the network. One part of squaring this circle is therefore for SEDAPAL to make their intentions clear.

To have a better understanding of current institutional responsibilities and the scope for reform, the next section maps out these responsibilities across key sector stakeholders.

8.3.2 Mapping institutional responsibilities

As set out above, the focus is on how institutions function, the incentives which those institutions provide to stakeholders, and how those stakeholders exert influence. It is therefore important to understand who those stakeholders are, alongside their formal and informal roles. A useful tool to do this is institutional responsibility mapping, as set out in Table 23 below. Stakeholders have been categorised by sector (e.g. national or local government, private, etc.), and both their formal responsibilities ('what should be happening') and the reality ('what actually happens') in FSM in Lima are described. A final column summarises some of the main challenges faced.

The main messages of Table 23 are the following:

- At both national and local levels, no responsibilities for FSM have been clearly designated across stakeholders, which discourages the development of FSM services. Sector planning, and thus, public budgets are unlikely to encompass FSM if no stakeholder can be held accountable for investments and results. Indeed, budget allocations are primarily directed to the expansion of the sewerage network and treatment facilities (both for grey and blackwater, and solid waste). Moreover, given the current segmentation of the sanitation sector across different institutions (as shown in Table 23), a clear designation of responsibilities is needed (as is the case for sewerage). Indeed, several KIIs expressed that sector or national development plans that encompass FSM cannot be developed without a prior definition and allocation of competencies. Evidence from KIIs also suggests that, although there seems to be no political opposition to the development of FSM, there is no political will either to carry this forwards – this is partly driven by the persistent demand for sewerage (and piped water) by poor non-sewered dwellers, which drives political campaigns and sanitation policy more broadly, as well as the lack of actual commitment and actions by government counterparts.

- Although there are no formal regulations or legal frameworks for FSM, these seem to be flexible enough to encompass the provision and regulation of FSM services either by

SEDAPAL directly or through private/tertiary service providers (sub-contracted by SEDAPAL). However, current demand is limited and there is very little knowledge about potential demand (i.e. volume of fecal sludge to be emptied, transported, treated, etc.). A reuse market for fecal sludge also remains to be legalised and developed. Thus, there are no clear incentives to develop a market from the supply side.

- Poor households in peri-urban Lima face significant financial restrictions to pay for the FSM services currently offered, with emptying services ranging between USD $120 and $240 (as reported in FGDs). The common practice of digging new pits once the ones in use fill up has also contributed to the maintenance of the current *status quo*. However, limited space, land tenure issues and health hazards and risks, as well as delays in getting access to sewerage (which can take between 8 to 10 years), is encouraging people to explore other alternatives, as is the case of UDDTs offered by X-Runner and PEBAL.

Overall, as shown in the CSDA scorecard in Figure 10, the whole FSM chain needs to be formally enabled, developed and sustained. Even if the current legal frameworks for SWM service providers allows for the inclusion of FSM service providers, there is an urgent need to explicitly include FSM within urban development plans and budgets, and define competencies across sector institutions. From the table, it seems that the Ministry of Housing should be the institution that has responsibility for ensuring that appropriate FSM services exist, while SUNASS should continue to oversee the services themselves. SEDAPAL should be the main service provider, as this would allow for an integration of FSM services within the provision of WSS in Lima, regardless of whether services are provided directly or through the private/tertiary sector.

Without a proper distribution and designation of responsibilities for FSM, to which stakeholders are held accountable, it will not be possible to establish FSM services and develop a strong FSM market. There are no obvious incentives for stakeholders to undertake FSM activities, and they cannot be expected to independently take this venture forwards.

Table 23 Mapping institutional responsibilities for FSM

Sector	Stakeholder	Formal role	The reality	Core challenge
National government	**Ministry of Housing, Construction and Sanitation (MoHCS)**	Guarantee the provision of high quality urban water and sanitation services and encourage its sustainable use.	There are no specific policies for on-site sanitation or FSM in urban areas, and no budget has been allocated for these purposes.[39]	Although the problems with on-site sanitation in peri-urban areas are acknowledged by different stakeholders at national and local levels, responsibilities for on-site sanitation and FSM are not adequately allocated and thus no plans or interventions are carried out. Current focus on FSM nationally is on rural rather than urban areas.
	Ministry of Environment	Reduce and prevent the contamination of water sources, air pollution, and soil degradation. Currently drafting the 'Law of Solid Wastes'.	'Law of Solid Wastes' is mainly focused on SWM and it is uncertain if it will incorporate some or all components of the FSM chain.	
	Ministry of Health – Directorate for Environmental Health & Health Directorate (DESA)	Guide the design of sanitation policies to prevent diseases and improve health. 80% of budget allocated is directed towards drinking water quality assurance, with the remaining 20% directed towards waste water management.	They carry out health promotion and prevention activities, and inspections of potential foci of infection due to mismanagement of on-site sanitation facilities, but they do not actively participate in specific FSM programmes or encourage FSM development.	
	National Superintendence of Sanitation Services (SUNASS)	Regulate and supervise the provision of sanitation services, and improve the quality and access to drinking water and sewerage.	No guidelines for FSM, but they currently oversee the provision of fecal sludge emptying and transport services for public institutions and households with septic tanks.	A small random sample of SPs is supervised (10%) on a periodic basis, which is insufficient to enforce regulations and apply the necessary sanctions.[40]

[39] On-site sanitation and blackwater treatment is significantly more developed for rural areas. For instance, there is a practical manual for households that provides information about containment, emptying and treatment of fecal sludge (*Manual Tecnico de Difusion – Sistema de Tratamiento de Aguas Residuales para Albergues en Zonas Rurales*).

[40] Sanctions include corrective measures, such as public notices to discourage non-compliance of legal frameworks, refunds to affected users, or any other measure that SUNASS considers necessary to revert SPs non-compliance.

Sector	Stakeholder	Formal role	The reality	Core challenge
	Technical Organism for the Management of Sanitation Services (OTASS)	Regulate, promote, supervise, audit and restructure the administration and management of service providers, and guarantee their efficiency, autonomy and social integration.	OTASS recently started its operations and it has currently provided support to some service providers (EPS). No specific concerns for FSM – this institution is solely concerned on administrative, managerial and financial efficiency and sustainability.	There seems to be an overlap between SUNASS and OTASS functions – instead of integrating or adding responsibilities to existing institutions, the sector seems to be becoming increasingly segmented.
Local government	**Drinking Water and Sewerage Service of Lima (SEDAPAL)**	Provide adequate access to drinking water and sewerage, as well as treatment and disposal of waste water.	FSM services for other types of on-site sanitation besides septic tanks are not considered. Due to issues with land-titling and high costs, which prohibit the provision of services to poor peri-urban areas, they are currently exploring alternative options to sewerage, including FSM coupled with 'sanitation marketing'.	Funding and limited ability and/or willingness to pay from poor households may be an issue in scaling-up FSM services in the future.
	Metropolitan Municipality of Lima	Design and assess urban plans and interventions. They also approve SP registration and grant licenses for their operation.	They have an indirect role in FSM by providing land titles to poor households and encouraging them to settle in areas where the provision of sewerage in the future is possible.	Focus on sewerage as the only alternative and limited knowledge of the potential demand for FSM services. They also have a limited budget for sanitation interventions.
	District municipalities	Support district social and economic development, and plan and coordinate with different governmental agencies the implementation of local policies and interventions.	They support local communities to make official requests to SEDAPAL for the provision of drinking water and sewerage, but they have no plans to develop on-site sanitation and FSM as an alternative.	
NGOs	**X-Runner (PEBAL also provides similar services)**	Provide UDDTs, and emptying, transport, treatment and reuse of FS.	They only serve a few number of households in lowest-income non-sewered areas (approx. 480) but uptake and satisfaction have been high. Services remain unaffordable for many households (between US $9 and $16 per month).	They have very low visibility and have been unable to get the necessary funding to scale-up their services. The inexistence of a legal and formal market for fecal sludge end-products also hinders service development.
Private sector	**Services providers (e.g. DISAL,**	Provide SWM services, emptying and transport of fecal sludge from septic	No operations in peri-urban areas due to limited willingness and ability to pay by	Current business is profitable and no incentives to develop FSM in peri-urban

Sector	Stakeholder	Formal role	The reality	Core challenge
	Megapack Trading, Tecnisan)	tanks, and construct and operate sanitary landfills.	poor households. Limited access to dwellings and pits, as well as inadequate equipment/emptying methods, may also be a deterrent for the provision of services. SWM services are not always timely.	areas as market scale is unknown.
	Poor households	Pay for drinking water, sewerage and SWM.	Poor households that rely on on-site sanitation dig and cover their own pits, building new ones as needed. No access to FSM services.	Low visibility and lack of ability and/or willingness to pay for current supply of fecal sludge services. Conception of on-site sanitation as an inferior or temporary service as compared to sewerage by some, and very limited knowledge of FSM services, with the exception of those provided through NGOs (e.g. X-Runner and PEBAL)

8.3.3 The influence and interests of stakeholders in FSM reform

When considering reform options, as in a redistribution or introduction of FSM responsibilities, it is crucial to consider how stakeholders might respond, e.g. who would be supportive and who would oppose – in other words, their interest, or whether they stand to gain or lose from any change to the *status quo*. With a limited amount of time and effort to put into preparing the ground and working with different stakeholders, it would be wise to use that time efficiently and target it at the right people. Therefore, information about stakeholders' interests is not enough. It must be used in combination with an analysis of their relative influence. This will allow to identify who potentially opposes the reform and, among them, who has enough decisive power to prevent it from being implemented. Since there is no clear reform proposal on the table at this stage, the analysis is fairly generic and relates to a general improvement in containment and emptying services.

Interest and influence can be scored and mapped onto a stakeholder matrix, as in Figure 13 below. Although stakeholder matrices can help start a conversation about stakeholder engagement in reform processes they have inherent limitations, e.g. it is not possible to be certain about how different stakeholders would respond, stakeholders are not homogeneous, etc. In the matrix shown below, the question of whether each stakeholder would support or oppose a move towards developing full-scale containment and emptying practices in peri-urban Lima is considered, i.e. a move towards preventing the construction of new, inadequate and non-emptiable pits and an associated rise in the demand for emptying services. Their relative interest and influence to cause or prevent such a change is assessed and scored on a scale from -10 to 10. Thus, a score of (-10, -10) represents a stakeholder that strongly opposes the reform but has minimal influence. On the contrary, a score of (10, 10) is representative of a stakeholder that shows strong support and is also decisive for the reform to be implemented.

Figure 13 Stakeholder matrix for improving containment and emptying practices

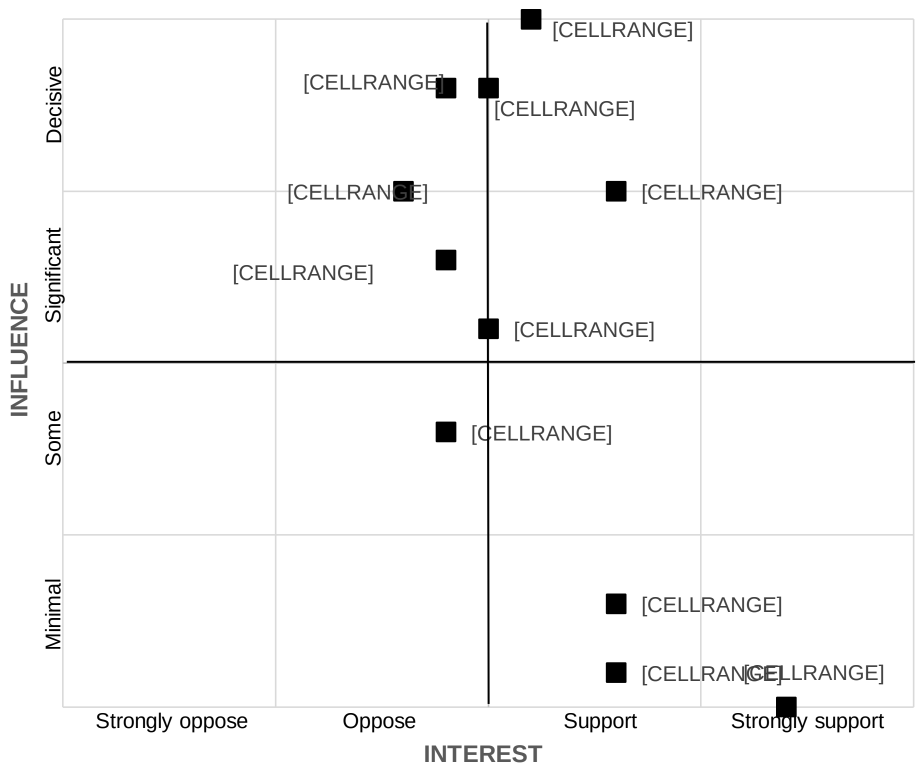


Figure 13 suggests that the majority of stakeholders would hold a neutral position, i. e. they would not actively support or discourage a reform that enhances FSM services in poor peri-urban areas in Lima. This is based on the general consensus conveyed across all KIIs that there would not be a strong opposition against the development of formal FSM services, assuming that the reform process is fair and actively engages all stakeholders, but is also a reflection of the current situation, where FSM remains highly underdeveloped and there are no plans or investments in developing the sector. All ministries, with the exception of the Ministry of Environment, would potentially take a position of neutrality or indifference, and are highly influential. Their support may initially be moderate, actively supporting changes to legislation to include FSM but possibly displaying some caution for political reasons – for example, providing access to sewerage (and other basic services) to poor peri-urban areas is usually advocated during elections, so a shift towards FSM (especially if not regarded as an adequate medium- to long-term solution by households) may have a political cost. Given that the Ministry of Housing, Construction and Sanitation has the main responsibility for guaranteeing access to sanitation services, this entity is likely to be more supportive as compared to the Ministry of Health, which would still perceive some benefits via a potential reduction in water-related diseases. The Ministry of Environment might be slightly more reticent to take an FSM reform forwards given that there are no clear and documented hazards to the environment from poor use of on-site sanitation in peri-urban areas of Lima, and poor solid waste management is a more predominant concern and complaint from poor households.

SEDAPAL was placed in an influential and supportive position, given its primary role in the provision of water and sewerage, as well as its recent interest in exploring alternative options to sewerage in poor peri-urban areas. SEDAPAL's interest position is also conveying the current situation, where they have had very little involvement in the development of FSM services to date, which may be partly explained by the lack of explicit competencies for on-site sanitation, but also due to the demand for sewerage exclusively on behalf of poor households. With regards to the supervisory or regulatory agencies, OTASS has lower influence than SUNASS, given the nature of its role and, similarly to the Ministry of Environment, it is likely to have a neutral interest in the development of FSM services. SUNASS, on the other hand, being the main regulatory agency may show some slight opposition to the development of FSM, partly due to the lack of clarity in the allocation of responsibilities between SUNASS, OTASS and the Ministry of Housing (as regularly mentioned in KIIs), but also because it will increase its regulatory burden and overall operational costs.

At the local level, the Metropolitan Municipality of Lima also has significant influence (although below that of national regulatory agencies), but may take a neutral position or potentially oppose the introduction of FSM services, as they are currently trying to prevent migrants from settling in 'inconvenient' peri-urban areas, which the provision of FSM may counteract. Similarly, district municipalities, although having some influence, may slightly oppose the development of FSM services. This position is explained by their current lack of involvement in the development of FSM and on-site sanitation alternatives, and their limited accountability to people living in peri-urban areas. Indeed, when asked about the involvement of local leaders in ensuring the provision of piped water and sanitation, most FGD participants mentioned that they have not received any direct support from district municipalities, with local mayors usually making several promises during elections, which remain unfulfilled after their time in office. Moreover, district municipalities manifested their concerns with the lack of adequate planning and budgeting in the sanitation sector, which may have a negative effect on their level of support if they foresee that the reform will not materialise as planned.

Finally, NGOs and private stakeholders (service providers and households) generally have minimal influence but are likely to be the ones with the highest interest in ensuring an FSM market is developed given their widespread concerns with their pits potentially filling up and the lack of space to build new ones, as well as their positive experiences with UDDTs (where available and affordable) and reuse in the form of compost. In the particular case of NGOs (X-Runner and

PEBAL), support may be moderate as they may be displaced or forced out of the market if other tertiary/private service providers become widespread. On the contrary, current SWM service providers may see their markets expand but may be cautious with SEDAPAL's oversight and control (e.g. will SEDAPAL allow for competition between SPs or will prices be pre-determined? What will the contract between SPs and SEDAPAL entail with regards to fecal sludge transport to treatment plants?). Finally, given that households without access to sewerage encompass 8% of the total Lima population, they have very low visibility and influence, and while the majority are likely to support the provision of on-site sanitation and FSM services (as manifested through FGDs for both affordable UDDTs and pit emptying), some will still be reticent to accept these services with a preference for traditional sewerage, especially if on-site sanitation alternatives are not coupled with adequate water supply, which is also very deficient in peri-urban areas.[41]

In summary, the stakeholder matrix suggests that it is SEDAPAL who will have the decisive influencing power over making FSM services happen in poor urban areas. Therefore, it is likely that supporters of reform would do well to invest their time in working with SEDAPAL to move proposals forward.

8.4 Illustrating the incentive problem

It is helpful to consider the problem of poor FSM in Lima in two dimensions. The first dimension is *static*, that is, the way households, service providers and government stakeholders are currently dealing with on-site sanitation and FSM (partly described in Table 23 above). The second dimension is *dynamic* – the city is changing both spatially (e.g. people settling illegally in expanding peri-urban areas) and demographically (urban population growth and inward migration). In terms of policy, the static problem requires an action which could be implemented immediately but may have a slow response over time – for example, there may be ways of persuading households to improve the quality of their pits to minimise environmental and health hazards. The dynamic problem, however, requires longer-term involvement and engagement in areas that are more the domain of urban planning than sanitation policy and practice, e.g. ensuring that rural migrants settle in adequate areas and that land titles are provided to encourage investment in private sanitation facilities and allow for the provision of FSM services in these areas.

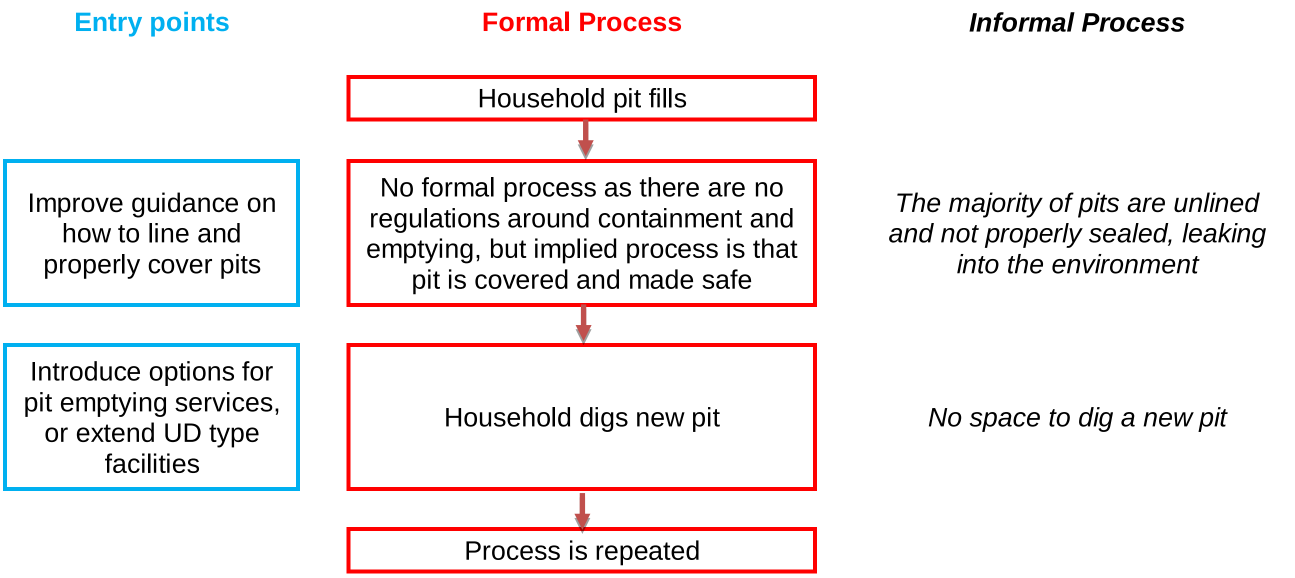
A useful tool to illustrate these problems is *process mapping*. This tool aims to understand the interaction between formal and informal "steps" in a process, and identify entry points for engagement. Similarly to the stakeholder matrix presented above, it is important to assess the roles of the key stakeholders in a process, how and where they exert influence, and the incentives they face in both formal and informal systems.

For this analysis, we have focussed on the process for dealing with a pit when it fills up, given the predominance of this practice in poor non-sewered areas. This is shown in Figure 14 below. The central column shows the formal process which is supposed to be followed by the household, while the right column shows elements of the informal process, i.e. what really happens. Given that there are no formal guidelines for containment and emptying, households cover the pits themselves with whatever material and resources they have available, usually including lime, wood, stones, soil, and in exceptional cases, cement. Many pits are also treated with muriatic acid to aid decomposition and prevent overflow. After the pit is sealed, a new pit is built, if space permits. There are increasing concerns from households with the lack of space to dig new pits on their plots if the one in use fills up, with some people even reporting neighbours already digging their pits on public dirt roads or green areas.

[41] FGDs revealed that some poor settlements rely on private tanker trucks for their water supply, which are generally more expensive but also unreliable (e.g. service is not available when needed). Many households perceive their water to be unsafe, and claim that the water has visible particles and a bad taste.

In terms of entry points, there are two potential ways in which the formal process could be improved to discourage households from following the informal process. On one hand, training and guidance could be provided on how to build and properly cover pits. Although some settlements have benefited from training provided by SEDAPAL and NGOs, the majority of households learn from their neighbours or relatives. A second entry point could be the introduction of affordable pit emptying services or the extension of coverage of UDDTs, which have had good uptake on behalf of poor non-sewered households. While the first entry point provides a 'stop-gap' solution, minimising environmental and health hazards in the short-term, the second entry point is likely to be a more sustainable alternative, improving the situation for poor urban dwellers in both the short- and long-run.

Figure 14 Process mapping for a pit filling up



Other key processes could be mapped to try and identify more entry points for the development of FSM services. The main message is that informal processes, and the incentives which make them happen, are crucial to understanding why good ideas do not always work out in practice.

8.5 Implications for FSM in Lima

This chapter has summarised aspects of the analysis conducted through key informant interviews and focus group discussions by World Bank consultants to help explain why the CSDA looks as it does, i. e. why there are no formal FSM services in Lima for poor non-sewered households. The fact that the majority of the CSDA is red (i.e. FSM across the whole chain and at different stages is poor) has precluded a focused look at key parts of the sanitation chain, which may be more appropriate for other cities.

From a government perspective, at both local and central levels, it is crucial to allocate competencies across different stakeholders and hold them accountable to specific targets and budgets. Many of the KIIs suggest that unless responsibilities are clearly identified (for instance, between the Ministry of Housing, OTASS and SUNASS), it is unlikely for central and local governments, and regulatory agencies alike, to fully support the development of formal FSM services in poor peri-urban areas. As described through the stakeholder mapping exercise, the Ministry of Housing should probably have the responsibility for ensuring that appropriate FSM services exist, with SUNASS playing the main regulatory role, and SEDAPAL being the main service provider.

Focussing on service provision and the development of an FSM market, it is crucial to minimise the main blockages at both supply and demand. From the supply side, a pricing scheme needs to be set up that allows for FSM services to be profitable SEDAPAL and/or for tertiary/private sector stakeholders, but at the same time affordable for poor peri-urban households. FGDs suggest that households are likely to be more willing to pay small amounts on a monthly basis (as they do for other public services) rather than a single and relatively high fee upon emptying. On the other hand, from the demand side, households' practice of digging a new pit once the one in use fills up needs to change through formal training and guidelines, and enforced through legislation related to fecal sludge containment and emptying. Households are already manifesting their concerns with the lack of space to continue digging pits in the future, so they are definitely open to sustainable and affordable alternatives to solve their sanitation needs. Based on the stakeholder mapping exercise, SEDAPAL seems to be the most obvious candidate for service provision, with a progressive involvement of the tertiary/private sector as required.

To address the “so what” questions, which are often a response to this kind of analysis, the next section considers potential intervention options in the context of the above analysis.

9 Intervention options

This section proposes interventions to improve fecal sludge management services for poor non-sewered areas of Lima and provide an effective enabling environment within which those services can be appropriately developed and sustainably managed. These interventions are mainly informed by the assessment carried out by SEDAPAL and WSP through the Reimbursable Advisory Services (RAS) in Lima and the results of the household survey data, the SFDs and the CSDA described earlier.

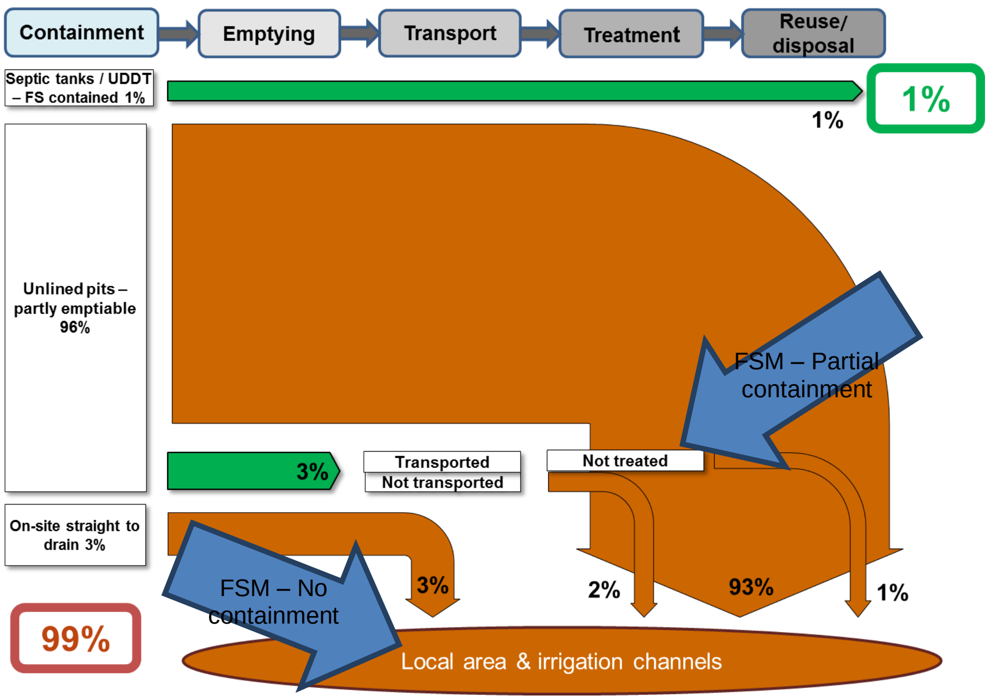
To support planning decisions for improving FSM services over time, this chapter starts by referring back to key results responding to the question *"Where are we now?"* using the fecal waste flow diagrams as a means to illustrate the key challenges. It then goes on to propose responses to the question *"Where do we want to get to?"* that acknowledge components of the enabling environment, current studies and ongoing sectoral reforms, as well as good practice and relevant experience from elsewhere.

Addressing the next question *"How do we want to get there?"* is a further process that requires strong leadership at the city level, engagement of city authorities and key stakeholders, detailed studies and analysis to identify specific plans and solutions that can support an incremental and strategic planning approach.

9.1 Identified weaknesses

The key starting point for presenting weaknesses in the existing services for poor non-sewered areas in Lima is the fecal waste flow diagram, as this identifies the extent to which fecal sludge is managed (or not) through the current sanitation service chains. From this diagram, "problems" or "weaknesses" in the process of managing fecal sludge at the key stages in the chain can be highlighted (see Figure 15 below), pointing to where interventions are needed to improve the *status quo*.

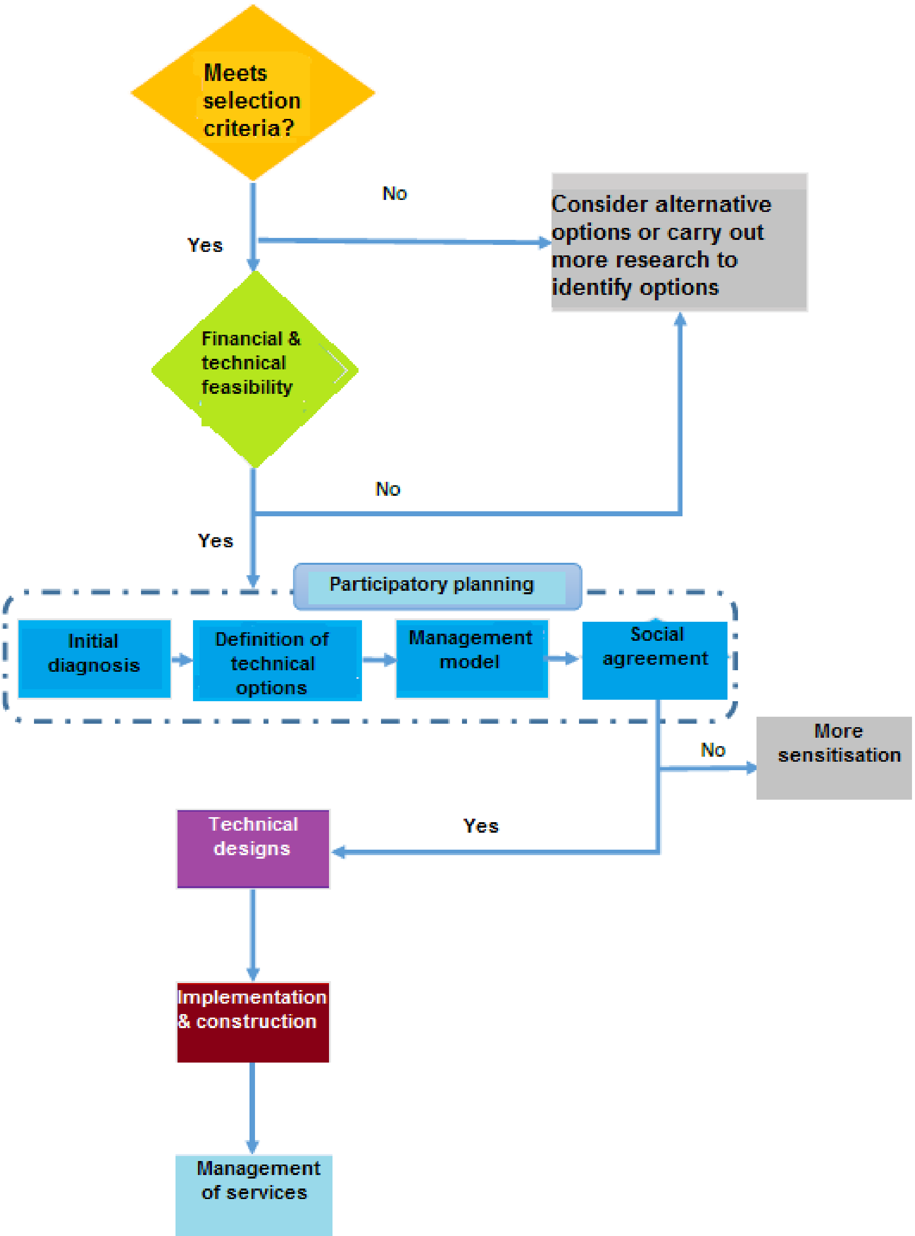
Figure 15 Fecal waste flows in non-sewered areas: results and problems



9.2 Proposed solutions

Through the RAS, a decision tree was developed (see Figure 16 below) to assess possible intervention options. The decision tree aims to (i) identify the communities that need to be prioritised; (ii) assess the financial and technical feasibility of interventions in priority communities, and (iii) identify household preferences to be included in the design of alternative WSS solutions. Potential interventions should be designed to minimise water wastage, be more profitable than conventional solutions (i. e. sewerage), be able to be fully implemented in the short-run, and be flexible enough to meet the needs of households and adapt to their ability to pay.

Figure 16 Decision tree for WSS services in Lima



The first step of the decision tree is to identify the communities to be intervened (i.e. community meets the selection criteria). Based on discussions with SEDAPAL, the criteria for community selection include:

- There are no plans for the extension of the sewerage network in the next five years, and/or no national plans for investment in the area.

- Land is legally occupied and physically accessible.
- Local authorities are required and willing to support the interventions proposed.
- Population density is above the required minimum, increasing the likelihood of financial feasibility.

If the community or area of intervention meets the selection criteria, both the technical and financial feasibility of the project need to be assessed – this includes investment, operational and maintenance costs. Tariff levels and costs of services are to be assessed in coordination with SUNASS, the main regulatory agency.

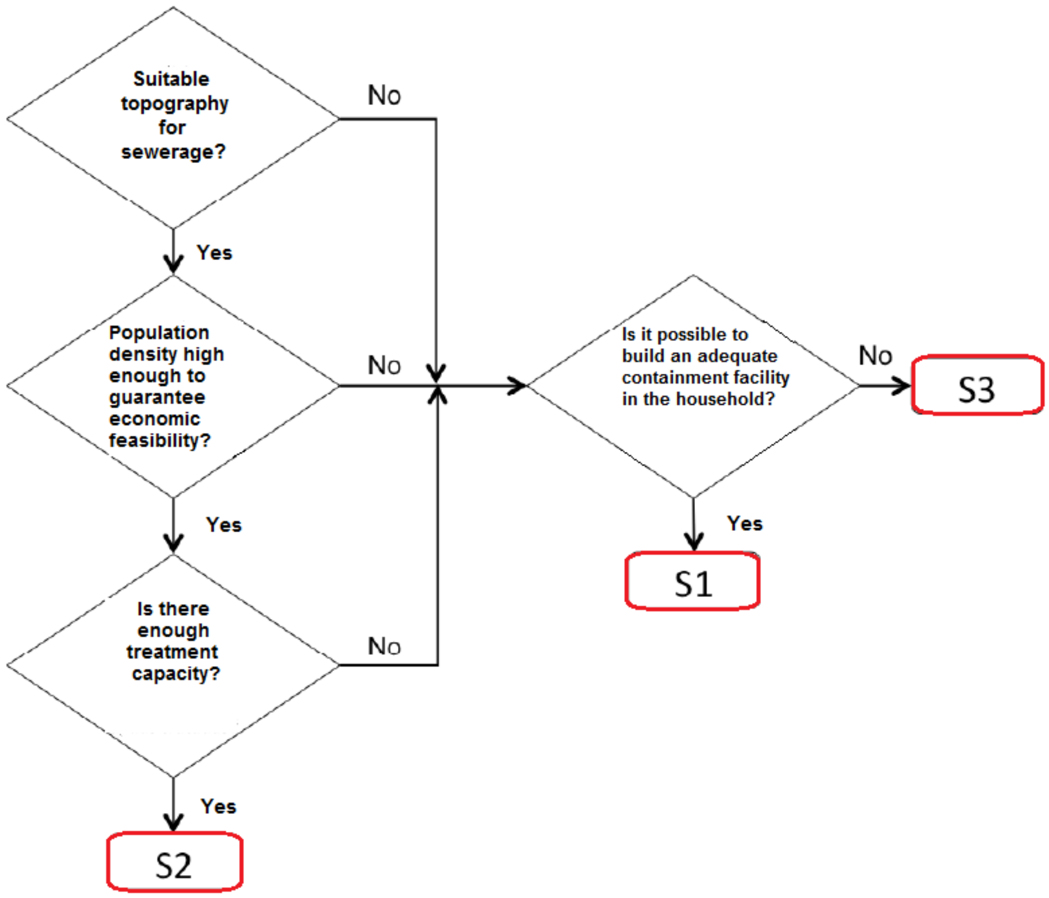
Subsequently, if the solution is technically and financially feasible, a participatory planning needs to be carried out, enabling a direct dialogue between SEDAPAL, SUNASS, other key stakeholders, and community members. The objective of this step is to understand the current status of WSS services (i.e. initial diagnosis), define the activities to be carried out and the competencies of each stakeholder involved, and finally, identify and select the best management model (considering services decentralisation, focusing on the client, and public, community, private/tertiary or joint public-private management). A social agreement or covenant will finally be established between SEDAPAL and the community to ensure the accountability of service provision and management.

Although there are several options that can be used for the provision of alternative WSS services, SEDAPAL aims to provide services that are efficient, able to create economies of scale, and allow for the participation of the tertiary/private sector. Three different interventions have been considered:

1. On-site FS containment and greywater disposal, with FS emptying and transport services provided by tanker trucks (i.e. mechanical emptying), discharge at a FS treatment plant and compost and/or fertilizer production (S1);
2. Small community or condominial sewerage system, with decentralised wastewater treatment plants and wastewater reuse in green areas (S2), and
3. UDDTs with on-site greywater disposal and specialised FS treatment with compost and/or fertilizer production (similar to current X-Runner services) (S3).

The decision tree for these options is depicted in Figure 17 below, providing an initial assessment of where these options might be suitable across peri-urban areas of Lima.

Figure 17 Decision tree for alternative sanitation services



Considering also SFD and CSDA, the key messages for action through the service chain are:

- *Containment*: Increase the availability of affordable options for improved non-networked containment quality (including pit lining materials, twin-pit, UDDTs), to eventually bring to an end the practice of abandoning simple pits. Increase skill-sets of artisans and builders to ensure quality construction, as well as public awareness and practices affecting appropriate management of latrine pits to ease emptying (e.g. separate disposal options for greywater and solid waste). As decentralised networked options become available in low-income areas, facilitate connecting households to these systems, with separate handling of blackwater and greywater.

- *Emptying and transport*: Increase the availability of a range of small- and medium-sized service operators emptying pit contents (urine, dried feces and/or fecal sludge). Support service providers with a range of technical improvements to manual/mechanised pumps, tankers and transport vehicles suited to the topography, space limitations and affordability of low-income areas.

- *Treatment and reuse*: Identify a range of technologies and application suited to various locations and the up-stream service functions. For example; anaerobic baffle reactors, up-flow anaerobic sludge blankets, fecal sludge drying beds, reed bed systems, lagoons, etc. where sufficient households are connected to decentralised sewer networks; composting facilities where households are serviced by dry non-networked systems such as twin-pit, twin-vault or container-based latrines (with or without urine diversion). The choice of technology and locations should account for the market-potential from end-use of wastewater, treated fecal sludge, urine, dried feces and associated effluent discharges.

For any service option, the choice and implementation must adopt an integrated approach through the full service chain. This means taking account of the need for sufficient and reliable water supplies, solid waste management services and drainage networks to ensure optimal sanitation service provision during operation, maintenance and management of each option. Each stage of the service chain must also account for the range of physical and institutional constraints necessary to provide citizens with a reliable service that protects both public and environmental health. These include tenancy and land ownership, topography and space, affordability, capacity and resources to deliver and sustain service functions.

Table 24 below sets out specific technical interventions, whereas the sections following the table consider interventions more related to the enabling environment. The options in the table are not necessarily mutually exclusive and in presenting the “Where do we want to get to?” they do not specify interim or staged approaches. These are discussed in the following section.

Table 24 Technical interventions to improve the service chain, based on existing system type

System type (key problems)	Potential solutions for lowest-income non-sewered areas of Lima					
	Containment	Emptying	Conveyance	Treatment	Disposal	End-use
On-site sanitation with storage in mostly unlined pits (emptiable) **(1) Poorly constructed and managed pits** **(2) Absence of safe or effective removal of fecal sludge from existing pits** **(3) Most pits abandoned, rather than emptied**	Improve design and construction standards for existing pits – including wider range of pit lining options to enhance emptying potential Where off-set pits are in use, consider an upgrade to a twin-pit system (with junction box and second pit) – either for combined excreta (e.g. simple twin-pit), or dry sanitation options with urine diversion (UDDTs) Ensure correct construction of septic tanks (1- or 2-compartment, with soakaway or infiltration trench). Promote as an option where appropriate, affordable and accessible to emptying services Improve pit / ST access arrangements, to enable easier emptying Explore options for connecting pour-flush or cistern-flush latrines to decentralised sewerage options (DEWATS) Promote wider use of soakaways or local drainage systems for management of greywater	Promote use of a wider range of appropriate, low-cost pit-lining options, as part of sanitation marketing Incentivize households to construct pits that can be emptied periodically, rather than abandoned or replaced – including use of twin-pit arrangements Ensure pits and tanks are built with access points for emptying that are appropriately sized and accessible to emptiers Test and scale-up wider range of emptying options – both manual and mechanised	Mobilize a wider range of transport options – including improved manual and small-scale mechanised transport, for FS, separated urine and/or dry feces Identify the feasibility and extent of localised sewer networks (settled, condominial, small-bore) to support DEWATS	Consider and build decentralised fecal sludge treatment sites, to support areas with increased levels of emptying – such as drying beds, or composting plants for dried feces with separate urine treatment and storage Locate decentralised treatment sites (for ABRs, reed beds, lagoons, etc.) to ensure safe and efficient access for emptying service providers	Identify the current location of unofficial disposal / discharge sites and address key public and environmental health risks Explore extent and feasibility of required excreta disposal at DEWATS sites (blackwater or effluent discharge) against potential for viable endues options	Explore opportunities for fecal sludge reuse in: agriculture (nutrient value), industry (e.g. energy value as a dried fuel source, anaerobic digestion), etc. Explore opportunities for reuse of urine (nutrient recovery) and dried feces (e.g. soil conditioner or fuel source)

System type (key problems)	Potential solutions for lowest-income non-sewered areas of Lima					
	Containment	Emptying	Conveyance	Treatment	Disposal	End-use
On-site sanitation with no storage (not emptiable) **(1) No effective containment of FS** **(2) fecal sludge discharging directly to environment with no pre-treatment**	Promote and introduce a range of options that provide on-site containment of FS, including: (i) twin-pit composting toilet; (2) dry sanitation urine-diversion toilets (UDTs); (3) improved simple pits, and (4) septic tanks	*As above, plus*: identify and pilot requirements (awareness, knowledge, skills, tools and products) to enable household-level safe handling and disposal or re-use of correctly stored fecal sludge from twin-pit systems Extend the services of NGOs providing and servicing dry sanitation container-based options (UDDTs) and consider wider engagement in similar technologies and service providers	*As above* *Note:* may not be required for household-level management of dried FS	*As above, plus:* increase awareness, skills, tools and products to ensure fecal sludge from household-level twin-pit systems is safe to handle (through correct storage)	*As above, plus:* increase awareness, skills, tools and products to support safe disposal (e.g. direct burial) of fecal sludge from household-level twin-pit systems	*As above, plus:* increase awareness, skills, tools and products to support safe handling of correctly stored fecal sludge from household-level twin-pit systems (e.g. application to local land where demand exists, simple or co-composting)
No sanitation facility **(1) Indiscriminate contamination from FS in the local area**	Invest in new household-level container-based options and UDDTs, where acceptable to users Promote and introduce a range of simple, but durable pit latrines (basic and improved) Raise awareness about the safe management of child feces	Increase variety and scope (range) of emptying services to additional facilities: (see above) Identify and invest in new / innovative servicing of household containment options that have no outlet	*As above*	*As above*	*As above*	*As above*

9.3 Program design and prioritisation

Based on the analysis of broader findings from the FSM study, the following sub-sections consider the key areas of the Enabling Environment (as defined and grouped within the City Service Delivery Assessment of the *Enabling, Developing and Sustaining* components) and identify actions to support any infrastructure-focused investments in the poor non-sewered settlements of Lima. While drawing on the CSDA results, these sections also account for good practice and relevant experience from elsewhere.

9.3.1 Enabling: policy, planning and budget

Policy – There is a complete absence of policy relating to FSM, which requires reviewing existing policy and incorporating FSM as a first step (for instance, in the Law for Solid Waste Management). This will need a strong commitment from national and local level stakeholders (e.g. MoHCS, SUNASS, Lima Metropolitan Municipality), as scale of FSM services is currently extremely limited and universal coverage with sewerage by 2017 is the present target.

Regulation – Legislation for FSM exists in the form of general laws (such as the SEDAPAL byelaws under Title 1, Article 2) addressing removal of feces from latrines and septic tanks; but without the scale of services, application and enforcement are likely to be extremely weak. It will be necessary to review existing regulation to strengthen it in view of a proposed expansion of FSM services.

Institutional roles – Current legislation does not clearly define competencies for all sector stakeholders, which hinder the development of FSM policy and services. As mentioned in the PFC chapter, both planning and budgeting are unlikely to happen if responsibilities are not allocated and there is no accountability for investments and results. Although there are some mechanisms for support to private service providers (e.g. operation under a competitive market, regulatory frameworks), these are unlikely to have much impact on actual service provision, especially for the urban poor. More active involvement from SEDAPAL in bringing both public and private stakeholders together to develop a joint framework for FSM is highly recommended. This should be complemented by a revision of existing legislation to ensure it enables more flexible and responsive services, while addressing minimum service standards to protect public health through the stages of the FSM service chain.

Service provision and planning – The National Urban Sanitation Programme does not show an obvious commitment to expand or develop the scope of on-site sanitation options or FSM services, with sewerage being considered as the first-best and long-term option for urban areas. Only once political commitment is oriented towards the development of FSM, will plans and capacity needs be adequately acknowledged and addressed.

Budget – There are no budgetary arrangements identified that are specifically for FSM services in urban areas. This will require attention along with policy and planning reviews to identify the scale of financing required and potential sources.

9.3.2 Developing: equity and outputs

Choice / reducing inequity – There is almost a total absence of FSM service options for residents of poor non-sewered areas. Containment facilities are poorly constructed and managed with no enforcement of standards to prevent this from happening. There needs to be much greater attention to incentives for households to improve latrine quality, with associated incentives developed for SEDAPAL and other emptying service providers so they can offer a range of affordable, responsive and safe services to those who demand them. A greater understanding of community-level needs and wants, as well as household willingness and ability to pay for different service levels is also required.

Outputs – The fecal waste flow diagram (SFD) highlights a total absence of safe and effective services for the whole of the service chain. This requires technical assistance for all stages of service delivery that address the technical interventions mentioned in Table 24, as well as supporting capacity development of institutions and agencies that will be responsible to deliver them. It will also require attention to training of artisans, builders and entrepreneurs in a range of available options, as well as public information and marketing to promote. Sources of committed financing for this also need to be identified, as well as regular monitoring of achievements against improved service coverage targets, indicators and standards.

9.3.3 Sustaining: O&M, expansion and service outcomes

Cost recovery and standards – Again, all stages of the service chain need to be addressed with appreciation of costs affecting households and service providers. Options for financial transfers also need to be considered (e.g. water bill surcharge, environmental tax), ensuring that charges reflect the level of service received by the customer, i.e. those with a lower service level, should pay less. This will likely need an incremental approach to achieving service standards, phased over time and adopting a realistic, doable attitude.

Demand and sector development – Demand for services is almost non-existent, reflected by the lack of FSM actors and little government attention to the scale of the problem. Sector development needs to come first, with improved service options available, marketed and more widely applied (probably with initial external financial support and "friendly" regulation to allow more actors to enter the market), before demand achieves any significant level for service options to become self-sustaining.

9.3.4 Resulting prioritised interventions: guidelines for action

Considering the results from the CSDA and PFC (Sections 7 and 8 respectively), it is possible to recommend where actions are most needed in relation to the non-technical components of the enabling environment (such as policy and planning, institutional arrangements, capacity and financing), to support technical responses.

For such actions to be effective, recommended interventions must respond to how well developed the enabling environment currently is. Based on the assessed status of FSM service development using these tools, the following Service Delivery Action Framework tables present a range of non-technical, 'institutional' interventions. Actions are grouped according to the current status of the enabling environment: Basic, Intermediate or Consolidating.

The set of recommended actions have been developed from good practice and informed by the experience of the authors in relation to the enabling environment for urban sanitation. They are tailored to how well developed the enabling environment currently is, with a view to strengthening it. As the actions account for the current realities in a city, they must be recognised as essentially sequential and should be viewed as dynamic; that is, actions are proposed as being at the Basic stage before moving towards the Intermediate, then the Consolidating stages. Where a city is identified to already be delivering FSM service needs from one of these stages, the resulting set of actions are taken from the 'next stage'.

The recommended sets of actions are shown within the boxes that have a bold outline and shading.

'Action'

As progress is made through these stages, actions can shift from being mainly about identifying, reviewing or building awareness of services, through to actions that are more about establishing, strengthening and promoting commitment to services, and on towards actions that are about strengthening, consolidating and expanding engagement to achieve a more sustainable range of enhanced services. The actions also move from prioritising public health protection (which may include developing temporary measures), to ensuring the protection of the environment and looking at the potential for the reuse of fecal sludge end products. In the case of Lima, it is clear that a strong focus must be on providing the poor with a range of options to eliminate the continued practice of digging informal, unlined pits and abandoning them when full, or allowing blackwater to discharge directly into the environment. The implications for risk to health and environmental contamination are significant, while interventions must ensure sanitation services are ensured throughout the service chain.

The actions proposed in Table 25 below, considering services to the poor non-sewered areas of Lima, are all within the stage of basic actions. Such basic actions **¡Error! No se encuentra el origen de la referencia.**are considered to be appropriate within the context of an almost total absence of attention to FSM services at the time of the study, although the scale and significance of the challenges faced do appear to have been gaining increasing political attention. They are considered appropriate to address the increasing likelihood of public health risks resulting from a failure to address FSM service limitations, were the conditions in the enabling environment identified during the study to continue as they are currently.

Table 25 Service delivery action framework for poor non-sewered areas in Lima

Stages of action		**Basic actions** *Critical interventions for public health protection*	**Intermediate actions** *Strengthening existing foundations*	**Consolidating actions** *Focussed on full-chain, sustainable services*
National	Policy, legislation and regulation	• Review national sanitation policy and ensure FSM is included • Review the regulatory framework around the protection of public health and the environment from poor sanitation	• Set norms and minimum standards for public health and environmental protection • Establish a legal basis from which to regulate FSM services	• Require local regulation and its enforcement • Develop a policy and regulatory framework to incentivise improved treatment and re-use options for fecal sludge where feasible
	Institutional arrangements	• Review institutional arrangements for sanitation – ensure FSM is included • Identify an institutional framework for FSM services with defined roles, responsibilities and coordination mechanisms	• Establish an institutional framework for FSM services with defined roles, responsibilities and coordination mechanisms • Establish institutional roles for fecal sludge treatment and re-use options	• Strengthen the institutional framework to enhance all FSM service outcomes, with fully recognised and implemented roles, responsibilities and coordination mechanisms
	Planning, monitoring and evaluation	• Build awareness of FSM in national planning entities and relevant sector ministries (works, housing, health, environment, etc.)	• Develop plans to enhance public access to fecal sludge emptying services • Establish a monitoring framework against standards of FSM services – focusing on household and institutional emptying services • Establish systems to evaluate service quality	• Establish a framework to monitoring quality standards of all FSM services, including fecal sludge treatment facilities and re-use arrangements • Develop plans to enhance treatment capacity and re-use technologies
	Capacity and TA	• Identify the scale of the existing capacity gap and the technical assistance required to address FSM service needs	• Build public and private sector capacity for city-wide FSM services	• Strengthen public and private sector capacity for city-wide FSM services, including good fecal sludge treatment and markets for re-use
	Financing	• Build awareness and agreement around the budgetary requirements for FSM services	• Develop programs with FSM funding windows and incentives for cities	• Mobilize finance for fecal sludge processing, re-use and disposal
Local	Legislation and enforcement	• Review and, if required, establish byelaws, and ensure that they address on-site systems and FSM services	• Strengthen byelaws and their enforcement • Introduce regulation of service providers • Establish incentives to increase disposal at recognised fecal sludge transfer and treatment sites	• Consolidate regulation of pollution of receiving waters or the like • Introduce penalties for indiscriminate fecal sludge dumping by service providers • Enforce use of emptiable facilities

Stages of action		Basic actions *Critical interventions for public health protection*	Intermediate actions *Strengthening existing foundations*	Consolidating actions *Focussed on full-chain, sustainable services*
	Institutional arrangements	• Review local institutional arrangements for sanitation – ensure FSM is included • Identify an institutional framework for FSM services, with agreed and defined roles, responsibilities and coordination mechanism	• Establish an institutional framework for FSM services, with agreed and defined roles, responsibilities and coordination mechanism • Establish institutional roles for fecal sludge treatment and re-use options	• Strengthen institutional roles for managing improved fecal sludge treatment re-use facilities and options
	Planning, monitoring and evaluation	• Conduct rapid diagnostic studies by area, with a gender and pro-poor focus • Develop local plans for fecal sludge services, finance and institutional needs • Plan and design fecal sludge treatment options	• Establish revenue streams (e.g. water bill surcharge, extra property tax) • Refine and implement local service plans • Establish systems for monitoring and evaluating achievement of service standards	• Introduce plans to enhance treatment capacity and re-use arrangements • Strengthen monitoring and evaluating of fecal sludge treatment facilities and re-use arrangements against service standards
	Promotion	• Stimulate customer demand and WTP for FSM services	• Disseminate information about FSM services to the public	• Stimulate market demand for re-use of FS
	Capacity and technical assistance (TA)	• Identify capacity gaps and TA required to help improve FSM services • Promote the emergence of private sector emptying services • Implement basic (possibly temporary) measures to more safely dispose of fecal sludge that is currently dumped in the environment	• Promote or support development of improved, emptiable containment facilities • Strengthen FSM service providers (business development, financing options, etc.) • Pilot scheduled desludging (if applicable) • Pilot use of fecal sludge transfer stations (if applicable) • Build or rehabilitate fecal sludge processing plants	• Consolidate and expand use of scheduled desludging, transfer stations, etc. – based on outcome of pilot studies • Develop business models for re-use of treated FS
	Financing	• Identify the extent of financing required to address service improvements to the poorest	• Introduce specific pro-poor financial arrangements (such as targeted subsidies)	• Identify opportunities for financial flows generated from the sale of fecal sludge end products
Users	Planning	• Consult with communities to identify what they need and want	• Gain user feedback on improved FSM services	• Gain user feedback on current and future fecal sludge re-use options
Users	Tenant sanitation	• Engage and consult with landlords on constraints to FSM services	• Develop assistance and enforcement packages for landlords	• Focus on enforcement of service quality for landlords

10 Economic analysis of intervention options

Nb. The technology costing is based exclusively on secondary data. All costs and benefits are given at the HH level, since the secondary data was not suitable for extrapolating population-level estimates of the costs and benefits.

10.1 Introduction

This chapter provides an analysis of four possible sanitation intervention options for the low-income non-sewered areas of Lima. The analysis spans the whole sanitation chain (i.e. containment, emptying, transport, treatment and reuse), and is broken down by cost component, allowing a detailed view of the points in the chain where the costs are incurred.

Two key pieces of information were required to conduct this analysis. Firstly, an estimate of the damage cost, which assigns a monetary value to the negative consequences of poor sanitation, i.e. “the cost of doing nothing”. Secondly, an estimate of the costs of the proposed intervention. This requires a clear intervention design for a well-defined population, and sufficient information that allows for each component to be costed.

10.2 Methodology

Four hypothetical models are presented in this analysis: three are based on secondary data from existing literature on sanitation in Lima, while the remaining one draws from the reported costs of a specific programme intervention. Costs were updated to reflect inflation to date and were estimated for each component and at each stage of the sanitation chain.

The damage costing is based on the health-related costs associated with diarrhoeal incidence and treatment only. The unit of analysis for all interventions is the household.

All costs are presented as annualised costs per HH. Annualisation was conducted using a standard formula (see below) which incorporates a discount rate *r*[1] that represents the opportunity cost of capital.

$$Value_{t+n} = Value_t * Discount\ factor$$

$$Discount\ factor = (1 + r)^n$$

Where
$r =$ average annual interest rate
$n =$ assumed lifespan in years

The choice of a discount rate is a key parameter of the costing. The higher the discount rate, the higher the opportunity cost of capital and consequently, the higher the annualised costs. However, the discount rate does not affect the ratios between different cost options. A discount rate of 6% was used here as this is the long term rate of CPI inflation in Peru. The World Bank uses a rate of 10% for infrastructure projects.

All of the analysis was conducted using the Economics of Sanitation Initiative (ESI). As such, many of the assumptions used in the damage costing are based on the ESI’s standard settings.

10.3 Data sources

The primary source of data for this analysis was Platzer et al (2008), a study that presents three hypothetical sanitation interventions for areas of Lima without sanitation access. Interventions were modelled on a target population of 10,000 and draw on cost data specific to Lima. Two waterborne (i.e. sewer based) systems and one UDDT model with centralised collection and treatment were considered. The study also analyses the costs of providing an improved water supply in conjunction with the different sanitation options (as was similarly done in the RAS), and their comparative costs. Given the focus of our research on FSM, we have not considered the costs of providing an improved water supply, although we acknowledge that it is unlikely for sewerage to be provided without an improved water connection.

The costs derived by Platzer et al (2008) were updated to reflect inflation to date and have been disaggregated into the different cost categories used by the ESI (i.e. CapEx, CapManEx, and recurrent costs) and the different stages of the sanitation chain. CPI inflation as reported in the World Bank's world development indicators was used. The analysis also draws on the household survey data collected as part of this study. The probability of death by disease is drawn from the WHO Global Burden of Disease data (for additional information, see WHO, 2012).

10.4 Hypothetical intervention options

The four intervention options considered in the analysis are the following:

1) A full on-site solution – Urine Diverting Dry Toilets (UDDTs) with on-site composting

This option encompasses the installation of a twin vault UDDT system with urine and greywater infiltration. Costs are based on the reported average construction costs incurred by the Peru-based NGO Rotaria del Peru. Rotaria has installed over 800 UDDT systems in Peru. Each UDDT constructed is individual and made from locally available materials. In many cases, the latrine is designed to be upgraded by the addition of showers and a full bathroom.

2) A waterborne system with treatment through an anaerobic lagoon

Under this option, all households have a pour-flush latrine connected to a sewage network. The model assumes pre-treatment is carried out with an anaerobic lagoon followed by manual grit removal, and secondary treatment in facultative and maturation lagoons. The hypothetical model is devised for a population of 10,000 households assuming that the lagoon treatment serves a wider population of 200,000 households. Annex A contains some of the key design specifications for this model.

Treatment via lagoons is not recommended by Platzer et al (2008) as open lagoons have severe odour problems. However, this option was included as a lower bound estimate for a waterborne system, as anaerobic pre-treatment is comparatively cheaper than other options.

3) A waterborne system with primary treatment by up-flow anaerobic sludge blanket reactors (UASBs) and secondary treatment through lagoons

This option has the same specifications as Option 2 above, with the exception that pre-treatment is given by UASB reactors as opposed to anaerobic lagoons. The design population for the sewer network is 10,000 households, and the treatment design assumes a population of 40,000 households.

4) UDDTs with semi-centralised collection and treatment

This model assumes that all households have UDDTs. The difference from Option 1 is that this model is based on single-vault UDDTs that are emptied by a municipal operator on a quarterly basis. Urine is stored on-site and is also collected quarterly. This design considers trucks that have been adapted to collect urine and feces simultaneously. The costs quoted also include the construction costs for greywater infiltration pits. The design population is 10,000 households.

10.5 Design populations

The existing sanitation infrastructure and coverage is used as the base for costing the hypothetical interventions. Table 26 presents the results for the lowest-income non-sewered areas of Lima.

Table 26 Type of sanitation facilities and containment for lowest-income non-sewered areas

	Septic tanks (lined and unlined)	Lined pit	Unlined pit	Total
Cistern Flush	3%	1%	0%	**4%**
Pour / manual flush	6%	17%	0%	**24%**
Pit latrine with slab	17%	17%	9%	**43%**
Pit latrine without slab	1%	7%	21%	**29%**
Total	**28%**	**42%**	**30%**	**100%**

In all of the four intervention options considered, the route down the sanitation chain requires the majority of household to build/purchase a new sanitation facility. However, given the current type of sanitation facilities owned by households (Table 26), some of the costs were lowered – for the two options based on UDDTs, none of the costs were lowered as the construction of UDDTs requires an overhaul of all existing infrastructure. For the two waterborne options considered, 50% of the costs of the latrine (excluding the sewer connection) were lowered for the 28% of the population with either a cistern or pour/manual flush.[42]

As described above, the four options are all costed for slightly different design populations (households served). It is not proposed that any one of these options is suitable for the entire non-sewered population; rather, costs should be considered as indicative per household costs.

10.6 Technology cost analysis

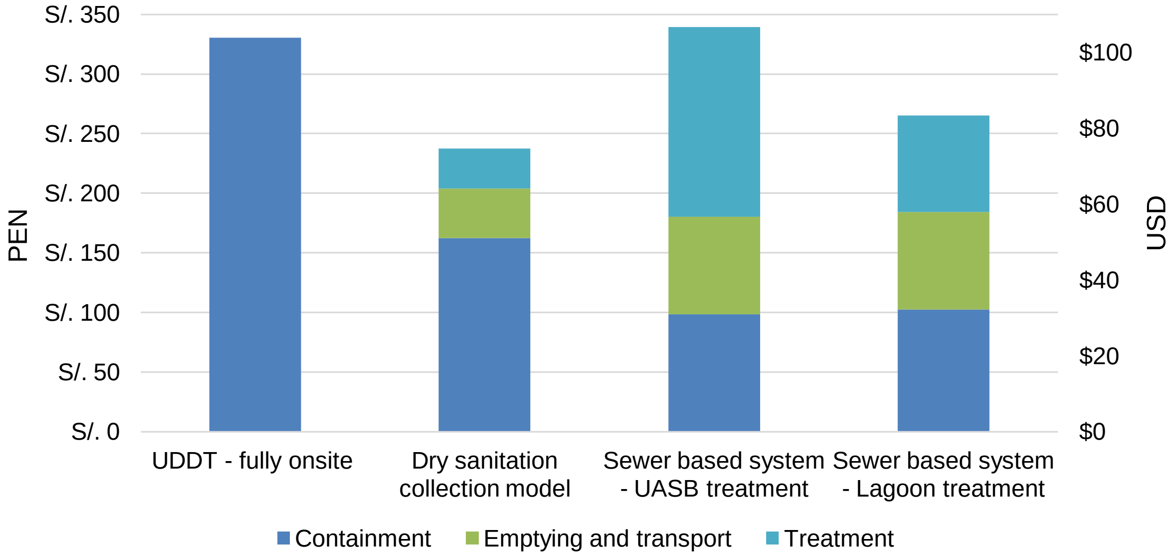
Figure 18 presents the total annualised costs for the three routes through the sanitation chain that are proposed in the Platzer et al (2008) study. For more information, Annex F contains a summary table with the data underscoring these calculations. Overall, the UDDT collection model has the lowest total cost per household. The waterborne system with primary treatment by anaerobic lagoons is only marginally more expensive than the UDDT collection option. The fully onsite option is the most expensive overall.

In all cases the cost of the on-site facility (i.e. the latrine and blackwater containment system used by the household) is the largest component of the costs. In the case of the fully on-site UDDT

[42] This assumption assumes that the above ground component would be adapted as opposed to constructed from scratch.

system, all of the costs are related to containment, while for the semi-centralised collection system, costs include on-site urine storage and greywater infiltration pits, both of which are key drivers of the total costs. In the case of the waterborne systems, costs are driven by the connection to the sewer network, which is given as a fixed cost and accounts for 75% of the containment costs. Figure 18 presents the total annualised costs for the four intervention options.

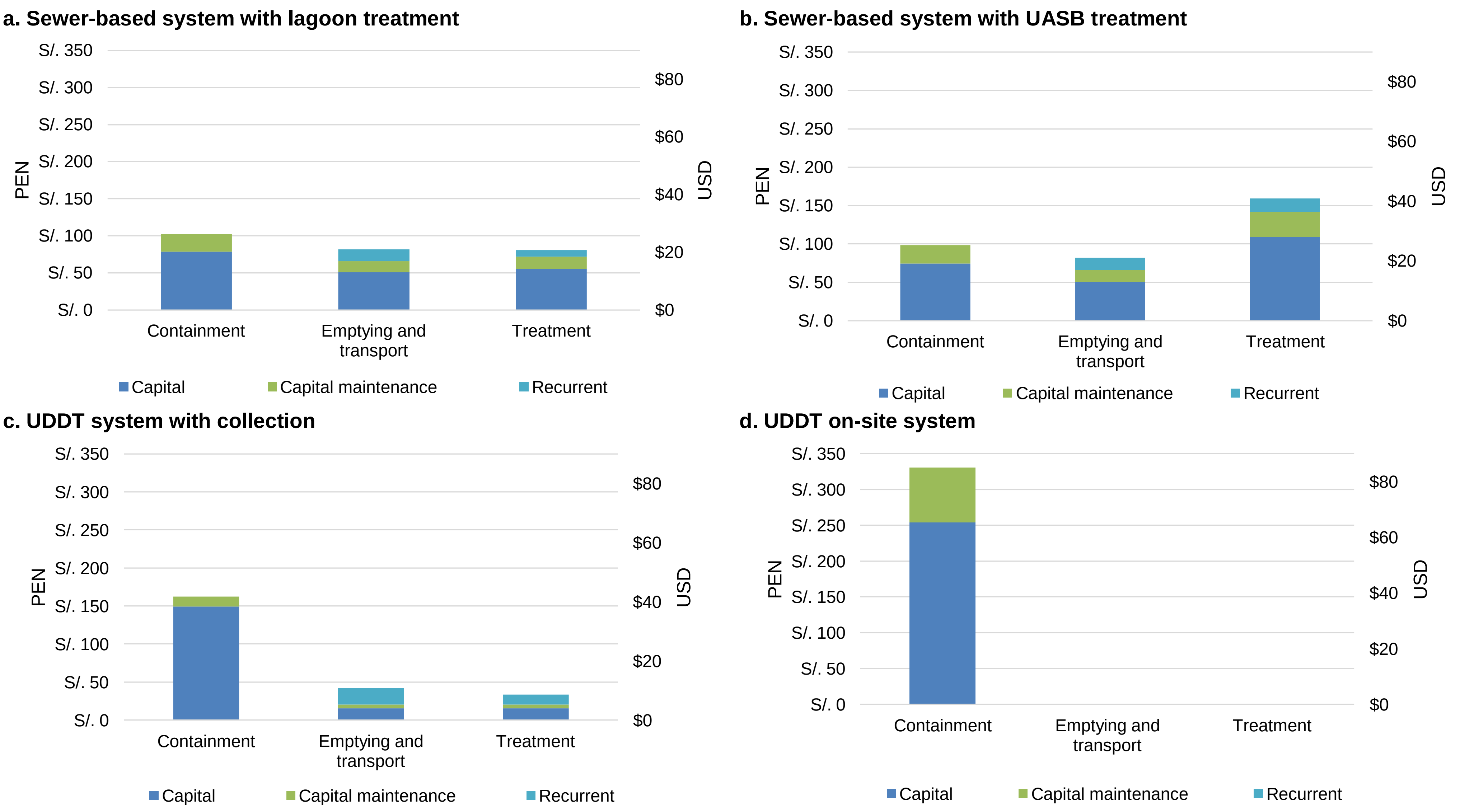
Figure 18 Total annualised costs per household for different technologies (Peruvian Nuevos Soles and USD)



As mentioned previously, despite the high containment costs, the UDDT collection option intervention is comparatively cheaper overall than the two waterborne options. The emptying and transport costs associated with the sewer-based options mainly encompass the costs of laying and maintaining the sewer network from the household service line to the treatment facility. These costs are roughly twice the costs associated with the emptying and transport for the UDDT options.

The remaining of this section presents the costs for three of the four interventions options, disaggregated by type of cost (i.e. CapEx, CapManEx, and recurrent costs). Figure 19 below presents the annualised costs of the four options and the stages at which they are incurred along the sanitation chain, as well as the cost components of the expenditures.

Figure 19 Annualised cost components of the sanitation interventions (cost per household in Peruvian Nuevos Soles and USD)



For the UDDT fully on-site option, the annualised onsite CapEx costs are extremely high relative to the other options: just over S/.331 (~US $101) compared to a range of between ~S/.100 – S/.160 (~US $30 – $50) as all costs are incurred in the construction of the sanitation facility (i.e. containment).

The sewer-based option with primary treatment by an anaerobic lagoon entails heavy capital investment for each part of the chain – at least 60% of the total cost incurred over the lifecycle of the infrastructure. For this option, the treatment costs are lower than those for containment, emptying and transport. It has been included as a lower bound estimate for a waterborne system, as primary treatment with anaerobic lagoons are comparatively cheap. In the case of the UASB option, the costs of treatment are higher than the costs of containment, emptying and transport – this is the only system for which this is the case. Again, capital expenditure remains the largest component of the costs across all stages of the sanitation chain.

For the UDDT dry collection model, the costs are mainly associated with containment, given that they include the construction of a greywater soakaway and urine storage. The greywater soakaway itself accounts for 57% of the on-site capital investment. Unlike the sewer-based options, recurrent costs encompass a higher proportion of total costs, especially at emptying, transport and treatment stages of the sanitation chain. As a proportion of annualised costs, recurrent costs are around 51% of the total costs at emptying and transport stages. On the contrary, for the sewer-based system with primary treatment with a UASB reactor, recurrent costs are only 20% of total annualised costs.

10.7 Damage costs and cost-effectiveness analysis

The damage costing analyses the out-of-pocket expenditure and productivity losses, as well as the costs related to premature loss of life, due to diarrhoea. The data for the damage costs associated to diarrhoeal incidence and out of pocket expenditures were drawn from the household survey data collected through this study. Data for the damage costs associated with premature loss were drawn from the WHO global burden of disease estimates. It should be emphasised that this is a limited damage costing and represents only the costs of poor sanitation associated with diarrhoeal disease. Table 27 presents the annualised costs per household. Damage costs are given in absolute terms and as a proportion of GDP.

Table 27 Damage costs of poor sanitation

	Total costs in PEN (USD)		Proportions	
	Per household	Per capita	% of total damages costed	% of GDP
Health care associated costs	S/. 70 ($21.4)	S/. 17 ($5.1)	32.05	0.09
Premature loss of life	S/. 149 ($22.6)	S/. 35 ($10.8)	67.95	0.19
Total	S/. 219 ($66.8)	S/. 52 ($15.9)	100	0.28

Table 28 presents the data on the cost of avoiding deaths and illnesses related to diarrhoea. There is an emerging consensus that if the cost per DALY averted is less than three times annual GDP per capita, it may be considered cost-effective, while any intervention that costs less than total annual GDP per capita is highly cost effective (Marseille et al, 2014). The values presented in Table 28 assume that half of the damage costs are averted due to the intervention. Under this assumption, all of the interventions are cost-effective as they cost between 1.5 times (UDDT) and 2 times (Waterborne – UASB) annual GDP per capita. The interventions fall out of the cost-effectiveness bracket if they mitigate less than 25 – 32% of the damage costs and become highly cost-effective if they mitigate over 75 – 97% of the damage costs.

Table 28 Cost-effectiveness analysis (Peruvian Nuevos Soles and USD)

	UDDT twin - fully on-site	UDDT collection system	Waterborne system - UASB treatment	Waterborne system – lagoon treatment
Cost per death averted	S/. 1,346,543 (US $410,227)	S/. 1,601,140 (US $488,152)	S/. 1,782,255 (US $543,370)	S/. 1,747,253 (US $532,699)
Cost per case of illness averted	S/. 89 (US $27)	S/. 105 (US $32)	S/. 117 (US $36)	S/. 115 (US $35)
Cost per DALY averted	S/. 27,767 (US $8,466)	S/. 33,042 (US $10,074)	S/. 36,780 (US $11,213)	S/. 36,057 (US $10,993)
Cost per DALY averted as a percentage of GDP per capita per annum	149%	178%	198%	194%

10.8 Concluding remarks

The technology cost analysis reflects the findings of the Platzer et al (2008) in that the FSM option entailing the collection and semi-centralised treatment of fecal waste is comparatively more cost effective than the two conventional sewer-based options proposed. Through annualising these cost, and estimating where along the sanitation chain they are incurred, it is clear that the driving force behind this is the considerably lower costs associated with the transport and treatment of fecal waste.

Despite the differences in the technology costs, and based on a limited damage costing, all of the proposed intervention options are cost-effective by international standards. It is only by assuming the interventions mitigate less than 3% – 25% of the damage cost that cost-effectiveness no longer holds.

11 Conclusion

This study has identified several key challenges in ensuring the continued provision of safe sanitation services in peri-urban areas of Lima. Besides increasing urbanisation rates, one of the main issues in Lima is the relatively low visibility of sanitation issues for the urban poor, as only 8% of the city's population relies on on-site sanitation, with the majority of citizens having access to sewerage. Other concerns relate to the type of terrain inhabited by the urban poor, mainly hilly and rocky or sandy areas that are difficult to access and where building adequate sanitation facilities is generally costly (both in terms of time and capital investments). In addition, most of these areas have been illegally inhabited, and although land tenure has progressively been granted, many households are at risk of getting evicted, which generally discourages expenditures on improving housing conditions.

Furthermore, the very few available FSM services only service public institutions (schools, hospitals, etc.) and wealthier households, which can guarantee payment. Given the lack of knowledge about the size of the demand for FS emptying and transport services and the risk of no-payment on behalf of poor households, private/tertiary sector providers are unwilling to invest in the development of an FSM market. As has been pointed out at several instances across this study and the RAS, SEDAPAL should naturally have the responsibility for the provision of FSM services, ensuring their integration with all other WSS conventional services, with the private/tertiary sector (e.g. SWM firms) potentially intervening as sub-contractors.

Given the inexistence of a FSM market for the urban poor, priority should be given to the following:

1. Ensuring adequate containment facilities are built and maintained by households – besides encouraging the use of FS emptying and transport services, improved containment will also minimise issues with the lack of space to build additional pits as well as health hazards related to poor sealing of full pits.

2. FSM and on-site sanitation alternatives need to be properly included in policy and planning documents, and a specific budget should be allocated to ensure that FSM services are provided. Given that SEDAPAL's conventional WSS services will not reach many of the households living in peri-urban areas in the next 5 to 10 years (if not more), FSM needs to be considered as a medium- to long-term option for peri-urban communities. Although SEDAPAL's upcoming pilot is a good starting point, FSM services will only be scalable if a supportive enabling environment is in place.

3. Part of the profitability of FSM markets originates from the possibility of reusing treated FS. Currently, the Peruvian legislation considers FS as a toxic waste, which limits exclusive FS treatment and prohibits FS reuse. This may eventually become an important barrier for the sustainability of FSM services, and is currently an impediment for NGOs, like X-Runner, which are having to store their end-products indefinitely.

4. Sensitisation at all levels (community, local authorities, national authorities) will be key when planning to carry out on-site sanitation interventions as there is a bias (as is the case for most of Latin America) towards sewerage in urban areas. On-site sanitation is generally seen as a long-term alternative only for rural areas, with urban dwellers only considering piped water and sewerage as their options (e.g. all of X-Runner's clients consider UDDTs as a short-term alternative and they are all waiting for SEDAPAL to provide conventional services).

SEDAPAL (with the support of the World Bank) is considering different alternatives to improve coverage in peri-urban areas. These are:

- On-site FS containment and greywater disposal, with FS emptying and transport services provided by tanker trucks (i.e. mechanical emptying), discharge at a FS treatment plant and compost and/or fertilizer production;

- Small community or condominial sewerage system, with decentralised wastewater treatment plants and wastewater reuse in green areas, and

- UDDTs with on-site greywater disposal and specialised FS treatment with compost and/or fertilizer production.

How and where these interventions are actually taken forwards will depend on the pilot outcome and the characteristics of the different peri-urban settlements. Besides the priority areas listed above, active engagement from all sector stakeholders through continuous consultations is an imperative if these alternatives are to become a reality for the urban poor.

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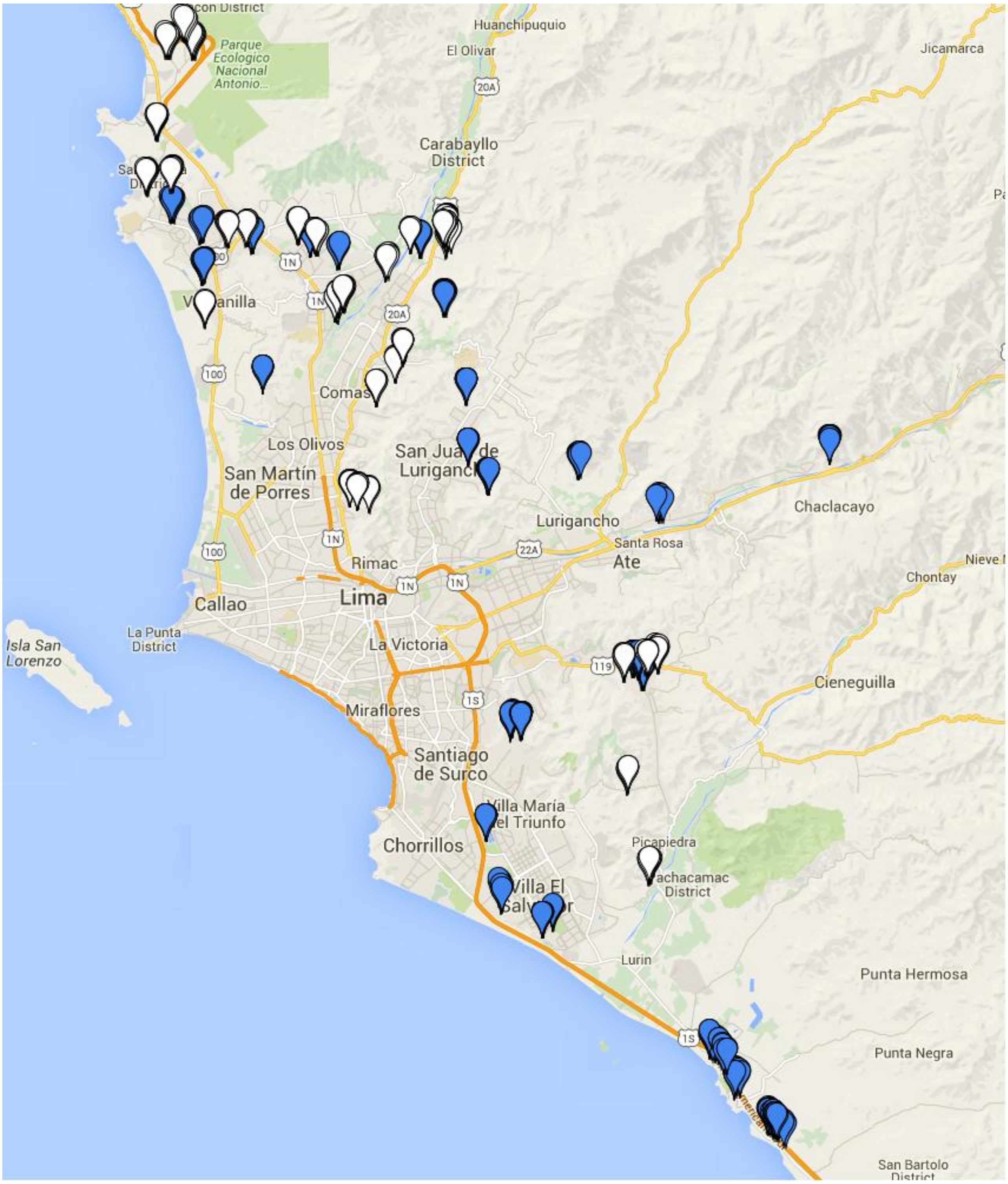
Annex A Map of sampled areas



Non-sewered areas (sub-sample A)

Lowest-income non-sewered areas (sub-sample B)

Annex B Methodology

B.1 Overall design

A key component of this study was primary data collection, since it aimed to build on an earlier 12-city FSM study based only on secondary data (Peal & Evans, 2013). The study had six different data collection instruments, four quantitative and two qualitative, each of which contribute to various project components shown in Table 1 in the introduction of this report. These instruments are summarised in Table 29 below.

Table 29 Summary table of data collection instruments

	Instrument	Data source	N per city
Quantitative	Household survey	Survey of households (i) in non-sewered areas of Lima (Sample A),[43] (ii) in lowest-income non-sewered settlements (Sample B)	720 (360 in each sample)
	Observation of service provider practices	Observations of containment	6
	Testing fecal sludge characteristics	Samples from (i) pits/tanks, (ii) truck/vessel outflow, and (iii) compost for reuse.	7
	Transect walks	(i) Observation of environmental and public health risks through transect walks	40 (30 in Sample A, 10 in Sample B)
		(ii) Drinking water supply samples, tested for fecal contamination and chlorine residual	60 (30 in each sample)
		(iii) Drain water samples, tested for fecal contamination	30 (in the 10 districts in Sample B)
Qualitative	Key informant interviews (KIIs)	(i) government (e.g. council / utility, ministries) (ii) service providers along the sanitation chain (iii) other key FSM agencies	As required
	Focus group discussions (FGDs)	FGDs with non-sewered, low-income and informal communities	10

The overall design decided by WSP was that the OPM/WEDC team should lead on methodology and analysis, while actual data collection would be managed by two types of consultants contracted separately. A local firm, Akut Peru, was contracted by WSP to conduct primary data collection under all of the above instruments, except for the Key Informant Interviews. In addition, a short-term consultant (Eng. Ruddy Noriega) was contracted to conduct the Key Informant Interviews and produce a draft of the Service Delivery Assessment and Prognosis for Change.

Detailed research protocols for the instruments in the table above are available in a separate instruments report here. This section briefly summarises each instrument, and the ensuing section describes the sampling approach.

[43] Excluding the 27 districts in both Lima and Callao that in 2007 had a sewerage coverage above 90%.

Household survey

The household survey aimed to collect data from households using on-site sanitation (particularly those living in informal or low-income settlements) regarding their use of FSM services and preferences for future FSM services. The household survey informs multiple components of this research. The sampling was carefully planned so as to allow representative conclusions to be drawn from non-sewered households in low sewerage coverage areas of Lima Metropolitan Area[44], and separate conclusions for lowest-income non-sewered areas[45] in particular, on a purposive basis. Questionnaire sections included a household roster, dwelling characteristics, use of water and sanitation infrastructure, usability and observation of latrines, satisfaction and planning on sanitation, and pit / septic tank filling up and emptying.

Observation of service provider practices

The observation protocol involved making visual inspections about fecal sludge from pits or tanks to final disposal, in particular watching service providers (SPs) go about their business. Observations required the identification of hazards, hazardous events, and an assessment of possible risks at each stage (containment, emptying, transport, treatment and end-use or disposal) of the fecal sludge management chain. However, given the limited scope of FSM services in Lima, observations mainly focussed on the containment and emptying stages of the chain.

Testing fecal sludge characteristics

The characteristics of fecal sludge will vary, depending on many factors including, but not limited to, the length of time for which it has been stored, the season, and the storage conditions (e.g. whether the sludge was in a lined or unlined pit). Assessment of the characteristics was performed in (i) latrines / pits currently being used, (ii) abandoned pits, (iii) urine-diverting (UD) sanitation facilities, and (iv) during removal, as this will influence the removal methods that could be used.

Transect walk

The transect walk enabled participants to make a subjective and qualitative assessment of the physical and environmental conditions within a community. During the walk, participants make systematic observations, discuss them and record their findings using a standard reporting format. The information collected complements data from household questionnaires, observations, and sample collection and analysis. For this study, a transect walk provides information about the broad environmental risks to public health, in particular with respect to the presence of fecal material and solid waste, and the likelihood that these enter drainage channels and water sources. When all observations are complete, participants ask community members a few short questions to gain information about typical behaviours in the community that could be a source of risk (e.g. latrines discharging to drains, overflowing latrines, illegal dumping of fecal sludge, etc.) and the frequency of those behaviours throughout the year (e.g. daily, weekly, seasonal, etc.). These walks were designed to give an overall picture of conditions in a neighbourhood – they did not aim to allow detailed maps to be drawn with fecal sludge flows to be physically tracked, nor did they aim to make operational recommendations at the neighbourhood level.

[44] In the other case country studies, sampling was designed to draw representative conclusions for the city as a whole, and lowest-income non-sewered areas in particular. However, Lima has a very high sewerage coverage (estimated at 92% in 2012), so to be able to assess FSM services, the study focussed on the low sewerage coverage areas of the city, i.e. 22 districts where sewerage coverage was below 90% in 2007.

[45] Lowest-income areas were selected based on national poverty levels (i.e. districts with a poverty index level above 20%).

Testing water supply and drain water quality

During transect walks, samples of drinking water supplies and water flowing in irrigation channels and greywater deposits or puddles were taken from a selection of UALs in the city and tested for levels of *E. coli.* The results help to identify the extent to which there is an association between poor FSM services and resulting levels of fecal contamination in the local environment (i.e. in water supplies, irrigation channels, etc.). This information, together with results from transect walk observations, reported sanitation behaviours and practices in the community and other data sources, helps build-up a picture of the public health risks associated with poor FSM services, related to contamination levels (hazard), exposure and vulnerability.

Key informant interviews

Key informant interviews (KIIs) are the way in which primary information was sought to address key questions about how both the 'enabling environment' and the operating environment affects FSM services (past, current and future). KIIs were held with stakeholders having responsibility or interest in FSM services at city-level and beyond, allowing the enabling and operating environments to be better understood in relation to their influence within the city.

Focus group discussions

The objective of focus group discussions (FGDs) with residents of informal settlements was to gather qualitative data that would complement, validate, or perhaps challenge responses made during the household survey. Questions focused on obtaining information relating to household sanitation and FSM practices (particularly identifying the practices of "others", as individuals are reluctant to talk honestly about their own, or their families' practices), service levels, past interventions, risks and other issues associated with FSM services that affect their community.

B.2 Sampling

B.2.1 Household survey

The main sampling method design was for the household survey, with the sampling approaches for other instruments using the selected clusters as a basis. Therefore, the household survey is discussed first, and the remaining instruments are covered afterwards. Overall, it is crucial to understand that in the sampling, two pictures were being sought: the first to give an understanding of the situation of non-sewered households in (1) low sewerage coverage areas of Lima, and (2) a specific understanding of the situation in lowest-income areas.

Given the high level of sewerage coverage in Lima, Peru, the study population were non-sewered households in the city located in areas where sewerage coverage was below 90%, as reported in the 2007 National Census. This encompasses 314,087 households in 22 urban districts within the boundaries of Lima Metropolitan Area (i.e. Lima and Callao municipalities), here on referred to as 'Lima'. These districts are listed below in Table 30.

Table 30 Sampling frame for Lima

District	No. of occupied dwellings	No. of dwellings and proportion without sewerage	
	Total	Total	%
Lima			
Punta Negra	1,415	1,393	98.4%
Punta Hermosa	1,767	1,678	95.0%
Pachacamac	17,403	16,087	92.4%
Cieneguilla	4,569	3,667	80.3%
Puente Piedra	51,150	33,217	64.9%
Santa Rosa	2,963	1,905	64.3%
Pucusana	2,799	1,595	57.0%
Lurigancho	38,756	21,629	55.8%
Lurín	14,562	7,676	52.7%
San Bartolo	1,406	731	52.0%
Carabayllo	46,933	22,804	48.6%
Ancón	8,236	3,388	41.1%
Ate	108,849	32,075	29.5%
Villa María del Triunfo	83,947	21,689	25.8%
Villa el Salvador	75,883	15,988	21.1%
San Juan de Lurigancho	189,671	38,218	20.1%
Chorrillos	62,408	12,202	19.6%
San Martin de Porres	123,863	16,103	13.0%
San Juan de Miraflores	69,942	8,400	12.0%
Santa Maria del Mar	215	23	10.7%
Comas	95,036	9,874	10.4%
Callao			
Ventanilla	70,874	43,745	61.7%

Source: 2007 National Census.

There were two sub-sample areas (denoted A and B). Sub-sample A was representative of non-sewered areas in districts that had less than 90% sewerage coverage in 2007 – which are referred to across the report as 'non-sewered areas' – while sub-sample B focused on the lowest-income non-sewered households. Sub-sample B is not representative as households were purposively selected to be able to locate and focus on the most vulnerable on-site sanitation users. The aim of sub-sample A was to get estimates for non-sewered households in low sewerage coverage urban areas at minimum cost and administrative burden. Hence, the sample has a relatively small sample size, for example compared to what would be necessary for studies with different objectives (e.g. an evaluation aiming to attribute impact to a specific sanitation intervention).

Sub-samples and sampling units

For sub-sample A, the Primary Sampling Units (PSUs) were districts and the Secondary Sampling Units (SSUs) were *Secciones Censales*[46] or census tracts[47]. Lists of districts and census tracts were collected from National Institute of Statistics and Information (INEI).

[46] A census tract is equivalent to part of or a complete *Unidad Administrativa Local (UAL)*. An UAL is an administrative unit akin to "urban neighbourhoods".

[47] In a household survey, households are the sampling unit we are interested in, but it is difficult and expensive to sample 1,000 households from across a city completely randomly, as you would potentially have to go to 1,000 different localities. Therefore, most surveys take an intermediary approach using clusters of households. This approach has three

For sub-sample B, households were chosen based on three different criteria: (1) UAL is one of SEDAPAL's (Lima's utility) priority areas; (2) observed poverty and (3) not connected to sewerage. Areas prioritised by SEDAPAL are those that are unlikely to gain access to sewerage in the next four years, which encompass 33 *Unidades Administrativas Locales (UALs)*. The poverty status of the household was determined based on road characteristics, access to public services (i.e. electricity, water and sewerage), and dwelling characteristics. The focus of the sample were *asentamientos humanos* (i.e. human settlements) in both rocky and sandy peri-urban areas of Lima[48].

Finally, the Tertiary Sampling Units (TSUs) were households, in both cases.

A map showing the location of sampled district and SSUs within districts is shown in Annex A.

Sample sizes

Given that in both sub-samples, the sampling is purposive (i.e. in sub-sample A, the focus is non-sewered households and in sub-sample B the focus is lowest-income non-sewered households), there is no specific level of confidence. To be consistent with other city case studies, the sample size for each sub-sample was 360 households, giving a total number of 720 households surveyed across both sub-samples.

Sampling methodology

<u>Sub-sample A – non-sewered areas</u>

A three-stage sampling approach was followed. In the first stage, 10 districts/PSUs were sampled from the 22 districts with a sewerage coverage below 90% using probability proportionate to size (PPS), listed in Table 30 above. In the second stage of sampling, 30 census tracts were randomly selected from the PSUs (i.e. 3 per district). This can legitimately be called a non-sewered sample of census tracts of low-sewerage coverage areas of Lima.

Households (TSUs) were sampled using systematic random sampling. Each supervisor and enumerator was given a map of the UAL divided into twelve equally-sized blocks. Upon arrival to the first block (previously selected by Akut), the enumerator surveyed the first house (starting from the northeast corner of the block and walking in a clockwise direction). After completing the first survey, the enumerator jumped the following 4 houses, and interviewed the next one (i.e. the 6th house). The enumerator followed this 'jump system' until 12 questionnaires were completed[49].

In cases where the household did not wish to participate, it was replaced with the adjacent / neighbouring household. There were two additional types of replacements. On one hand, if in a census tract less than 20% of households were found not to be connected to sewerage, the tract was randomly replaced with another one from a list of 20 census tracts. On the other hand, if

sampling units. The district is the primary sampling unit (PSU), the census tract / neighbourhood is the secondary sampling unit (SSU) and the household is the tertiary sampling unit (TSU). The reason we say SSU instead of census tract / neighbourhood is the former can be clearly defined geographically, whereas the latter means different things to different people. The size of a SSU will differ across cluster surveys. The gold standard is to use census enumeration areas (usually between 200 and 400 households), but this is not always possible.

[48] The reason for distinguishing between rocky and sandy areas is that, in the former, households are generally unable to dig deep pits and thus rely on containment structures that fill up and overflow frequently. Digging pits in sandy soil is easier, and there is usually a higher rate of infiltration, so pits are expected to last for a longer time.

[49] A differentiated systemic jump was used, depending on the number of households in the census tract without access to sewerage. For census tracts with 100 or more households without sewerage, a jump of 5 households (k = 5) was used. For census tracts with 51 – 99 households without sewerage, k = 3. Finally, for census tracts with 30 – 50 households without sewerage, k = 1 (i.e. every other household was surveyed).

during fieldwork a census tract had less than 30 non-sewered households, the tract was replaced by the community or neighbourhood closest to the end-point of the sewerage network.

The final list of districts and UALs included in sub-sample A are listed in Table 31 below.

Table 31 Districts and UALs included in sub-sample A

District	Name of UAL	Replacement
Carabayllo	Programa de Vivienda Los Claveles	Yes, during fieldwork
Carabayllo	Asociación de Vivienda Las Gardenias	Yes, during fieldwork
Carabayllo	Asociación de Vivienda Valle First	Yes, during fieldwork
Lurigancho	AAHH Casa Huerta La Campina Sector A	No
Lurigancho	Asociación de Vivienda Camposol	Yes, during fieldwork
Lurigancho	AAHH Alto Huampani	No
Pachacamac	Asociación de Vivienda Villa Jardin La Hoyada	Yes, random
Pachacamac	Asociación de Vivienda Los Rosales	Yes, random
Pachacamac	Asociación Los Girasoles	Yes, during fieldwork
Puente Piedra	Urbanización Las Casuarinas	Yes, random
Puente Piedra	Asociación de Vivienda Las Begonias de Copacabana	Yes, during fieldwork
Puente Piedra	AAHH Ampliación Las Lomas	No
Punta Hermosa	Asociación de Vivienda Jahuay	No
Punta Hermosa	Agrupación Familiar Ampliación Santa Cruz	No
Punta Hermosa	Urbanización El Carmen	No
Punta Negra	Asociación de Vivienda Familiar Costa Azul	No
Punta Negra	AAHH Villa Mercedes	No
Punta Negra	AAHH Las Lomas de Punta Negra	No
San Juan de Lurigancho	Asociación de Agrupación Familiar Pilcomoso de la Libertad	Yes, during fieldwork
San Juan de Lurigancho	Agrupación Familiar Los Leones	Yes, during fieldwork
San Juan de Lurigancho	Agrupación Familiar San Martin	Yes, during fieldwork
San Juan de Miraflores	Asociación Agrícola Industrial de la Rinconada	No
San Juan de Miraflores	AAHH Alto Progreso	No
San Juan de Miraflores	AAHH Intihuatana	Yes, during fieldwork
Ventanilla	AAHH Feliz Moreno	Yes, during fieldwork
Ventanilla	AAHH Jaime Yoshiyama	No
Ventanilla	AAHH Cosmovisión	No
Villa El Salvador	Cooperativa Las Vertientes	No
Villa El Salvador	Grupo Familiar Ampliación Oasis Grupo 2	Yes, during fieldwork
Villa El Salvador	Asociación de Vivienda Santa Rosa de Villa el Salvador	Yes, during fieldwork

Source: AKUT Fieldwork Report.

Sub-sample B – lowest-income non-sewered areas

A purposive sampling method was used. First, through a meeting with SEDAPAL, 33 low-income and priority UALs[50] (i.e. areas that are unlikely to get access to sewerage in the next 4 years) in 8 districts were selected (Ancon, Carabayllo, Comas, Independencia, Pachacamac, Puente Piedra,

[50] SEDAPAL's database refers to UALs rather than census tracts. However, census tracts in sub-sample A either refer to part of or a complete UAL, so for ease of understanding, these terms may be used inter-changeably.

Santa Rosa and Ventanilla). UALs that were previously selected in sub-sample A or confirmed to have access to sewerage (i.e. 13 UALs), were excluded, leaving a sample of 20 UALs. The remaining 10 UALs were selected based on proximity to the end-point of the sewerage network, i.e. the closest non-sewered UAL to an excluded prioritised area. 18 of the UALs selected had sandy soil, 11 were predominantly rocky areas, while the remaining UAL was in located in a farming area. For sampling households / TSU, the same process was followed as in sub-sample A.

Districts and UALs included in sub-sample B are listed in Table 32 below.

Table 32 Districts and UALs included in sub-sample B

District	Name of UAL	Replacement	SEDAPAL Priority Area
Ancon	Asociación de Vivienda La Variante de Ancón	No	Yes
Ancon	Asociación de Vivienda Las Lomas de Ancón	No	Yes
Ancon	Asociación Popular Villa Maria de Ancón	No	Yes
Carabayllo	Asociación de Productores Pecuarios Pampa de San Antonio	Yes	No information
Carabayllo	AAHH Las Lomas de Torre Blanca Alta	No	No
Carabayllo	Asociación Sol y Campo	Yes	No information
Carabayllo	Asociación Agrícola 11 de Noviembre	No	No
Carabayllo	Urbanización Los Cipreses	Yes	No information
Comas	AAHH Villa San Camilo	No	No
Comas	AAHH Señor de la Misericordia	No	Yes
Comas	AAHH Ampliación Buenos Aires – III Zona Colique	No	No
Independencia	Asociación de Vivienda Ampliación Las Gardenias	No	No
Independencia	Asociación Ampliación San Juan Bautista Comité 13	No	No
Independencia	AAHH Santa Rosa de Lima III Etapa	Yes	No information
Pachacamac	AAHH JIREH	No	Yes
Pachacamac	AAHH Los Cedros de Manchay	No	Yes
Pachacamac	Asociación de Vivienda Ecológica Los Alpes	No	Yes
Pachacamac	Centro Poblado Rural Quebrada Verde	No	Yes
Pachacamac	Asociación de Vivienda San Judas Tadeo	No	Yes
Puente Piedra	Asociación de Vivienda Nueva Vida	Yes	No information
Puente Piedra	Asociación de Vivienda Santo Domingo de Copacabana	Yes	No information
Puente Piedra	Asociación de Vivienda Rosario de Copacabana	No	Yes
Puente Piedra	Asociación de Vivienda La Fortaleza	No	Yes
Puente Piedra	Asociación de Vivienda Santa Teresa	No	Yes
Puente Piedra	Asociación de Vivienda Luis Pardo	Yes	No information
Santa Rosa	Asociación de Vivienda PROFAM Sector 8	No	Yes
Santa Rosa	Asociación de Vivienda Las Brisas de Santa Rosa II Etapa	No	Yes
Santa Rosa	Asociación ADESESEP	Yes	No information
Ventanilla	AAHH Jose Maria Arguedas	Yes	No information
Ventanilla	AAHH Ampliación Costa Azul	No	No information

Source: AKUT Fieldwork Report.

B.2.2 Other instruments

Observation of service provider practices and testing fecal sludge characteristics

Fully recorded observations were made at 6 different locations (latrines in use, abandoned latrines, urine-diverting (UD) sanitation facilities and mechanical emptying trucks), at the containment and emptying stages of the sanitation service chain. Tests were also carried out at the reuse stage for UD bi-products, as there is no composting for other type of on-site sanitation facilities. Tests at transport and treatment stages were excluded as there are no specific fecal sludge services (except for public institutions and richer households). Overall, the chosen observations reflect existing fecal sludge management practices as much as possible.

Tests for fecal sludge characteristics were carried out on fecal sludge and dried excreta collected during the observations of SPs, so their sampling method is identical.

Transect walks

Transect walks were conducted in 40 UALs in total: all 30 census tracts of sub-sample A and 10 randomly selected UALs from the full list of sub-sample B UALs. Section 4 in the report includes an explanation of the format and scoring used during the transect walks.

Testing water supply and drain water quality

Samples of drinking water supplies were taken in 20 different UALs; 10 in sub-sample A and 10 in sub-sample B. Water samples were taken from either the same water source or from the three most common drinking water supplies identified in the UAL (verified by asking community members). Samples were taken at the source of the supply and tested for levels of *E. coli* to identify contamination in the supply itself and avoid measuring contamination resulting from poor water storage or handling practices. Similarly, water samples from irrigation channels / dumping sites were taken in 10 UALs from sub-sample B, from either the same location or from three different locations and also tested for levels of *E. coli*, to identify contamination from poor sanitation and fecal sludge handling within the UAL. A standard procedure for collecting samples was followed, with samples sent to registered laboratories for testing.

Key informant interviews

The total number of interviews required, as well as the range and extent of questioning, was influenced by the availability of current and reliable data from other sources, as well as constraints on time and resources. Selection of interviewees was purposive, based on advice received from stakeholders and existing knowledge of the World Bank consultant.

Focus group discussions

10 FGDs were held with households from 10 UALs from sub-sample B, which were randomly selected from the total of 30 sub-sample B UALs in lowest-income non-sewered areas.

B.3 Fieldwork implementation

Pretesting, training and piloting

Initial pre-testing was carried out by Akut to refine the instruments a week prior to the enumerator training. During the training, all data collection instruments were piloted in UALs excluded from the final samples but that belong to the sampling frame, i.e. any of the 22 districts with less than 90% sewerage coverage.

Field team composition

For the quantitative survey, two field teams were deployed for data collection. Each team was composed by one Supervisor and four Household Enumerators. An experienced Field Manager was responsible for ensuring overall management, field implementation and quality assurance.

Data collection

The field teams collected the majority of the data from the 60 sampled UALs in 4 weeks during December 2014 to January 2015. On average, each team spent one day in a PSU. Each household interviewer conducted the survey in 6 households per day, and thus each team with 2 interviewers completed 12 households in a cluster in one day. For the transect walks (TWs), five teams of two participants conducted all 40 TWs over 7 days.

Data entry, cleaning and analysis

The quantitative survey data were entered into SPSS at Akut's offices in Lima, using various data quality checks, including range checks, skips and internal consistency checks. After data cleaning checks, data were then transferred into the statistical software Stata. Data were analysed using Stata in OPM's offices in Oxford.

B.4 Limitations

This study has two key limitations which need to be considered to understand the strengths and weaknesses of the data and the conclusions that can and cannot be drawn from the analysis. These should be considered in the context of the objectives of the study (see Section 1.2 in the main report). These are:

- **Socio-economic survey** – household surveys with enumerators skilled in social research can only really ask questions of householders. Although enumerators were trained to observe and identify different characteristics of sanitation facilities, they cannot always make accurate technical inspections of the infrastructure, which would require a different skillset. Therefore, it is necessary to take the household's responses at face value (e.g. about the destination of their blackwater).

- **Sampling method –** sample surveys are designed to estimate indicators for a broader population. Therefore, they cannot produce detailed data for specific neighbourhoods without dramatically increasing the sample size and appropriate stratification. The sample size for this study is relatively small compared to what would be necessary for an impact evaluation, for example. In a similar vein, transect walks aimed to build up a broad picture rather than specific maps or explanations for individual neighbourhoods. Finally, the study only focuses on non-sewered residential areas and households of Lima, excluding sewered residential areas, and all public establishments and institutions.

Annex C Fecal waste flow matrices

Table 33 Fecal waste flow matrix – city-wide

		Containment		Emptying		Conveyance		Treatment		Overall
		of which		*of which*		*of which*		*of which*		**Safe:**
Type of system	*% pop. using*	*contained*	*not contained*	*emptied*	*not emptied*	*transported*	*not transported*	*treated*	*not treated*	**52%**
Sewered (off site centralised or decentralised)	92%	100%	0%	100%	0%	73%	27%	73%	27%	
		92%	0%	92%	0%	67%	25%	49%	18%	**49%**
Septic tank – FS contained	3%	100%	0%	100%	0%	100%	0%	100%	0%	
		3%	0%	3%	0%	3%	0%	3%	0%	**3%**
Unlined pit – partially emptiable	4%	3%	97%							
		0%	4%							
Straight to drain/similar	0.4%	0%	100%							
		0%	0.4%							
Straight to sea, river, lake	0%									
Open defecation	1%	0%	100%							
		0%	1%							
		Containment	98%	Emptying	94%	Transport	94%	Treatment	67%	
Unsafe:	**48%**		**5%**		**0%**		**25%**		**18%**	
Affected zones		*Local area and beyond via drains (amount direct to groundwater not identified)*		*Local area (via overflowing latrines or dumped FS)*		*Neighbourhood (via leakage/overflow from sewers or drains)*		*Receiving waters (via sewer outfall/discharge)*		

(orange)	from household survey
(yellow)	from secondary data
(grey)	de facto value

Table 34 Fecal waste flow matrix – non-sewered areas

		Containment		Emptying		Conveyance		Treatment		Overall
		of which		*of which*		*of which*		*of which*		**Safe:**
Type of system	*% pop. using*	*contained*	*not contained*	*emptied*	*not emptied*	*transported*	*not transported*	*treated*	*not treated*	**1%**
Sewered (off site centralised or decentralised)	0%									
Septic tank – FS contained	1%	100%	0%	100%	0%	100%	0%	100%	0%	
		1%	0%	1%	0%	1%	0%	1%	0%	**1%**
Unlined pit – partially emptiable	96%	3%	97%	90%	10%	44%	56%	0%	100%	
		3%	93%	3%	0%	1%	2%	0%	1%	
Straight to drain/similar	3%	0%	100%							
		0%	3%							
Straight to sea, river, lake	0%									
Open defecation	0%	0%	100%							
		0%	0%							
		Containment	97%	Emptying	1%	Transport	1%	Treatment	1%	
Unsafe:	**99%**		**96%**		**0%**		**2%**		**1%**	
Affected zones		*Local area and beyond via drains (amount direct to groundwater not identified)*		*Local area (via overflowing latrines or dumped FS)*		*Neighbourhood (via leakage/overflow from sewers or drains)*		*Receiving waters (via sewer outfall/discharge)*		

(orange)	from household survey
(yellow)	from secondary data
(grey)	de facto value

Annex D CSDA scoring table criteria

Sub-question		Question	Containment	Emptying	Conveyance	Treatment	End-use/disposal	Indicator/ Score	Comments
Enabling: What are current policies, planning issues and budgetary arrangements?	1. Policy	**1.1 Policy**: Is FSM included in an appropriate, acknowledged and available policy document (National/ local or both)?	0	0.5	0.5	0	0	1: policy is appropriate, approved (or in draft form), acknowledged and available 0.5: policy is appropriate, approved (or in draft form), but not clearly acknowledged / available 0: policy not available, or inappropriate to the context	Legislation exists for the sanitation sector as a whole, but there are no specific provisions for FSM. Law 26338 (General Law for Sanitation Services) encompasses the disposal of feces from latrines and septic tanks as part of service provision. Law 30045 (Modernisation of Sanitation Services) also encompasses feces disposal in both urban and rural areas (besides water supply and sewerage) according to the following principles: universal access, social inclusion, environmental protection, firm independence and efficiency. Law 30045 also defines competencies across different sector stakeholders (e.g. regulatory agencies, service providers). Other relevant laws include 28611 (General Environmental Law), 27314 (General Solid Waste Law) and 27972 (Municipalities Law). Nothing specific for fecal sludge treatment and just one mention of 'residual water reuse' in Law 28611.
		1.2 Institutional roles: Are the institutional roles and responsibilities for FSM service delivery clearly defined and operationalized?	0	0	0	0	0	1: roles defined and operationalised 0.5: roles clearly defined but not operationalised, or not-defined by work in practice 0: roles not defined / not operationalised	Competencies are defined in Law 30045 for the provision of sanitation services, including feces disposal. A large proportion of the Law refers to service providers (EPSs), which are currently in charge mainly of solid waste management and FSM for public institutions (e.g. Mega Pack Trading). There is no explicit regulation for the provision of FSM services, but rather general principles that apply to all sanitation services. Interviews suggest that roles and responsibilities are neither operationalised (as FSM services are not provided) nor clear (Sedapal, SUNASS, DIGESA, DESA). There is a National Building Regulation that

Sub-question		Question	Containment	Emptying	Conveyance	Treatment	End-use/disposal	Indicator/ Score	Comments
									determines the standards for sanitation facilities, but only considers septic tanks and sewerage.
		1.3 Regulation: Are there national and/or local regulatory mechanisms (i.e. bylaws and means of enforcement) for FSM?	0	0.5	0.5	0	0	1: regulatory mechanisms for FSM exist and are operational 0.5: regulatory mechanisms for FSM exist but are not operational 0: no regulatory mechanisms for FSM exist	Regulation for FSM services would be the same as that applicable to service providers more broadly (defined in Law 30045). There is very limited regulation in place for the provision of services to households in urban areas; KIIs have mixed opinions, but generally lean more towards 'no regulation'.
		1.4 Service provision: does the policy, legislative and regulatory framework enable investment and involvement in FSM services by appropriate service providers (private or public)?	0.5	0.5	0	0	0	1: legal framework enables investment, with evidence of increasingly formalised involvement 0.5: legal framework doesn't address investment, but evidence of involvement (through formal or informal mechanisms) in practice 0: legal framework doesn't enable investment and/or no evidence of involvement (through formal or informal mechanisms)	Question was not addressed, but Law 30045 (Modernisation of Sanitation Services) makes provisions for public sector investment and encourages PPPs. However, KIIs mentioned that there are no clear incentives for private sector involvement in the provision of FSM services // Provision of on-site sanitation in urban areas by NGOs, such as XRUNNER.
	2. Planning	**2.1 Targets:** Are there service targets for (each part of) the FSM service chain in the city development plan, or a national development plan that is being adopted	0	0	0	0	0	1: targets are clearly included 0.5: service levels are included, but no targets stated 0: no reference to service levels or targets	The national target is 100% sewerage by 2017, with no mention of FSM as a short-, medium- or long-term alternative. The possibility of a national or local plan is hindered by the fact that there are no designated responsibilities among key stakeholders for FSM.

Sub-question		Question	Containment	Emptying	Conveyance	Treatment	End-use/disposal	Indicator/ Score	Comments
		at the city level?							
		2.2 Investment: Is FSM incorporated into an approved and used investment plan (as part of sanitation) - including ensuring adequate human resources and Technical Assistance? (Ideally a medium term plan, but if not, at least an annual plan)	**0**	**0**	**0**	**0**	**0**	1: investment plan for FSM exists, based on identified needs and addressing human resource and TA needs 0.5: investment plan for FSM exists, but does not address human resource or TA needs 0: no investment plan for FSM	Investment plans with on-site sanitation mainly address rural areas through the National Rural Sanitation Programme. It is not clear if the National Urban Sanitation Programme also encompass on-site sanitation & FSM, but KIIs suggest that this is not the case.
	3. Budget	**3.1 Fund flows:** Does government have a process for coordinating FSM investments (domestic or donor, e.g. national grants, state budgets, donor loans and grants etc.)?	**0**	**0**	**0**	**0**	**0**	1: coordination of investments is defined and operationalised 0.5: coordination of investments is defined, but not operationalised 0: no coordination of investments defined	KIIs were not aware of a coordination process for FSM. However, funds are always insufficient to meet investment needs in sanitation.
		3.2 Adequacy & structure: Are the annual public financial commitments to FSM commensurate with	**0**	**0**	**0**	**0**	**0**	1: annual public financial commitments are sufficient to meet >75% of requirements (estimated need if no targets set)	FSM is not established and there are no public financial commitments over the coming 5 years to address FSM in peri-urban areas. More generally, as mentioned above, sanitation funds have always been insufficient to meet the needs identified.

Sub-question		Question	Containment	Emptying	Conveyance	Treatment	End-use/disposal	Indicator/ Score	Comments
		meeting needs/targets for Capex and Opex (over the coming 5 years)?						0.5: annual public financial commitments are sufficient to meet >50% of requirements (estimated need if no targets set) 0: annual public financial commitments insufficient to meet 50% of requirements (estimated need if no targets set)	
Developing: What is the level of expenditure, degree of equity and level of output?	**4. Capital expenditure**	**4.1 Capital funding:** What is Capex expenditure per capita on FSM (3 year average)?	**0**	**0**	**0**	**0**	**0**	Range of Capex expenditure (This will be matched to service levels and needs)	Question was not addressed, but FSM is not established.
	5. Equity	**5.1 Choice:** Is there a range of affordable, appropriate, safe and adaptable technologies for FSM services available to meet the needs of the urban poor?	**0**	**0**	**0**	**0**	**0**	1: range of technical options exist (i.e. are “offered” formally) and are used by the urban poor 0.5: range of options exist, but are not accessed by the urban poor, or just not used 0: options are not present	Formal services are very expensive for the urban poor. FSM services are only available for beach houses in rich areas, and for public establishments. The Ministry of Environment suggests there may be some informal provision of services, for all residual water (greywater and blackwater), but not exclusively for FS. Informal providers would empty contents in nearby drains.
		5.2 Reducing inequity: Are there specific and adequate funds, plans and measures to ensure FSM serves all users, and specifically the urban poor?	**0**	**0**	**0**	**0**	**0**	1: funds, plans and measures are codified and in use 0.5: funds, plans and measures are codified but not in use 0: no funds, plans and measures codified	There are no specific measures to provide services for the urban poor. KIIs mentioned that they would need to carry out a demand diagnosis to know if service provision for the poor is a feasible option. Law 30045 does include universal access and social inclusion as principles for service provision.

Sub-question		Question	Containment	Emptying	Conveyance	Treatment	End-use/disposal	Indicator/ Score	Comments
	6. Outputs	**6.1 Quantity / capacity:** Is the capacity of each part of the FSM value chain growing at the pace required to ensure access to FSM meets the needs/demands and targets that protects public and environmental health?	0	0	0	0	0	1: capacity growing at a pace to meet >75% of the needs/demands and targets to protect health 0.5: capacity growing at a pace to achieve >50% of needs/demands and targets to protect health 0: capacity insufficient to meet 50% of the needs/demands and targets to protect health	No FSM services - there were some previous initiatives to expand access to latrines, and currently there is provision of dry sanitation facilities, but there is nothing beyond containment. KIIs of SWM service providers suggests that they may have the capacity to undertake FSM services. These providers are currently subject to environmental and public health regulation, which would also apply if FSM services were to be formalised. However, there is no demand analysis available to determine if quantity / capacity at each stage of the FSM chain is sufficient.
		6.2 Quality: Is the quality of FSM sufficient to ensure functioning facilities and services that protect against risk through the service chain?	0	0	0	0	0	1: >75% of services that protect against risk and are functional through the service chain 0.5: >50% of services that protect against risk and are functional through the FSM service chain 0: less than 50% of services that protect against risk and are functional through the FSM service chain	No FSM services. Formal solid waste management service providers transport waste to approved disposal sites (e.g. landfills or Sedapal collection sites), but informal service providers do not. Illegal dumping is partly due to lack of adequate monitoring on behalf of local authorities (e.g. DIGESA, Lima Municipality).
		6.3 Reporting: Are there procedures and processes applied on a regular basis to monitor FSM access						1: regular reporting on both access and quality of FSM services, with information disseminated	THIS QUESTION WAS MOVED TO SERVICE OUTCOMES – ALL SCORES ARE ZERO.

Sub-question		Question	Containment	Emptying	Conveyance	Treatment	End-use/disposal	Indicator/ Score	Comments
		and the quality of services and is the information disseminated?						0.5: regular reporting on either access or quality of FSM services (with information disseminated or not) 0: no regular reporting on either access or quality of FSM services	
Sustaining: What is the status of operation and maintenance, what provisions are made for service expansion and what are current service outcomes?	7. O&M	**7.1 Cost recovery:** Are O&M costs known and fully met by either cost recovery through user fees and/or local revenue or transfers?	0	0	0	0	0	1: O&M costs known and >75% met (through appropriate mechanisms) 0.5: O&M costs known and >50% met 0: O&M costs not known and/or <50% met	Costs are not known – as mentioned by KIIs, a diagnosis is needed to be able to assess the viability of FSM services. The number of SWM service providers which are requesting licenses is growing, indicating that this is a profitable business (i.e. O&M costs are being covered).
		7.2 Standards: Are there norms and standards for each part of the FSM value chain that are systematically monitored under a regime of sanctions (penalties)?	0	0	0	0	0	1: norms and standards exist, are monitored and sanctions applied 0.5: norms and standards exist and are monitored, but no sanctions applied 0: norms and standards (if they exist) are not monitored	There are general norms / standards in Law 30045 for service providers and markets, but there is nothing specific for FSM. KIIs mentioned that monitoring is deficient and could be improved.
	8. Expansion	**8.1 Demand:** Has government (national or city authority) developed any policies and procedures, or	0	0				1: policies, procedures or programs are being implemented, with resulting demand for services growing and being responded to	All KIIs said that there was nothing being done on behalf on national authorities to promote demand for FSM services.

Sub-question		Question	Containment	Emptying	Conveyance	Treatment	End-use/disposal	Indicator/ Score	Comments
		planned and undertaken programs to stimulate demand of FSM services and behaviours by households?						0.5: policies, procedures or programs are being implemented (or partially implemented), but resulting demand is not fully addressed 0: policies, procedures or programs are not being implemented	
		8.2 Sector development: does the government have ongoing programs and measures to strengthen the role of service providers (private or public) in the provision of FSM services, in urban or peri-urban areas?	**0**	**0**	**0**	**0**	**0**	1: programs and measures to strengthen service provision have been/are being implemented; service providers are organized, their actions are coordinated and the FSM services they provide are expanding. 0.5: programs and measures to strengthen service providers have been implemented or partially implemented; the majority of service providers remain largely disorganized and the FSM services they provide are not expanding at an appropriate rate.	The majority of government stakeholders do not provide any programs to strengthen the role of service providers. Apparently, DIGESA does offer some support to service providers, mainly for capacity building, but none of the local stakeholders or NGOs were aware of this support.

Sub-question		Question	Containment	Emptying	Conveyance	Treatment	End-use/disposal	Indicator/ Score	Comments
								0: programs and measures to strengthen the service providers do not exist (or exist on paper only and have not been implemented); the service providers remain disorganized and the FSM services they provide are not expanding.	
	9. Service outcomes	**9.1 Public Health:** What is the magnitude of public health risk associated with the current fecal sludge flows (through the stages of the fecal sludge service chain)?	**0.5**	**0**	**0**	**0**	**0**	1: low level risk identified (compare to Excellent result from PHRA) 0.5: medium level risk identified (compare to Good or Bad result from PHRA) 0: high level risk identified (compare to Terrible result from PHRA)	The practice in Lima is to dig a new pit once the one in use is filled-up. Pits are sometimes not deep enough (esp. in rocky soils in the hills) or not sealed properly. TWs suggest some households dump fecal sludge along with other solid HH waste. Around 92% of the city has sewerage.
		9.2 Quantity: Percentage of total fecal sludge generated by the city that is managed effectively, within each part of the service chain	**0**	**0**	**0**	**0**	**0**	Identify a score for each stage of the service chain (containment / emptying / transport / treatment / disposal / end-use): 1: >75% of fecal sludge generated is managed effectively, at that stage of the service chain 0.5: >50% of fecal sludge generated is managed effectively, at that stage of the service chain	Scores are based on the SFD for lowest-income areas, as this is where the absence of FSM services is affecting effective management of FS. The practice of abandoning pits once full that has been used for many years is proving to be a hazardous and unsustainable practice.

Sub-question		Question	Containment	Emptying	Conveyance	Treatment	End-use/disposal	Indicator/ Score	Comments
								0: <50% of fecal sludge generated is managed effectively, at that stage of the service chain	
		9.3 Equity: To what extent do the city's FSM systems serve low-income communities? (Containment, Emptying and Transport services only)						1: FSM systems and services are widespread and readily available in low-income communities 0.5: FSM systems and services are available on a partial / piecemeal basis in low-income communities (or in some) 0: FSM systems and services are not available to any significant extent in low-income communities	THIS IS CONSIDERED AS PART OF QUESTION 5.2.
		Scores	**1**	**1.5**	**1**	**0**	**0**		

Annex E Public health risk assessment: scoring used

Observations: To standardise this process, a number of pre-set questions are answered by the observer at each stage of the process, with the observer selecting the most appropriate response from a pre-selected list (including 'Other' and 'Don't know' options) in each case. Each set of responses is ranged to indicate a High / Medium and Low risk activity, with a score allocated to each response High risk = 3, Medium risk = 2, Low risk = 1. 'Other' or 'Don't know' responses had to be considered separately and an appropriate score allocated depending on additional information provided (photographs, notes, etc.).

- For example, one Transport stage question was "During the transport of faecal sludge, does sludge spill into the surrounding environment?" Response categories were: Sludge spillage occurs along the route at various times (scores 3 = High risk); Slight sludge spillage occurs at specific times, e.g. going down slopes or over rough ground (scores 2 = Medium risk); No spillage occurs – equipment contains all of the sludge during transport (scores 1 = Low risk).

Tables showing the full set of observation questions and the rating values of responses are available from the links in Annex F.

For each stage of the service chain, a collated score was put into a risk category based on scoring ranges (again, High / Medium / Low ranges). These scoring ranges were based on experience of approaches for assessing risk to water supplies and from sanitation facilities in other studies. In some cases, the **highest** risk score would be considered as the most relevant to identify – particularly in relation to contact between fecal sludge and drinking water supplies or human directly (through hands, feet, etc.).

Table 35 Risk scores along the service chain

Stage of the service chain	Max risk score per stage	Score range for risk level		
		Low	Med	High
Containment	27	9-14	15-21	22-27
Emptying	9	1-4	5-7	8-9
Transportation	9	1-4	5-7	8-9
Treatment	15	1-8	9-11	12-15
Disposal	18	1-9*	10-14*	15-18*
End use	12	1-6	7-9	10-12

*** Note relating to Disposal scores:**
If Qn1 scores 2 or 3, and Qn2 or Qn3 score 2 or 3, this implies medium (no scores of 3) or high (one or more scores of 3) risk
If Qn1 scores 2 or 3, and Qn4 and Qn5 both score 2 or 3, this implies medium (no scores of 3) or high (one or more scores of 3) risk

Using the rating and scoring process during observations of emptying practices, a summary of identified risks is shown in Table 11. The observations follow the practice as far along the service chain as is possible – which changes depending on the latrine type. Although the number of observations carried out is small, these results may be taken as somewhat representative of what emptying practices occur in Lima, given the limited extent to which this happens at all.

Table 36 Risk of immediate human exposure with FS, at each step of the process

No.	Containment type	Containment	Emptying	Transportation	Treatment	Disposal	End use
1	Pit	Low	Low	Low	Not observed	Not observed	Not observed
2	Septic tank	Low	Low	Low	Not observed	Not observed	Not observed
3	Pit	Med	Low	Low	Not observed	Not observed	Not observed
4	Abandoned pit	Low	n/a	n/a	n/a	Med	n/a
5	Two-vault UD	Low	Low	n/a	Low	Low	Low
6	Portable UD container	Low	Low	Low	Low	Med	Med

Transect walks: Participants used a standard reporting format to allocate scores to help represent a qualitative assessment of the relative impact from physical and environmental conditions on being able to achieve effective and safe FSM services in that locality.

Categories included in the conditions that were recorded included: drainage infrastructure and use (noting the presence of storm water, greywater and/or blackwater); evidence of open defecation, dumped fecal sludge or solid waste; public latrine coverage; access to water points; housing density; conditions of roads and paths. Each category was pre-allocated 5 observed responses, ranging from very poor conditions (scoring 5) through to very good conditions or no evidence found (scoring 1). Scores of 1 therefore represent the lowest impact and 5 the highest impact on FSM services. Results from the 40 transect walks (10 in subsample A PSUs and 10 in subsample B PSUs) are shown in Table 37.

For certain categories relating to FSM (for example evidence of open defecation, fecal sludge, blackwater in drains) that scored 3 or more, participants identified the location of the observation, how often the particular risk occurred in the area, by asking members of the community for information, and the mechanism for human contact and contamination route (through people walking in bare feet, entering drains, blackwater in drains overflowing near to homes, etc.).

Tables showing the format for scoring conditions in the PSUs during the Transect Walks and for collecting further details where high risks were seen, are available from the links in Annex F.

Table 37 Transect walk – results of scored observations

PSU/Category	Drainage (storm water and greywater)	Drainage (blackwater)	Access to water points	Evidence of solid wastes in paths/roads	Evidence of human fecal materials (OD/dumped FS)	Evidence of animal fecal materials	Household latrine coverage	Public latrine coverage	Presence of wastewater and/or fecal sludge treatment facilities	Housing density	Paths	Roads
SAMPLE A												
PSU 2	5	5	3	4	1	3	3	1	1	2	3	2
PSU 3	4	1	3	4	1	3	4	1	1	2	4	4
PSU 4	5	5	3	4	1	4	3	1	1	3	2	2
PSU 6	5	5	2	4	1	4	4	1	1	2	2	3
PSU 7	4	5	4	3	1	1	3	3	1	3	2	2
PSU 8	4	1	3	4	1	4	3	2	1	3	4	3
PSU 11	4	1	3	3	1	4	3	1	1	2	3	2
PSU 14	4	1	3	4	1	4	4	1	1	4	4	4
PSU 16	4	1	3	4	1	4	3	1	1	2	3	2
PSU 18	4	1	3	4	1	4	3	1	1	4	2	2
PSU 19	4	1	4	4	1	5	3	1	1	2	2	2
PSU 20	4	1	3	4	3	3	4	1	1	4	4	5
PSU 22	4	1	3	4	1	3	3	1	1	2	2	3
PSU 23	4	1	3	4	4	4	3	1	1	2	3	3
PSU 24	4	4	3	3	1	4	3	1	1	1	2	2
PSU 25	4	1	3	4	1	3	3	1	1	3	3	3
PSU 26	4	1	2	4	2	5	3	2	1	2	3	3
PSU 27	5	1	3	4	1	4	3	1	1	2	3	2
PSU 28	4	1	3	3	1	1	4	4	1	3	4	4
PSU 29	4	1	3	4	2	3	3	1	1	4	4	4

PSU/Category	Drainage (storm water and greywater)	Drainage (blackwater)	Access to water points	Evidence of solid wastes in paths/roads	Evidence of human fecal materials (OD/dumped FS)	Evidence of animal fecal materials	Household latrine coverage	Public latrine coverage	Presence of wastewater and/or fecal sludge treatment facilities	Housing density	Paths	Roads
PSU 30	4	1	5	4	1	1	4	1	1	5	5	5
PSU 31	5	1	3	4	1	3	3	1	1	3	3	3
PSU 32	5	5	3	4	1	4	3	1	3	4	3	4
PSU 33	4	1	4	4	1	1	4	1	1	4	4	4
PSU 35	5	1	3	4	1	3	3	1	1	4	2	3
PSU 36	4	1	3	4	1	4	3	3	1	4	2	3
PSU 37	4	1	3	5	1	5	3	1	1	4	2	2
PSU 38	4	1	3	4	1	1	3	1	4	4	2	2
PSU 39	4	1	3	3	1	4	3	3	1	4	2	2
PSU 40	4	1	3	4	1	4	3	2	1	4	2	2
SAMPLE B												
PSU 1	4	1	3	4	1	1	3	3	1	3	3	2
PSU 5	5	5	4	4	1	4	3	1	1	3	2	2
PSU 9	4	1	3	4	1	4	4	3	1	3	4	2
PSU 10	4	1	3	4	1	4	4	1	1	4	3	3
PSU 12	4	1	3	3	1	1	4	1	1	5	5	5
PSU 13	4	1	3	3	1	4	3	1	1	4	3	2
PSU 15	4	1	3	4	1	5	4	1	1	4	2	4
PSU 17	5	1	3	4	1	4	3	1	1	3	2	2
PSU 21	5	5	4	4	1	4	3	1	1	3	2	2
PSU 34	4	1	3	2	1	5	4	1	1	4	2	2

Note: 5 = highest risk observed, 1 = lowest risk observed.

Annex F Additional tables for the economic analysis of interventions

Table 38 Design parameters for all intervention options

General design parameters	
Average urine production	1.1 litres per capita per day (LPCD)
Average fecal matter production	51 litres per annum
Proportion of feces that is water	80%
Quantity of water required per flush	15 litres
Basic water consumption (waterborne system)	150 LPCD
Basic water consumption (UDDT system)	100 LPCD
Waterborne system assumptions	
Median distance between properties	10 metres
Assumed indirect costs	20% of investment costs
Length of main sewer relative to secondary sewer	10%
Cost of canal	31 USD/Metre
Cost of secondary sewer	41 USD/Metre
Cost per control pit	642 USD
Cost per connection between main and secondary sewer	192 USD
Control pit interval	80 Metres
Retention time in secondary lagoon treatment	20 days
UDDT collection system assumptions	
Area required in composting treatment	180 m3
Required composting storage time	2 Months
Number of trucks required to serve 10,000	4 Trucks
Feces/urine collection interval	3 Months
Truck capacity (urine)	9.2 m3
Truck capacity (feces)	0.8 m3
Emptying time per HH	10 minutes
Offloading time of the truck	15 minutes
Average velocity of truck	40 km/h
Average distance between collection and treatment facility	8 km
Days trucks are operational per year	92%

Table 39 Technology costing data (Peruvian Nuevos Soles)

Intervention option	Type of cost	Containment	Emptying and transport	Treatment	Total
UDDTs with on-site composting	Capital	S/. 3,500	S/. 0	S/. 0	**S/. 3,500**
	Annualised	S/. 254	S/. 0	S/. 0	**S/. 254**
	Capital maintenance	S/. 1,050	S/. 0	S/. 0	**S/. 1,050**
	Annualised	S/. 76	S/. 0	S/. 0	**S/. 76**
	Recurrent	S/. 0	S/. 0	S/. 0	**S/. 0**
	Total annualised cost	**S/. 331**	**S/. 0**	**S/. 0**	**S/. 331**
Waterborne system with anaerobic lagoon primary treatment	Capital	S/. 1,083	S/. 696	S/. 762	**S/. 2,541**
	Annualised	S/. 79	S/. 51	S/. 55	**S/. 185**
	Capital maintenance	S/. 325	S/. 209	S/. 229	**S/. 762**
	Annualised	S/. 24	S/. 15	S/. 17	**S/. 55**
	Recurrent	S/. 0	S/. 16	S/. 9	**S/. 25**
	Total annualised cost	**S/. 102**	**S/. 82**	**S/. 81**	**S/. 265**
Waterborne system with UASB reactor primary treatment	Capital	S/. 1,029	S/. 696	S/. 1,502	**S/. 3,227**
	Annualised	S/. 75	S/. 51	S/. 109	**S/. 234**
	Capital maintenance	S/. 325	S/. 209	S/. 451	**S/. 984**
	Annualised	S/. 24	S/. 15	S/. 33	**S/. 72**
	Recurrent	S/. 0	S/. 1	S/. 18	**S/. 34**
	Total annualised cost	**S/. 98**	**S/. 82**	**S/. 159**	**S/. 340**
UDDT collection model	Capital	S/. 2,057	S/. 201	S/. 201	**S/. 2,459**
	Annualised	S/. 150	S/. 16	S/. 16	**S/. 181**
	Capital maintenance	S/. 175	S/. 60	S/. 60	**S/. 296**
	Annualised	S/. 13	S/. 5	S/. 5	**S/. 22**
	Recurrent	S/. 0	S/. 22	S/. 13	**S/. 35**
	Total annualised cost	**S/. 162**	**S/. 42**	**S/. 34**	**S/. 238**

Table 40 Technology costing data (USD)

Intervention option	Type of cost	Containment	Emptying and transport	Treatment	Total
UDDTs with on-site composting	Capital	$1,067	$0	$0	**$1,067**
	Annualised	$78	$0	$0	**$78**
	Capital maintenance	$320	$0	$0	**$320**
	Annualised	$23	$0	$0	**$23**
	Recurrent	$0	$0	$0	**$0**
	Total annualised cost	**$101**	**$0**	**$0**	**$101**
Waterborne system with anaerobic lagoon primary treatment	Capital	$330	$212	$232	**$775**
	Annualised	$24	$15	$17	**$56**
	Capital maintenance	$99	$64	$70	**$232**
	Annualised	$7	$5	$5	**$17**
	Recurrent	$0	$5	$3	**$8**
	Total annualised cost	**$31**	**$25**	**$25**	**$81**
Waterborne system with UASB reactor primary treatment	Capital	$314	$212	$458	**$984**
	Annualised	$23	$15	$33	**$71**
	Capital maintenance	$99	$64	$137	**$300**
	Annualised	$7	$5	$10	**$22**
	Recurrent	$0	$5	$5	**$10**
	Total annualised cost	**$30**	**$25**	**$49**	**$104**
Dry collection model	Capital	$627	$61	$61	**$750**
	Annualised	$46	$5	$5	**$55**
	Capital maintenance	$53	$18	$18	**$90**
	Annualized	$4	$1	$1	**$7**
	Recurrent	$0	$7	$4	**$11**
	Total annualized cost	**$49**	**$13**	**$10**	**$72**