SFD Promotion Initiative

Lima, Peru

Final Report

This SFD Report was created through desk based research by WEDC as part of the SFD Promotion Initiative. It is primarily based on a recent World Bank FSM diagnostic report. See Acknowledgments.

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SFD Promotion Initiative

sustainable sanitation alliance

giz Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

On behalf of Federal Ministry for Economic Cooperation and Development

UNIVERSITY OF LEEDS

WORLD BANK GROUP Water

wsp water and sanitation program

WEDC

Loughborough University

CSE

eawag aquatic research

Sandec Sanitation, Water and Solid Waste for Development

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SFD Report **Lima, Peru,** 2016

Produced by:

Claire Furlong

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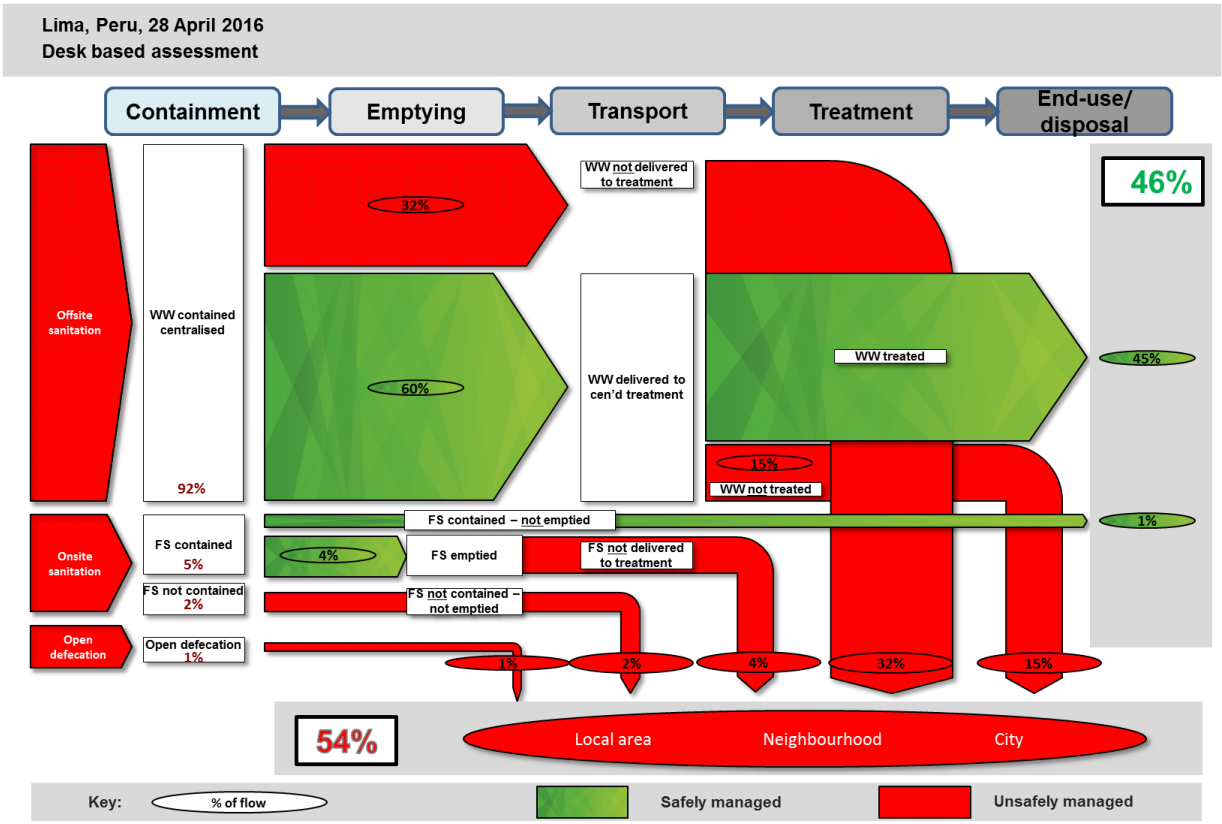
1. The Diagram



2. Diagram information

The excreta flow diagram (SFD) was created through desk based research by WEDC (Water, Engineering and Development Centre) Loughborough University.

Collaborating partners: The World Bank Water and Sanitation Program and Oxford Policy Management Ltd.

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3. General city information

Lima the capital of Peru and the third largest city in Latin America covering an area of 2,700 km^2. It is located on the Pacific coast in an area of high seismic activity. Metropolitan Lima consists of the Province of Lima and the Constitutional Province of Callao (which is an ocean port). These provinces are sub-divided into 49 districts. The provinces and districts are administratively autonomous, so that citywide planning and development is undertaken only by means of negotiated decisions.

The city lies within the valleys of three main rivers: Rímac, Chillón and Lurín. The dominant soil type is alluvial gravel.

Lima is located in a coastal desert. Because of this Lima is classified as a subtropical desert or low-latitude arid hot climate (Köppen classification: BWh). The average temperature in Lima is 20°C, with a variation of 6°C. The total annual precipitation averages 6mm (Climatemps, 2016). Lima has two seasons; winter (May to November) and summer (December to April), but there is little temperature variation during these seasons; the main difference is in cloud cover.

Approximately one third of Peru's population live in metropolitan Lima (ODI, 2015). It has an estimated population of 9,904,727 (City population, 2015). The population density of the city is approximately 3,700 people per km^2 and the annual growth rate is approximately

1.6%. Over 48% of the population live in slums (ODI, 2015).

4. Service delivery context

Peru has ***national policies*** and plans for the sanitation sector, but all relate to sewered systems. There is a lack of policy relating to faecal sludge management. The National Environmental Action Plan contains goals for wastewater:

Goal 1.1: by 2021 100% of urban domestic wastewater should be treated and 50% of treated effluent should be reused.

The National Sanitation Sector Plan quantifies the amount of investment required for universal sanitation coverage. In order to achieve Goal 1.1 an investment of US$ 16.3 billion is required.

Housing Resolution was formed to prioritise and allocate investment in the sanitation sector. This favours sewer rehabilitation over wastewater treatment plant projects, and prioritises those with the highest amounts of co-financing, which could make it difficult to reach universal wastewater coverage.

The Water Resources Act contains the ***regulations*** for the discharge and reuse of treated wastewater. This Act defines the conditions and procedures for the authorisation of discharging and reuse of treated wastewater, and prohibits the discharge and reuse of untreated wastewater. This is not enforced as it is known the untreated wastewater is used in agriculture.

The Solid Waste Act governs the solid waste produced during wastewater treatment. All sludge and solid waste generated from primary treatment are considered to be hazardous waste and should be disposed at a secure landfill. There are no criteria for the reuse of treated sludge. It should be noted that there are no formal regulations or legal frameworks for faecal sludge management generated from offsite sanitation.

The discharge from all wastewater treatment plants needs to meet the maximum permissible limits regardless of their size. The parameters covered are fats and greases, thermotolerant coliforms, BOD_5, COD, pH, total suspended solids and temperature. The frequency of monitoring is dependent on the volume of the waste stream and is set by Ministerial Resolution. Compliance must be reported to the Ministry of Housing, Construction and Sanitation.

5. Service outcomes

92% of the populations' excreta discharge directly to sewers. Of this stream 65% (or 60% of the populations' excreta) reaches a wastewater treatment plant. This is due to the treatment capacity in Lima being presently 65% of volume of waste entering the sewers. This is then partially treated (75%).

3% of the populations' excreta is contained in sealed tanks, 3% in unlined pits (which are never emptied) and 1% in lined pits. The sealed tanks and lined pits are emptied by vacuum tankers. The faecal sludge is the taken to Hauycoloro landifill site.

6. Overview of stakeholders

Nationally the Ministry of Housing, Construction and Sanitation overseas the sanitation sector via the National Sanitation Unit. The Ministry of the Environment deals with the legal aspects of solid waste (e.g. sludge and faecal sludge) while the Ministry of Agriculture monitor effluent and water bodies via the National Water Authority. The Ministry of health is in charge of the public health aspect of poor sanitation. It can be seen at ministerial level there is segmentation of the sector.

The main sanitation provider in Lima is SEDAPAL (The Water and Sewerage Service of Lima) which is a utility company owned by the state. There are only a few private operators in faecal sludge management, due to 92% of the population being sewered.

The regulation of this sector is undertaken by the Water and Sanitation Regulator (SUNASS) who are independent of the ministries. They are funded by a 2% levy on water and sewerage bills.

7. Credibility of data

A majority of the data in this report and

executive summary, unless stated otherwise is taken from:

The World Bank Water and Sanitation Program 2016 Report: Fecal Sludge Management: Diagnostics for Service Delivery in Urban Areas, Case study report – Fecal sludge management in Lima, Peru.

The World Bank study was based on a household survey, transect walks, observations, key informant interviews and focus group discussions. It also incorporates a review of the enabling environment for FSM in Lima. It should be noted that no other stakeholders were involved in the production of this report.

8. Process of development

The fate of infiltrate from soakaways and pit latrines has been disregarded in the SFD. It was deemed to have little, if any, direct impact on health or the local environment (through ground water pollution). The SFD represents only the flows of wastewater and faecal sludge through the sanitation service chain.

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SFD Lima, Peru, 2016

Produced by:
WEDC, Dr Claire Furlong in collaboration with the World Bank Water and Sanitation Program and Oxford Policy Management Ltd.

This Executive Summary and the SFD Report are available from:
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Table of Contents

List of tables

List of figures

Abbreviations

BOD_5	Biochemical Oxygen Demand over 5 Days
COD	Chemical Oxygen Demand
ENAHO	National Household Survey (Encuesta Nacional de Hogares)
FSM	Faecal Sludge Management
GWI	Global Water Intelligence
INEI	National Institute of Statistics and Information (Instituto Nacional de Estadística e Informática)
NGO	Non-Governmental Organisation
ODI	Overseas Development Institute
OPM	Oxford Policy Management
PLANAA	National Environmental Action Plan (Plan Nacional de Acción Ambiental)
PNI	National Sanitation Sector Plan (Plan Nacional de Inversiones de Sector Saneamiento)
SEDAPAL	The Water and Sewerage Service of Lima (Servicio de Auga Potable y Alcantarillado de Lima)
SFD	Excreta Flow Diagram
SUNASS	National Superintendence of Sanitation Services (Superintendencia Nacional de Servicios de Saneamiento)
WEDC	Water, Engineering and Development Centre
WHO	World Health Organisation
WWTP	Wastewater Treatment Plant

1 City context

Lima is the third largest city in Latin America and the capital of Peru. It is the country's industrial, commercial and economic center. It covers areas of approximately 2,700 km². Metropolitan Lima consists of the Province of Lima and the Constitutional Province of Callao (which is an ocean port). These provinces are sub-divided into 49 districts (Figure 1). The provinces and districts are administratively autonomous, so that citywide planning and development is undertaken only by means of negotiated decisions.

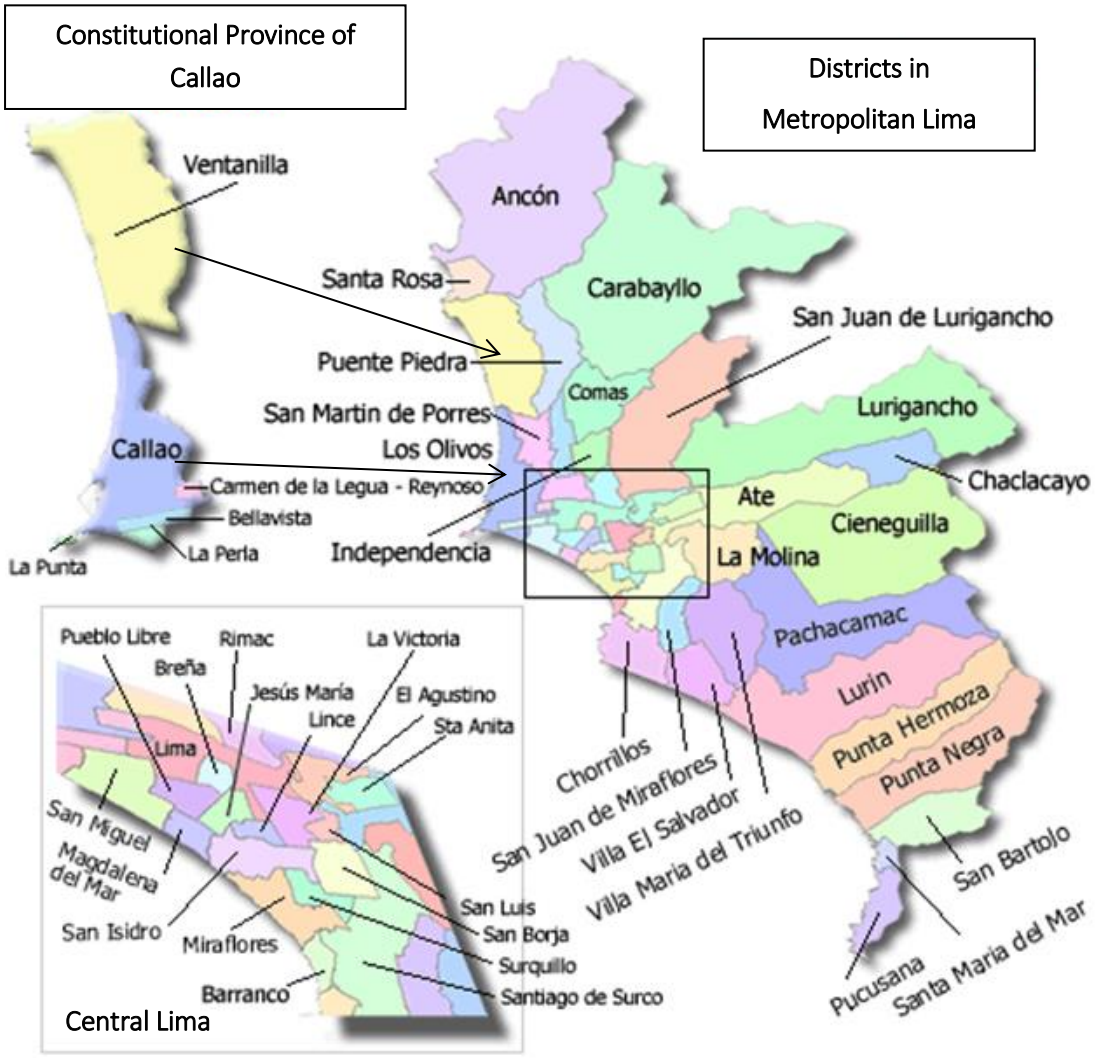

Figure 1: Metropolitan Lima and its districts (Adapted from Estamosjodidos, 2016)

1.1 *Geography*

Lima is located on the Pacific coast (12°1'S, 77°6'W) in a zone of high seismic activity. It lies within the valleys of three main rivers: Rímac, Chillón and Lurín and beneath the city lies two alluvial aquifers (Lerner et al., 1982). The depth of aquifers vary across the city, from being almost at the surface in Callao and upstream of Arte (where springs are found) to 75 m deep

(Lerner et al., 1982). The typical well depth in central Lima and Callao is between 100 and 150 m (Lerner et al., 1982). The dominate soil type in Lima is alluvial gravel (from river deposits) (Calderon et al., 2011).

1.2 *Climate*

Lima is located in a coastal desert which lies between the Andes and the Pacific Ocean. Because of this it is classified as a subtropical desert or low-latitude arid hot climate (Köppen classification: BWh). The average temperature in Lima is 20°C, with a variation of 6°C. The total annual precipitation averages 6mm (Climatemps, 2016). Lima has two seasons winter; (May to November) and summer (December to April). There is little temperature variation during these seasons; the main difference is in cloud cover.

1.3 *Population*

Approximately one third of Peru's population live in metropolitan Lima (ODI, 2015). The population is estimated to be 9,904,727 (City population, 2015), it is close to becoming a mega-city. The population density of the city is approximately 3,700 people per km² and the annual growth rate is approximately 1.6%[1]. Over 48% of the population live in slums (ODI, 2015).

2 Service delivery context description

A detailed review of the legislation relating to sewage treatment can be found in Diagnóstico de Las Plantas de Tratamiento de Aguas Residuals (GIZ/SUNASS, 2016).Unless otherwise specified the information this section has originates from this report.

2.1 *National Policy*

The National Sanitation Plan (El Plano Nacional de Saneamiento) 2006-2015 supplies the framework to harmonise the actions of the sanitation sector in Peru (Figure 2). The main objectives of this plan is to expand coverage of treatment to 100% of wastewater discharged to sewers by 2015. The Water and Sewerage Service of Lima (SEDAPAL: Servicio de Auga Potable y Alcantarillado de Lima) were expected to achieve this goal, but from the analysis in Section 3.1 it can be seen that this did not occur.

The National Environmental Action Plan (Plan Nacional de Acción Ambiental, PLANAA) 2011-2021 also contains goals for wastewater:

- Goal 1.1: by 2021 100% of urban domestic wastewater should be treated and 50% of treated effluent should be reused

This new goal also emphasises reuse. Treated and untreated wastewater are already reused in Lima due to its arid climate. The National Sanitation Sector Plan (Plan Nacional de Inversiones de Sector Saneamiento (PNI), 2014-2021) quantifies the amount of investment

[1] Calculated using the data from City population, 2016 and data from Section 1

required for universal sanitation coverage. In order to achieve Goal 1.1 an investment of US$ 16.3 billion is required.

Housing Resolution (Ministerial Resolucion No. 270-2014) was formed to prioritise and allocate investment in the sanitation sector. Under this resolution sanitation projects are rated between 0-5, in accordance with priority. In this scheme sewer rehabilitation projects are prioritised above new or rehabilitation of wastewater treatment plants (WWTPs). It also favours projects considered in the Optimisation Master Plan (Plan Masetro Optimizado) with the highest amounts of co-financing. This will make it difficult for SEDAPAL to reach Goal 1.1, as funding is directed to sewer rehabilitation and small WWTPs, rather than rehabilitation of current plants or the building of new large WWTPs.

The Water Resources Act (Ley de Recoursos Hidricos) contains the regulations for the discharge and reuse of treated wastewater. This act defines the conditions and procedures for the authorisation of discharging and reuse of *treated* wastewater, and prohibits the discharge and reuse of *untreated* wastewater. This is not enforced as it is known the untreated wastewater is used in agriculture (Global Group Japan Inc., 2011). Discharged treated wastewater must meet the maximum permissible limits (as dictated in law) and ensure the water body complies with the environmental quality standards. For reuse WHO reuse guidelines must be met. This act also gives the National Water Authority (Authoridad Nacional del Agua) the responsibility for controlling wastewater discharges and reuse.

The discharge from WWTPs must meet the maximum permissible limits which are set for all plants regardless of size (Supreme Decree No. 003-2010-MINAM). The parameters covered are fats and greases, thermotolerant coliforms, BOD_5, COD, pH, total suspended solids and temperature. The frequency of monitoring is dependent on the volume of the waste stream and are set by the Ministerial Resolution No. 273-2013-VIVENDA. Compliance must be reported to the Ministry of Housing, Construction and Sanitation.

The Solid Waste Act (Ley General de Residuos Sólidos y Su Reglamento) governs the solid waste produced during wastewater treatment, such as waste produced during screening and sieving, fat from degreasing and sludge. All sludge and solid waste generated from primary treatment are considered to be hazardous waste and should be disposed at a secure landfill. This act does not consider the reuse value of the sludge. No distinction is made between treated and untreated sludge, therefore Peru has no criteria for the reuse of treated sludge. It should be noted that there are no formal regulations or legal frameworks for faecal sludge management (FSM) generated from offsite sanitation.

The main objective of the National Climate Change Plan (Plan Nacional Ante el Cambio Climático) is to build the capacity to develop a low carbon economy. The plan proposes options for mitigating climate change in the sanitation sector, all relate to the capture, burning and utilisation of the methane

2.2 *Institutional roles*

The main provider of both drinking water and sanitation services is in Lima is SEDAPAL (a state owned utility company), which has been in operation since 1981. SEDAPAL is in charge of the operation, maintenance, control and development of water and sanitation services. It also undertakes tasks relating to regulation, planning, programming and financing. SEDAPAL provides services to both Lima and Callao. Additional stakeholders in the sector can be found in Table 1 and the interaction of the stakeholders and an organogram of the sector can be found in Figure 2. Currently there is segmentation of the sanitation sector across different institutions (Table 1 & Figure 2), so a clear designation of responsibilities is required (GIZ/SUNASS, 2016).

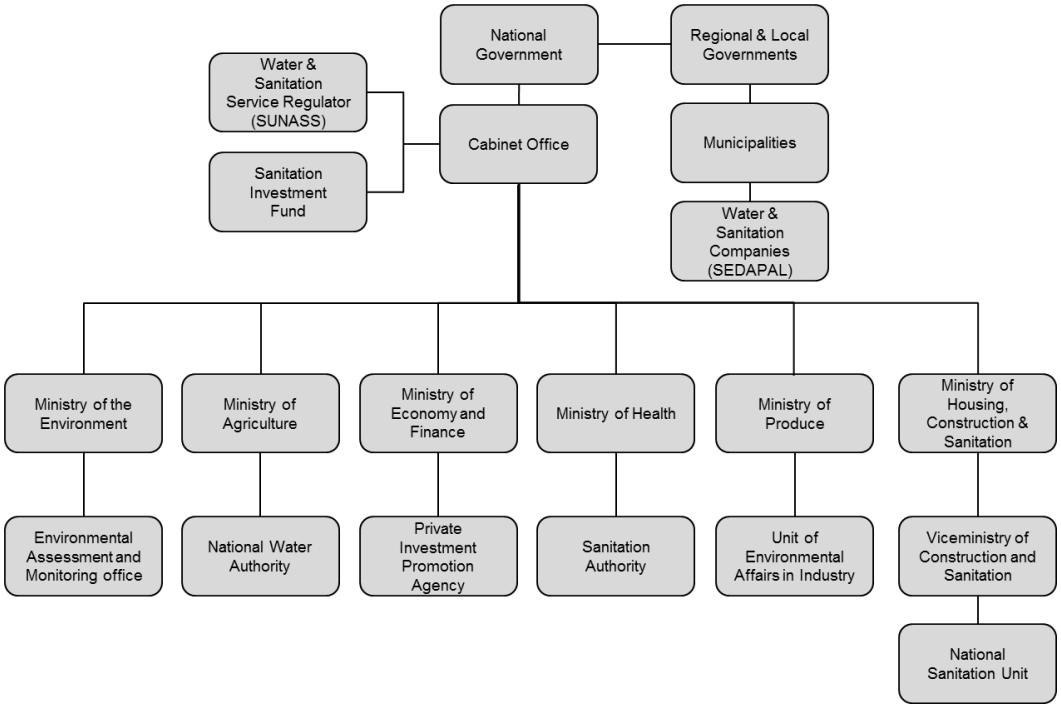

Figure 2: The government ministries and institutions associated with sanitation management

(adapted from GWI, 2015)

Table 1: Key stakeholders and their role in sanitation

Level	Stakeholder	Assigned roles
National government	Ministry of Housing, Construction and Sanitation	• Improve sanitation management • Guarantee the sustainability and improve access and quality of services • 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 • Funded by 2% levy on water and sewerage bills
	Ministry of Environment	• Reduce socio-environmental conflicts • Improve quality of life through a better environment (e.g. reduce pollution of water resources) • Developing new law for solid waste management, which includes emptying, transport, treatment and reuse of bio-solids i.e. faecal sludge
	Ministry of Health – Executive Directorate of Environmental Health	• Enforcement of sanitation regulation • Health promotion and inspection of possible risk areas related to poor sanitation
	National Water Authority	• The characterisation of water bodies • Compliance of WWTP with the Environmental Quality Standards
	General Directorate of Environmental Health – Sanitation Authority	• Technical regulation for water supply, management of greywater and blackwater, faeces disposal, and solid waste management • Monitoring and control of communicable diseases
Local government	Lima Metropolitan Municipality	• Encourage housing associations to formalise their communities and officially request access to basic public services. • Provide permits for solid waste collection • Health promotion
	SEDAPAL (Lima Water Supply and Sewerage Service)	• Mandates the operation, maintenance, control and development of water and sanitation services • Undertaking tasks related to regulation, planning, programming and financing, among others
Private sector & NGOs	Property Developers	• Install onsite sanitation or connect to sewerage
	Households	• Build sanitation facilities or request sewerage services
	Mega Pack Trading	• Provision of faecal sludge management services for public facilities

In terms of the stakeholders there is a lack of responsibility for FSM across the sector. As a result, sector planning and public budgets are unlikely to encompass FSM as no stakeholder can be held accountable for investments and results.

3 Service Outcomes

3.1 *Offsite systems*

Between 91-92% of the population are connected to the sewer network in Lima (ENAHO, 2013; SUNASS, 2013). The service is provided by SEDAPAL. In 2013 only 51% of the sewage entering the network was being treated (SUNASS, 2013), but this increased to 60-70% when South America's largest WWTP (La Traboada) became operational in 2016 (OPM, 2016). When La Chira WWTP becomes operational by the end of 2016 it is estimated that 80- 100% of sewage will be treated (OPM, 2016;World Bank, 2014). The effluent from both of these new WWTP is discharged via deep sea outfall (GIZ/SUNASS, 2016). As La La Traboada WWTPs will treat 56% of the populations wastewater (FutureEnviro, 2014), which is then discharged to sea, it is unlikely that Lima will meet Goal 1.1 for reuse set in PLANAA. This may also impact the current practice of using treated and untreated wastewater for irrigation. Of effluent samples taken across all SEDAPALS WWTPs in 2013, 84% met the BOD_5 and 56% met the thermotolerant coliform standards ((GIZ/SUNASS, 2016).

SEDAPAL has 24 WWTPs, including one that is not functioning and one under construction, covering all 48 of SEDAPAL service regions (GIZ/SUNASS, 2016). 21 of the WWTP have secondary treatment, four have tertiary treatment (two have sand filters and two have nutrient removal) and 15 have chemical disinfection of the effluent (GIZ/SUNASS, 2016). There is sludge treatment at all of the plants and the sludge is then disposed of at one of Lima's four landfills (GIZ/SUNASS, 2016).

In terms of the SFD it is assumed that 65% of the wastewater currently collected in the sewers reaches one of Lima's many WWTPs. This is on the basis of the wastewater treatment capacity. Once at the WWTP it is assumed that 75% of the incoming wastewater is treated on the basis of available data.

3.2 *Onsite systems*

The offset unlined pit is the most popular onsite sanitation option in Lima. Septic tanks are only found in high income areas which are not connected to sewers and have a piped water supply. It is unlikely that septic tanks function effectively, so in this report they are considered to be sealed tanks.

3.3 *Usage*

The usage data for different sanitation systems can be seen in Table 2. The data used to generate the SFD is from ENAHO (2013) as is the most recent large data set.

Table 2: Sanitation systems used in Lima

Type of sanitation system %	INEI 2007	ENAHO 2013	SUNASS 2013
Sewerage (toilet inside the home)	78	87	91*
Sewerage (toilet outside the home, but inside the building or compound)	7	4	N/A
Pit latrine	7	1	N/A
Septic tank	5	3	N/A
Unlined pit	N/A	3	N/A
River / channel (direct discharge)	1	<1	N/A
No service	2	1	N/A

*population connected to sewers

3.4 *Categories of origin*

This report and the SFD are based on an *in-depth* World Bank study on household faecal sludge management. It does not consider non-household generated faecal sludge, such as faecal sludge from schools. Schools were identified in the other city studies[2] as a potential significant contributor to faecal sludge flow across these cities. To include the flow of excreta from schools, a better knowledge of the use of school and home sanitation facilities is required, so usage could be split between locations and technology types.

3.4.1 Shared or communal toilet

Shared sanitation is defined by the Joint Monitoring Programme as a sanitation facility shared by two or more households. The average household size in Lima was found to be 4.4 (INEI, 2007). The World Bank study found that shared usage was relatively low in Lima even amongst those not connected to sewers (11%) and with the lowest income (11%).

3.5 *Emptying technologies for onsite sanitation*

7% of the population in Lima have onsite sanitation systems which can be emptied (Table 2). In the World Bank study 9 out of the 10 households in non-sewered areas that had pits or tanks currently in use and that filled up, claimed to have them emptied. It was reported that they were emptied by formal service providers (NGOs or private contractors) using a vacuum tanker (motorised emptying). The World Bank report identified two types of service providers: independent NGOs (i.e. X-Runner) and private companies servicing public establishments or dealing with solid waste management (i.e. Megapack Trading S.A.C.).

The World Bank report found that most households with unlined pit latrines abandoned them when full and built new ones. In many cases the pit was sealed (i.e. filled up with soil before being abandoned), but this was not always done, leaving the faecal sludge exposed within the pit.

[2] See reports for Kumasi, Nakuru, Niamey and Kisumu http://sfd.susana.org/

3.6 *End-use or disposal*

There are currently no faecal sludge treatment facilities in Lima, The motorised emptiers take the faecal sludge from onsite sanitation systems to Huaycoloro landfill site or discharge it illegally into the sewers.

3.7 *Drinking water supplies in the city*

96% of the population in Lima gain their water from SEDAPAL (piped water, standpipe or tankered), the rest of the population gain their water from a well or neighbours (INEI, 2007, SUNASS, 2013). SEDAPAL's water supply comes from the Rimac and y Chillon Rivers and is supplemented by water from the aquifers under the city (SEDAPAL, 2014). This water is treated at one of Lima's three water treatment plants la Atarjea, el Chillon or la Huchaipa (SEDAPAL, 2014).

3.8 *Risk to ground water*

In terms of identifying the risk to groundwater from sanitation sources, for generating the SFD it is assumed that course sand and gravel are the predominant rock type in the unsaturated zone (Section 1.1), and the depth to the stabilised water table is lower than 10 meters in most of the city (Section 1.1). It is assumed that less than 25% of sanitation facilities are within 10 metres of groundwater source due to most people having sewer connections (Section 3.1) and that less than 25% of sanitation facilities are uphill of groundwater sources. As a mixture of surface water and ground water are used for drinking water, therefore it is assumed that over 25% of the population use groundwater as a drinking source, but as a majority of the population are connected to a piped water supply (Section 3.7) which is assumed to be adequately treated, it has been stated that no ground water sources are used. Using these data a low ground water pollution risk was generated by the SFD matrix.

4 SFD

The data from Section 3 has been collated in Table 3 and this table was used as the basis for generating the accompanying SFD (Appendix 1). The assumptions made in the table below were that septic tanks were sealed tanks that were emptied by motorised emptiers. This is because most septic tanks are not constructed correctly, so do not function correctly. Pit latrines were defined as being lined with semi-permeable walls. As household had invested in lining the pit making them more stable it was assumed that these systems were also emptied by motorised emptiers. Unlined pits were assumed to be abandoned. An emptying efficiency of 95% was used as no technology fully empties these systems. No faecal sludge from these systems is delivered to treatment as it is generally disposed of at a landfill.

It should be noted that the SFD generated differs from the one in the World Bank study as different terms and definitions were used. Additionally this report uses a more conservative estimate for the amount of wastewater in the sewers that reaches the WWTPs of 65%,

compared to 72% used in the World Bank study. This is due to different data sources being used. Due to the margins of error associated with the data collected only streams which represent 1% of the population or more are shown in the SFD.

Table 3: Data used to generate the SFD

ENAHO terminology	SFD terminology level 1	SFD terminology level 2	%	Emptied	% emptied	% delivered to treatment	% Treated
Sewerage (toilet inside the dwelling)	Offsite sanitation	No onsite containment discharged to centralised combined sewer	92	N/A	-	65	75
Sewerage (toilet outside the home but inside the building or compound)							
Pit latrine	Onsite sanitation	Lined pit with semi permeable walls open bottom with no outlet no overflow	1	Motorised emptying	95	0	-
Septic tank		Sealed tank with no outlet no overflow	3	Motorised emptying	95	0	-
Unlined pit		Pit never emptied abandoned when full not adequately covered in soil	2	Not emptied	-	-	-
		Pit never emptied , abandoned when full and covered in soil	1	Not emptied	-	-	-
No service	Open defecation	Open defecation	1	N/A	-	-	-

The matrix has the ability to take into account the flow of infiltrate from soakaways and pit latrines, but has been disregarded in Lima. This was done to reflect the sanitation service chain more accurately in terms of wastewater and faecal sludge movement.

5 Stakeholder Engagement

The primary stakeholder in this process was the Water and Sanitation Program (WSP) of the World Bank who is the collaborating partner in this study. A majority of the data in this report unless stated otherwise comes from:

The World Bank WSP 2016 Report: Fecal Sludge Management: Diagnostics for Service Delivery in Urban Areas, Case study report – Fecal sludge management in Lima, Peru.

The World Bank study was based on a household survey, transect walks, observations, key informant interviews and focus group discussions. It also incorporated a review of the enabling environment for FSM. It should be noted that no other stakeholders were involved in the production of this report, as the World Bank had consulted with major stakeholder during their research.

6 Prospects for uptake and use of this study

The World Bank WSP 2016 Report: Fecal Sludge Management: Diagnostics for Service Delivery in Urban Areas, Case study report – Fecal sludge management in Lima, Peru, is being used internally with stakeholders, to improve and plan urban sanitation in the city. This report will be available externally on http://sfd.susana.org/ and enable external organisations to gain an overview of the current situation in Lima.

Acknowledgements

A majority of the data in this report unless stated otherwise is from the World Bank WSP Fecal Sludge Management: Diagnostics for Service Delivery in Urban Areas, Case study report – Fecal sludge management in Lima, Peru. That report was prepared by Oxford Policy Management Ltd and WEDC for the World Bank. This report was compiled as a part of the SFD Promotion Initiative project funded by the Bill and Melinda Gates Foundation.

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Appendix 1: SFD