RESOURCE RECOVERY & REUSE SERIES 6

6

Business Models for Fecal Sludge Management

Krishna C. Rao, Elisabeth Kvarnström, Luca Di Mario and Pay Drechsel

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RESEARCH PROGRAM ON Water, Land and Ecosystems

LED BY: IWMI International Water Management Institute

IN PARTNERSHIP WITH:

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Rao, K. C.; Kvarnström, E.; Di Mario, L.; Drechsel, P. 2016. Business models for fecal sludge management. Colombo, Sri Lanka: International Water Management Institute (IWMI). CGIAR Research Program on Water, Land and Ecosystems (WLE). 80p. (Resource Recovery and Reuse Series 6). doi: 10.5337/2016.213

/ faecal sludge / resource management / resource recovery / recycling / business management / models / waste disposal / dumping / sewerage / waste treatment / waste water treatment plants / solid wastes / pollution / composts / public health / sanitation / latrines / defaecation / stakeholders / finance / cost recovery / energy recovery / biogas / organic fertilizers / private enterprises / institutions / partnerships / licences / regulations / transport / septic tanks / nutrients / taxes / farmers / urban areas / landscape / household / incentives / case studies / Asia / Africa / Latin America / South Africa / Kenya / India / Rwanda / Nepal / Philippines / Lesotho / Bangladesh / Mozambique / Ghana / Senegal / Benin / Sierra Leone / Malaysia / Ethiopia / Vietnam / Mali / Sri Lanka / Burkina Faso / Peru / Haiti /

ISSN 2478-0510
e-ISSN 2478-0529
ISBN 978-92-9090-843-2

Front cover photograph: “Shit business is serious business” as seen in Accra, Ghana (credit: Priyanie Amerasinghe/IWMI).
Editors: Kingsley Kurukulasuriya and Mahen Chandrasoma
Designer: Michael Dougherty

Acknowledgments

Although this is mostly a literature survey, the authors are grateful for the information provided by different IWMI research projects funded by the Bill & Melinda Gates Foundation (BMGF); Swiss Agency for Development and Cooperation (SDC); Bundesministerium für wirtschaftliche Zusammenarbeit und Entwicklung (BMZ) (Federal Ministry for Economic Cooperation and Development), Germany; Government of the Netherlands through the International Water and Sanitation Center (IRC); United States Agency for International Development (USAID); and International Fund for Agricultural Development (IFAD). The authors thank Joseph Ravi Kumar (Water and Sanitation Program, World Bank), Kalanithy Vairavamoorthy (Practice Leader for Applied Research and Knowledge Transfer, IWMI) and Katharina Felgenhauer (Social Scientist for Public-Private Partnership, IWMI) for reviewing this report, and providing valuable insights, assistance and critique, and to Sasha Kramer (Sustainable Organic Integrated Livelihoods [SOIL], Haiti), Mbaye Mbéguéré (Office National de l'Assainissement du Sénégal [ONAS], Senegal) and Sharada Prasad (University of California, Berkeley, USA) for providing case-specific data.

Projects

This report was initiated as part of the WLE-RRR project *Fecal sludge business model development*, and benefitted from information collected by the following IWMI-led or co-led WLE projects:

- Scaling out the recovery of nutrients and organic matter from fecal sludge for food production in Ghana: From Waste to Food (WaFo) (funded by BMGF).
- Resource recovery and reuse: From research to implementation (funded by SDC).
- Safe nutrient, water and energy recovery - developing a business case: Enterprise based solutions for reuse of domestic and agro-industrial waste (funded by IFAD).
- Value at the end of the sanitation value chain (VeSV) (funded by IRC).
- Fecal sludge and urine reuse in agriculture: Opportunities for addressing phosphorus needs in India (funded by USAID through the Partnerships for Enhanced Engagement in Research [PEER] program of the National Academy of Sciences [NAS]).
- Marketing strategy and value chain for *'Fortifer'*, an innovative organic fertilizer (funded by BMZ).

Collaborators

This research study was a collaboration of the following organizations:

International Water Management Institute (IWMI)

SP Technical Research Institute of Sweden

Donors

This survey was supported by the Resource Recovery and Reuse (RRR) Flagship of the CGIAR Research Program on Water, Land and Ecosystems (WLE).

This research was carried out as part of the CGIAR Research Program on Water, Land and Ecosystems (WLE) and supported by CGIAR Fund Donors (http://www.cgiar.org/who-weare/cgiar-fund/fund-donors-2).

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ACRONYMS AND ABBREVIATIONS

AAWSA	Addis Ababa Water and Sewerage Authority
ABR	Anaerobic Baffled Reactor
AMA	Accra Metropolitan Assembly
BCR	Benefit-Cost Ratio
BSF	Black Soldier Fly
BSFL	Black Soldier Fly Larvae
BOLT	Build-Operate-Lease-Transfer
CBO	Community-based Organization
CITENCO	Ho Chi Minh City Environmental Company
CREPA	Centre Régional pour l'Eau Potable et l'Assainissement à faible Coût
CSA	Cesspool Services Association
CSIR	Council for Scientific and Industrial Research
CSO	Civil Society Organizations
DEWATS	Decentralized Wastewater Treatment System
DSK	Dushtha Shasthya Kendra
Eawag	Swiss Federal Institute of Aquatic Science and Technology
EU	European Union
FLT	Fresh Life Toilet
FS	Fecal Sludge
FSM	Fecal Sludge Management
GDP	Gross Domestic Product
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH
GSMA	Groupe Spéciale Mobile Association
HP SADCO	Hai Phong Sewerage and Drainage Company
ICRC	International Committee of the Red Cross
IPA	Innovations for Poverty Action
IWK	Indah Water Konsortium Sdn Bhd (Sendirian Berhad ≈ Ltd.)
IWMI	International Water Management Institute
KMA	Kumasi Metropolitan Assembly
LGU	Local Government Unit
MoU	Memorandum of Understanding
MDG	Millennium Development Goal
MSW	Municipal Solid Waste
NEMA	National Environment Management Authority
NFC	Near Field Communication
NGO	Nongovernmental Organization
O&M	Operation and Maintenance
ONAS	Office National de l'Assainissement du Sénégal (National Sanitation Office of Senegal)
ONEA	Office National de l'Eau et de l'Assainissement (National water Supply and Sanitation Office of Burkina Faso)
OSS	On-site Sanitation System
PPP	Public-Private Partnership
PSMBV	Programme de Structuration du Marché des Boues de Vidange (Market Structuring of Faecal Sludge Management Program)
PSTC	Population Services and Training Center
RBF	Results-based Financing
REC	Rwanda Environment Care
RRR	Resource Recovery and Reuse
Sandec	Department for Sanitation, Water and Solid Waste for Development, Swiss Federal Institute of Aquatic Science and Technology
SDG	Sustainable Development Goal
SIBEAU	Société Industrielle Béninoise de l'Environnement et de l'Aménagement Urbain
SMS	Short messaging service
SOIL	Sustainable Organic Integrated Livelihoods
SSA	Sewerage Services Act
TED	Technologies for Economic Development
TOSHA	Total Sanitation and Hygiene Access
UDDT	Urine-diverting Dry Toilet
UGSM	Uaiene Gama de Serviços de Maputo
UHT	Underground Holding Tank
UNDP	United Nations Environment Programme
URENCO	Urban Environment Company
USAID	United States Agency for International Development
US EPA	United States Environmental Protection Agency
VP	Value Proposition
WASA	Water Supply and Sewerage Authority, Dhaka, Bangladesh
WHO	World Health Organization
WLE	CGIAR Research Program on Water, Land and Ecosystems
WMD	Waste Management Department
WRC	Water Research Commission, South Africa
WSA	Water and Sanitation for Africa (formerly CREPA)
WSIA	Water Services Industry Act
WSP	Water and Sanitation Program, World Bank
WSUP	Water and Sanitation for the Urban Poor

SUMMARY

With 2.7 billion people currently relying on on-site sanitation and a global cost of USD 260 billion per year due to inadequate water supply and sanitation, financial and institutional strengthening will be needed to ensure that capital investments into the Sustainable Development Goals (SDGs) translate into effective service delivery. This report aims to increase our knowledge about locally appropriate fecal sludge management models based on data from 23 countries. The SDG indicator 6.2.1 under target 6.2 (sanitation and hygiene) emphasizes the importance of "safely managed sanitation services" which goes beyond the "access to improved sanitation" target of the Millennium Development Goals (MDGs). In the context of sanitation services, on-site sanitation systems (OSSs), such as septic tanks and pit latrines, receive renewed attention as (i) the predominant feature across rural and urban areas in most developing countries, and (ii) due to their continuing competitive advantage for future developments. The SDG target comes well in time, as the management of fecal sludge captured in OSSs remains one of the most neglected challenges of the last few decades. Constrained by limited policy attention and missing treatment plants for fecal sludge from OSSs, data on pit desludging, transport and disposal thus remain extremely scarce. Given the need for transporting of sludge, fecal sludge management (FSM) is often handled by truck operators of the (in)formal private sector or a mix of public and private operators, and in many settings the service falls in a grey area outside regulatory frameworks or utility jurisdictions.

SDG target 6.2 is set to change this. To improve sanitation service delivery also for OSSs, sector support requires enabling policies and incentive systems to advocate and mainstream the 'business' of FSM. An interesting aspect of OSSs is that the sludge collected from households (similar to farmyard manure) is not only rich in organic matter, nutrients and energy, but there is also very little risk of chemical contamination compared to sludge captured in sewerage systems often co-serving industrial areas. This offers the potential for both a safe resource and cost recovery. Indeed, an emerging set of entrepreneurs are recognizing the opportunities in human waste and are gradually playing an important role in leveraging private capital to help realize the commercial value of waste.

Based on the analysis of 44 FSM cases from Asia, Africa and Latin America, this report shows opportunities as well as bottlenecks that FSM is facing from an institutional and entrepreneurial perspective. The business cases cover either parts (or all) of the FS sanitation service chain (Figure 1). Business cases targeting only access to private or public toilets have been excluded from this study as they have been well covered in other literature.

Given the common situation of publicly financed waste and sanitation services, the term 'business' model might appear out-of-place in this sector. However, with increasing calls for cost recovery and private sector participation, the thinking is changing and business models are needed to conceptualize sustainable sanitation service chains. This report addresses the following groups of business models which cover different parts of the FSM service chain:

FIGURE 1. SANITATION SERVICE CHAIN FOR ON-SITE SANITATION SYSTEMS.

- Models for toilet access and *in-situ* energy recovery
- Models for emptying and transport of fecal sludge
- Models linking emptying, transport and treatment
- Models emphasizing reuse at the end of the service chain
- Models covering the entire sanitation service chain from toilet access to reuse.

Depending on the (often limited) information available, models have been assessed for financial, institutional, monitoring and regulatory implications, as well as possible environmental and health concerns, which could affect the successful implementation of FSM in a particular region.

Based on the case studies, interviews and literature, this report also tried to compare the financials of FSM (operations and capital) to serve a set population in India and Ghana for different components of the sanitation service chain. However, there is a significant need for more data to provide better advice on options for sustainable FSM. This report is only a start.

Finally, changing the 'business-as-usual' scenario in the conservative sector of waste and sanitation is a big challenge. It requires much more efforts in the form of capacity development and the exploration of strong incentive systems for inter-sectoral collaboration, especially between sanitation and agriculture or landscaping, to build new alliances in support of SDG 6 along with the interlinked targets around water, energy, rural-urban linkages and food security.

1. IMPORTANCE OF FECAL SLUDGE MANAGEMENT

On-site sanitation systems (OSSs), such as septic tanks and pit latrines, are a major pillar for providing access to toilets in rural and urban areas, and this is not limited to developing countries (Figure 2). OSSs currently serve more than 2.7 billion people globally and this number is expected to be as high as 4.9 billion by 2030 (Cairns-Smith et al. 2014). Despite significant progress under the Millennium Development Goals (MDGs) to increase access to improved sanitation, investments in the subsequent steps, such as the safe collection, disposal and treatment of fecal sludge (FS) from on-site sanitation systems, remain a significant challenge (Koné 2010; Blackett et al. 2014). The lack of treatment services often results in unsafe disposal of FS, which poses health and environmental hazards that may undermine improvements in drinking water supply and health services. Therefore, indicator 6.2.1 under target 6.2 (sanitation and hygiene) of the Sustainable Development Goals (SDGs) emphasizes the importance of "safely managed sanitation services," i.e., fecal sludge management (FSM) beyond the provision of toilets.

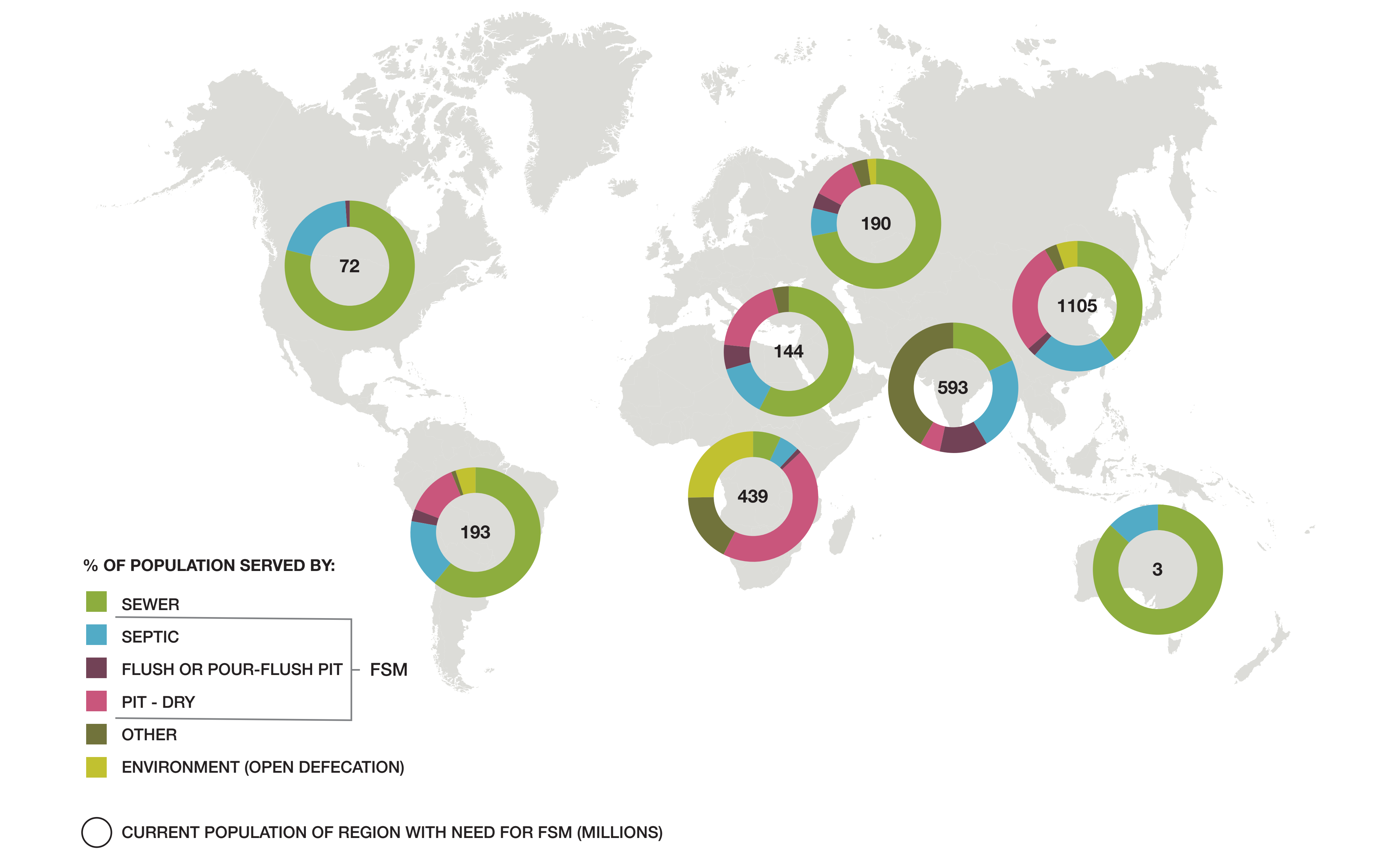
The global cost of inadequate water supply and sanitation was estimated at USD 260 billion annually (WHO 2012). The total annual capital costs of meeting SDG target 6.2 have been estimated at USD 19.5 billion for achieving basic sanitation and USD 49 billion for safe fecal waste management (Hutton and Varughese 2016). However, neither basic sanitation in terms of toilet access nor capital investments, in general, are sufficient to address the institutional, financial and management challenges of poor sanitation. There is a need not only for sustained efforts to ensure households use these latrines and create a community free of open defecation, but also for the provision of sustainable services to empty pits and transport the waste generated for safe disposal or treatment. As long as septic trucks desludge in the environment, a community should not be referred to as 'open defecation free'.

Before the SDGs were formulated, improved *access* to sanitation was one of the major policy goals throughout developing countries, with the main emphasis on the eradication of open defecation, hygiene and improved toilet facilities. The management of the generated sludge received increasing attention when it became obvious that neither public funding to expand the piped sewerage network in and around existing city centers or over long distances in rural areas nor the water required to flush these pipes might be available. Therefore, un-sewered OSSs remain an important and cost-competitive solution within many regional sanitation portfolios (Chowdhry and Koné 2012; Dodane et al. 2012; Cairns-Smith et al. 2014). The comparison of Benefit-Cost Ratios (BCRs) between urban and rural Vietnam, Philippines, Indonesia, Cambodia, Lao People's Democratic Republic and China (Yunnan), for example, showed that dry and wet pits return the highest benefits on investments, also compared to off-site wastewater treatment systems (UN ESCAP, UN-Habitat and AIT 2015).

While sanitation services around sewerage systems are mostly provided by government agencies which also regulate or operate wastewater treatment plants, and establish policies on environmental sanitation (Chowdhry and Koné 2012), on-site sanitation systems and FSM are handled by the informal and private sectors or a mix of public and private operators in many locations. In many settings, the service falls outside regulatory frameworks, policies or utility jurisdictions.

An interesting aspect of FS from domestic on-site sanitation systems is the potential for safe resource recovery from septage compared to sewage sludge generated in conventional sewer and wastewater treatment systems, since the latter has mixed sources of waste (i.e.,

FIGURE 2. POPULATION SERVED BY DIFFERENT SANITATION SYSTEMS.



Source: After Cairns-Smith et al. 2014.

domestic, industrial and urban runoff). Resource recovery allows for possibilities to apply market-based principles at least on parts of the service delivery chain where waste can offer incentives for business development and cost recovery (Murray and Buckley 2010). Thus, instead of degrading the environment, resource recovery and reuse (RRR) seeks to shift the focus away from waste that needs disposal toward creating a valuable resource that can benefit farmers, create jobs and generate funds to improve sanitation services.

So far, RRR of urban septage as peri-urban fertilizer has been largely research driven or took place with limited attention to safety in the informal sector (Cofie et al. 2005; Kvarnström et al. 2012). However, with increasing interest in a green and circular economy, and new technical innovations available for energy and fertilizer generation, there is scope for resource recovery to play an increasingly significant role (EAI 2011; Otoo et al. 2015). Indeed, an emerging set of entrepreneurs are recognizing the opportunities in human waste and are gradually playing an important role in leveraging private capital to help realize the commercial value of waste (Murray and Buckley 2010; Murray et al. 2011; EAI 2011). For any revenue generation along the sanitation service chain, market-based approaches are required and this indicates the need for resource recovery and reuse inter-sectoral collaboration with agriculture (forestry, landscaping, etc.) to avoid the common shortfalls of supply-driven market approaches.

The objective of this report is to provide options for sustainable FSM from OSSs based on the analysis of business cases and models, which can be applied to FSM either for specific components of the sanitation service chain or applicable to the entire chain. Given the common situation of publicly-financed waste and wastewater collection and treatment, the term ‘business models’ might appear out of place in this sector. However, with increasing calls for cost recovery and private sector participation, the thinking is changing (Koné 2010). To attract the private sector, fill funding gaps along the service delivery chain and make the service sustainable, clear inter-institutional arrangements and revenue models are needed, also if sanitation is and remains to be a ‘social business model’.

Depending on the information available, the business models are based on a review of business cases from Asia, Africa and Latin America. The business cases were assessed based on field study, literature review and structured interviews funded by the RRR Flagship of the CGIAR Research Program on Water, Land and Ecosystems (WLE) (https://wle.cgiar.org/RRR). Analysis of the business cases helped to develop conceptual business models for FSM which are also presented. For other business cases around toilet access, refer, for example, to Graf et al. (2014)[1].

This report is divided into two parts:

- Part I: Summarizes the analyses and key findings of business cases and business models for different components of the sanitation service chain.
- Part II: Provides details of the business models together with related case examples.

[1] See also www.toiletboard.org/the-toilet-accelerator and, for example, a recently suggested Build, Own, Operate, Transfer (BOOT) model for Kumasi (www.wsup.com/resource/improving-the-quality-of-public-toilets-in-kumasi/).

'Honey Suckers', a term given to the business of vacuum truck operations, in Dharwad, India.
Source: Sharada Prasad CS on Flickr

PART I: ANALYSIS OF BUSINESS MODELS FOR FECAL SLUDGE MANAGEMENT

2. SANITATION SERVICE CHAIN

The functioning and process flow of an OSS is characterized by access to toilets, emptying, transport, treatment and disposal or reuse as highlighted in Figure 3, and this is referred to as the 'sanitation service (delivery) chain'. The chain was used as a framework for analyzing the physical flow of FS through the system (Trémolet 2011; Blackett et al. 2014), and this report uses the chain to present the stakeholders and business models in FSM.

FIGURE 3. SANITATION SERVICE CHAIN FOR ON-SITE SANITATION SYSTEMS.

The different parts of the chain are briefly described below:

Access to toilet: Practices of open defecation or lack of adequate sanitation facilities are dealt with through the provision of an improved sanitation system, such as pit latrines and septic tanks, which safely contain and store human excreta.

Emptying and transport: Septic tanks and pit latrines contain human excreta and gradually fill up over time. Once they are full, the sludge collected needs to be emptied and transported to a designated treatment site.

Treatment: FS collected from on-site sanitation systems is treated so that its solid and liquid fractions do not harm public health and the environment.

Disposal: Safe disposal of treated sludge, especially the part which does not provide value for resource recovery for reuse, is critical to ensure isolation of the waste from human and environmental contact.

Reuse: FS contains resources such as nutrients, energy and water, all of which have intrinsic value and can offer monetary gain for the treatment plant. Depending on the process applied for treating FS, different types of products can be produced depending on the type of resource recovered.

Reuse offers an additional value proposition to FS treatment with potential for revenues by valorization of intrinsic resources in FS. As highlighted in Figure 4, resources in FS are primarily in the form of energy, nutrients and water (although other value propositions are possible, e.g., building material). The business models discussed in this report are limited to nutrient and energy recovery solutions, without going into much detail about the technology.

a) Nutrient recovery from FS

Human excreta contains organic matter which, if applied to poor soils, can improve its biophysical characteristics such as water-retention capacity. Human excreta also contains all the macro- and micro-nutrients that humans need, and also aids plant growth (Kengne et al. 2014). Recovering organic matter and nutrients in a safe way (e.g., through composting) from FS is well known and such practices have been historically recorded, especially where excreta-producing households and farms are in close proximity. In an urbanizing world, this situation has fundamentally changed, resulting in a disconnect between excreta-generating centers and food production areas.

The resulting situation is of a much different scale, involving new stakeholders and requiring incentive systems (e.g., business models, policies) to re-close the loop.

In this report, only the more common nutrient recovery examples are included, while acknowledging the potential of other technologies (Box 1) that could, for example, leapfrog the nutrient extraction by generating directly high-value protein and fat from FS, which could be marketed at a higher price than any fodder crop.

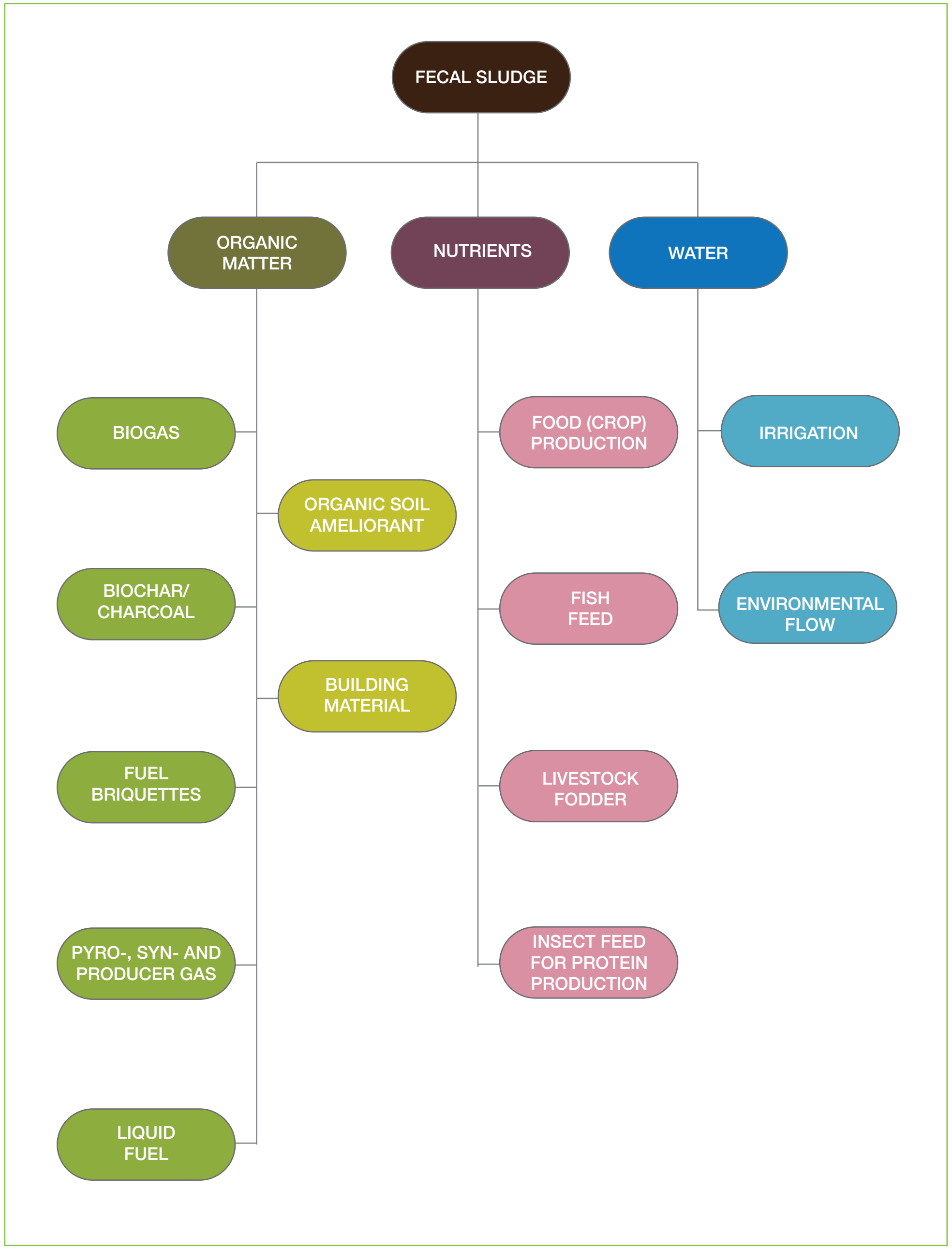
BOX 1. INNOVATIVE VALUE PROPOSITION: PROTEIN AND OILS FROM SOLID AND FECAL WASTE.

Black Soldier Flies (BSF) are non-pest detritivores (*Hermetia illucens*) whose larvae feed on decomposing matter, e.g., organic waste or feces (Nguyen 2010; Banks et al. 2014). Black Soldier Fly Larvae (BSFL) can be safely used for the bioconversion of organic waste (including FS) into protein and oil. BSFL have a high content of protein and fats, and can be used as high-protein animal feed and unsaturated fats (rich in Omega-3) for the livestock industry and pet food markets. AgriProtein, a South African start-up, has raised more than USD 10 million to build its first commercial farm to process over 100 tonnes/day (t/d) of food waste and animal manure to produce among others 7 t/d of animal feed with a 50% protein content, 3 t/d of unsaturated fat oil and 20 t/d of quality compost. AgriProtein's products have been approved as chicken and fish feed in South Africa, and they hope to obtain licenses to export their products to Europe and USA where other companies already work with BSFL (Medeiros 2014; AgriProtein 2015; Byrne 2015).

b) Energy recovery from FS

FS is rich in organic carbon and energy can be recovered in the form of heat and/or electricity through various biological, mechanical and thermal processes. Technologies used to recover energy include anaerobic digestion to produce biogas, gasification to produce syngas, pyrolysis to yield bio-oil (fuel), syngas and biochar, and incineration to generate heat. Recovering energy often results in the loss of certain nutrients due to volatilization (except in the case of anaerobic digestion, where the digestate [cake, effluent] is rich in nutrients). In the business model for toilet access and *in-situ* energy recovery (see section 6), the focus is restricted to commercially proven energy-recovery technologies such as anaerobic digestion. There are upcoming cases of converting fecal sludge into briquettes for cooking or industrial use (EAI 2011; Muspratt 2016).

FIGURE 4. RESOURCE RECOVERY AND REUSE OPTIONS FOR FECAL SLUDGE.



3. BUSINESS MODELS FOR FSM

In this report, 'business modeling' is used as a tool to articulate different FSM solutions – their costs, potential for revenue generation and interaction between diverse stakeholders in FSM (municipalities, governments, donors, policymakers, entrepreneurs, community-based organizations [CBOs] and nongovernmental organizations [NGOs]). The business models highlight the common barriers to be overcome by FSM stakeholders, and also potential opportunities and scope for increased private sector participation in sanitation service delivery. For now, the sanitation sector is still dominated by public sector actors and the role of the private sector is only gradually emerging in various components of the sanitation service chain - construction of toilets, emptying and transport of FS from OSSs, and operational contracts from the public sector to operate and manage treatment plants. This report analyzes the business models from both public and private sector perspectives. The business models presented in this report cover all components of the sanitation service chain except for access to toilets[2], unless the model also links to treatment, disposal or reuse along the chain.

3.1 Generic Business Model for FSM

The generic business model for FSM is presented using an adapted business model canvas framework by Osterwalder and Pigneur (2010), which allows to highlight multiple-value propositions as they occur across the sanitation service chain. At the core, the business model canvas describes how a business creates, delivers and captures value, and hence it helps the business develop an operational process of delivering a product or service to a target customer segment. The business model canvas presented (Figure 5) has the following elements:

- ***Customer segment:*** People, organization or institution that the business aims to serve.
- ***Value proposition:*** Products or services that create a value for a target customer segment.
- ***Channels:*** A process used to deliver the value proposition to a customer segment.
- ***Customer relationships:*** Types of relationships a business establishes with a target customer segment.
- ***Revenue streams:*** Cash generated by the business from each customer segment.
- ***Key resources:*** Most critical assets required for the business.
- ***Key activities:*** Critical activities that the business must undertake.
- ***Key partners:*** Strategic partners that play a crucial role in the operations.
- ***Cost structure:*** All costs incurred by the business to operate the business model.
- ***Social and environmental costs and benefits:*** Negative and positive externalities resulting from the business model.

The generic business model canvas for FSM can be interpreted by first linking the customer segment and the corresponding value proposition offered, followed by customer relationships and channels through which the value proposition is delivered to the customer segment. The next step is to analyze revenue streams from the value proposition offered and the relationship between remaining elements of the canvas to the corresponding value proposition. The canvas provides multiple value propositions, and its corresponding customer segments and other elements are categorized with specific color codes. The business model canvas presents generic key value propositions for providing FSM services. Broadly, the business models for FSM discussed in Part II of this report can be classified under the following five value propositions:

- ***Value Proposition 1 (VP1)*** – *Access to Toilet and Treatment for Reuse*[3]*:* Providing an improved sanitation service to communities through access to toilet, and recovery of nutrient or energy through treatment of FS.
- ***Value Proposition 2 (VP2)*** – *Emptying and Transportation of FS:* Providing a timely sanitation service for emptying pits and septic tanks when they are full.
- ***Value Proposition 3 (VP3)*** – *Treatment of FS for Disposal:* A healthier and safe environment through appropriate treatment of FS.
- ***Value Proposition 4 (VP4)*** – *Reuse through Nutrient Recovery:* Producing high-quality compost as a soil ameliorant.
- ***Value Proposition 5 (VP5)*** – *Reuse through Energy Recovery:* Improving access to energy.

Depending on the value proposition offered by the business, its customer segment will vary: for a business providing emptying and transportation services, the customer segment is individual households, businesses and institutions (VP2); and for treatment of sludge to ensure a cleaner and healthier environment for its citizens (VP3), it is the municipality. The customer segments for reuse value propositions depend on the type of resource recovered: for a business providing treatment of FS for recovery of nutrients (VP4), the primary customer segment is farmers, plantations, agricultural departments and landscapers; for the sale of fertilizer and the energy recovery business (VP5), it is households, the community and energy-intensive businesses. The other elements of the business canvas are self-explanatory.

[2] There are many reports and initiatives analyzing toilet access options, increasingly from a business perspective (refer, for example, www.toiletboard.org).
[3] This report does not focus on business models for access to toilets unless it also has treatment for disposal or a reuse component of the sanitation service chain.

FIGURE 5. GENERIC BUSINESS MODEL CANVAS FOR FSM.

Key partners

* Municipal corporation & local authorities
* Technology suppliers
* Financial institutions
* Community-based organizations
* R&D institutions (e.g., local university)

Key activities

* Toilet provision
* Waste collection
* FS collection
* FS treatment
* Organic waste and FS collection
* Compost production
* Compost – Sales & marketing
* Biogas production
* Biogas sale
* Customer relationship management

Key resources

* Appropriate technology and equipment
* Labor
* Finance
* License and contracts for collecting waste

Value propositions

* VP1: Access to toilet and increased revenue from reuse
* VP2: Timely emptying and transportation of FS
* VP3: FS treatment for healthy and safe environment
* VP4: High-quality compost (soil ameliorant)
* VP5: Reliable and renewable energy service

Customer relationships

* Direct sale of toilet
* One-on-one service provision
* Contract from municipality
* Direct or through contracts
* Direct compost sales
* Distributors
* Direct energy sale
* Power purchase agreement

Channels

* Direct
* Municipality
* Word-of-mouth
* Brochures and other media communications
* Distributors and extension agents

Customer segments

* Community
* Businesses
* Households
* Businesses
* Municipality
* Farmers
* Municipal park department
* Agriculture department
* Agroforestry
* Fertilizer industry
* Households
* Community
* Small businesses
* Public sector (e.g., municipality, ministry, etc.)
* Institutions

Cost structure

* Fixed investment cost (construction, trucks, equipment, etc.)
* Operation and maintenance cost (labor, raw material input, utilities, sales and marketing, license, etc.)
* Interest payments

Revenue streams

* Sale of toilet and reuse products
* Emptying fees and, in some instances, FS delivery fees
* FS disposal fees, sanitation tax and O&M budget support
* Sale of compost
* Sale of energy

Social and environmental costs

* Potential health risk for those in direct contact with FS (can be mitigated with the use of protective equipment)
* Improper FS treatment and disposal causing environmental and health risks for citizens

Social and environmental benefits

* Reduced pollution of water bodies and soils
* Reduced human exposure to untreated fecal sludge
* Job creation
* Improved soil and agricultural productivity
* Improved energy security

Note: Colors indicate relevance to corresponding value proposition (VP). Beige is applicable to all VPs. R&D - Research and Development.

3.2 Typology of Business Models for FSM

The business models presented in this report were developed and analyzed based on a review of 44 FSM cases from Asia (15), Africa (27) and Latin America (2) (Figure 6), taking into consideration the key challenges faced by the FSM stakeholders (Table 1).

Figure 7 presents the various business models discussed in this report. Cases and models were clustered into the following types based on the value propositions described earlier and prominence of the model along the sanitation service chain:

- Models for toilet access and *in-situ* energy recovery
- Models for emptying and transport of fecal sludge
- Models linking emptying, transport and treatment
- Models emphasizing reuse at the end of the service chain
- Models covering the entire sanitation service chain from toilet access to reuse.

FIGURE 6. CASE EXAMPLES FROM ASIA, AFRICA AND LATIN AMERICA.

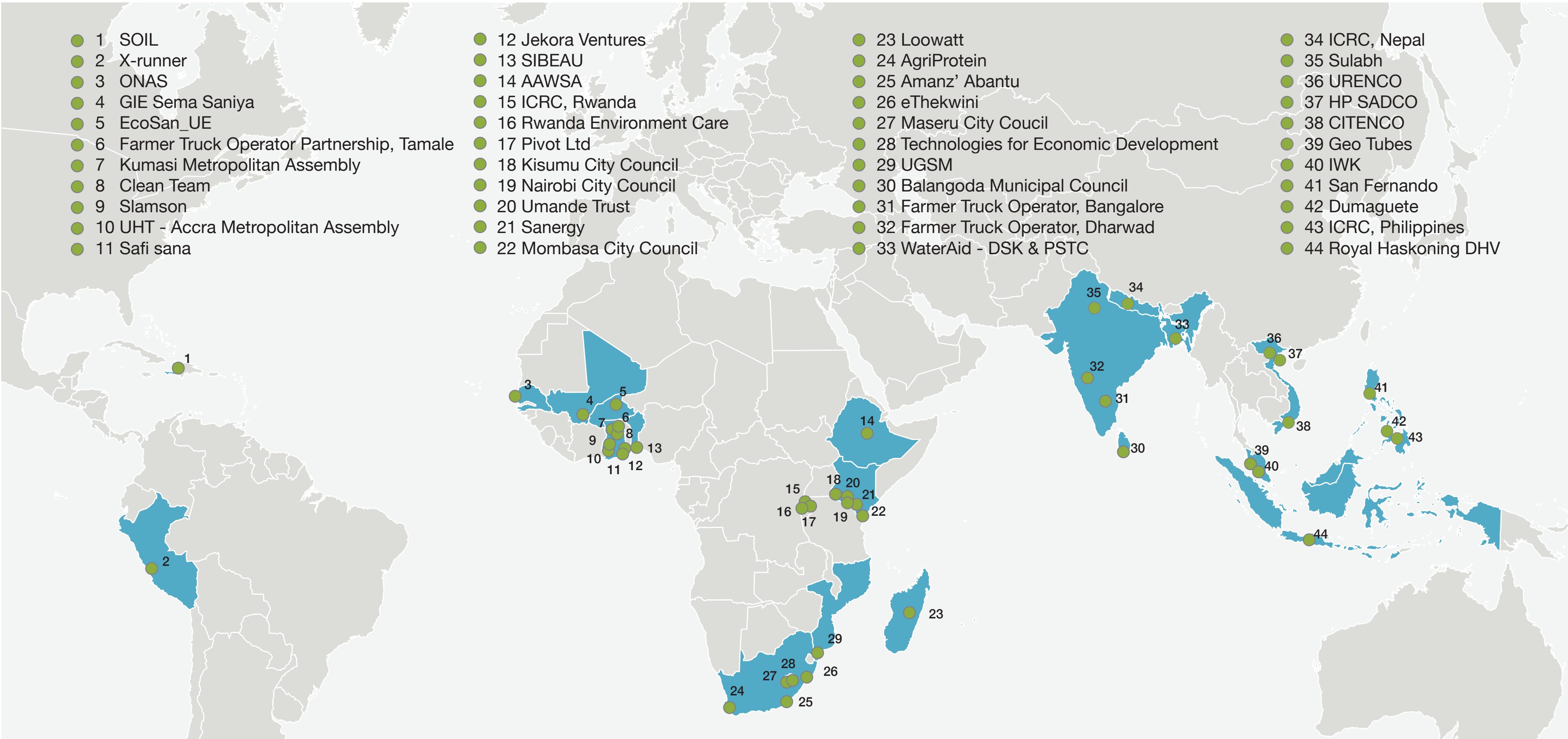
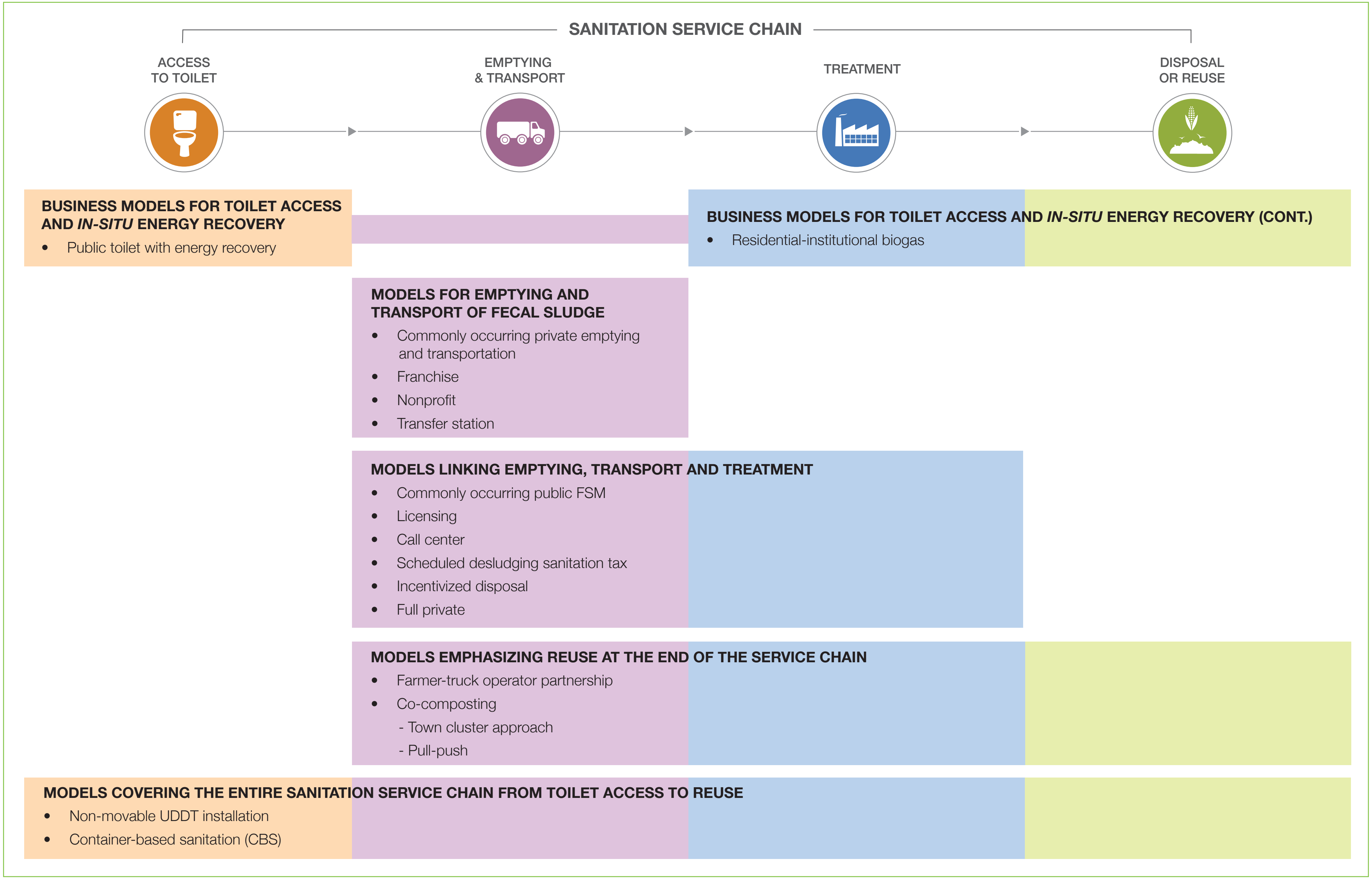


FIGURE 7. TYPOLOGY OF BUSINESS MODELS DISCUSSED IN THIS REPORT.



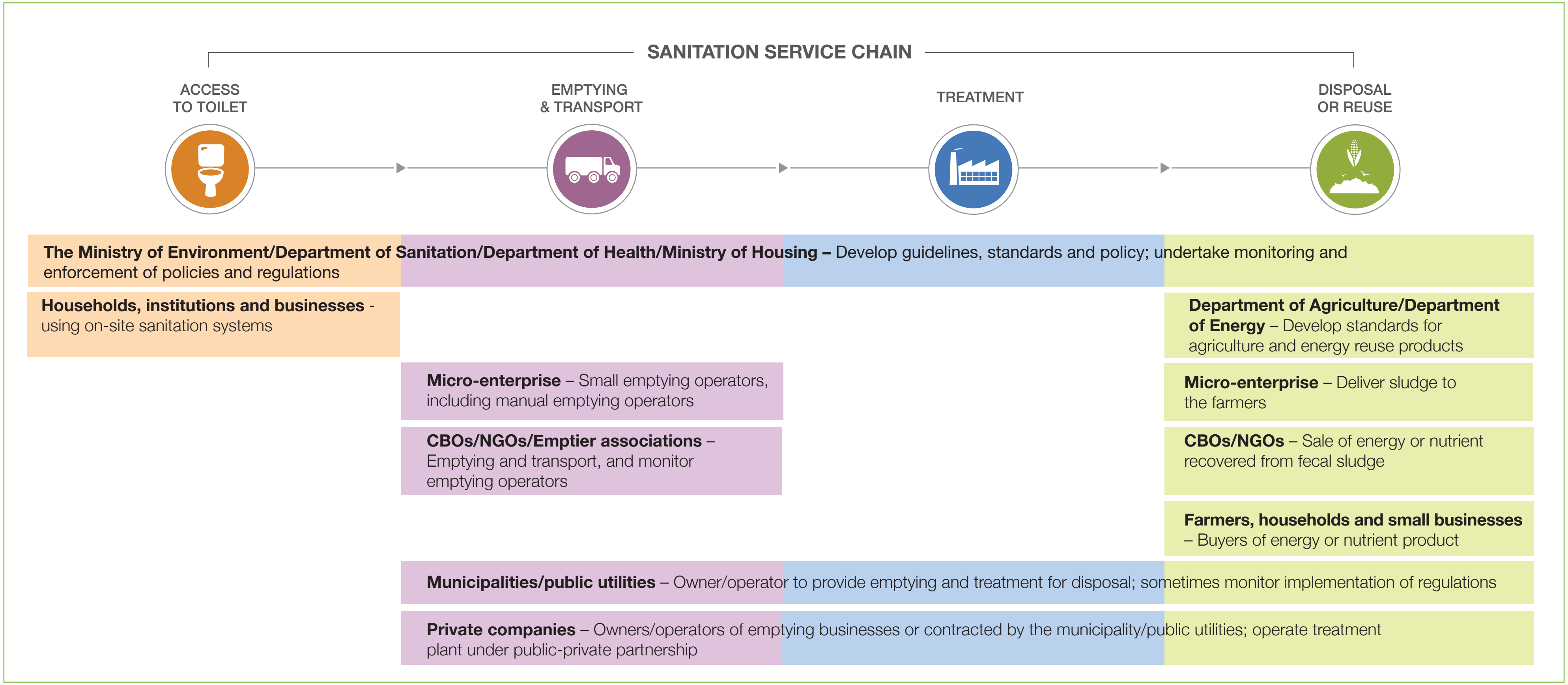
4. INSTITUTIONAL FACTORS IN THE PROVISION OF FSM SERVICES

4.1 FSM Stakeholders and Regulations

Based on the FSM business cases analyzed and corresponding business models developed, the key stakeholders engaged in FSM can be categorized across the components of the sanitation service chain as presented in Figure 8.

Households, businesses and institutions are the key stakeholders in the *Access to toilet* component of the chain. In the *Emptying and transport* component, the type of stakeholder engaged varies according to region, population, regulations and institutional arrangements, accessibility to toilets and market demand (including affordability). In most regions, municipality/public utilities are responsible for the provision of sanitation services. Private companies are sometimes contracted by municipalities/public utilities for desludging activities. Also, private companies operate independently in regions where public entities are unable to provide reliable timely services. Where households are difficult to access by trucks, the sludge is disposed of manually by operators, i.e., manual emptying. CBOs or NGOs with social mandates may play a key role in emptying and transportation in underserved

FIGURE 8. STAKEHOLDERS AND THEIR FUNCTIONS IN FSM.



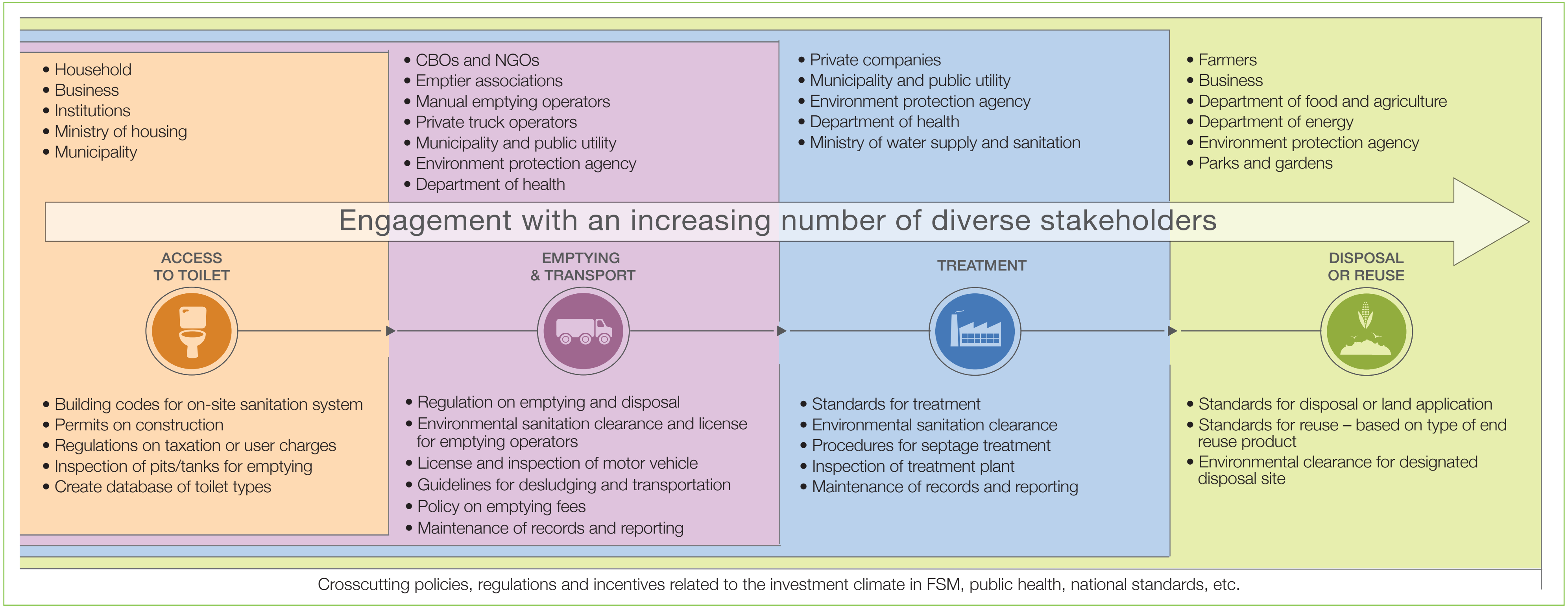
communities. In certain regions, private truck operators have formed associations primarily to lobby their business.

The *Treatment* component of the chain is generally managed by either the municipality or a (governmental) public utility. In very few cases, the municipality/public utility contract operations to a private company. There are examples of private companies in Benin, Mali and Gabon (Bassan 2014) that own and operate treatment plants. In the *Reuse* component, stakeholders engaged depend on the type of resource recovered (energy or nutrient) from FS. Private truck operators are one of the key stakeholders that deliver sludge to farmers who directly use FS on farms. NGOs and CBOs can play a key role in marketing (through awareness creation) and sale of reuse-based products.

There are additional stakeholders in FSM such as financial institutions, central and state governments that finance different parts of the sanitation chain, and institutions and ministries that are in charge of building codes and water resource protection. Stakeholders involved in the implementation and monitoring of regulation and policy either cut across more than one component of the sanitation value chain. Different institutions are involved in the formulation of regulatory standards and guidelines, and it is typically the responsibility of a regional equivalent of the Ministry of Environment and Health. The regulatory and monitoring agency at the local level is highly contextual. It can be the responsibility of the municipality, environment department and/or health authority monitoring the public or private service provider.

Figure 9 provides a snapshot of stakeholders, and relevant policies, regulations and guidelines across the sanitation service chain. As observed from the figure, in FSM, as we engage with more components of the service delivery chain, engagement with different stakeholders with varying interests increases. The diverse actors may make on-site sanitation service delivery, especially with regards to resource recovery, more difficult to implement and regulate.

FIGURE 9. INCREASING COMPLEXITY OF REGULATIONS AND STAKEHOLDERS ALONG THE SERVICE CHAIN.



4.2 Key Challenges for Stakeholders across the Sanitation Service Chain

Stakeholders across the sanitation service chain face numerous challenges and barriers (Table 1), and the success of a business model depends on its ability to address these challenges.

TABLE 1. KEY CHALLENGES FACED BY STAKEHOLDERS ALONG THE SERVICE CHAIN.

FSM COMPONENT	STAKEHOLDERS	KEY CHALLENGES
Tank/pit access	Households, businesses and institutions	▪ Where is the tank or pit actually located? ▪ Can a vacuum truck access the septic tank? ▪ How does one know when it is time for desludging? ▪ Who will desludge the septic tank? ▪ What is the cost of desludging the septic tank? ▪ Quality and timely service provision
Emptying and transport	Truck operators, manual emptying	▪ Can the vacuum truck access the septic tank? ▪ Where can the sludge be disposed in a cost-effective manner? (key cost factor is distance to the sludge disposal site) ▪ How can more clients be reached? ▪ Without sufficient designated disposal sites, where to desludge?
Treatment for disposal or reuse	Public entity such as municipality or private company	▪ Land availability for treatment plant ▪ Labor skills to manage treatment plant ▪ Optimize operation cost ▪ Operation cost recovery ▪ How cost-effective is treatment for disposal versus treatment for reuse? ▪ What is the market for the reuse product? ▪ Is my treatment appropriate to meet the standards for final effluent output from the treatment plant?
Nutrient reuse	Farmer and small business	▪ Perception of the product since it is made from fecal matter ▪ How do I certify that my product is safe? ▪ How much compost to apply on which soil and crop? ▪ What is the quality of the product in comparison to known products (manure, fertilizer and other compost)?
Regulations across the sanitation service chain	Municipality and relevant government authorities	▪ How to incentivize households to check or empty their septic tanks before they overflow? ▪ Where manual desludging is banned, there could be a legal conflict as only manual desludging is possible due to the location of the tank? ▪ Concerns of public health and environmental safety ▪ Reduce indiscriminate disposal of fecal sludge ▪ Lower monitoring efforts to ensure regulatory compliance ▪ In some cases, potential for contracting private operations ▪ Reduction in the dependence on subsidies ▪ Equity in terms of access to services and costs of services

4.3 Cost Recovery for Different Types of Sanitation Systems

Sustainable cost recovery for sanitation services can in principal draw on 'The 4 **T**s' to cover costs throughout the life cycle of the combined infrastructure and service: (i) **T**ariffs, which are collected from customers in return for a service provided; (ii)

Taxes, which are raised by the government through the tax system; (iii) **T**ransfers, which are funds made available through international donors and a range of other charitable entities through grants, low-interest loans and underwriting projects through guarantees; and (iv) **T**rade, which represents revenues that can be made by selling resources recovered through the service provided (ISF-UTS 2014).

Capital costs for sewer systems are often covered by central or state funding. The customer of a sewer system pays a one-off connection fee which is often subsidized to encourage further connections to the system. Capital costs for an OSS are, however, shared between the household (majority), private truck operators and possibly the local authority or utility, if the FS collected is subjected to any treatment. Operation and maintenance (O&M) costs of sewerage systems are mostly covered by the water and sewerage tariff. O&M costs of OSSs are covered on-plot by the house owner, paying a market price for emptying the FS. Box 2 highlights the inequity in cost recovery based on different sanitation systems. Provision of sanitation through either sewer or OSS needs to be given equal importance and promoted based on its viability in the given local context.

BOX 2. INEQUITY IN COST RECOVERY BETWEEN DIFFERENT TYPES OF SANITATION SYSTEMS.

A study conducted in Dakar, Senegal, illustrated the inequity in cost recovery and service costs for customers connected to different types of sanitation systems (Dodane et al. 2012). Office National de l'Assainissement du Sénégal (ONAS) is the national sanitation authority in Senegal and it is a utility which is actually providing services to customers connected to both on-site and sewerage systems. The study showed that ONAS incurred a loss for both sets of customers. However, it also showed that customers connected to OSSs bore 84% of the cost of service delivery, and those connected to sewerage systems only bore 4% of this cost. Moreover, customers connected to OSSs paid five times more for the service than those connected to sewerage systems. Such inequities in cost recovery and actual costs borne by customers connected to different sanitation systems are unfortunate, especially for the poor who are often connected to OSSs and are paying more for the service than those that are wealthier. From a business perspective, subsidizing sewerage systems and treatment plants creates an unfair marketplace for service providers along the OSS service chain.

5. FINANCIALS OF THE SANITATION SERVICE CHAIN

In this section of the report, we look at the financials of FSM (operations and capital) in different regions and for different components of the sanitation service chain (excluding access to toilets) to highlight important cost factors. For a more detailed presentation of data across cities and countries, see, for example, Kome (2011). For ease of comparison, the data is reported here in a standardized format to 'serve' a population of 100,000 population equivalent (p.e.). The numbers presented in this section should, however, only be considered as an approximate starting point to show ranges. Actual costs in any specific context may differ substantially.

5.1 Emptying and Transportation

The data used to analyze business operations for emptying and transportation were based on the landscape studies conducted in Asia and Africa (funded by the Bill & Melinda Gates Foundation) (Chowdhry and Koné 2012), and a study conducted by the Water and Sanitation Program (WSP) of the World Bank on the business of collecting FS in Latin America (Rojas-Ortuste 2012). The cost and revenue of emptying depend on the type of emptying practiced – with obvious differences between manual emptying and the use of mechanical trucks.

In the case of *manual emptying,* there are hardly any capital costs involved (USD 20-100 per unit) unless investments are made in mechanical handheld equipment, such as gulper pumps (USD ~40-1,400 per unit), screw auger (USD ~700 per unit), and diaphragm pumps (USD 300-850 per unit) (Strande 2014). Typical tools used in manual emptying include buckets, ropes and shovels. A few manual emptying businesses rent these tools and the primary cost incurred is mostly labor costs. Most people involved in manual emptying do not use protective gear such as hand gloves or body suits, and are thus in direct contact with the feces, which could cause skin rashes and other related health issues due to direct exposure to pathogens. Appropriate risk mitigation measures, such as the use of protective gear, hygiene standards and provision of training, would probably only marginally increase the capital and operation costs, but would have significant positive health and economic impacts.

Sludge is disposed of manually by burying it in nearby land, dumping it in open fields or in open drains. In some instances, the disposal of sludge involves travelling to a site located a significant distance away. In such instances, cheap transport methods, such as push carts, cycle carts or bullock carts, three-wheelers, modified bikes attached to carts or container trailers, etc., are used. On average, and depending on the region, operators involved in the manual disposal of sludge earn USD 20 to 400 per month as profit (Chowdhry and Koné 2012).

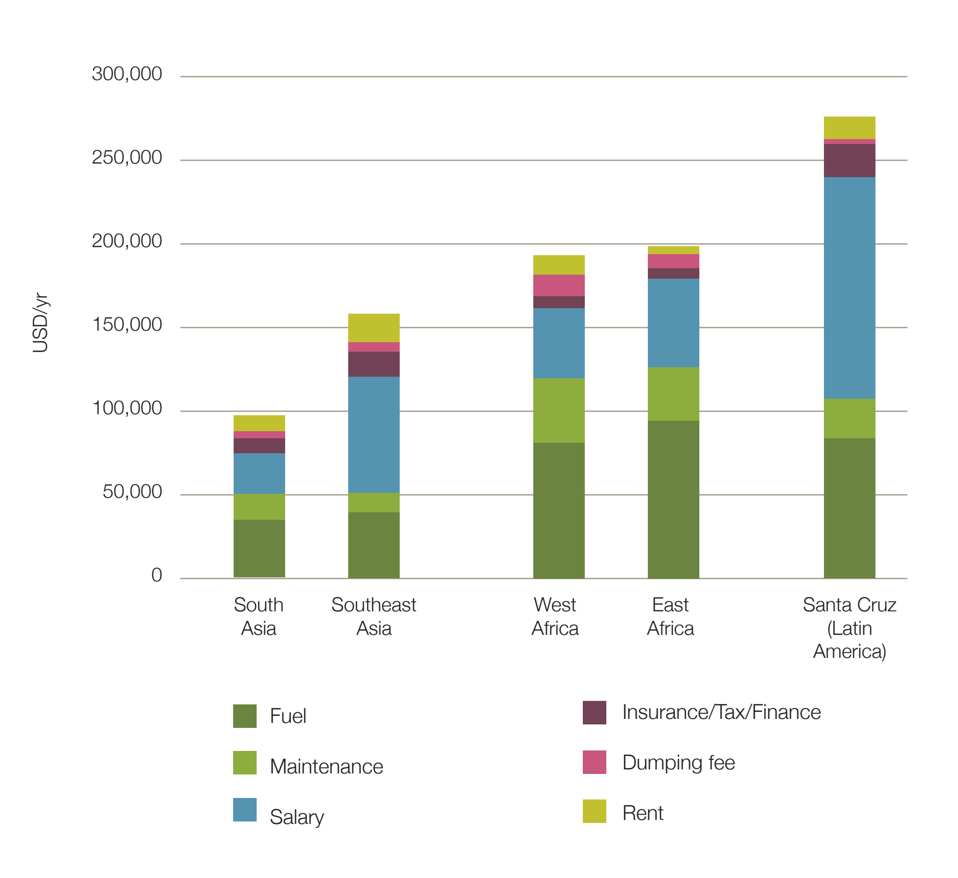
Mechanical emptying: For a business using mechanical trucks for emptying sludge, the key capital cost is the truck itself. The following approximate capital costs will have to be incurred to serve a population of 100,000 p.e.:

- USD 180,000 in South Asia and USD 234,000 in Southeast Asia, excluding Malaysia where the capital cost for FS collection may reach up to USD 627,000.
- USD 210,000 in West Africa (with the highest cost in Senegal [USD 270,000] and lowest in Nigeria and Burkina Faso [about USD 180,000]) and USD 325,000 in East Africa (Kenya being the most expensive [USD 350,000]).
- USD 520,000 in Santa Cruz (Latin America).

The differences in the capital cost in these regions are partly due to the size of truck used (3 m^3 to 10 m^3), availability of second hand trucks, local assembling of trucks and import taxes. The average size of trucks in Africa is twice that of Asia. In Asia, trucks are mostly locally assembled, where a second hand truck is modified to include vacuum pumps, hoses and containers. In Africa, second hand vacuum trucks from Europe are more common. Import tax results in high capital cost in some of the countries (especially Africa). In Malaysia, the price of a new truck that is 4.5 m^3 in size can be as high as USD 95,000 (inclusive of import taxes and insurance), while the price of a similar truck is 60% cheaper in China. Due to high import taxes, trucks are locally assembled in Malaysia. However, they still need to import the vehicle chassis, engine and vacuum pump motors.

The operational costs of a business using mechanical trucks include labor (two to three people per truck), fuel, and periodic repair and maintenance of the truck. Minor costs incurred mostly include telephone expenses and advertisement costs (printing leaflets and visiting cards). Some of the businesses also have office rental costs, while most operate from their homes. Figure 10 shows the breakdown of annual O&M costs to serve 100,000 p.e. in different regions. As the data are of secondary nature deriving from different studies, any direct comparison can only be indicative and requires verification using same methodologies. With this note of caution in mind, it appears as if Asia has the lowest O&M costs with ~USD 144,000 on average, with USD 90,000 in India (South Asia) and USD 155,000 in Southeast Asia. This is followed by Africa with ~USD 189,000 on average, with – not shown in Figure 10 – the highest costs in Senegal (USD 260,000) and the lowest in Nigeria (USD ~120,000), both in West Africa. In Santa Cruz (Latin America), O&M costs are ~ USD 273,000.

FIGURE 10. ANNUAL O&M COSTS FOR FS EMPTYING BUSINESSES IN DIFFERENT REGIONS.



Source: Based on data from Chowdhry and Koné 2012, and Rojas-Ortuste 2012.

O&M costs vary significantly with the frequency of desludging and the quantity of FS desludged (vs. tanker volume), which is linked to the number of people per household, number of trips which can be made per day, and distance required to travel to dispose the sludge. The breakdown of operating expenses across the regions differs significantly – fuel and maintenance expenses in West and East Africa are almost twice that of Asia, which could be due to the use of secondhand trucks with lower fuel efficiency and more frequent breakdowns or the need to travel longer distances (or traffic time) to dispose the sludge far out of town. The latter could be improved by optimizing transport routes through strategically located treatment plants or transfer stations. In general, the viability of transportation services depends significantly on their ability to desludge as soon as possible after serving a household to minimize time in traffic, and accept the next job.

Given the relatively higher expenditures and truck capacities in Africa than Asia, Chowdhry and Koné (2012) also reported that higher household fees are charged by African emptying businesses (USD 60, on average, with the highest charge being USD 80-100 in Kenya and Nigeria, and around USD 40 in Burkina Faso, Ethiopia and Senegal) than in Asia (USD 28, on average, with the highest charge in Southeast Asia, excluding Malaysia (USD 80) and the lowest in India and Bangladesh (USD 20-30)). In Latin America, a study conducted by Rojas-Ortuste (2012) found that truck operators were charging different fees per city, ranging from USD 32-41, USD 90-99, USD 120-164 and USD 158-233 per household in Santa Cruz, Managua, Guatemala City and Tegucigalpa, respectively. The fees charged to institutional customers are 50-100% higher, which increases profitability of the business significantly.

In absolute terms, the profit earned per truck in Africa (USD 12,000) is higher than that in Asia (USD 5,600) and Santa Cruz (Latin America) (USD 5,500-7,000). The profit margin seems to oscillate between 67% to 85% in Asia, 32% to 50% in Africa and 20% to 30% in Santa Cruz (Latin America) (Chowdhry and Koné 2012; Rojas-Ortuste 2012). Usually, companies with a single truck earn much less than multi-truck businesses (on average, USD 350 versus USD 1,000-1,400 for medium to large companies). This is due to inefficiency and susceptibility to downtime of having a single truck, inability to quickly serve a fixed customer base, or to get contracts from institutional customers asking for a service guarantee (Chowdhry and Koné 2012). However, for a 100,000 p.e., the annual profit is similar across the regions and is about USD 70,000. This is only an average estimation and profits may change depending on the distance to travel, size of the business and households' willingness-to-pay. Hence, in some contexts, like small towns with few calls per week, or where dumping sites are far out of town, businesses may also incur a loss.

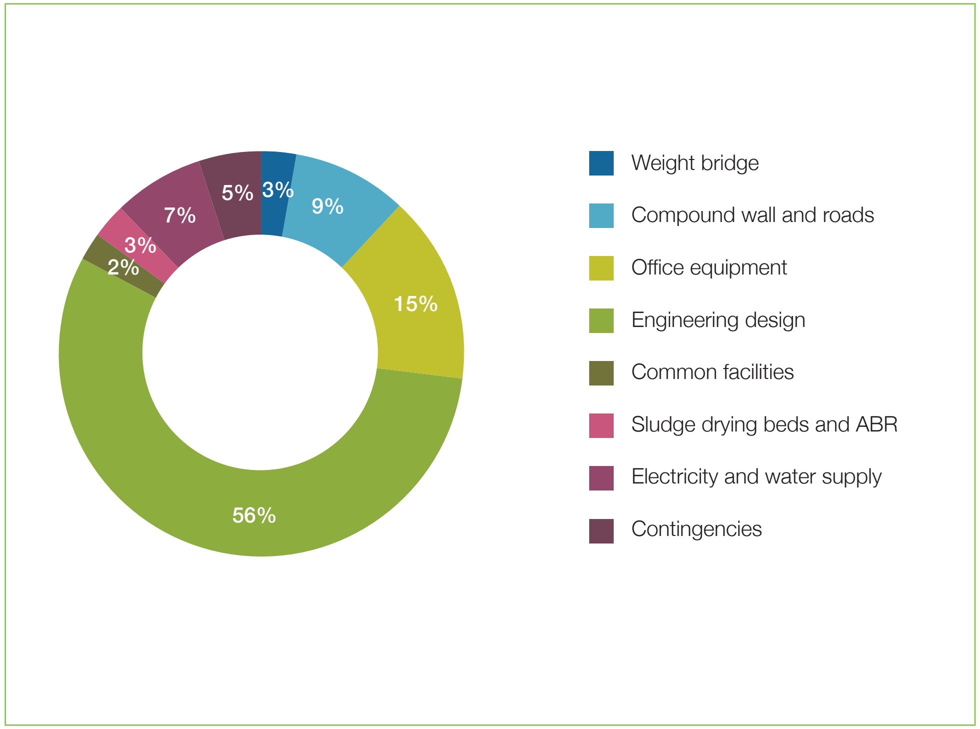
5.2 Treatment for Disposal

The data used to analyze treatment costs were derived from an internal design report by the International Water Management Institute (IWMI) (IWMI 2014a, 2014b) on the construction and operation of a FS treatment plant in India and Ghana. The indicators for Ghana were supplemented with data from Dodane et al. (2012) and Nikiema et al. (2014). Although different technologies are available for the treatment of FS, the financial assessment assumed that unplanted sludge drying beds were used. Unplanted sludge drying beds are multi-layered (sand and gravel) filters with an under-drain at the bottom that collects leachate (Nikiema et al. 2014). The financial assessment made this assumption for the following reasons:

- Widely common, simple and easy to operate in developing countries.
- Relatively low O&M cost.
- They are 'passive' systems', which do not require electricity or artificial heat.

The capital costs of most of the FS treatment plant is towards construction - to build receiving stations, drying beds and storage of dried FS (Figure 11). In addition to sludge-drying beds, the treatment component includes Decentralized wastewater treatment systems (DEWATS) (anaerobic baffled reactor [ABR] and anaerobic filters) to treat the effluent generated during the dewatering process.

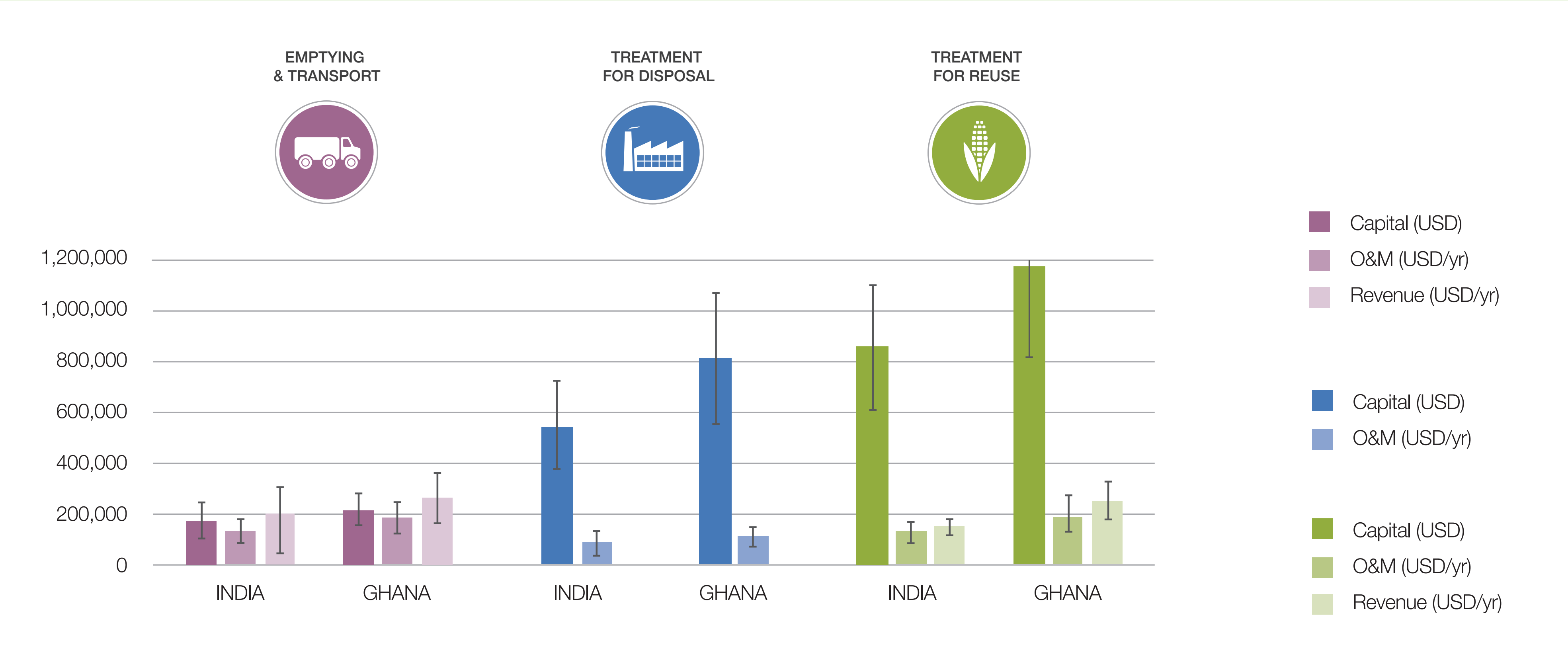
FIGURE 11. BREAKDOWN OF CAPITAL COSTS OF THE FS TREATMENT PLANTS IN THE INDIAN SCENARIO.



A comparative analysis of financials for each component of the sanitation service chain can be conducted, for example, for 100,000 p.e. For illustration purposes, we used data from Ghana and India (Figure 12). The total cost of treatment for disposal and reuse included the cost of transportation. In the scenarios constructed, household size, frequency of desludging and number of trips per day were varied. The resulting capital and O&M costs, as well as land requirements for treatment, etc., can provide first estimates which can be adjusted with changing assumptions. For example, with an assumed higher frequency of desludging in Ghana (on average, once every 1.5 to 2 years) than in India (once every 3 to 4 years) and the number of trips done by each truck per day (Ghana 3.5; India 2) as well as differences in household sizes, the quantity of sludge hauled per year was higher in the Ghana scenario and hence also the size and capital cost of the treatment plant (USD 539,000 in India versus 812,500 in Ghana). Also, O&M costs are higher in Ghana (ca. USD 100,000) than India (ca. USD 40,000). However, if equal volumes of sludge treated are considered, the cost of both plants will be similar with capital costs of around USD 550,000.

Although the capital costs of a fecal sludge treatment plant are considerably higher than the emptying and transport businesses, O&M costs are relatively lower due to lower maintenance cost, especially of pond-based systems with almost no expense on fuel/energy for pumping. Most of the O&M costs of a treatment plant are towards labor. This may significantly change if a different technological option is adopted or if there is a significant change in the scale of the treatment plant.

FIGURE 12. FINANCIALS OF THE SANITATION SERVICE CHAIN IN THE SCENARIOS OF GHANA AND INDIA.



5.3 Treatment for Reuse and Cost Recovery from Reuse

An alternative to Treatment for Disposal is Treatment for Reuse, whereby resources in FS, such as nutrients or energy, are recovered and sold. There are different RRR alternatives. Depending on the type of resource recovered (energy or nutrient), and the value proposition and target customer segment, the technological process applied varies significantly.

5.3.1 Financial Analysis of Co-composting

A financial assessment was carried out for the co-composting process – the stabilization of dewatered FS with an organic fraction of municipal solid waste (MSW) via aerobic processes. Co-composting is one of the most mature FS reuse experiences in many developing countries, and more information on successful case examples is provided in the section *Co-composting Model*. The data used for this analysis were based on two internal design reports made available by IWMI (IWMI 2014a, 2014b), and data adapted from Steiner et al. (2002) for the evaluation of cost and financial performance.

The capital cost for co-composting is slightly higher in Ghana (USD 1.17 million) than in India (USD 832,000) to serve for 100,000 p.e. The higher cost in Ghana is due to larger quantities of sludge processed, resulting in larger civil engineering requirement (e.g., bigger trucks requiring larger waste receiving station, co-composting platform, co-compost storage room, larger rooftop area) and higher machine costs for compost sieving, packing or, if considered, compost pelletization. O&M costs of co-composting are also higher in Ghana (USD 196,000) than in India (USD 125,000). In both Ghana and India, co-composting has a higher O&M cost than treatment for disposal due to higher labor requirements. Figure 13 provides a breakdown of O&M costs of the co-composting plant. As shown in the figure, labor (manpower) and civil maintenance cover bulk of the costs.

5.3.2 Cost Recovery from Reuse

To assess the cost recovery potential from reuse, the operating costs of two treatment scenarios, namely treatment for disposal and treatment for reuse, were compared (Figure 14) for the scenarios assumed for Ghana and India to achieve operational cost recovery based on user charges for the sanitation service. The total operational cost per capita per year (including transportation) for the treatment for disposal is about USD 1.84 to 2.88 per capita in both countries. The net operation cost per capita per year for treatment for reuse could decrease from USD 1.27 to 1.47 due to revenue earned from the sale of compost. These earnings, if fed into the same budget, could theoretically be used to reduce charges for using the sanitation service by 1/3 to 1/2. These numbers are, however, only ballpark

FIGURE 13. BREAKDOWN OF O&M COSTS OF THE CO-COMPOSTING PLANT IN THE INDIA SCENARIO.

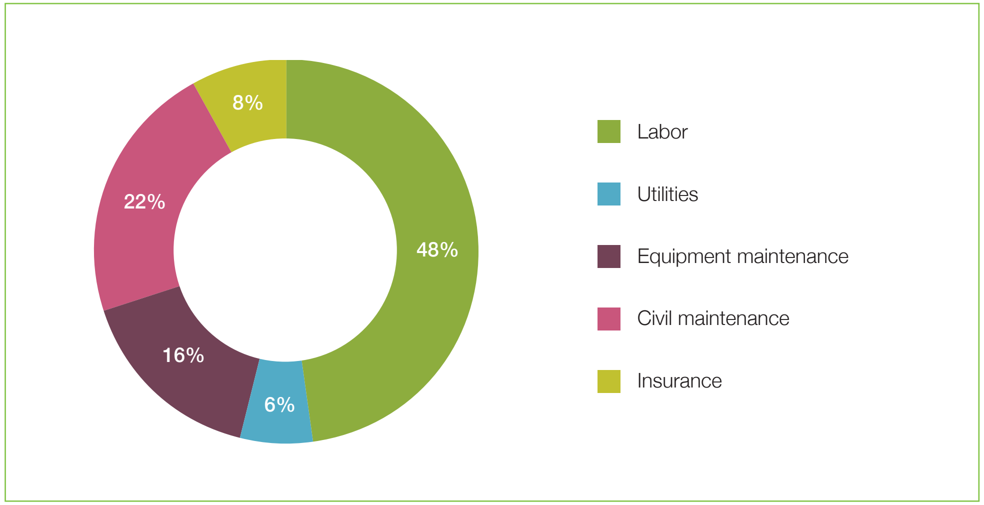
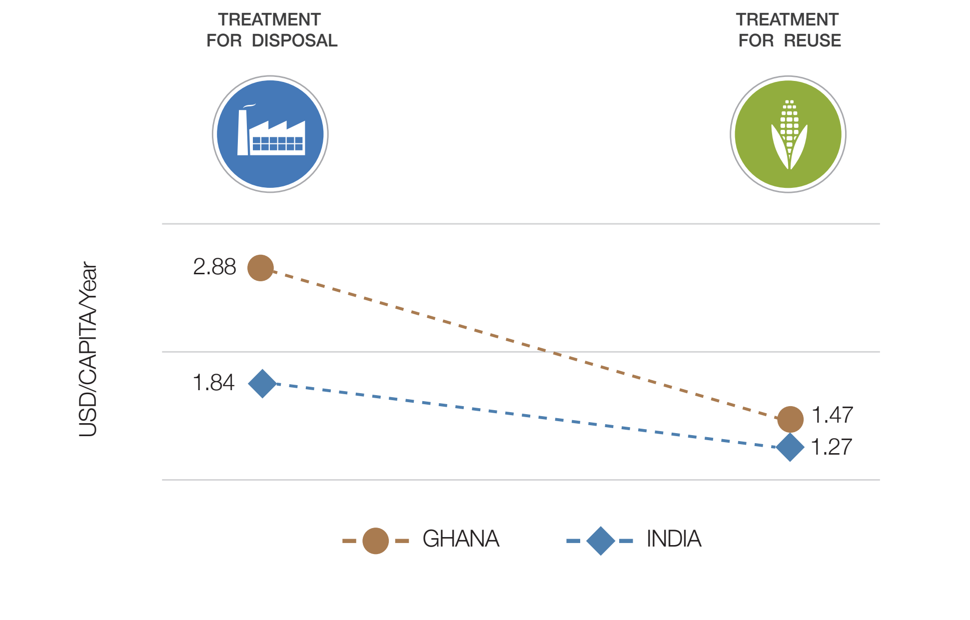


FIGURE 14. OPERATIONAL COST PER CAPITA PER YEAR COMPARING DISPOSAL AND REUSE.



figures as the level of cost recovery varies within the regional context depending among others on the compost market, willingness-to-pay, acceptance of the product, competition and subsidy on fertilizer (Box 3).

BOX 3. COST RECOVERY FROM REUSE: CASE STUDY FROM INDIA.

IWMI carried out a feasibility assessment to set up a co-composting treatment plant serving three neighboring towns (Budhni, Shahganj and six wards of Hoshangabad closer to Budhni) with a total population of 7,784 households in the state of Madhya Pradesh, India (IWMI 2014a). The population produced about 40 m^3 of FS per day from scheduled desludging of septic tanks once every two years, and two towns (Budhni and Shahganj) produced 12.8 tonnes of MSW per day. This waste can produce 4.4 tonnes of compost on a daily basis. An assessment was carried out to evaluate the monthly usage fee that needs to be charged per household in order to cover the operation cost of the treatment plant.

- To recover the operation cost of collection and transportation of FS, and the O&M cost of the treatment plant, the monthly fee that needs to be charged per household ranges between INR 84 (USD 1.3) and INR 122 (USD 1.88).
- The selling price of normal compost varies between INR 1,400 (USD 21) and INR 4,000 (USD 62) per tonne in India, and depending on the selling price of compost, the monthly fee that needs to be charged per household reduces by INR 20 (USD 0.31) and INR 57 (USD 0.9) if reuse is factored into the overall business model and the compost revenues feed into the same budget.

A well-designed and conceived reuse plan presents a good opportunity to decrease the overall cost of the FSM chain, if this is supported by the contractual agreements of the actors involved. Nevertheless, reuse is not a panacea for FSM, as this may increase the complexity of the treatment plant, stakeholders involved and related financial risks, given that it requires broader expertise, higher investment and O&M costs. If the market and selling price of the resource generated are not sufficient to cover at least the additional O&M cost related to reuse then reuse can become a burden and the business will incur financial losses.

Workers collect and transport human waste to a site where it is processed into fertilizer. Source: Neil Palmer/IWMI

PART II: DESCRIPTION OF BUSINESS MODELS AND CASE EXAMPLES

The business models described in this report use a template as illustrated in Figure 15. Description of the business model uses the sanitation service chain to depict key stakeholders across each component of the chain, and the mode of interaction between these stakeholders:

- ***Service flow:*** This depicts the type of service rendered by one stakeholder to another.
- ***Financial flow:*** This indicates the (contractually agreed) exchange of money between the stakeholders. Typically, a service rendered has a corresponding financial transaction. The various financial transactions discussed in the business model are stated in Table 2.
- ***Institutional relationships:*** Typically, it is a regulatory measure that influences the operations of the business model, for example, issuing license permits and monitoring to ensure regulatory compliance, issuing contracts, etc.

FIGURE 15. COMMON ELEMENTS OF THE BUSINESS MODEL FOR FSM.

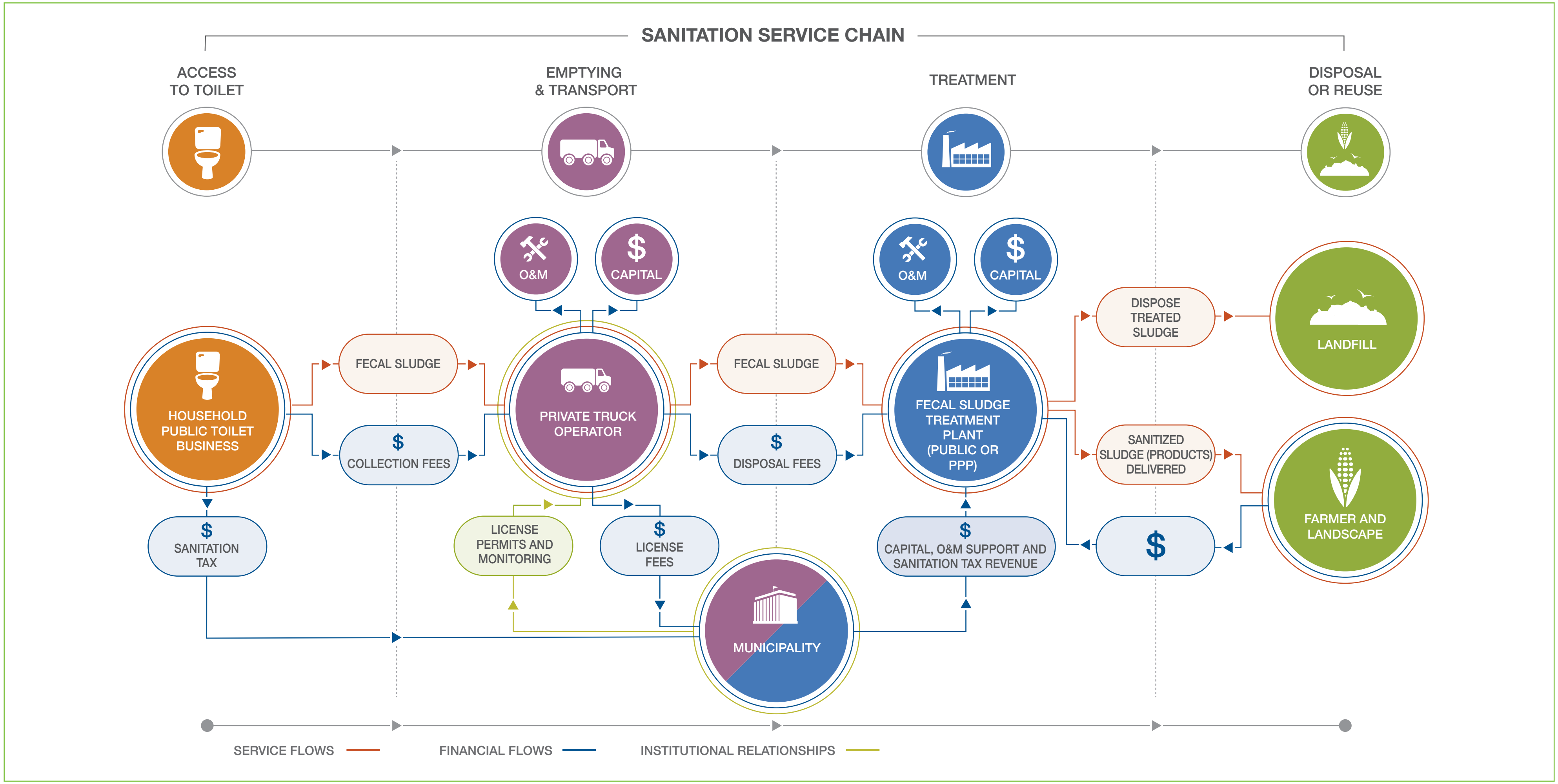


TABLE 2. FINANCIAL TRANSACTIONS IN BUSINESS MODELS FOR FSM.

FINANCIAL TRANSACTION	DESCRIPTION
Sanitation tax	It is a tax or fee paid by users of on-site sanitation services to the local authority or public utility towards the treatment of FS. In some business models, this tax is used for the collection and transportation of FS in addition to treatment. The tax is collected through either a property tax or surcharge on water bill.
Collection fees	Fees charged to users of on-site sanitation services for the collection and transportation of fecal sludge by an emptying enterprise (e.g., truck operator and manual emptying service).
License fees	A private emptying enterprise obtains a permit to operate the business. A permit is obtained from either the local authority or public utility based on whether it is either an annual renewal fee or a one-time fee.
Disposal fees	Fees charged by treatment plants to private emptying enterprises for disposal of sludge.
Disposal incentive	Payment given to private emptying enterprise to incentivize them to dispose sludge at designated disposal sites.
Capital	Cost incurred in purchasing equipment, and construction of facilities and associated infrastructure.
O&M	Operation and maintenance costs are periodic costs incurred in operating the equipment and infrastructure.
Budget support	Typically, cash transfers from governments to public utilities towards capital and O&M costs of treatment plants.

The business models presented have associated features that could benefit or limit successful implementation of FSM in a region. The template used in this report for assessing these features is presented in Table 3. For a municipality or other local entity responsible for FSM, the features associated with the business models can guide users to short-list the most suitable models applicable to their context. A feasibility assessment can then be undertaken for the short-listed business models by using a multi-criteria framework, such as the one developed by IWMI (Otoo et al. 2016).

TABLE 3. TEMPLATE OF FEATURES OF BUSINESS MODELS THAT COULD BENEFIT OR LIMIT FSM IN A PARTICULAR REGION.

FINANCIAL IMPLICATIONS	
Benefits for emptying operations	-
Reduces emptying cost to households	-
Requires subsidy	-
Improve cost recovery of FSM	-

REGULATORY AND MONITORING IMPLICATIONS	
Requires close monitoring for regulatory compliance	-
Modification of sanitation codes and policy	-

INSTITUTIONAL IMPLICATIONS	
Requires public sector involvement	-
Requires private sector involvement	-

ENVIRONMENTAL AND HEALTH IMPLICATIONS	
Reduces indiscriminate disposal of sludge	-
Concerns of public health and environmental safety	-

Assessment key:
Y – Yes, an essential feature of the model and has a direct influence.
P – Possible influence on the model and could create an enabling environment.
N – No, feature has no influence on the model.
NA – Feature is not applicable to the model.

The features of business models specified in Table 3 are described below:

A. Financial implications

- *Benefits for emptying operations:* Designed to benefit emptying operations either through additional revenue gains or reduced operation costs.
- *Reduces emptying cost to households:* Designed to reduce emptying costs incurred by users of on-site sanitation systems either through incentives via regulatory process or respective design of the business model.
- *Requires subsidy:* Support from donors or the government is required for business operations.
- *Improve cost recovery of FSM:* Improves the overall cost recovery of FSM due to additional revenue gains in the form of user charges or sale of reuse products.

B. Institutional implications

- *Requires public sector involvement:* Requires involvement of the public sector in the provision of FSM services.
- *Requires private sector involvement:* Requires involvement of private companies in the provision of FSM services.

C. Regulatory and monitoring Implications

- *Requires close monitoring for regulatory compliance:* Requires increased (more than normal) regulatory and monitoring role from public sector agencies.
- *Modification of sanitation codes and policy:* Introduces mechanisms that will likely require modification of existing sanitation codes and policies.

D. Environmental and health implications

- *Reduces indiscriminate disposal of sludge:* Provides incentives to reduce indiscriminate disposal of FS.
- *Concerns of public health and environmental safety:* The business model is not designed to address public health and environmental safety issues, and hence raises concerns.

6. MODELS FOR TOILET ACCESS AND *IN-SITU* ENERGY RECOVERY

The business models presented in this section are focused on the direct link of the two ends of the sanitation service chain – access to toilets and resource recovery. Access to toilets is through the public toilets and treatment allows energy recovery from the FS. These business models do not engage in the emptying and transportation component of the service chain, as waste generation, treatment and reuse take place in close proximity. A variation to the business model is where the focus is on the treatment for reuse component of the chain, for example, in the case of hotels and residential institutions where large quantities of FS are generated and there is no space for on-site treatment.

The business models discussed in this section offer the following value propositions:

- Savings in energy costs by using environmentally friendly renewable energy.
- Low-cost liquid fertilizer.

6.1 Public Toilet with Energy Recovery Model

This business model can be initiated by an entrepreneur or CBO and requires partnership with the municipality to provide land for the public toilet. In addition to the value propositions stated above, the business model offers an improved sanitation service to residents of the community and city on a fee-for-usage basis (Figure 16). Biogas is generated by treating human excreta from the public toilets. The biogas generated can be used internally for lighting or for the provision of hot water for bathing, resulting in energy savings. Alternatively, biogas can be sold to neighboring businesses (e.g., street vendor) or households. The bio-slurry from the bio-digester is rich in nutrients and can be sold as liquid fertilizer to farmers or used for landscaping around the toilet complex; however, the liquid fertilizer needs to be sanitized further.

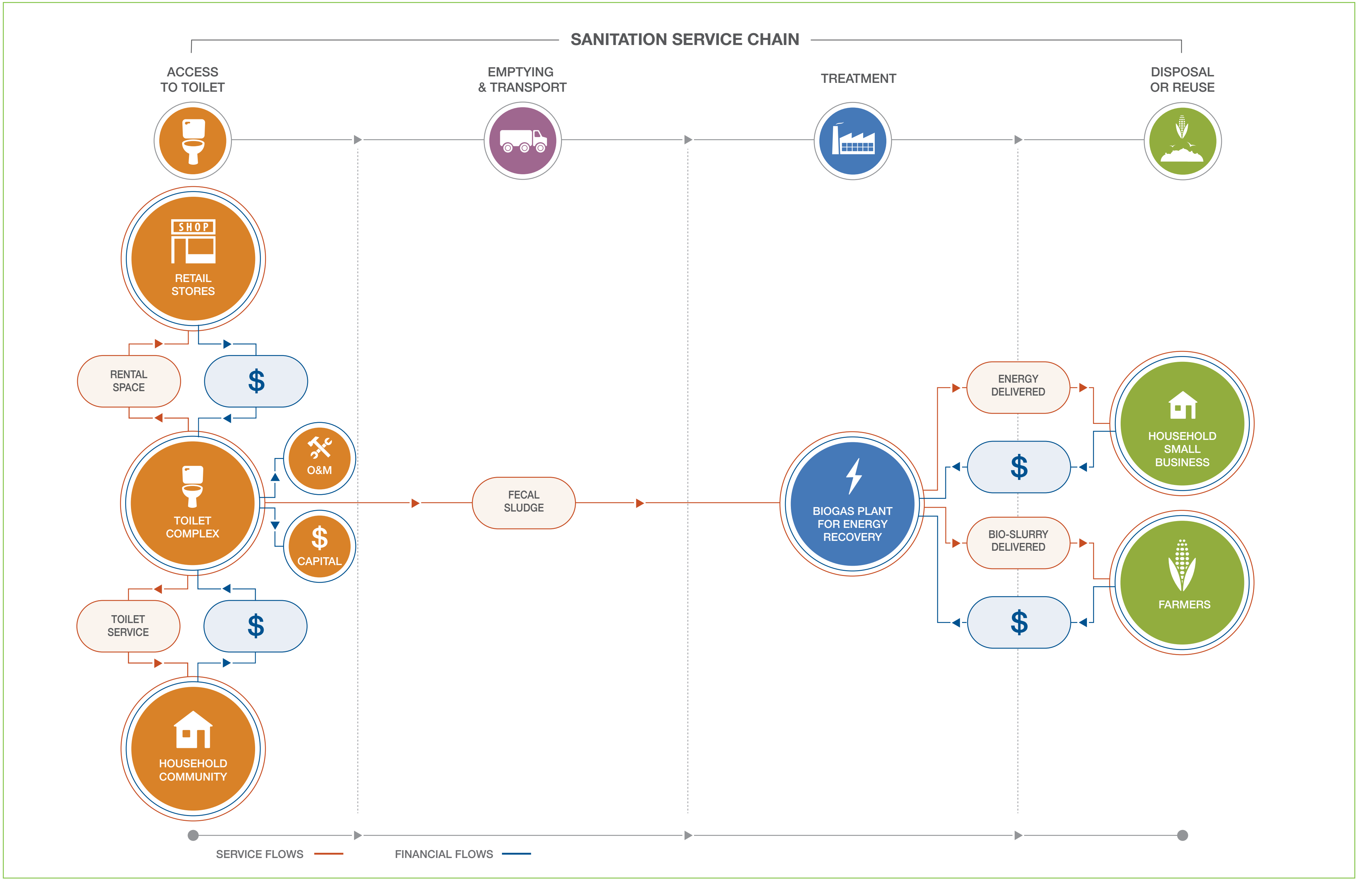
Depending on the available land area, the toilet complex can rent out space to other private businesses such as retail stores or newspaper and magazine stands to vend their goods and sell the wall space for advertising. Table 4 provides some characteristics of the business model. The business can be profitable with majority of the revenue earned from the fee charged for the provision of toilet services, followed by rental space and sale/savings incurred from the biogas produced.

TABLE 4. FINANCIAL DETAILS OF THE PUBLIC TOILET WITH ENERGY RECOVERY MODEL SERVING ABOUT 2,000 PEOPLE A DAY.

BUSINESS SCALE	~2 TONNES FS TREATED/DAY
Population served	Up to 2,000 people
Biogas production	About 50 m^3/day
Investment required	USD 10,000 to 23,000 for public toilet and biogas plant
Annual operational cost	USD 4,000 to 10,000
Annual revenue	USD 11,000 to 15,000 ▪ USD 10,000 to 13,000 from toilet fees ▪ USD 850 to 1,150 from rentals
Land required	0.01 ha (biogas plant)

A variation to this business model is to collect and transport FS from the public toilets across the city to a centralized processing facility, where the FS is processed to generate electricity and produce organic fertilizer. A similar model has been implemented by Sanergy in Kenya (see below), which owns and operates public toilets by franchising its operations

FIGURE 16. PUBLIC TOILET WITH ENERGY RECOVERY MODEL.



to local entrepreneurs, and processing the FS collected to generate electricity and produce compost. For larger centralized processing facilities, biogas can be upgraded by removing carbon dioxide, hydrogen sulfide and other possible pollutants to increase methane concentration. The upgraded biogas can be directly injected into the natural gas pipeline, used as a vehicular fuel or bottled to facilitate ease of storage and transportation (Kirch et al. 2005). See Table 5 for features of this business model.

TABLE 5. BENEFITS AND LIMITING FACTORS OF THE PUBLIC TOILET WITH ENERGY RECOVERY MODEL.

FINANCIAL IMPLICATIONS		REGULATORY AND MONITORING IMPLICATIONS	
Benefits for emptying operations	NA	Requires close monitoring for regulatory compliance	N
Reduces emptying cost to households	NA		
Requires subsidy	P	Modification of sanitation codes and policy	Y
Improve cost recovery of FSM	P		

INSTITUTIONAL IMPLICATIONS		ENVIRONMENTAL AND HEALTH IMPLICATIONS	
Requires public sector involvement	P	Reduces indiscriminate disposal of sludge	Y
Requires private sector involvement	P	Concerns of public health and environmental safety	Y

Y – Yes, P – Possible, N – No, NA – Not applicable; see Table 3.

Case examples from Kenya and India

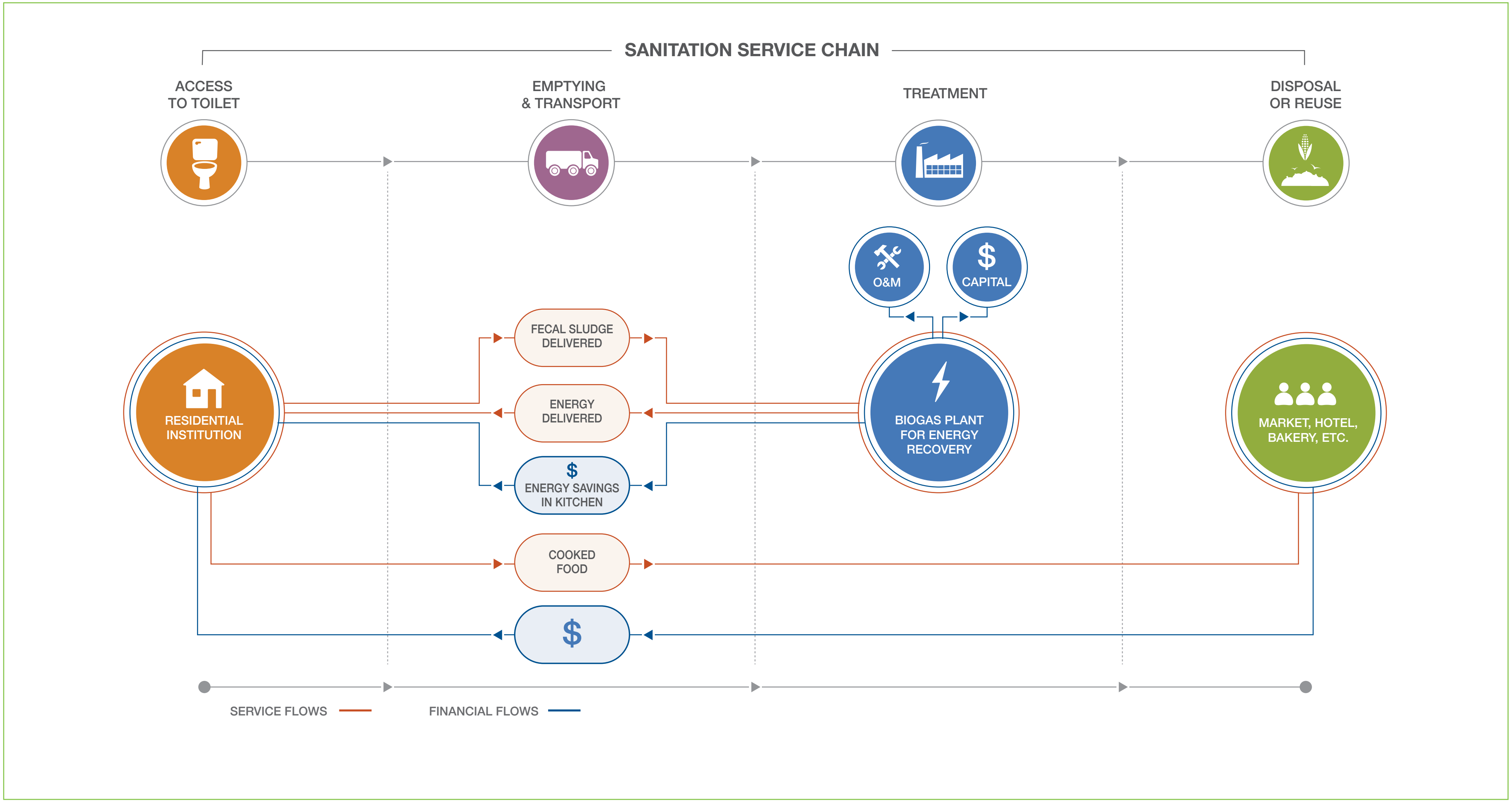
Umande Trust, Kenya (Otoo and Drechsel Forthcoming): In Kenya, Umande Trust runs 57 bio-centers (public toilets) across Nairobi's informal settlements in partnership with the Nairobi Water and Sewerage Company. Umande Trust is a civil society organization (CSO) with a mission to improve water, sanitation and environmental services in the urban centers of Kenya. It works with local communities and local governments in urban areas to construct bio-centers, such as Total Sanitation and Hygiene Access (TOSHA). Umande Trust mobilizes local communities to form CBOs that operate and manage these bio-centers. The trust provides technical guidance and appropriate training to the CBO to operate and manage the bio-center. The primary revenue source for the bio-centers is from providing toilet services. In addition, these bio-centers also provide rental space for shops and generate biogas from the FS collected from the toilets. The biogas generated is either used internally for heating water or sold to street food vendors for cooking. On average, these bio-centers are used by 1,000 users on a daily basis. The cost incurred to construct the bio-center was nearly USD 22,500 (in 2006), with an additional USD 10,000 for community mobilization, campaigns and training to sensitize the community on the technology. The major income source for the business is from the provision of toilet services, which accounts for 88% of the total revenue, followed by rental income and the sale of biogas or energy savings. The bio-centers are not making any revenue from selling the bio-slurry as fertilizer.

Sulabh International Social Service Organisation, India (Otoo and Drechsel Forthcoming): Sulabh International is a nonprofit organization that has built over 7,500 public pay-and-use toilet complexes, with 200 of them linked to biogas systems across India. The toilet complexes have been built in partnership with either the local government or private sponsors. When partnering with the government, the capital cost is financed from the central government, state government and local community at a ratio of 60:30:10. The estimated cost of the toilet complex is about USD 4,000, and Sulabh charges 20% of the total cost spent on consultation and implementation fees, and takes on the responsibility for maintenance for a period of 30 years. In the public toilets linked with biogas plants, 75% of the additional cost of the biogas plant (about USD 4,000) is financed by the government and biogas is internally used for lighting or providing hot water for bathing. For a typical toilet complex that caters to approximately 2,000 users per day, annual revenue is about USD 10,800, whereas the operating costs are USD 10,320, thereby leaving very little surplus to cover capital costs. Within Sulabh's current portfolio of 7,500 toilets, around 50% are generating enough revenue to be self-sustaining and profitable.

6.2 Residential-institutional Biogas Model

This business model is driven by the availability of a significant amount of human waste from distinct sources such as hotels, university hostels, larger administrations or prisons (Figure 17; Table 6). The human excreta is fed into a bio-digester where it is combined with other organic waste from kitchens and gardens (mostly leaf litter). In addition to the value propositions stated earlier, this business model offers reduced cost for emptying and transportation of sludge. The biogas produced is used, for example, in the institutional kitchen for cooking, thereby allowing the institution to make substantial savings by not having to purchase fuel for cooking. The bio-slurry from the digester can be used for landscaping or growing vegetables, but the slurry needs to be sanitized further.

FIGURE 17. RESIDENTIAL-INSTITUTIONAL BIOGAS MODEL.



There can be two significant variations of this business model:

- The institution could potentially create a source of income by using the biogas to either cook or make processed food that can be sold in nearby markets.
- A private biogas technology enterprise implements a Build-Operate-Lease-Transfer (BOLT) model to sell the biogas technology.

In the BOLT model, the enterprise has a lease agreement with the institution for land to install the bio-digester, which acts as security for the private enterprise to operate the biogas facility. The biogas generated is sold as fuel to the residential institution, and on recovery of the capital and operating cost, including expected returns on the investment, the private enterprise transfers the investment to the residential institution and exits from the lease agreement. The long-term benefits to the residential institution are savings on fuel and obtaining financing for building the biogas treatment facility.

TABLE 6. BENEFITS AND LIMITING FACTORS OF THE RESIDENTIAL-INSTITUTIONAL BIOGAS MODEL.

FINANCIAL IMPLICATIONS		REGULATORY AND MONITORING IMPLICATIONS	
Benefits for emptying operations	NA	Requires close monitoring for regulatory compliance	N
Reduces emptying cost to households	NA		
Requires subsidy	N	Modification of sanitation codes and policy	Y
Improve cost recovery of FSM	Y		
INSTITUTIONAL IMPLICATIONS		**ENVIRONMENTAL AND HEALTH IMPLICATIONS**	
Requires public sector involvement	N	Reduces indiscriminate disposal of sludge	NA
Requires private sector involvement	P	Concerns of public health and environmental safety	N

Y – Yes, P – Possible, N – No, NA – Not applicable; see Table 3.

Case examples from Rwanda, Nepal, the Philippines and Lesotho

International Committee of the Red Cross (ICRC) (Butare and Kimaro 2002; Gauthier et al. 2012; KIST 2005; Lohri et al. 2010; UNEP 2011; ICRC 2012): The International Committee of the Red Cross (ICRC), under its Water and Habitat Unit, implemented numerous institutional biogas sanitation systems across prisons in Rwanda, Nepal and the Philippines. ICRC's prison biogas plants use human waste and, in some cases, kitchen waste to generate biogas, which is used as fuel for cooking in the prisons. The biogas systems consist of fixed dome digesters of varying sizes (from 10 to 500 m^3) according to the number of detainees in each prison (from 100 to 5,000). Depending on the size of the biogas plant and region, the capital cost ranges from USD 13,000 to USD 74,000. The average cost of a biogas plant in the Philippines, Nepal and Rwanda is USD 230/m^3, USD 250/m^3 and USD 300/m^3, respectively, and the O&M costs are 2% of the total investment cost. The savings from biogas through reduced consumption of firewood amounts to USD 26-53 per day in Rwanda; in the Philippines, a saving in energy amounting to 5% is reported, and energy savings in Nepal range from 17% to 41%.

Decentralized treatment in Lesotho (Vogeli et al. 2014): Technologies for Economic Development (TED) is an NGO in Lesotho which provides treatment solutions for on-site sanitation systems using biogas production and DEWATS. The treatment occurs in a three-step process: biogas digester, anaerobic baffled reactor and planted gravel filter. TED has installed more than 100 biogas plants combined with DEWATS at both household and community level. The biogas plants primarily treat blackwater and greywater from the toilet, bathroom, kitchen and laundry. In some cases, the plant is fed with kitchen and livestock waste to increase biogas production. Plants of varying sizes have been installed with the biogas produced being used for either cooking or heating water. A study conducted by Swiss Federal Institute of Aquatic Science and Technology – Department of Sanitation, Water and Solid Waste for Development (Eawag/Sandec) found that, in Maseru, Lesotho, households used storage tanks to collect the wastewater generated. The authorities do not allow storage tanks with soak-away systems. In some cases, the soak-away systems do not function properly due to soil conditions, thus requiring regular emptying of storage tanks. Some households require their tanks to be emptied twice a month, which costs them LSL 6,000 (USD 600) per year. Even though the investment cost for a biogas plant is much higher than individual storage tanks, the operational costs are significantly lower as biogas plants require emptying once every 5 years, resulting in operation costs of about LSL 50 (USD 5) per year and it also provides energy savings.

7. MODELS FOR EMPTYING AND TRANSPORT OF FECAL SLUDGE

A common question raised in FSM is "what happens when the pit is full?" Typically, it is the responsibility of the local municipality to provide a sanitation service to its residents. However, in practice, emptying services are provided by both the public and private sectors. The business models discussed in this section offer the following value propositions:

- Provide timely and high-quality emptying services for households and institutions.
- Appropriate disposal of sludge for improved environment.

In many cases, the emptying services form associations (Box 4).

BOX 4. ASSOCIATION OF PRIVATE TRUCK OPERATORS.

In most cities in Africa and Asia, private truck operators have come together to form emptying associations, which help them to lobby, complement learning from peers, demarcate geographical boundaries of operations, and develop a set of informal rules for plying truck operations, including fixing tariffs for emptying. Local authorities or public utilities can engage with these associations to regulate tariffs, develop a peer-monitoring system to manage indiscriminate disposal of sludge, and mitigate barriers in operating emptying businesses. The private emptier associations in Africa have different names, such as Cesspool Services Association (CSA) in Accra, Ghana; Private Emptiers' Association in Kampala, Uganda; and Union des Structures de Vidange in Cotonou, Benin. In Senegal, manual emptying operators are organized into Economic Interest Groups.

- According to Boot and Scott (2008), CSA in Accra sets a tariff for emptying, and monitors truck movements (times of entry to and exit from disposal sites) to inform the Waste Management Department (WMD). CSA believes that it has the capacity to influence policy.
- In Cotonou, the Union des Structures de Vidange was formed to monitor indiscriminate dumping, complement and assist fellow truck operators, and engage with city authorities to regulate desludging tariffs (Valfrey-Visser and Schaub-Jones 2008; Okoundé 2002).
- In Dakar, Senegal, the Association of Senegalese Sanitation Workers is comprised of 47 companies and 200 trucks. The role of the association is to increase membership, centralize resources, register and map domestic sanitation, create a consumer database, map desludging services, make capital improvements and manage fecal sludge. ONAS engages the association to monitor FS emptying, planning of treatment plants, and call center operations (Refer to the *Call Center Model*) (SuSanA 2013b).

7.1 Commonly Occurring Private Emptying and Transportation Model

In a commonly occurring scenario (Figure 18; Table 7), when an emptying business is initiated by a private entity (mechanical or manual emptying), the households or businesses with on-site sanitation systems contact the private entity to provide emptying services on a fixed agreed tariff. Ideally, the private entity is required to transport and safely dispose the FS either to a treatment plant or to a designated disposal site, typically a landfill.

The treatment plants or designated disposal sites, if they exist, are typically owned and operated by the public sector. Typically, private entities are charged disposal fees (also known as tipping fees) for disposing FS at the treatment plant. Disposal fees can work as a disincentive for private operators. In developing countries, where monitoring of disposal of sludge is weak, illegal and unsafe disposal of sludge into open lands, storm water drainage or into the sewerage network is common (Chowdhry and Koné 2012).

TABLE 7. BENEFITS AND LIMITING FACTORS OF THE COMMONLY OCCURRING PRIVATE EMPTYING AND TRANSPORTATION MODEL.

FINANCIAL IMPLICATIONS	
Benefits for emptying operations	N
Reduces emptying cost to households	P
Requires subsidy	N
Improve cost recovery of FSM	N

REGULATORY AND MONITORING IMPLICATIONS	
Requires close monitoring for regulatory compliance	Y
Modification of sanitation codes and policy	N

INSTITUTIONAL IMPLICATIONS	
Requires public sector involvement	P
Requires private sector involvement	Y

ENVIRONMENTAL AND HEALTH IMPLICATIONS	
Reduces indiscriminate disposal of sludge	N
Concerns of public health and environmental safety	Y

Y – Yes, P – Possible, N – No, NA – Not applicable; see Table 3.

7.2 Franchise Model

This business model is run by a large company which can be either a private or public entity, and it authorizes an entrepreneur with access to proprietary knowledge, processes and trademarks to operate the business in a specific geographic location (Figure 19; Table 8). The franchisor (large company) signs a contractual agreement with the franchisee (entrepreneur) to legalize the rules and norms for operating the franchise. The model is applicable to both manual and mechanical emptying operations.

The franchisor's goal is to achieve scale, and reduce high transaction costs of customer identification and provision of service. Hence, their role is to provide proven lines of business,

FIGURE 18. COMMONLY OCCURRING PRIVATE EMPTYING AND TRANSPORTATION MODEL.

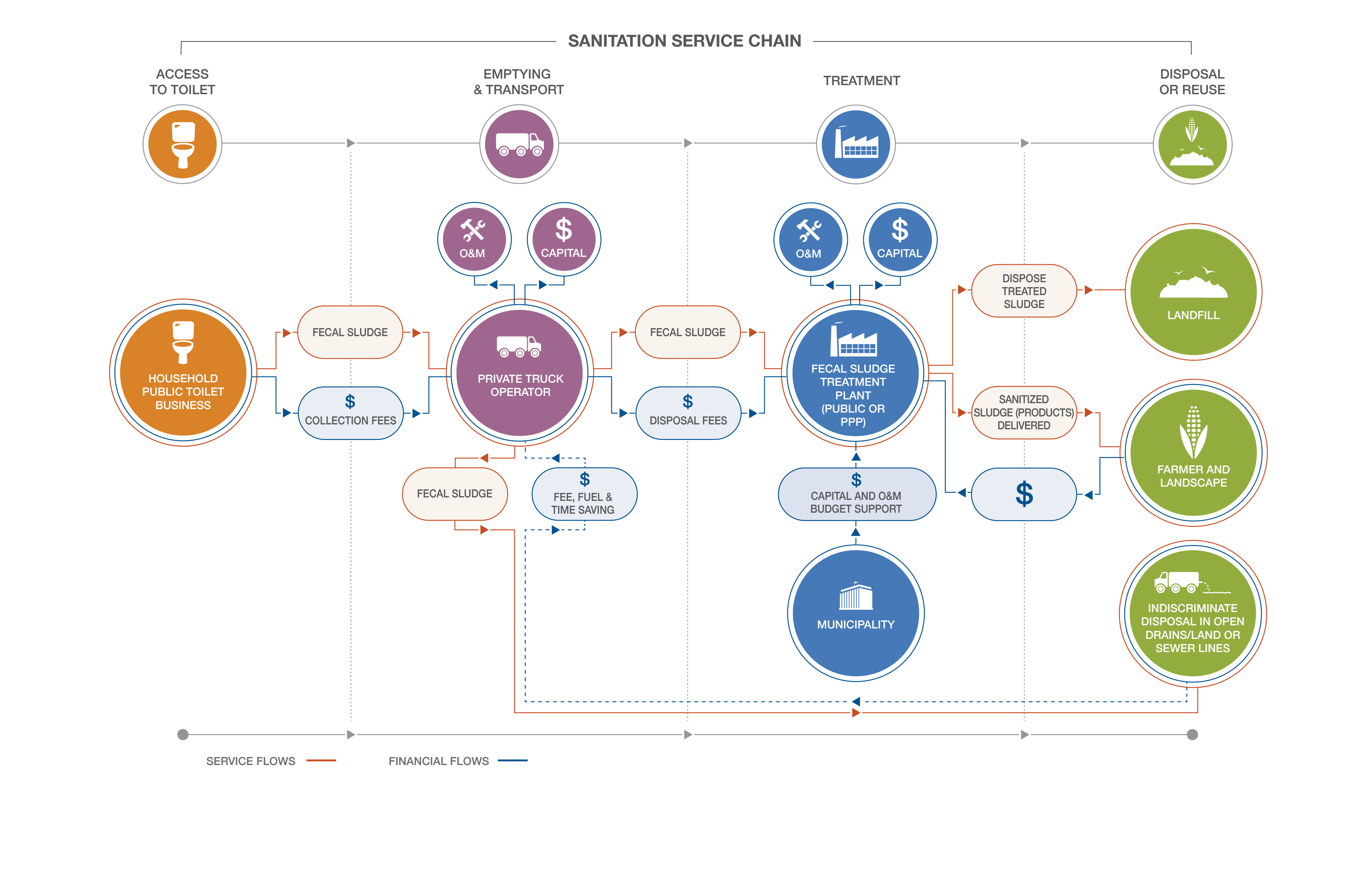
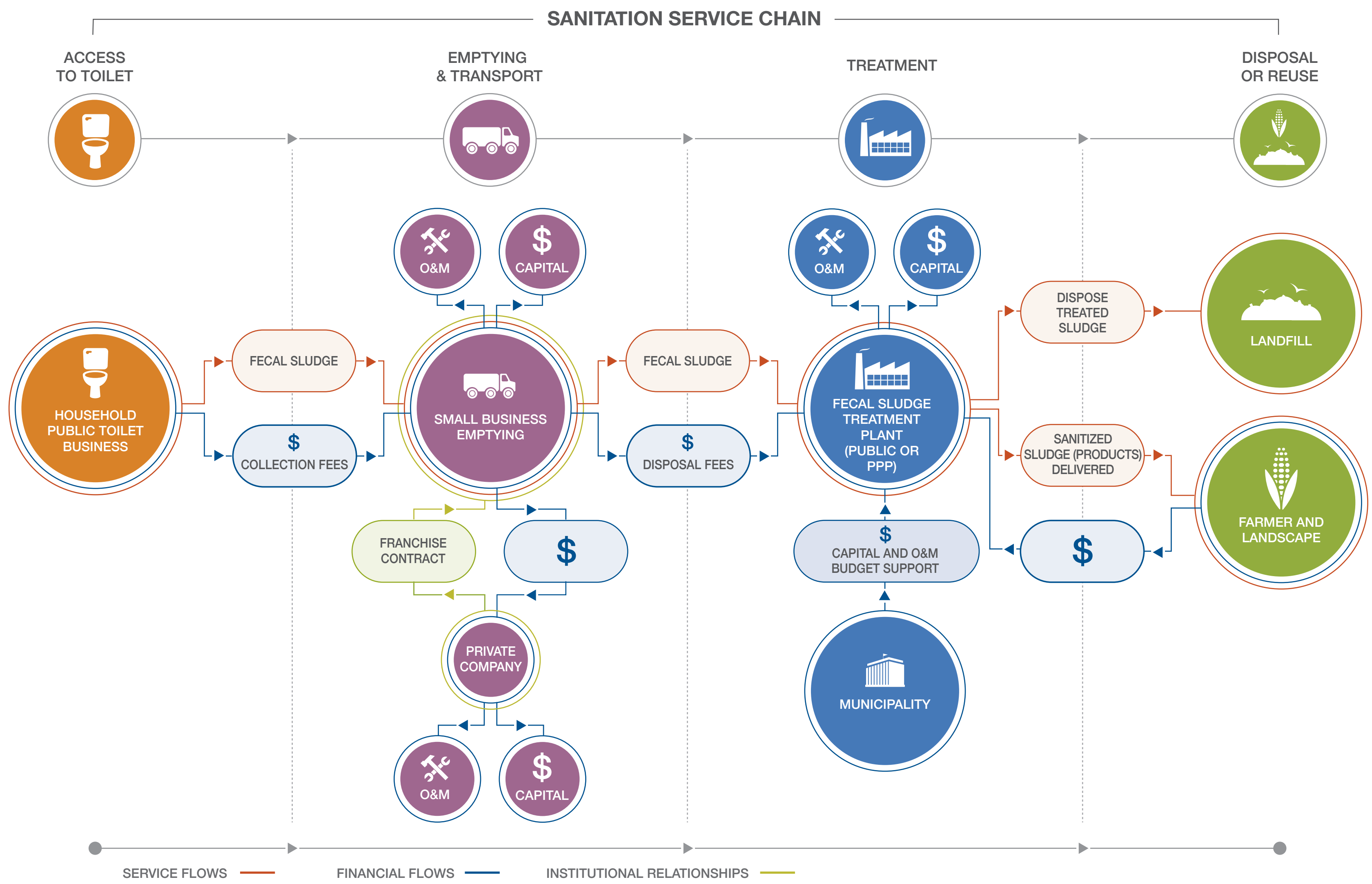


FIGURE 19. FRANCHISE MODEL.



brand and advertise the service in a larger geographic region (e.g., city level). The franchisee operates within a limited geographic area, and finds customers and provides services. The operational cost of emptying – labor, fuel, repair and maintenance of equipment, and logistical cost for identifying and serving the customer – is the responsibility of the franchisee. The franchisor can provide financial assistance to the franchisee. There can be variations to the model by incorporating leasing of trucks into the franchise system. The fixed monthly rental is the key revenue for the franchisor. Thus, should the franchisee fail to make the repayments, the emptying equipment can be repossessed and given to another operator.

TABLE 8. BENEFITS AND LIMITING FACTORS OF THE FRANCHISE MODEL.

FINANCIAL IMPLICATIONS		REGULATORY AND MONITORING IMPLICATIONS	
Benefits for emptying operations	N	Requires close monitoring for regulatory compliance	Y
Reduces emptying cost to households	N		
Requires subsidy	N	Modification of sanitation codes and policy	N
Improve cost recovery of FSM	P		
INSTITUTIONAL IMPLICATIONS		**ENVIRONMENTAL AND HEALTH IMPLICATIONS**	
Requires public sector involvement	P	Reduces indiscriminate disposal of sludge	N
Requires private sector involvement	Y	Concerns of public health and environmental safety	Y

Y – Yes, P – Possible, N – No, NA – Not applicable; see Table 3.

Case example from South Africa

Amanz' abantu Services (Pty) Ltd, Eastern Cape Province, South Africa (WIN-SA 2011; African Water Facility 2014; Wall et al. 2012, 2014; Eales 2005; Ive et al. 2015): The Council for Scientific and Industrial Research (CSIR), Water Research Commission (WRC) of South Africa, and Amanz' abantu[4] Services (Pty) Ltd. (a provider of water services from the private sector) developed a social franchising[5] concept for the maintenance and servicing of water and sanitation facilities. In 2009, with additional funding from Irish Aid and the Eastern Cape Provincial Department of Education (DoE), a pilot of the concept was implemented to provide routine servicing of water and sanitation facilities at approximately 400 schools in the Butterworth education district of the Eastern Cape in South Africa. Amanz' abantu established a subsidiary, Impilo Yabantu[6] Services, to play the role of franchisor and be responsible for the manual emptying of pit latrines from schools and households. The pilot had six micro-entrepreneurs trained and contracted as franchisees under the supervision of the franchisor Amanz' abantu through its subsidiary partner Impilo Yabantu. The services provided by the franchisees include: (i) cleaning sanitation facilities, and providing education and awareness-raising on hygiene among the community; and (ii) emptying pits and septic tanks.

Implio Yabantu provides a number of support functions to franchisees, such as management, administration, marketing, procurement, operational support, quality management, safety, health and environment, and training. Technical support is provided to help franchisees with a servicing strategy after completing the initial diagnostics of the situation, and to identify appropriate methods for emptying the latrines. In the pilot, franchisees received financial support in the form of loans to purchase equipment and repay them in tranches. The franchisees are expected to payback a percentage of their revenues and system loyalty to the franchisor, in exchange for the support and the right to use the brand within the rules of operating the franchisee.

The franchise model of Amanz' abantu has resulted in the creation of local jobs, especially for the poor communities in the region. The model has helped the franchisors to focus their energy and time to seek out new technologies and better ways of dealing with the waste, and to bring in innovation and efficiency within the system. The franchisees have seen growth opportunities within the business and ploughed the benefits back into local communities. The provision of emptying services is perceived to be a straightforward task and franchisees who perform poorly are replaced by Implio Yabantu. The primary concern is regulating the franchisees to consistently provide a high quality of service, and prevent them from selling the equipment and disappearing. The Impilo Yabantu franchise has expanded from six franchisees in the pilot stage to 22, with each franchisee having five to 15 employees. The franchise model is now routinely servicing more than 1,300 schools, and provides desludging services to more than 4,000 households.

7.3 Nonprofit Model

This model is initiated by donors who provide grants to NGOs to create small businesses providing emptying services to underserved communities. The goal of the donor and NGO is to create awareness of the importance and benefits of desludging, improve the operations of emptying and disposal of FS, and ensure an appropriate institutional and regulatory environment for operations (Figure 20; Table 9).

[4] A Xhosa phrase which means "Water for people."
[5] The term 'social franchising' is similar to commercial franchising except that it might not have a maximize profits motive and is driven by social goals such as employment to underserved communities or the disabled. The goal of profits is primarily to ensure self-sustainability.
[6] A Xhosa phrase which means "Hygiene for people."

FIGURE 20. NONPROFIT MODEL.

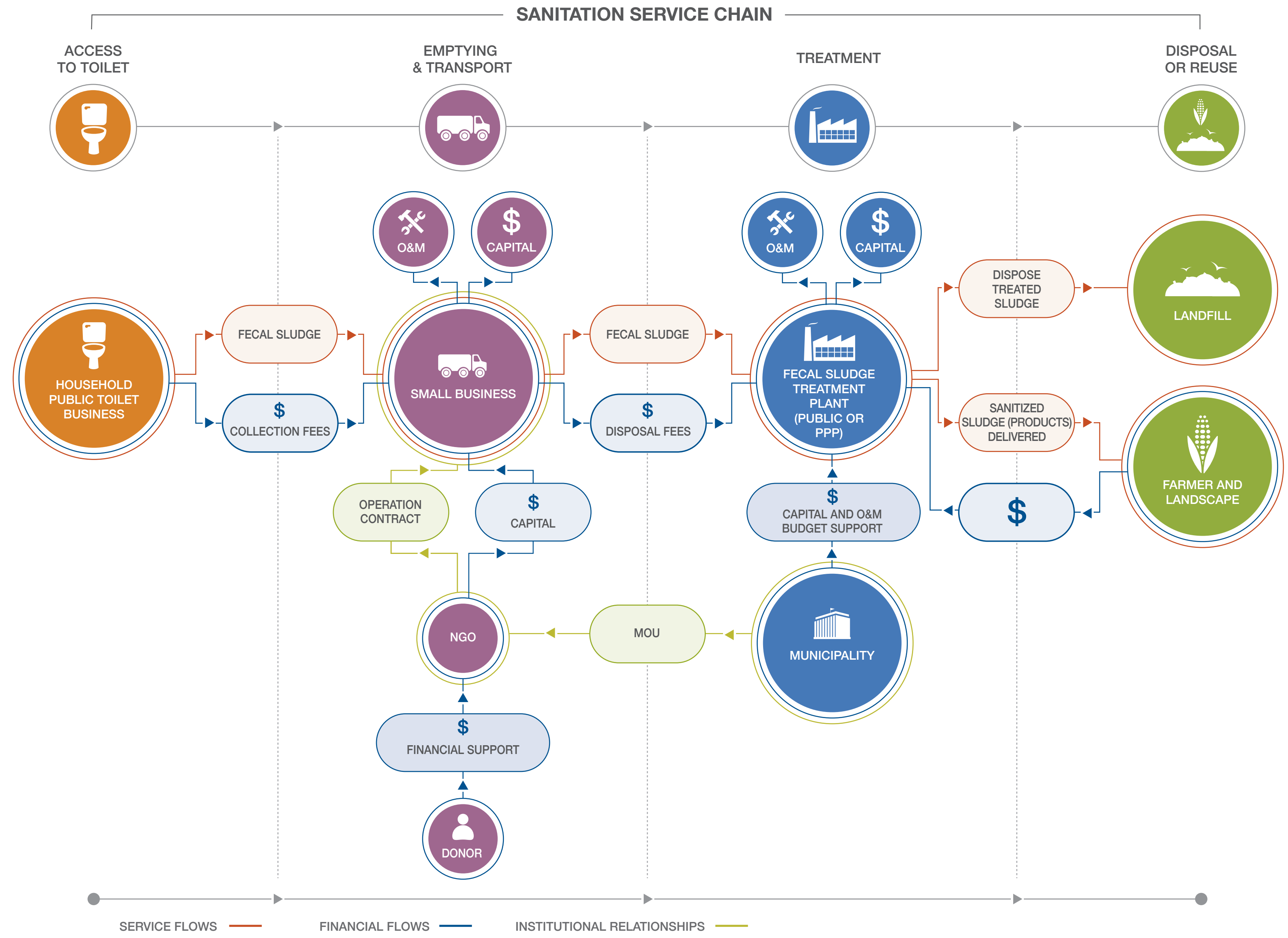


TABLE 9. BENEFITS AND LIMITING FACTORS OF THE NONPROFIT MODEL.

FINANCIAL IMPLICATIONS	
Benefits for emptying operations	N
Reduces emptying cost to households	N
Requires subsidy	Y
Improve cost recovery of FSM	N

REGULATORY AND MONITORING IMPLICATIONS	
Requires close monitoring for regulatory compliance	N
Modification of sanitation codes and policy	N

INSTITUTIONAL IMPLICATIONS	
Requires public sector involvement	P
Requires private sector involvement	P

ENVIRONMENTAL AND HEALTH IMPLICATIONS	
Reduces indiscriminate disposal of sludge	P
Concerns of public health and environmental safety	P

Y – Yes, P – Possible, N – No, NA – Not applicable; see Table 3.

The model has a two-phased approach. In the first phase, the NGO owns and operates the emptying service, and simultaneously identifies and mobilizes entrepreneurs, especially those engaged in manual emptying, and trains them in business operations. In the second phase, the NGO transfers the operations to the trained entrepreneurs. In addition, the NGO engages with local authorities to improve the institutional and regulatory environment for emptying. For the initial set of entrepreneurs, the NGO may provide the necessary capital free or as interest-free loans from the donor funds. However, in the long term, the NGO must engage with local banks or financing entities to bridge possible financing gaps.

The model addresses the following key aspects:

- Create awareness on emptying and encourage small entrepreneurs in the sanitation business.
- Kick-start emptying operations to stimulate demand for services until the market for emptying matures sufficiently for the business to be driven by market-based principles.
- Works in regions where institutions (provision of service by local authorities or private emptying businesses) are weak or lack the necessary capacities to provide sanitation services.
- Engage workers involved in manual emptying to operate mechanical trucks in regions where manual emptying is illegal, thereby preventing the loss of employment of those involved in manual emptying.

Case example from Mozambique and Bangladesh

Uaiene Gama de Serviços de Maputo, Mozambique (Hawkins and Muxímpua 2015; WSUP 2013a, 2013b; ICLEI 2012): Water and Sanitation for the Urban Poor (WSUP) is a nonprofit organization focusing on developing commercially viable models to help water utilities and municipal authorities deliver improved water and sanitation services (www.wsup.com). In Maputo, Mozambique, WSUP engaged with a local private enterprise, Uaiene Gama de Serviços de Maputo (UGSM), for providing emptying services since they had an existing market network. UGSM provides primary refuse collection services to residents in *bairros*[7] of Maxaquene A and B in Maputo. WSUP also created relationships with the Conselho Municipal de Maputo (CMM), the local municipal council, and also with the communities in the *bairros*. In the target *bairros* of Maxaquene A and B, vacuum tankers are unable to operate due to difficulty in accessing septic tanks. WSUP provided hand-operated gulper pumps with a system of carts to ferry waste to strategically stationed vacuum trucks operated by UGSM. These vacuum trucks transport the waste to the treatment plant. WSUP provided an interest-free loan (USD 20,000) to UGSM for the emptying equipment (gulper pumps, collection buckets, hand carts and protective clothing) along with technical support and training to provide emptying services. In return, UGSM is committed to financing the vacuum trucks. Depending on the type of containment (pit latrines versus septic tanks), depth and diameter, and client capacity to pay, UGSM charged USD 20-60 per emptying session.

Dushtha Shasthya Kendra (DSK), and Population Services and Training Centre (PSTC), **Dhaka, Bangladesh** (WaterAid 2011; DFID 2005): In Dhaka, Bangladesh, WaterAid, a global nonprofit organization that addresses the water and sanitation crisis globally, recognized the growing demand for emptying of FS from OSSs. WaterAid engaged with its NGO partners, Dushtha Shasthya Kendra (DSK) and Population Services and Training Centre (PSTC), to introduce emptying and transportation services for FS from OSSs. Unlike other countries in the region, Bangladesh has not progressed significantly in mechanical emptying practices. In Dhaka, the emptying service is predominantly provided by workers specialized in manual emptying despite it being illegal, due to the lack of the mechanical emptying option. WaterAid saw the opportunity to introduce a small motorized emptying machine on wheels, fitted with a tank and a pump, referred to as Vacutug (developed in Kenya and adopted for the Bangladesh environment). Financial support provided by WaterAid Bangladesh helped DSK and PSTC procure 2 m^3-Vacutugs to provide emptying services. The business operations are small with

[7] Bairro is the Portuguese term for an urban district.

one to two employees (driver and/or operator), and a part-time supervisor. Both NGOs have collaborative arrangements with the Dhaka Water Supply and Sewerage Authority (WASA) for disposing of FS in lifting points of the sewerage system. DSK had faced opposition from manual emptying operators because the Vacutug service was threatening their source of income. DSK worked with manual emptying operators to redefine their role as marketing agents for DSK, where they would identify and stimulate demand for the service. In this arrangement, the manual emptying operators were paid a commission of 10% to 30% of the fees charged to the households. This model continues to operate but faces a variety of technical and operational challenges undermining the viability of the service (Opel and Bashar 2013).

7.4 Transfer Station Model

Transfer station is an intermediate step in the emptying and transportation component of the sanitation service chain, prior to final disposal of septage at the treatment plant. It is a potential solution to reduce the indiscriminate disposal of FS. Transfer station is applicable in the following context:

- ***Distance and time:*** Longer distances or time required to transport sludge to the treatment plant can create financial disincentives (fuel costs and time spent) for vacuum truck operators, resulting in illegal disposal (Koné and Peter 2008).
- ***Inaccessible pits and manual emptying:*** On-site sanitation systems that are inaccessible to vacuum trucks are typically emptied either manually by an operator or using smaller vacuum trucks (e.g., vacutug and dung beetle). These emptying methods have a slow-moving transport system, and in order to make profits, it is important to minimize the travel distance to disposal sites.

It is well known that an emptying business can increase its profits by increasing the number of pits/tanks emptied vis-à-vis number of trips made on a daily basis. Strategically located transfer stations reduce the transport time for emptying operators, resulting in more tanks/pits emptied per day (Figure 21; Table 10). Alternatively, these businesses could charge higher fees based on the distance to the disposal point. However, it can create inequity issues, especially for the poor with lower ability to pay.

From the financial viability perspective, setting up a transfer station does not necessarily yield revenue, despite incurring operating costs for the entity managing the transfer station. Operations of transfer stations could be managed by the same entity managing the treatment plant. Therefore, transfer stations are likely to require subsidies from local governments, which can be based on volume and distance to transport sludge from the transfer station to the treatment plant.

TABLE 10. BENEFITS AND LIMITING FACTORS OF THE TRANSFER STATION MODEL.

FINANCIAL IMPLICATIONS	
Benefits for emptying operations	Y
Reduces emptying cost to households	P
Requires subsidy	Y
Improve cost recovery of FSM	N

REGULATORY AND MONITORING IMPLICATIONS	
Requires close monitoring for regulatory compliance	N
Modification of sanitation codes and policy	P

INSTITUTIONAL IMPLICATIONS	
Requires public sector involvement	Y
Requires private sector involvement	P

ENVIRONMENTAL AND HEALTH IMPLICATIONS	
Reduces indiscriminate disposal of sludge	Y
Concerns of public health and environmental safety	N

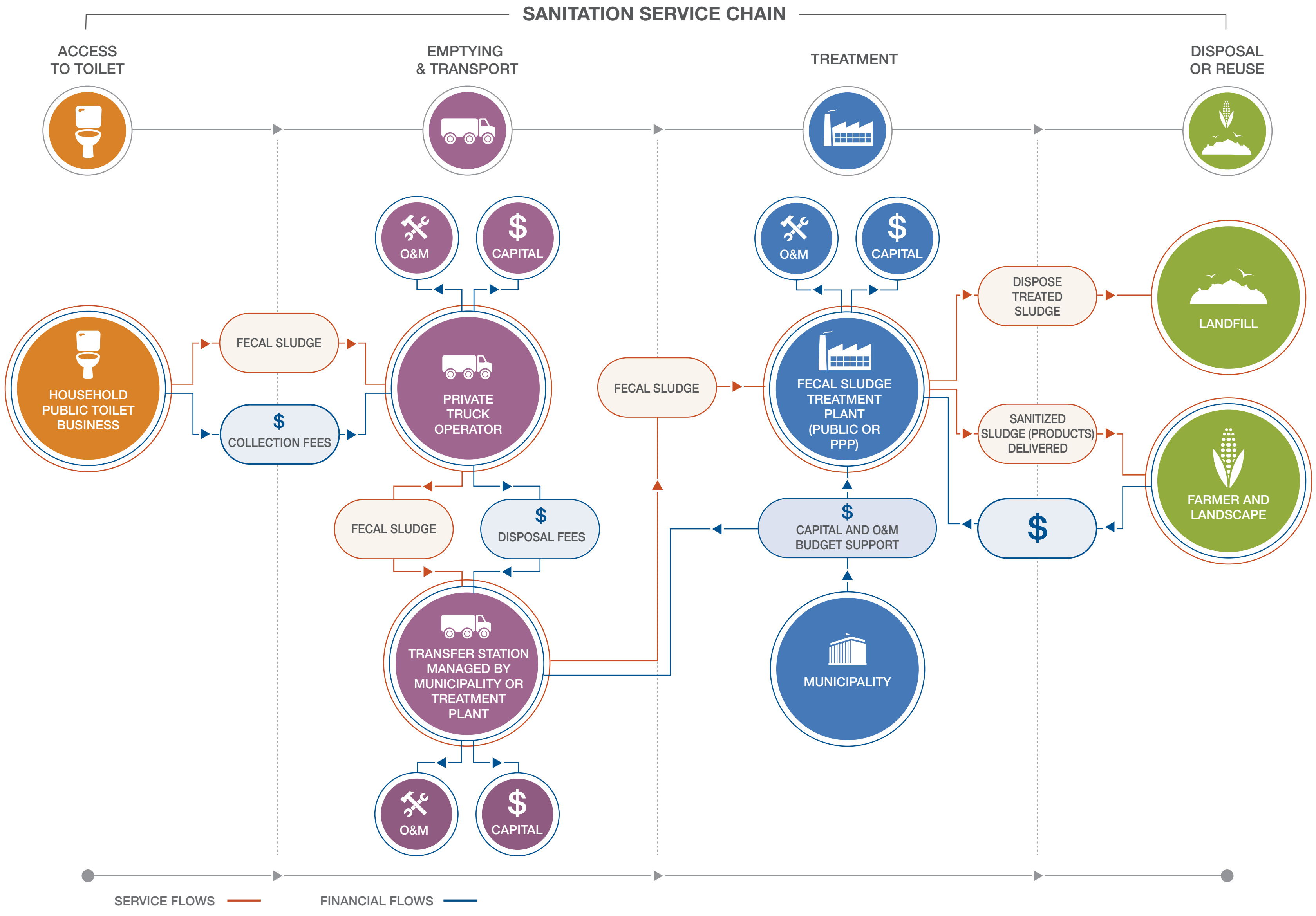
Y – Yes, P – Possible, N – No, NA – Not applicable; see Table 3.

Transfer stations have been piloted in Bangladesh, Zambia, Malawi (Rahman et al. 2015; Mulenga and Malambo 2015; De Gabriele and Heeger 2015), etc. In all these cases, it has been identified that the use of a transfer station improves the logistics and transport costs. For more information on different types of transfer stations, refer Mikhael et al. (2014) and Mukheibir (2016). There are many types of transfer stations, which can be broadly classified into two categories: (a) fixed, and (b) mobile.

Fixed transfer stations: These are permanent structures which are often underground holding tanks (UHT) that are watertight with an inlet pipe for disposal of sludge, and an outlet pipe for discharging sludge into larger vacuum trucks for carting away. They may also have a solid-liquid separator connected to the sewerage system, where the liquid is discharged into the sewerage network and may result in a substantial reduction in the volumes of FS to be transported by the trucks.

Mobile transfer stations: As the name suggests, this transfer station is mobile in nature and is strategically located. It can be a large truck located temporarily at sites, where a number of operators (mechanical and manual emptying) work. It could also consist of a detachable tanker trailer that is transported when it is full and is replaced with an empty one.

FIGURE 21. TRANSFER STATION MODEL.



The mobile stations have high applicability when there is a planned emptying initiative for a region/community (see section *Scheduled Desludging Sanitation Tax Model*) undertaken by smaller and slower transport equipment.

Case example for fixed transfer stations from Ghana, Sierra Leone and Malaysia

Geo-tubes, Malaysia (Ho et al. 2011): Based on empirical data collected by Indah Water Konsortium (IWK) in Malaysia, the piloting of Geo-tubes in transfer stations was modeled for the city of Melaka, which showed a significantly improved financial viability of the local medium-size FSM business towards a positive net present value. Geo-tubes (Box 5) allow to dewater the sludge and thus reduce its transport volume. In Malaysia, the price for emptying is fixed. Therefore, it is not financially attractive for private contractors to desludge septic tanks that are 30-50 km away from the centralized treatment plant. The objective of installing geo-tubes in strategic locations, including treatment plants for the leachate, was to ensure that the maximum distance traveled by truck operators to dispose the sludge was not more than 15 km. This resulted in improved truck performance by 54% due to the shorter travel distance, reduced operation cost per desludging activity by 8%, increase in revenue by 35% and an overall reduction of operation costs by 37%.

UHT, Accra, Ghana (Boot 2007): A well-known example of a UHT is from Accra, Ghana. In 1990, the Accra Metropolitan Assembly (AMA) and Waste Management Department (WMD) installed 60 UHTs with a capacity of 23 m^3 each to serve private manual emptying and dung beetle operators (contracted by WMD), who emptied OSSs that were inaccessible to vacuum trucks. The private vacuum truck operators were paid by the contracted manual emptying and dung beetle operators to remove sludge from the UHTs and transport it to the treatment site. There were challenges in the operation of these UHTs due to the institutional arrangement and the technology. From an institutional perspective, the process did not involve other informal manual emptying operators, who illegally disposed the sludge into UHTs, resulting in an increase in the frequency and cost of cleaning the UHTs. From a technological perspective, UHTs were not user-friendly to operate, especially when the waste was drier (sludge from pit latrines), and when FS stored over relatively long periods resulted in siltation of the sludge. This made sludge extraction infeasible, and the operations became too expensive and time consuming.

BOX 5. GEO-TUBES.

Geo-tubes, containers and bags are made from a geotextile fabric (e.g. polypropylene) and can be used for dewatering of fecal sludge. Geo-tubes have high durability, low maintenance, low energy or fuel usage, and they do not require additives. They work under all weather conditions, do not emanate bad odors and have no pest issues, as the dewatered sludge is contained in the tubes and not exposed. However, they need to be replaced. According to Ho et al. (2011), the geo-tube is environmentally friendly and traps the solids in FS. The solids collected can be easily transported to a landfill for disposal or sent for recovery of nutrients and then used as a soil conditioner. Geo-tubes also significantly reduce the operation cost in comparison to mechanical dewatering units.

Case example of a mobile transfer station from Lesotho and Ethiopia

Maseru, Lesotho (Strauss and Montangero 2002): The very first version of Vacutug (1 m^3 tank) developed by Manus Coffey, an Irish manufacturing company, was used to empty pits. Since it was uneconomical to transport such small tankers to designated disposal sites, the city of Maseru developed a system of mobile transfer stations where the Vacutug transferred the sludge contents into a conventional vacuum truck located at the closest proximity it could travel to the emptying site.

Addis Ababa, Ethiopia (Defere and Yemane 2011): In Addis Ababa, Ethiopia, the Addis Ababa Water and Sewerage Authority (AAWSA), a public utility service, built four mobile transfer stations. The sludge (from OSSs) emptied by vacuum trucks (3 m^3) is transferred into larger trucks, which then take it to the treatment plant. The transfer stations service only AAWSA-operated vacuum trucks and trucks operating the farthest distance from the treatment site. It was observed that the transfer stations reduce the travel distance by 12 km per trip.

8. MODELS LINKING EMPTYING, TRANSPORT AND TREATMENT

The business models discussed under this section focus on the emptying and treatment component of the sanitation service chain. In comparison to the business models discussed in the previous section 7, the ‘boundaries’ of the business models described below are expanded to incentivize emptying and transportation businesses to deliver FS to the treatment plant. By formalizing transactions between the emptying and treatment component of the chain, the emptying businesses can be incentivized to deliver FS to treatment plants and avoid indiscriminate disposal. Reuse can be a consideration but is not central to the model, as those described in section 9.

The business models discussed in this section offer the following value propositions:

- Provide emptying services for households and institutions.
- Improve the business environment for the emptying enterprises through incentives.

8.1 Commonly Occurring Public FSM Model

A commonly occurring scenario observed is the ownership and management of FSM by the public sector for collection, transportation and treatment (Figure 22; Table 11). Users of OSSs approach local authorities, which are usually the municipality or the state-run water and sewerage companies, to provide emptying services. The service is provided for a pre-fixed price. The sludge collected is transported to a treatment plant or landfill site which is also owned and operated by a public utility or the local municipality.

TABLE 11. BENEFITS AND LIMITING FACTORS OF THE COMMONLY OCCURRING PUBLIC FSM MODEL.

FINANCIAL IMPLICATIONS		REGULATORY AND MONITORING IMPLICATIONS	
Benefits for emptying operations	N	Requires close monitoring for regulatory compliance	N
Reduces emptying cost to households	N		
Requires subsidy	Y	Modification of sanitation codes and policy	N
Improve cost recovery of FSM	N		

INSTITUTIONAL IMPLICATIONS		ENVIRONMENTAL AND HEALTH IMPLICATIONS	
Requires public sector involvement	Y	Reduces indiscriminate disposal of sludge	Y
Requires private sector involvement	N	Concerns of public health and environmental safety	N

Y – Yes, P – Possible, N – No, NA – Not applicable; see Table 3.

Case examples from Malaysia and Vietnam

Indah Water Konsortium Sdn Bhd, Malaysia (Ho et al. 2011): In Malaysia, the Sewerage Services Act (SSA) came into force in 1993 ending the responsibility of local authorities in sewerage and septage management. The Government of Malaysia awarded a concession to Indah Water Konsortium (IWK), which is wholly owned by the Ministry of Finance but operates as a private company. IWK was responsible for 88 local authority areas within Malaysia peninsular, with a customer base of 1.2 million people owning septic tanks and 800,000 owning pour flush systems. IWK undertook scheduled desludging of septic tanks within its service areas while also providing emptying services on demand within and outside its service areas. IWK was also responsible for operation of treatment facilities that came within their purview, from which it derives 90% of its revenue. In 2006, the Water Services Industry Act (WSIA) came into force and opened the sanitation sector to private participation as IWK was perceived to be monopolistic. IWK continues to provide emptying services in its concession areas and also engages private enterprises to undertake desludging, where it is not feasible for the organization to provide such services.

Urban Environment Company (URENCO) and **Ho Chi Minh City Environmental Company (CITENCO), Vietnam** (Nguyen et al. 2011): In Vietnam, there are public utilities operating as companies and funded by the government, such as the Urban Environment Company (URENCO) in Hanoi and Ho Chi Minh City Environmental Company (CITENCO) in Ho Chi Minh City. The utilities are responsible for desludging public toilets and they are also engaged in solid waste management. URENCO transports the sludge emptied from public toilets to its co-composting plant in Cau Dzien. In the case of CITENCO, the sludge collected is transported to a treatment site managed by a private company called Hoa Binh Fertilizer Company, where the sludge is dried, treated and sold as biosolids. CITENCO pays disposal fees to the fertilizer company for processing its “waste”.

8.2 Licensing Model

This business model is similar to the commonly occurring private emptying and transportation model. The key difference lies in the issuing of license/permits to the private truck operators by relevant public authorities to operate emptying businesses. Licensing helps in accounting for all emptying businesses in the city, and can potentially track these businesses to prevent illegal disposal of FS. The license/permit could be either a one-time fee or fees paid annually by the truck operators. The public authority issuing the license provides basic “dos and don’ts” to the truck operators, and they need to monitor for regulatory compliance by tracking the operations of private truck operators. The license is revoked, if the truck operator is found to be violating any regulations, especially engaging in the illegal disposal of FS in non-designated sites (Figure 23; Table 12).

In addition to the value propositions stated earlier, this business model potentially offers increased revenue from license fees collected for FS treatment purposes. In addition, close tracking of emptying operations can result in improved FSM. The primary advantage of this

FIGURE 22. COMMONLY OCCURRING PUBLIC FSM MODEL.

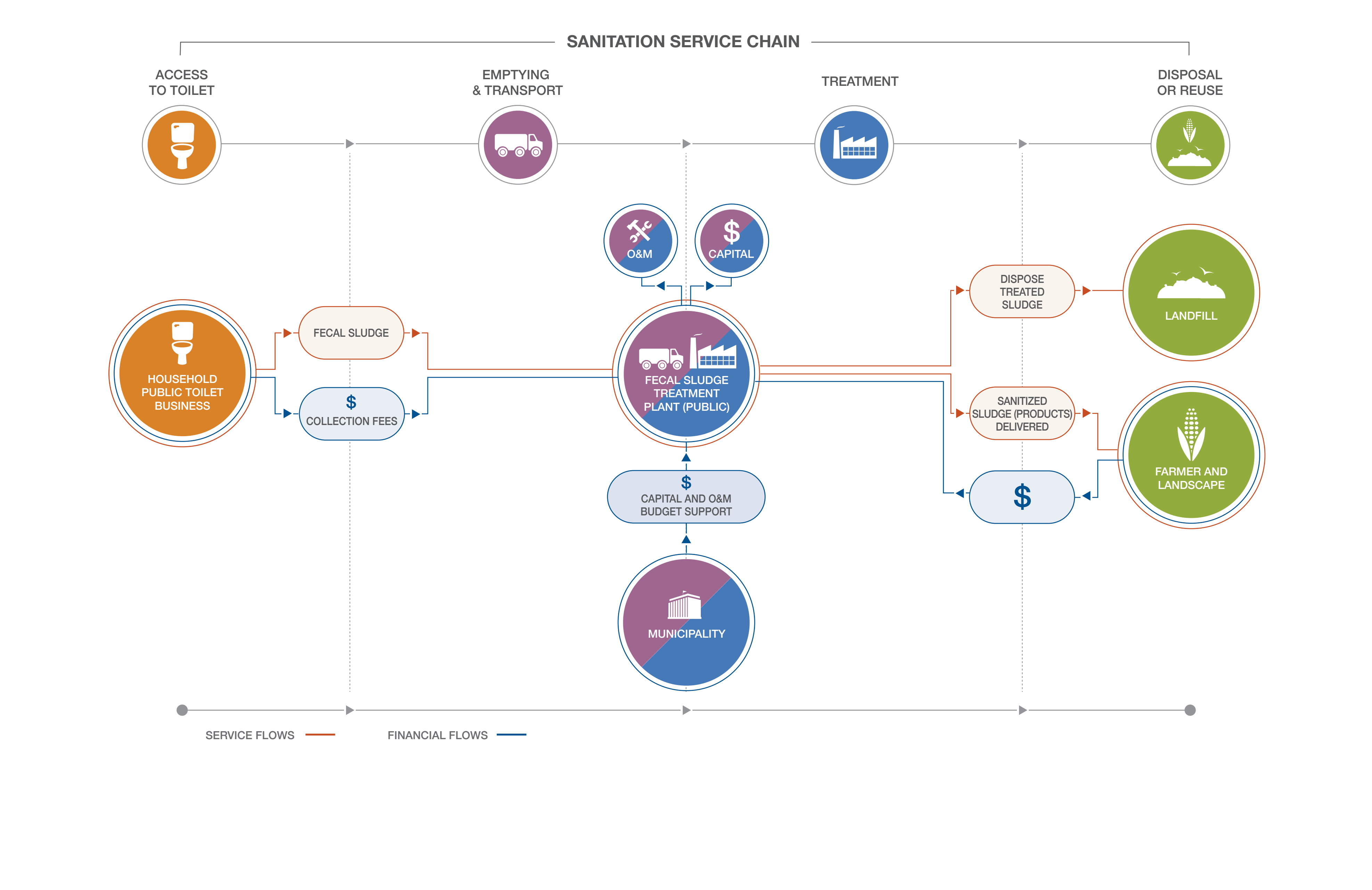
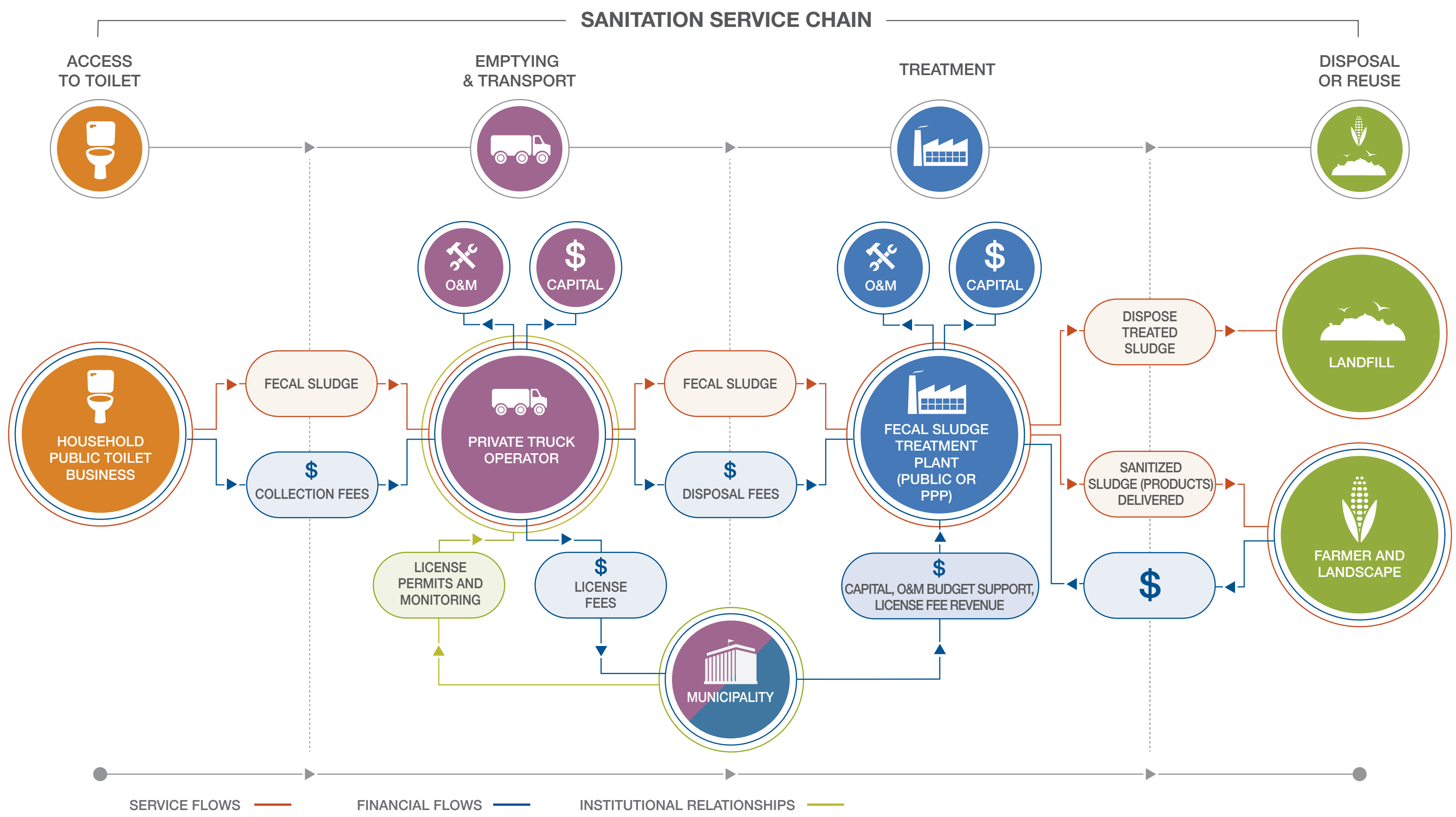


FIGURE 23. LICENSING MODEL.



model is that the government has a better understanding of the number of emptying operators, revenue transparency and high competition, thereby ensuring an improved FSM service to residents.

Case examples from Ghana and Kenya

Kumasi Metropolitan Assembly, Ghana (Mensah 2006; Vodounhessi and von Münch 2006; Thrift 2007; Owusu 2013): In Kumasi, Ghana, private truck operators have to

TABLE 12. BENEFITS AND LIMITING FACTORS OF THE LICENSING MODEL.

FINANCIAL IMPLICATIONS		REGULATORY AND MONITORING IMPLICATIONS	
Benefits for emptying operations	N	Requires close monitoring for regulatory compliance	Y
Reduces emptying cost to households	P		
Requires subsidy	P	Modification of sanitation codes and policy	Y
Improve cost recovery of FSM	N		
INSTITUTIONAL IMPLICATIONS		**ENVIRONMENTAL AND HEALTH IMPLICATIONS**	
Requires public sector involvement	Y	Reduces indiscriminate disposal of sludge	Y
Requires private sector involvement	Y	Concerns of public health and environmental safety	N

Y – Yes, P – Possible, N – No, NA – Not applicable; see Table 3.

obtain licenses from the Waste Management Department (WMD) at Kumasi Metropolitan Assembly (KMA). The objective of the city authority is to move away from providing direct services and facilitate participation of the private sector in providing desludging services. WMD in KMA has set rules for private sector participation and vets the operator before issuing a license. The truck operators have to comply with KMA regulations to prevent the license being revoked. The private truck operators have to pay disposal fees to KMA for disposing the sludge at the treatment plant managed by KMA. In Kumasi, strict monitoring combined with the threat of the license being revoked, which would highlight failure to comply with the regulations and community shaming, has drastically reduced the illegal dumping of FS.

Licensing in Kenya – Nairobi, Mombasa and Kisumu (Mwangi et al. 2011; Murray 2011): A study funded by the Bill & Melinda Gates Foundation on FS emptying practices in three cities in Kenya (Nairobi, Mombasa and Kisumu) identified different types of licenses/permits for truck operators – trade license, truck fitness certificate, FS disposal permit and FS operator license. The city authority issues trade licenses that require annual renewal for all types of businesses. The National Environment Management Authority (NEMA) issues certification of fitness for use to all FS emptying trucks, in order to avoid issues of bad odor or health risks. Also, NEMA's regulations require waste to be disposed at designated sites. Depending on the city, the truck operators are required to obtain permits from the utility firm managing the treatment plant to dispose FS on a per-trip basis. In Kisumu, there is no separate fee for disposing FS, as this is included in the annual license fees, which means that there is no record of the number of trucks using the facility on a daily basis.

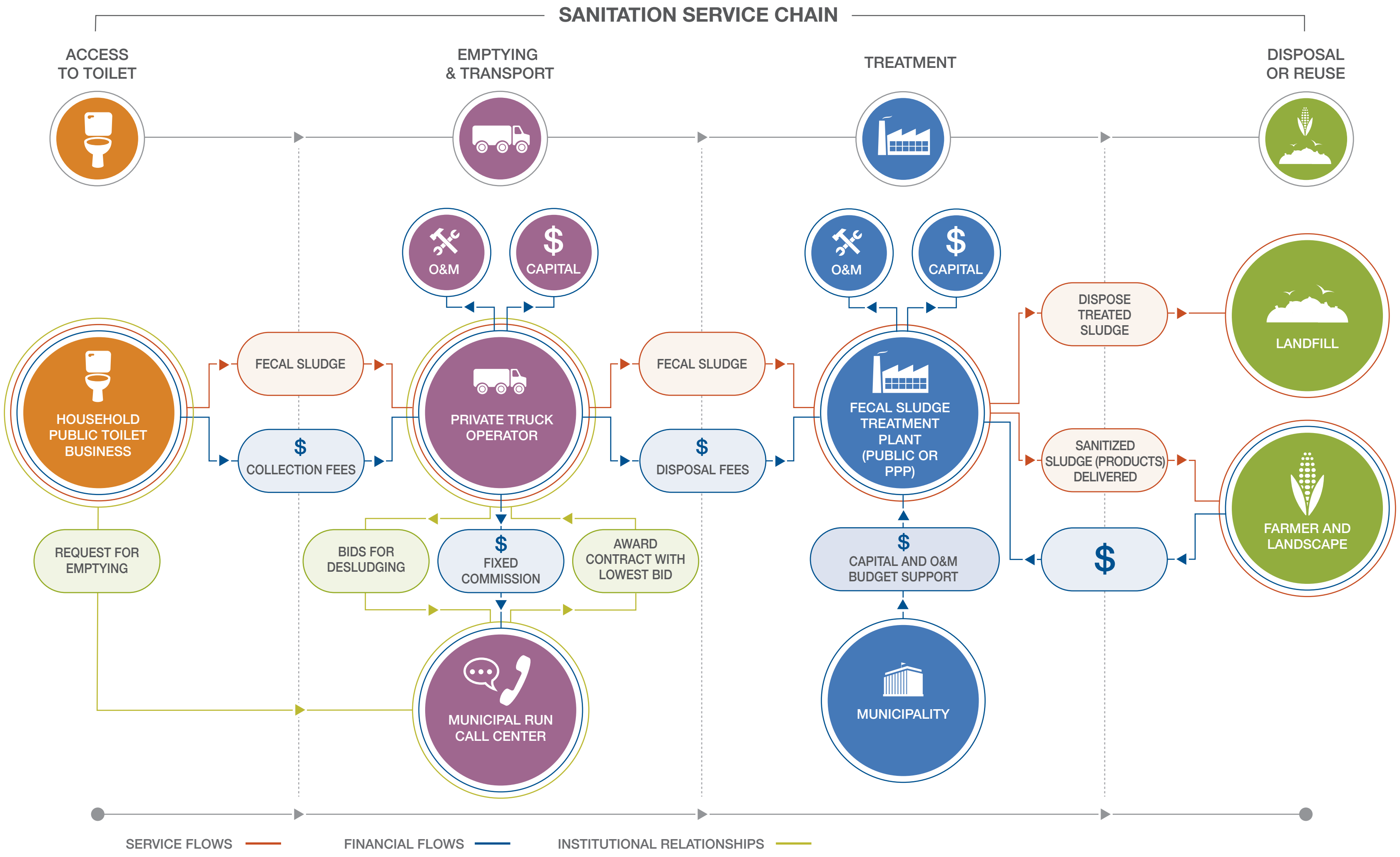
8.3 Call Center Model

This business model requires setting up a call center or a customer help center managed by the local authorities, which acts as a network orchestrator linking users of OSSs with vacuum truck operators. The truck operators register with the call center for a fixed annual fee which can also double up as a license or permit. Users of OSSs call the help center when their septic tanks or pits are full. The call center allocates the emptying of tanks/pits on a bidding basis, whereby a message is sent to the mobile phones of all the registered truck operators and the operator (in client proximity) offering the lowest bid is given the contract for emptying FS. The customer makes either a direct payment to the truck operator or to the call center for providing the emptying service. The call center may charge a fixed commission to the truck operator for every trip made to cover its operational costs, which can be collected, along with the disposal fees, at the time of sludge disposal at the treatment site. Alternatively, a fixed sanitation tax is charged to the household and commercial buildings to cover the operation cost of the call center and the treatment plant (Figure 24; Table 13). The sanitation tax can be collected either by adding a surcharge to water bills or through property tax as described in the section *Scheduled Desludging Sanitation Tax Model*.

This business model requires call center staff to be well trained to ask precise questions, such as accessibility to pits/tanks, type of OSS, etc. This information is provided to the truck operators along with the message sent for bidding requests, so that they have sufficient information to submit appropriate bids. The business model needs to have quality assurance checks to ensure that the required service standards are provided by the truck operators. Any operator failing to meet the standards should be warned and banned or financially penalized.

By issuing pit *emptying contracts*, it is possible to closely track whether the truck also delivers its load to the designated plant, thereby reducing the indiscriminate disposal of sludge. The business model can potentially lower the fee charged for emptying through the bidding system. The challenge in the business model lies in the possibility of incorrect information being collected by the call center, resulting in incorrect bids being submitted

FIGURE 24. CALL CENTER MODEL.



by the private truck operator. Also, there is insufficient empirical data yet on the required scale of operations (ratio of truck operators to households) to optimize a competitive service and the recovery of call center operation costs.

TABLE 13. BENEFITS AND LIMITING FACTORS OF THE CALL CENTER MODEL.

FINANCIAL IMPLICATIONS		REGULATORY AND MONITORING IMPLICATIONS	
Benefits for emptying operations	P	Requires close monitoring for regulatory compliance	N
Reduces emptying cost to households	Y		
Requires subsidy	P	Modification of sanitation codes and policy	P
Improve cost recovery of FSM	N		

INSTITUTIONAL IMPLICATIONS		ENVIRONMENTAL AND HEALTH IMPLICATIONS	
Requires public sector involvement	P	Reduces indiscriminate disposal of sludge	Y
Requires private sector involvement	Y	Concerns of public health and environmental safety	N

Y – Yes, P – Possible, N – No, NA – Not applicable; see Table 3.

Case example from Senegal

ONAS Call Center, Senegal (ONAS 2013, 2014, 2015; Mbéguéré 2015; SuSanA 2013b, 2014a, 2014b): In Dakar, Senegal, ONAS, under the Programme de Structuration du Marché des Boues de Vidange (PSMBV) (Market Structuring of Fecal Sludge Management Program) funded by the Bill & Melinda Gates foundation, initiated a call center model. ONAS took over 2 years to design and develop the call center, and the process involved extensive consultation with all relevant stakeholders, especially private truck operators. At the end of 2013, call center operations were launched. Operation of the call center evolved in a phased manner with the initial platform development followed by the beta launch phase and pilot launch, and finally commercial scale up. ONAS engaged with Water and Sanitation for Africa (WSA) and Innovations for Poverty Action (IPA) to develop a technical platform for the call center, and recruited and trained operators to manage the call center. Training was also offered to truck operators. In the post-beta phase, bugs in the systems were rectified and preparation for the pilot phase launch was carried out through promotional and awareness campaigns on the launch of the call center. ONAS also has every truck geo-referenced.

While a FS emptying business usually operates multiple trucks, the bid auctions announced by the call center do not apply to individual businesses but to individual trucks. This cuts communication pathways short and means that different trucks within the same company could compete for the same bid. When a customer calls the center, their location is listed in the auction and the information is sent to trucks that specifically operate in that location. The truck operators are familiar with the neighborhoods and submit their bids via the mobile phone short messaging service (SMS). At the end of the bidding period, the lowest bidder is notified. The call center takes customer feedback after every emptying to ensure quality control. In the event that a customer reports on poor quality of service, the relevant operator is penalized in future bids, whereby the offer made is marked up with a fixed penalized amount of CFA francs 2,000 (USD 3.5), which would make the offer less competitive.

Since the start of call center operations, as of July 2014, the call center had 138 trucks registered and it had emptied 499 septic tanks. The call center model had resulted in a significant decrease in emptying fees. For example, in the Commune of Sicap Mbao, between July 2013 and December 2014, emptying fees had declined by 14% (from USD 57 to 49). The call center service has expanded to the entire city and, on average, the emptying fee is about CFA francs 24,047 (USD 50), with the minimum fee at CFA francs 16,500 (USD 35). Since the launch of the call center, there has been an increase in the volumes of sludge delivered to treatment plants. The model could support, in particular, low-income households struggling with desludging fees, while high-income households might continue direct contracting to control who is entering their premises.

There are increasingly examples of the use of mobile phones and communication technologies for delivering sanitation services (Box 6).

8.4 Scheduled Desludging Sanitation Tax Model

This business model has two key aspects: a) sanitation tax collected from owners of OSSs, and b) mandatory scheduled desludging of tanks/pits. Sanitation tax is collected by the local authority either as a percentage of property tax or by the public utilities as a surcharge on water bills. Local authorities in discussion with the households using OSSs set up a mandatory scheduled desludging plan. The user of the OSS does not pay for the desludging services unless they require an unscheduled service. The revenue generated from the sanitation tax is designed to cover the O&M cost of

BOX 6. USE OF MOBILE PHONES AND INFORMATION AND COMMUNICATION TECHNOLOGIES (ICT) FOR DELIVERING SANITATION SERVICES.

More people have access to mobile phones than access to improved sanitation in most emerging markets. Gradually, smartphones have become increasingly affordable, and 2.9 billion people in developing countries are estimated to have smartphones by 2020. There is a huge potential in using mobile phones to help achieve sanitation-related development outcomes. According to a report by the Groupe Spéciale Mobile Association (GSMA) Mobile for Development Utilities program, the ecosystem created by mobile phones can help solve sanitation challenges in emerging markets, by capturing real-time data to help design efficient programs, and also assisting with issues of monitoring, O&M and financing. In addition, mobile phones can also optimize emptying services. A few examples of the use of mobile phones in the provision of sanitation services are given below:

- In Indonesia, as described in the section *Scheduled Desludging Sanitation Tax Model*, WSP of the World Bank piloted the use of smartphones and barcodes to improve operations of vacuum trucks. Barcodes are scanned at the household and treatment plant locations for data on customer information and to monitor the movement of trucks to prevent the illegal disposal of sludge.
- In Antananarivo, Madagascar, Loowatt developed a mobile application to coordinate logistics of waste collection and provide improved customer services to households with dry toilets.
- X-runner in Peru and Sustainable Organic Integrated Livelihoods (SOIL) in Haiti (see case examples in the section *Container-based Sanitation Model*) use mobile phones for undertaking surveys and providing customer service. X-runner sends reminders via SMS on payments due, which has resulted in lower default and 85% of the customers are making payments on time. X-runner provides dry toilets to customers, and has NFC (Near Field Communication) tags enabled through applications on Android smartphones on each customer's container to help identify customers and track waste collection. SOIL plans to use mobile phone technologies to send reminders to customers on waste collection and bill payments, and to also track collection of waste and performance of collectors.
- Sanergy in Kenya has partnered with SweetSense (a company providing low-cost, remote-monitoring solutions) to develop sensors to determine the filling rate of its Fresh Life Toilets in underserved settlements.

Currently, most of the case examples of mobile phone-based sanitation services are in nascent stages. In the future, we are likely to see more successful innovative, mobile phone-based sanitation solutions geared towards improved customer relationship, supply chain management, digitization of real-time data for designing sanitation models, financial services for bill payment and loan disbursement, campaigns for awareness creation and monitoring of behavioral change.

Source: Nique and Smertnik 2015.

collection, transportation and treatment of FS (Figure 25; Table 14). Local authorities can contract scheduled desludging to private truck operators to collect and transport sludge to designated disposal or treatment sites. The private entity receives payment based on the quantity of sludge delivered to the treatment plant (preventing illegal dumping; see section *Incentivized Disposal Model*) and the number of households that used the desludging service.

A critical aspect of this business model is the difficulty in raising public awareness of the benefits of scheduled desludging, providing information to households and businesses on the scheduled date and time for desludging, and tracking the septic tanks that have been desludged. It is highly recommended that a locally relevant information system be developed to ensure successful implementation of the model, considering differences in household and tank sizes.

The business model yields benefits of improved performance and functioning of the septic tanks. If a tank is not regularly desludged, the sludge gradually fills the tank rendering less space for anaerobic digestion, and increasing the level of suspended solids and untreated effluent discharged from the tank (AECOM International Development, Inc. and Sandec-Eawag 2010). The business model also has benefits from optimization of emptying (through zoned desludging), thus lowering transport costs. It reduces indiscriminate dumping and helps to design the treatment plant better, through known quantities of septage delivered. The challenge of the business model lies in ensuring dissemination of information on the desludging schedule and presence of a household member so that the trucks have access to the septic tanks.

To implement a scheduled desludging program for a town of 5,000 to 25,000 households, a tariff of USD 1 per month per family can result in full cost recovery of both capital and operations costs (SuSanA 2015a).

FIGURE 25. SCHEDULED DESLUDGING SANITATION TAX MODEL.

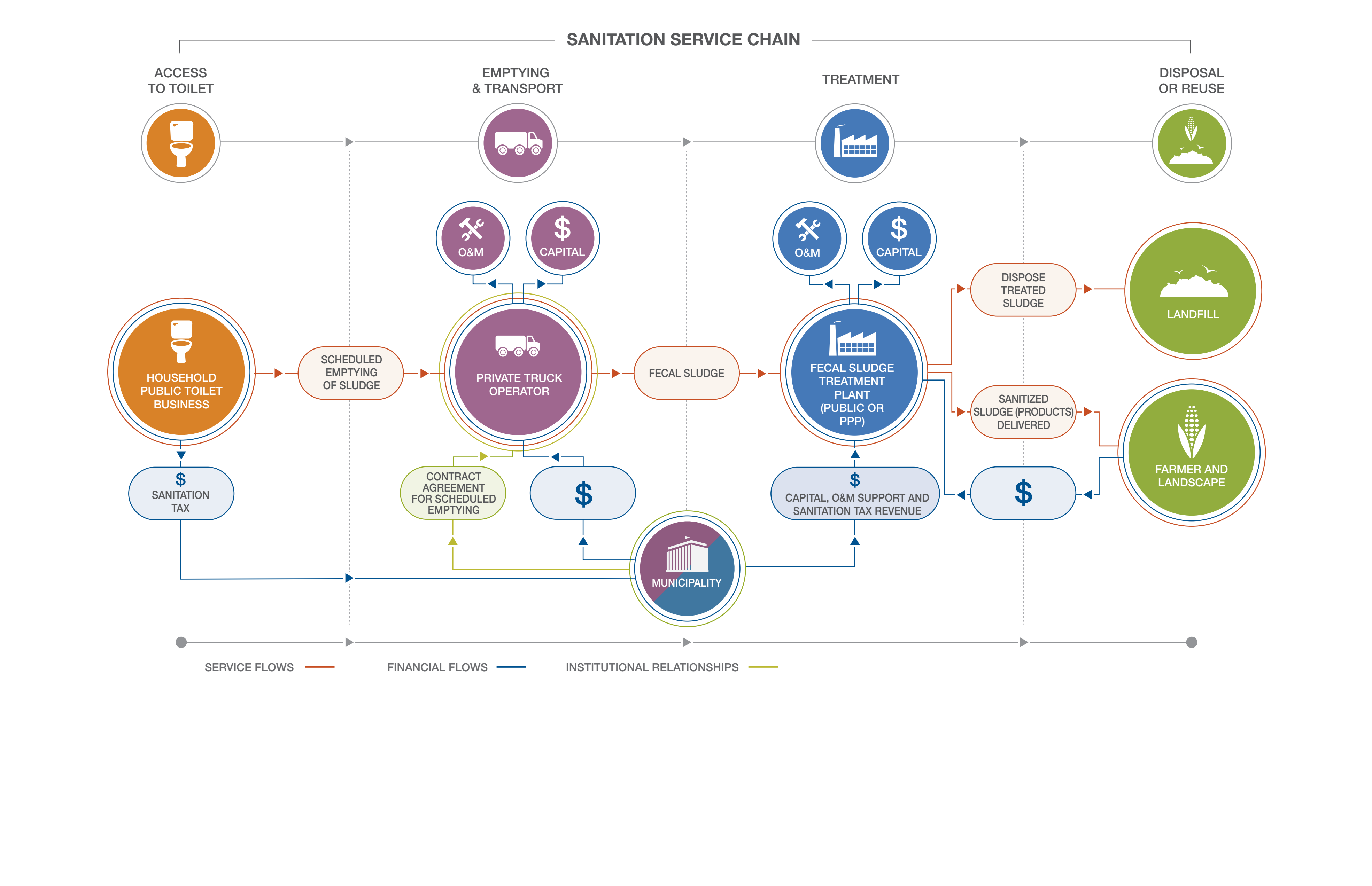


TABLE 14. BENEFITS AND LIMITING FACTORS OF THE SCHEDULED DESLUDGING SANITATION TAX MODEL.

FINANCIAL IMPLICATIONS		REGULATORY AND MONITORING IMPLICATIONS	
Benefits for emptying operations	P	Requires close monitoring for regulatory compliance	Y
Reduces emptying cost to households	P		
Requires subsidy	P	Modification of sanitation codes and policy	Y
Improve cost recovery of FSM	P		

INSTITUTIONAL IMPLICATIONS		ENVIRONMENTAL AND HEALTH IMPLICATIONS	
Requires public sector involvement	Y	Reduces indiscriminate disposal of sludge	Y
Requires private sector involvement	P	Concerns of public health and environmental safety	N

Y – Yes, P – Possible, N – No, NA – Not applicable; see Table 3.

Case examples from the Philippines and Vietnam

Dumaguete, Philippines (Peal et al. 2015; SuSanA 2015b; Robbins et al. 2012): In 2010, Dumaguete City local government unit (LGU), with about 22,000 households, 3,500 commercial and institutional buildings, and a septic tank coverage above 75%, initiated a scheduled desludging program on a five-year emptying cycle. The water district was responsible for the collection and transportation of the sludge, and invested in seven trucks, each of which was 3 m^3 in size. The LGU was responsible for O&M of the treatment plant, and it reported receiving 100% of the sludge from the planned desludged septic tanks. The capital cost for the collection, transport and treatment of FS was borne by the water district and the LGU. A scheduled desludging program engaged city workers to inform neighborhoods on the schedule of desludging. In addition, mobile public address systems to announce planned desludging activities would be dispatched in the neighborhood a day prior to the desludging event. A sanitary inspector assesses the quality of desludging and an entry is made in the database of the household desludged. The city, in discussion with citizens and other stakeholders, agreed on a tariff of PHP 2 (USD 0.05 cents) as a surcharge per cubic meter of water consumed for the desludging service. This tariff was considered to be affordable, and also sufficient to cover operation costs and recover capital costs in about 8 years.

San Fernando, Philippines (Robbins et al. 2012): Similar to the septage management program in Dumaguete City, scheduled desludging was implemented in San Fernando City of the Philippines which has a comparable population size of approximately 115,000 capita. The city contracted private companies to collect and transport the sludge to treatment plants. Since the water supply corporative serves less than 50% of the city population and greater percentage of households pay property tax, the city authorities decided to collect sanitation tax as a part of the property tax from households and institutions, and not as a part of the water bill. The establishment of a scheduled desludging system was achieved after a broad stakeholder consultation process, which resulted in changes to the sanitation code, customer fees, fines and the implementation process.

A new multi-stakeholder City Wastewater Management Council was established, which is responsible for enforcing scheduled desludging once every 5 years by contracting the service to private truck operators. Only households making property tax payments received desludging services. The process also resulted in a decrease in desludging charges for households not covered by the program from USD 133 to below USD 66 per desludged tank. The private truck operators were in agreement with the decreased fees as this process resulted in a steadier business for them.

Box 7 shows an example of how households' desludging needs can be monitored.

BOX 7. ICT SYSTEM TO TRACK SCHEDULED DESLUDGING IN INDONESIA.

The primary challenge of the scheduled desludging model is managing the database of desludged households, and organizing communication and awareness campaigns to inform people about the schedule for desludging. An efficient database with a well-planned, locally relevant management information system, and utilizing the latest ICT can potentially address these barriers. In Indonesia, Royal HaskoningDHV, an international engineering and project management consultancy, along with WSP of the World Bank and the Ministry of National Development Planning, are hoping to introduce a control card and web-based system to provide scheduled desludging. The web-based system works on a barcode which is attached to every customer's water meter, and the customer sends information via the Internet using the barcode. Every truck also has a barcode which is scanned at the time of desludging (Wibowo et al. 2015).

Hai Phong, Vietnam (Nguyen et al. 2011; Kome 2011): In Hai Phong City, Vietnam, FSM is managed by the Hai Phong Sewerage and Drainage Company (HP SADCO), a public sector organization, next to private sector operators. The company has a sludge treatment facility to treat sludge from sewers and septic tanks, and aims to regularly desludge all 160,000 septic tanks in the city on a five-year cycle. However, since 2000, HP SADCO has only desludged 25% of all septic tanks, due in part to the lack of any local regulations that require properties to desludge their septic tanks, low wastewater tariffs and missing legal framework to control private operators. Main reasons of financial loss are high annualized depreciation costs, and a limited number of trips per truck per day, while private operators run higher frequencies thereby reducing their running costs through illegal dumping. In 2005, under a World Bank project, the Vietnamese government signed an agreement to improve cost recovery for regular service provision, with a 15% surcharge initially added to the water bill, and it was agreed that the surcharge should be gradually increased to 25% over the years to come, compared to the normal surcharge of 10% in other cities. The model also foresees the creation of a legal framework and regulation for FSM activities, as well as enforcement of this by the city.

The city authority collects the fees and pays HP SADCO based on the approved plan of activities. According to Nguyen et al. (2011) and Macintosh (2014), the revenue collected via the water bill was used to cover most of the O&M costs of the sewerage and drainage system, with limited amounts feeding into scheduled desludging. A serious concern with regard to the fee increase is that household's willingness to pay could become a problem (Kome 2011). To support HP SADCO's initiatives, the United States Agency for International Development (USAID) is facilitating a water operator partnership between HP SADCO and IWK. IWK, Malaysia's national sewerage and septage treatment services provider, has a long history of experience in scheduled desludging programs. Using their experiences and expertise, IWK will assist HP SADCO with the improvement of a scheduled desludging program, development of a promotional campaign, and submission of proposed regulations to the city people's committee (Waterlinks 2015).

8.5 Incentivized Disposal Model

This model provides financial incentives to truck operators to encourage disposal of sludge at designated treatment sites. The objective of the model is to eliminate indiscriminate disposal of FS. The model does not charge disposal fees to truck operators to discharge FS at treatment sites, and instead the truck operators are paid a fixed price by the treatment plant for delivering FS (Figure 26; Table 15).

Such conditional cash incentives have been implemented in the education and health sectors. For example, in the education sector, meals are provided to children in schools and this helps poor households to send their children to schools (Schultz 2001; Bonds 2012). In this FS model, the truck operator has two sources of revenue: (a) from households for emptying their pits/septic tanks, and (b) from the treatment plant for delivering the sludge. The model is dependent on government support for the treatment plant, so that such incentives can be provided based on the socioeconomic benefits from reduced indiscriminate dumping of FS.

There are a number of variations to the business model that could be developed based on the context and through combinations of different models described in this report. For example, variations to the incentivized disposal model are by (a) incorporating licensing and sanitation tax as shown in Figure 27, or (b) incorporating reuse in the treatment plant, thereby allowing the sale of reuse products to compensate for the loss of revenue (see section *Push-pull Model*).

TABLE 15. BENEFITS AND LIMITING FACTORS OF THE INCENTIVIZED DISPOSAL MODEL.

FINANCIAL IMPLICATIONS		REGULATORY AND MONITORING IMPLICATIONS	
Benefits for emptying operations	Y	Requires close monitoring for regulatory compliance	N
Reduces emptying cost to households	N		
Requires subsidy	Y	Modification of sanitation codes and policy	Y
Improve cost recovery of FSM	N		

INSTITUTIONAL IMPLICATIONS		ENVIRONMENTAL AND HEALTH IMPLICATIONS	
Requires public sector involvement	Y	Reduces indiscriminate disposal of sludge	Y
Requires private sector involvement	Y	Concerns of public health and environmental safety	N

Y – Yes, P – Possible, N – No, NA – Not applicable; see Table 3.

8.6 Full Private Model

As the name suggests, this model is driven by the private sector across the sanitation service chain, from collection to transportation and treatment. Sludge reuse as fertilizer or solid fuel

FIGURE 26. INCENTIVIZED DISPOSAL MODEL.

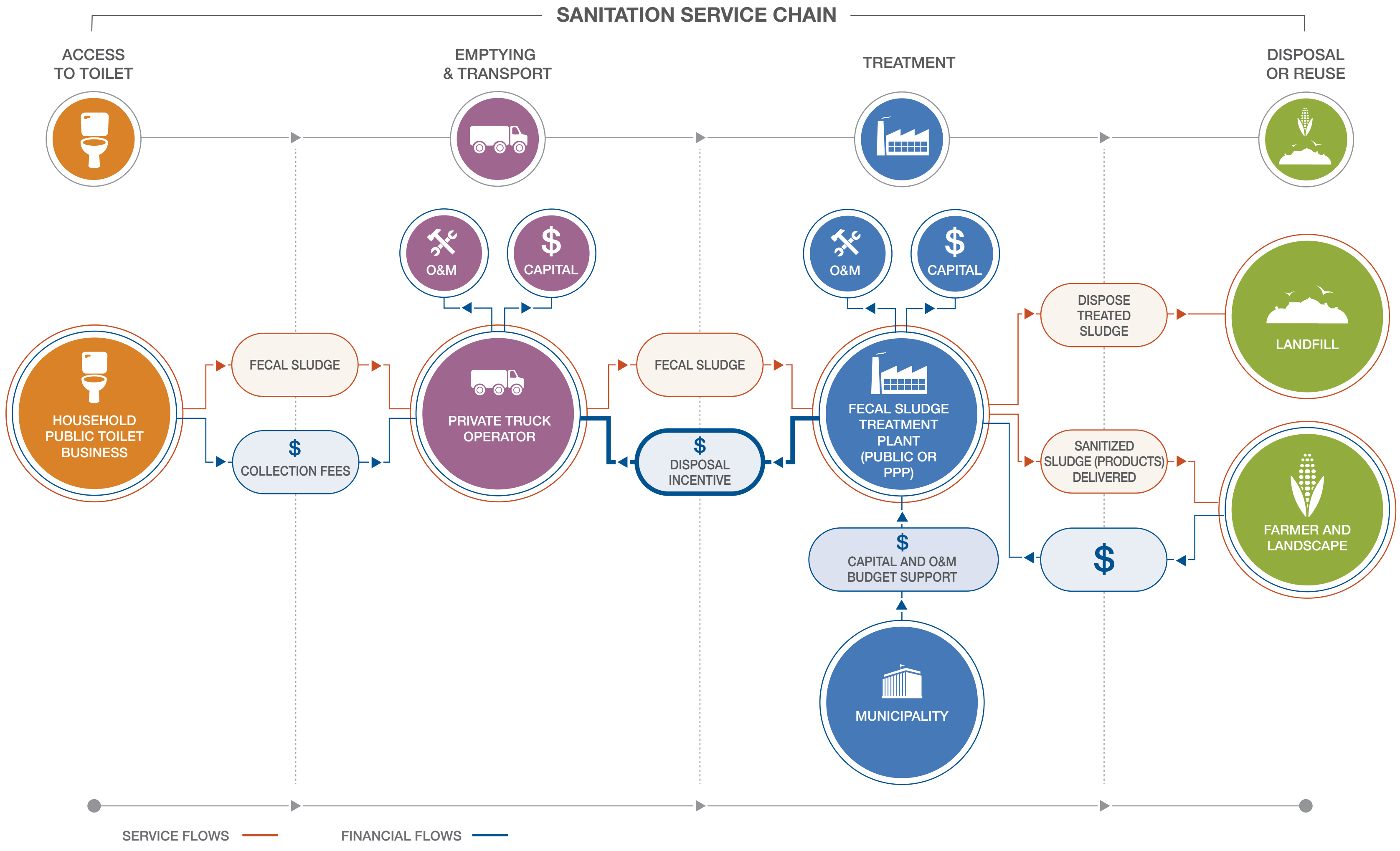
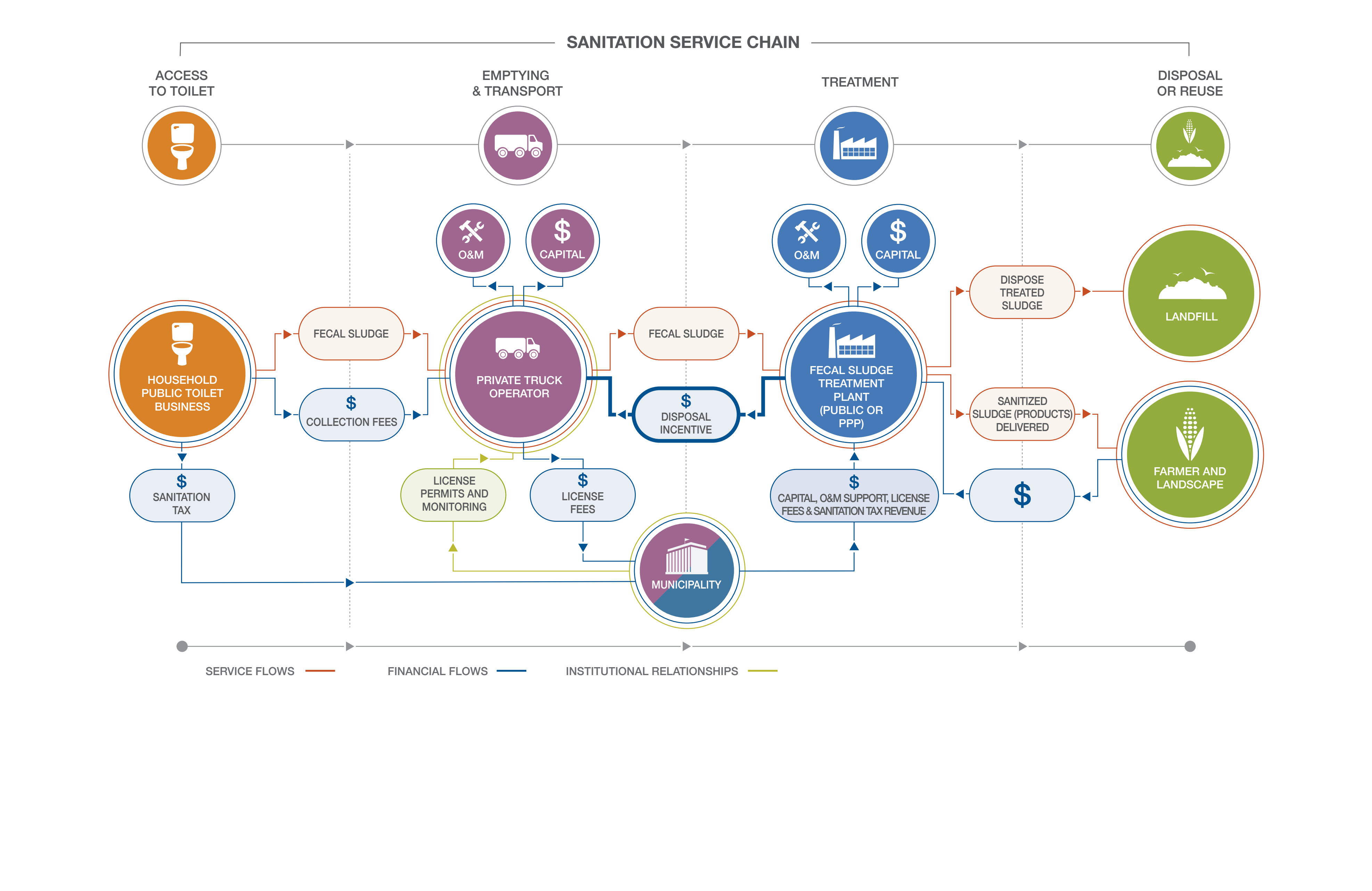


FIGURE 27. INCENTIVIZED DISPOSAL INCORPORATING LICENSING AND SANITATION TAX MODEL.



could be an additional option (Figure 28; Table 16). The model is largely facing similar challenges to those models described in section 10, except that the models in section 10 include, in addition, the provision of the toilet.

The private entity or entities invest capital in the emptying of FS from OSSs and transporting it to the treatment plant, and also for treating the sludge and - depending on demand - converting it into compost or dried sludge. The private partner(s) will require a license/permit from the municipality to operate emptying services and the treatment plant. They will earn revenue by providing emptying services to households and businesses, disposal fees from other private trucks delivering FS, and if there is demand from the sale of compost or dried sludge.

TABLE 16. BENEFITS AND LIMITING FACTORS OF THE FULL PRIVATE MODEL.

FINANCIAL IMPLICATIONS		REGULATORY AND MONITORING IMPLICATIONS	
Benefits for emptying operations	P	Requires close monitoring for regulatory compliance	Y
Reduces emptying cost to households	P		
Requires subsidy	N	Modification of sanitation codes and policy	N
Improve cost recovery of FSM	Y		

INSTITUTIONAL IMPLICATIONS		ENVIRONMENTAL AND HEALTH IMPLICATIONS	
Requires public sector involvement	N	Reduces indiscriminate disposal of sludge	N
Requires private sector involvement	Y	Concerns of public health and environmental safety	P

Y – Yes, P – Possible, N – No, NA – Not applicable; see Table 3.

Ensuring improved sanitation and hygiene in a city is largely the responsibility of the government, and the sanitation sector is heavily dominated by the public sector. The model has high applicability in regions where governments are interested in the privatization of FSM and the municipalities lack capacity to provide sanitation services. The model has concerns of the government promoting a private monopoly or in view of the possible negligence of safety regulations for profit maximization, and hence regulation is key.

The profitability of treatment plants can be a challenge and private entities will, therefore, be cautious to invest in treatment plants or reuse components without conducting a sound feasibility study. While donors or governments could provide incentives to encourage private sector investment, the opportunity for cost recovery could potentially be enhanced through the exploration of market demand for resource recovery and reuse (sale of composted sludge or dry fuel from sludge) and might require the plant operator to enter a strategic partnership, for example, with a private (or governmental) agricultural input supplier who can advise on market demand and (take over) sales strategies.

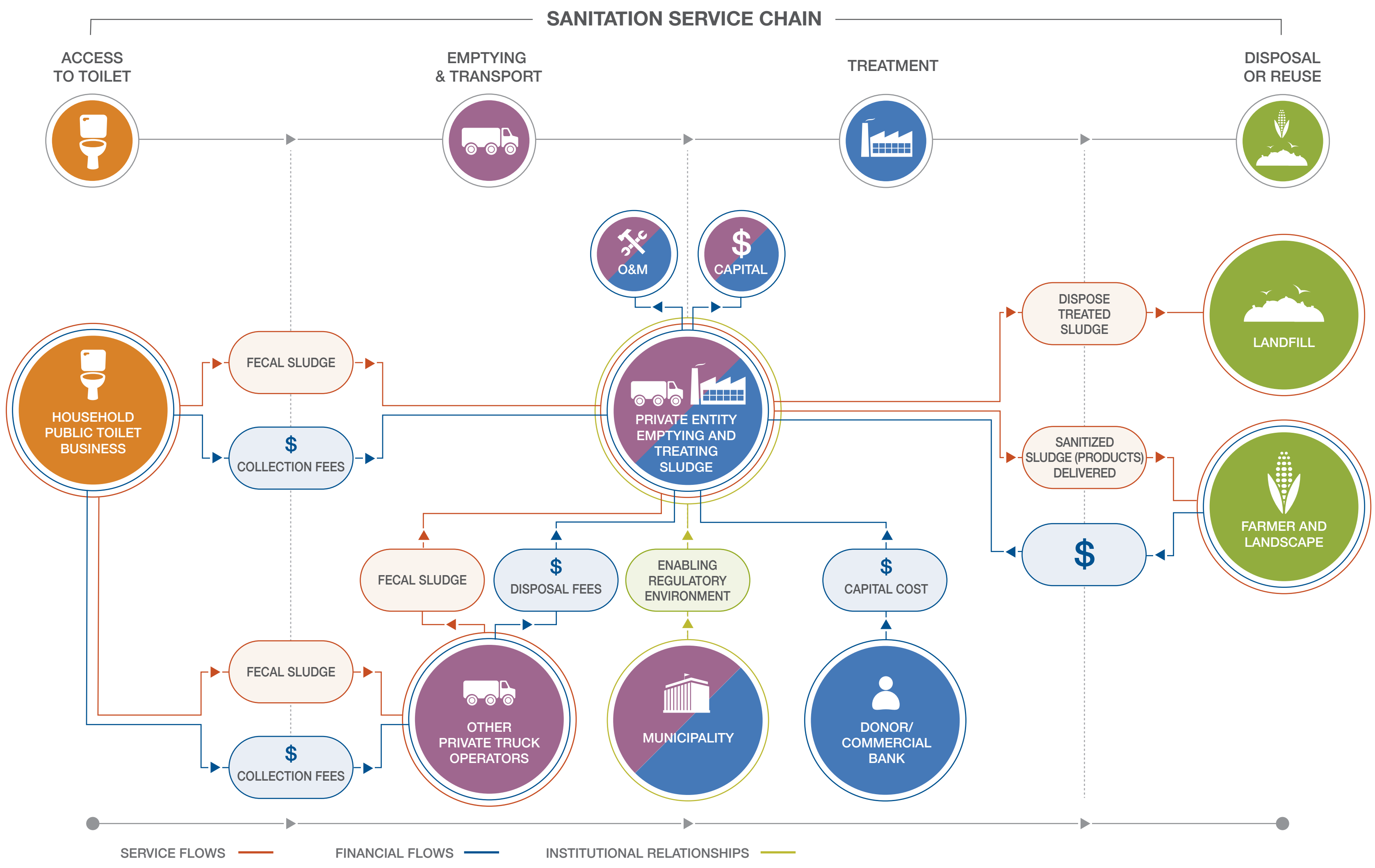
Case examples from Mali and Benin

GIE Sema Saniya, Bamako, Mali (Jeuland et al. 2004; Koné and Peter 2008; Strauss et al. 2003; Lipson et al. 2011): The GIE Sema Saniya,[8] a private entity engaged in solid waste management, and FS collection and transport (as a profitable business), initiated an expansion of its business into treatment of FS for communes V and VI of Bamako City. GIE Sema Saniya also planned to either sell the treated dried sludge produced at the two sites to farmers and horticulturists and/or use the dried sludge to produce cash crops in its own farms, whereby the revenue from these activities could partially recover the operation cost of the treatment plant. Investment for the capital cost was co-financed by the United Nations Development Programme (UNDP) Global Environment Fund through the Centre regional pour l'eau potable et l'assainissement (CREPA) Mali office (now known as Water and Sanitation for Africa [WSA]). Through discussions with the government, GIE Sema Saniya was able to ensure that the FS collected by other operators is delivered to the plant, thereby controlling indiscriminate dumping of FS. However, enforcement of this would be a challenge as reported by Jeuland et al. (2004), since other operators have to travel 17 km to the treatment plant and would incur a 50-100% increase in vehicle maintenance costs. One of the suggestions was to provide incentives to these operators by paying them a fixed reimbursement to dispose the sludge at the treatment site or to build sites closer to the city. The treatment plant was inaugurated and briefly operational (without the reuse component), and as of 2008, the treatment ponds were redesigned for aquaculture during the rainy season using rainwater runoff (Marc Jeuland, Duke University, pers. comm., July 2015).

SIBEAU, Cotonou, Benin (Valfrey-Visser and Schaub-Jones 2008; Champetier and Okoundé 2000; Hounkpe et al. 2014; Okoundé 2002): In Benin, Société Industrielle Béninoise de l'Environnement et de l'Aménagement Urbain (SIBEAU), a local private company, is involved in the collection, transport and treatment of septage. The treatment plant started operations in 1994 and is located at Ekpè (Sèmè-Kpodji), which is 13 km to the east of Cotonou. The treatment plant not only serves Cotonou City but also the Sèmè-Kpodji and Abomey-Calavi and receives septage from 7 am to 6 pm every day. In Cotonou, most households are served by

[8] GIE stands for *Groupement d'Intérêt Economique*, which means the economic interest group; *Sema* is the name of the principal neighborhood served; and *Saniya* is the Bambara term for sanitation or cleanliness.

FIGURE 28. FULL PRIVATE MODEL.



private companies including SIBEAU for emptying tanks, if not trucks from the city council and the military engineering department. The private truck operators formed an association called Union des Structures de Vidange, which was constituted in 1995 at the initiative of SIBEAU. The role of the association is to agree on a common tariff structure and peer monitoring to discourage indiscriminate dumping of FS, initiate dialogue with city authorities on desludging fees charged by them with a view to reducing competition, negotiate taxation and discuss any business-related barriers.

According to Hounkpe et al. (2014), the companies negotiate their desludging fees directly with clients (houses). The fees vary, depending on the geographical situation in the town, between USD 55 to USD 75 for a truck of 6 m^3 and from USD 120 to USD 150 for a truck of 12 m^3; i.e., an average of USD 11 received by the companies per cubic meter of wastewater collected. On the other hand, each truck entering the treatment plant has to pay an average of USD 2.62 per cubic meter of wastewater plus USD 1.67 per trip to SIBEAU, and an amount of USD 2.25 per trip to the city authorities, as well as the annual truck insurance and car tax. All vacuum truck operators are required to register with SIBEAU, but do not require a license from the City Council. The SIBEAU treatment plant is designed to treat 180 m^3 of septage per day using the waste stabilization pond system. It is the only treatment plant in Cotonou City and does not receive any financial support from the government. The sludge collected in the ponds are stored on-site and sold on request as a dry fertilizer to farmers located in adjacent areas to the treatment plant. To maximize revenues, environmental and public health protection is likely suffering (Hounkpe et al. 2014).

9. MODELS EMPHASIZING REUSE AT THE END OF THE SERVICE CHAIN

The business models discussed in this section offer two distinct value propositions:

- The *first value proposition* is to provide an improved sanitation service, and FSM for the residents and businesses through a high-quality waste management service.
- The *second value proposition* pertains to the reuse product, and it depends on the type of resource recovered (nutrients/organic matter/energy) from the FS and target customer segment.

The section is biased to the recovery of nutrients and organic matter for agricultural reuse, while large-scale (off-site) energy recovery from fecal sludge is only evolving (EAI 2011). However, there are promising business models emerging (Box 8).

BOX 8. PELLETS AND BRIQUETTES FROM FS IN GHANA AND RWANDA.

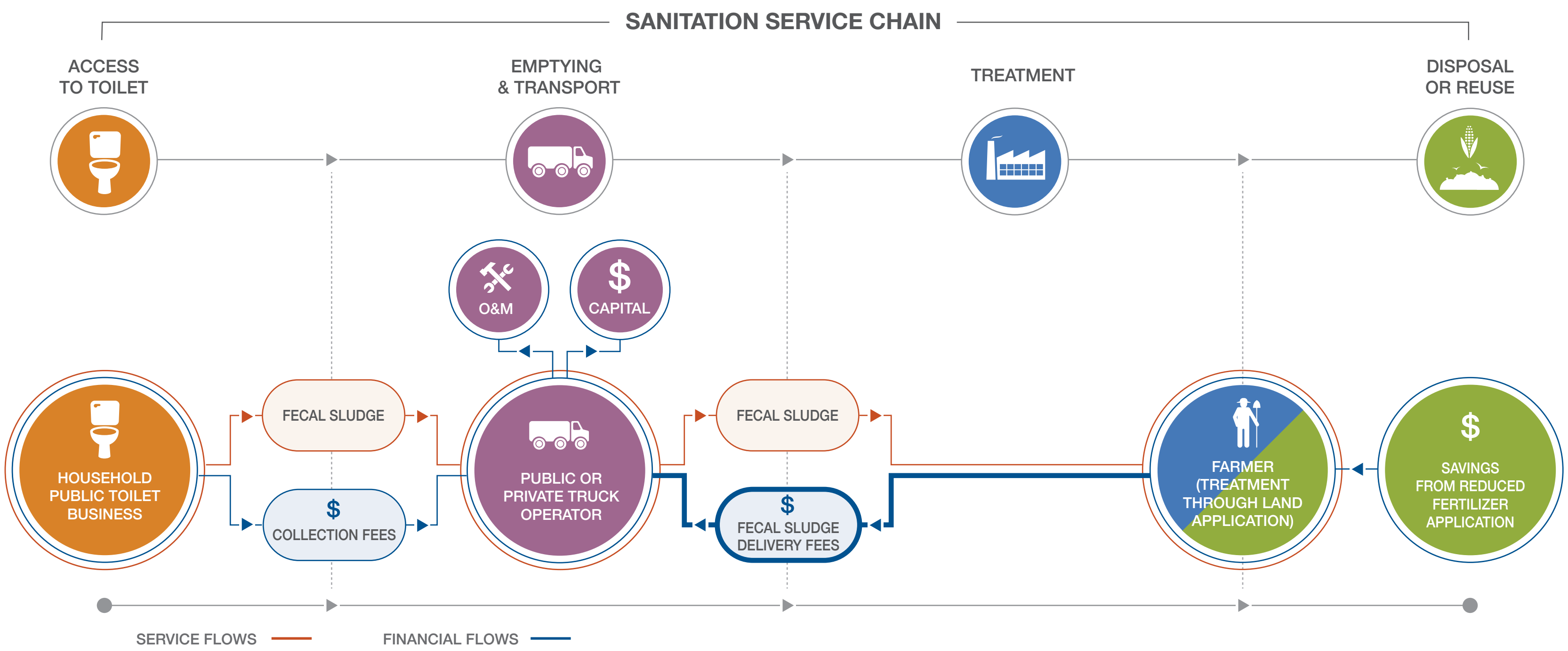
'Pivot' (http://pivotworks.co/) is an organization developing urban sanitation solutions to handle human waste from on-site sanitation systems, by treating and converting it into renewable fuel for industrial kilns and boilers. The company has a treatment plant in Kigali, Rwanda, to produce fuel and sell it to industrial customers such as cement companies. As per Pivot, the model to convert human waste to fuel can achieve operating breakeven point at a production rate of 12 tonnes per day, which means treatment of 1,100 m^3 (at 1.5% solids) of fecal sludge per day or 340 m^3 per day (at 5% solids). Therefore, the solution developed by Pivot is ideally suited to cities with populations above 500,000 people (Muspratt 2016). Another example is 'Slamson Ghana' (http://www.slamsonghana.com), which has developed a process to convert dried fecal sludge into charcoal. The charcoal is turned into briquettes using cassava flour as a binding agent, and the charcoal briquettes are used as cooking fuel (BBC 2015).

9.1 Farmer-truck Operator Partnership Model

This model is a partnership between private truck operators and farmers, where truck operators provide emptying services for OSSs and the sludge is disposed by selling it to peri-urban farmers as a form of cheap manure (Figure 29; Table 17). The examples of such a partnership (informal) are observed in many cities in developing countries. The reuse value proposition offered is low-cost manure to farmers who save costs on fertilizer, while paying a mutually defined fee to the truck driver. This is changing the common system where the driver pays for disposal.

The overall investment required for this type of business is to purchase trucks. The model is bypassing conventional sludge treatment by outsourcing this step to the farm where the sludge can be dried and applied in different safe ways (Keraita et al. 2014). The model cannot replace conventional treatment as its drawback is its seasonality, i.e., most crop farmers only need the FS in a short period of several weeks in anticipation of the planting season, while perennial plantation crops, forestry projects or landscapers could absorb FS around the year. The model is more common in the informal sector with so far limited support, although related health risks can be controlled (Box 9).

FIGURE 29. FARMER-TRUCK OPERATOR PARTNERSHIP MODEL.



BOX 9. LAND APPLICATION OF FS.

FS has to be treated prior to use. This can also be done on the farm. There are options for safe disposal and use of raw FS directly for land application. One example is deep row entrenchment that has been practiced in forestry applications. The United States Environmental Protection Agency (US EPA) guidelines recommend subsurface injection of untreated FS applied to slopes less than 8%, and the soil depth to seasonal high water table must be at least 0.5 m. Informally, land disposal in open lands is practiced in many developing countries, often without sufficient knowledge about occupational risks and options for risk reduction. To protect the food chain, the FS is best applied 2-3 months before the end of the dry season allowing sufficient time for natural pathogen die-off before fieldwork starts (US EPA 1999; Seidu 2010).

TABLE 17. BENEFITS AND LIMITING FACTORS OF THE FARMER-TRUCK OPERATOR PARTNERSHIP MODEL.

FINANCIAL IMPLICATIONS		REGULATORY AND MONITORING IMPLICATIONS	
Benefits for emptying operations	P	Requires close monitoring for regulatory compliance	Y
Reduces emptying cost to households	N		
Requires subsidy	N	Modification of sanitation codes and policy	Y
Improve cost recovery of FSM	Y		

INSTITUTIONAL IMPLICATIONS		ENVIRONMENTAL AND HEALTH IMPLICATIONS	
Requires public sector involvement	N	Reduces indiscriminate disposal of sludge	Y
Requires private sector involvement	Y	Concerns of public health and environmental safety	P

Y – Yes, P – Possible, N – No, NA – Not applicable; see Table 3.

Case examples from Ghana and India

Tamale, Ghana (Cofie et al. 2005; Keraita et al. 2014): In Northern Ghana (Tamale municipality), untreated FS is either spread on farms during the dry season or stored and dried in pits near the farm. A study supported by IWMI observed that the high temperature of the savanna climate and the long period of drying significantly treated the sludge and reduced pathogens to acceptable levels. There is strong seasonal competition amongst farmers to access FS from truck operators due to an increase in crop yields. Total revenue per hectare from using FS was approximately USD 312 higher than not using it. The increase in revenue is a result of a combination of improved yields and fertilizer savings (Murray and Buckley 2010). Farmers pay a minimal amount of about USD 2 as a token for transport (Cofie et al. 2005), and the benefits include a cost-effective, on-farm treatment and application process requiring minimal labor. An occupational problem associated with this practice can be itchy feet due to direct contact with untreated FS if rubber boots are not used. Health risks for the food chain are limited given natural pathogen die-off and the use of cereals, and can be minimized on farm as shown by Seidu (2010).

Bangalore and Dharwad, India (Kvarnström et al. 2012; Otoo and Drechsel Forthcoming): In Bangalore, India, 'honey suckers' (a term given to the business of vacuum truck operations) discharge FS collected on farmland in the vicinity of the city. Some farmers store and dry the sludge prior to use, and others use it directly in, for example, banana plantations. Due to lack of institutional structures and with a significant portion of the population served by OSSs, these honey suckers make money from emptying septic tanks and pit latrines. FS collected is most often given away to farmers to save on disposal fees, but sometimes it is also sold to farmers. An estimate of farmers' financial gains, as obtained through interviews with five farmers in Bangalore, showed that they save between INR 8,000 (USD 138) and INR 170,000 (USD 2,998) per year.[9] One of the farmers was also selling dried FS to other farmers at an estimated earning of INR 1,500 (USD 27) per tractor load.

In another example from Dharwad, India,[10] a farmer entered a partnership arrangement with FS truck operators who deliver the sludge to his farms. Although the partnership does not involve any financial transactions, it is mutually beneficial as the truck operators are looking for a place to dispose the sludge without driving far and the farmer wants a high-quality fertilizer. One observed on-farm practice is to fill the sludge in a series of pits on the farm and once these are full, the sludge dries and the pits are covered with mud. After a few months, the farmer auctions these pits to other farmers who bid for the composted material on a first-come-first-serve basis. Typically, the composted contents in the pits are sold at INR 1,500 (USD 25) per tractor load in comparison to a tractor load of cow dung, which varies from INR 5,000 to 7,000 (USD 80 to 110).

9.2 Co-composting Model

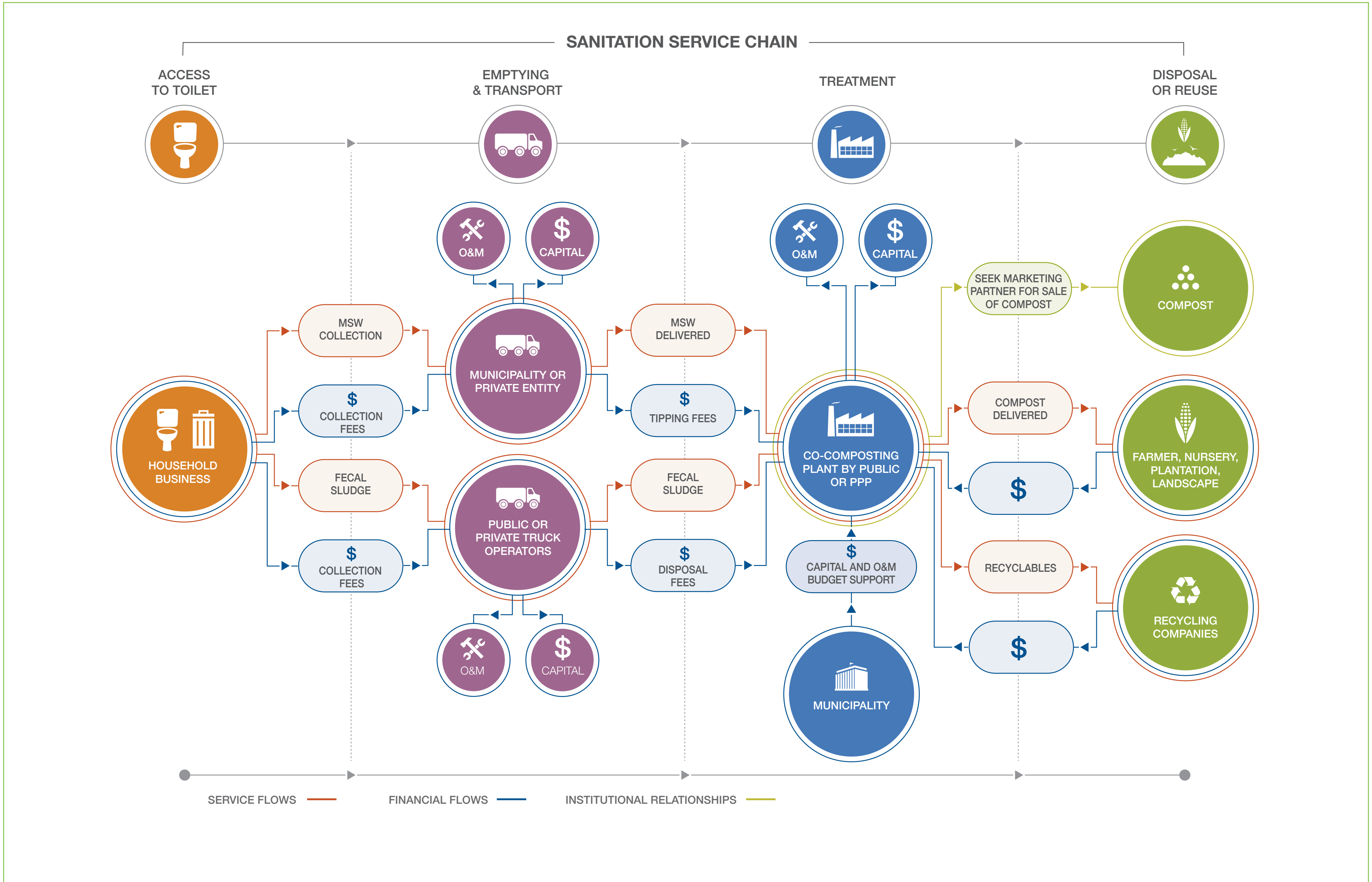
Compared to the previous model, the objective of the co-composting model is to produce a safe and valuable product for agricultural production before it reaches the farm. Like all composting efforts, there is a second value proposition as composting reduces the volume of waste by about 50%, which helps waste management to save on transport and disposal costs.

Co-composting refers to the simultaneous composting of at least two organic sources: Nitrogen-rich FS from on-site sanitation with the carbon-rich organic portion of MSW, sawdust or agro-waste to create the right carbon to nitrogen ratio for optimal composting, i.e., heat development and pathogen destruction (Cofie et al. 2016).

The co-composting business (Figure 30) thus requires linkages between those in charge of household waste (MSW) collection and those serving OSSs. The FS collected is dewatered

[9] The estimated savings are based on the difference between (1) the cost of purchasing farmland manure plus the labor cost of applying it, and (2) the cost of purchasing FS (this mostly comes at no cost) and the labor cost of applying it. It must be noted that the labor cost of applying fecal sludge is less due to the higher concentration of nutrients.
[10] Personal communication, Sharada Prasad, PhD student, University of California, Berkeley, USA.

FIGURE 30. CO-COMPOSTING MODEL.



and co-composted with the organic waste from households or saw mills, and the resulting sanitized product (co-compost) is sold to farmers, landscapers, nurseries, tree plantations, flower producers, etc., always targeting multiple market segments with demand throughout the year. The revenue of the treatment plant is usually a mix of two possible income streams: (i) from households or the city for the absorbed waste volume (FS and MSW); and (ii) from farmers and landscapers for the sold co-compost. Many compost stations rely, however, more on waste processing than compost sales, partly due to the comfort of being paid for the processed waste volume, while a better understanding of the agricultural market has transaction costs. To support reuse (closed nutrient loop, green economy), different strategies are found. These include public payments linked more to compost sales than production, the support of strategic partnerships with agri-input suppliers, and fertilizer subsidy programs extended to compost.

Depending on a possible co-involvement in waste collection, the business could charge fees for the solid waste collection besides the processing service. If the organic waste is procured from agro-industries, it is likely that the entity will have to pay for the waste since it often has a high (competitive use) market value. If the business is into collection of MSW, it could potentially have additional revenue from the sale of non-organic recyclables (metal, plastic).

The reuse value proposition offered by the FS-based co-composting model, compared to any normal composting of organic MSW, is to produce a nutrient-rich product. The co-compost can be further valorized by further enriching it with natural (e.g., rock phosphate) or industrial fertilizer, and/or selling it in a pelletized form for ease of handling and transport (Nikiema et al. 2014). The co-composting business model can offer an additional value proposition of providing energy by generating biogas from organic waste, and the slurry from the bio-reactor along with digested solids can be used to make compost.

Market development is one of the key aspects of any compost-based model, especially in regions where a supply chain for fertilizer and/or compost does not exist. The compost should be marketed to the most cost-effective (i.e., bulk purchase) customer segments to reduce marketing costs. It may well be that smallholder farmers (objective - poverty alleviation) might not be the ideal market segment, since the number of customer contacts will be high and the quantity sold per farmer will be low. Large bulk purchasers, such as flower businesses/horticulture, tree nurseries, real estate/landscaping and tree crop plantations, will have lower transaction costs, and are often capable enough to collect the compost from the treatment plant using their own trucks, i.e., without the need to establish a compost marketing/supply chain. An important additional advantage from these customer groups is their year-round demand while most smallholders only engage in seasonal production. Another important customer segment (or strategic partner) for the sale of compost is the Agriculture Department, especially if it has extension agents under it, or the Department of Forestry. To support the development of the compost sector, the Agriculture Department could provide either a minimum support price at which they agree to buyback the compost product, if the treatment plant is unable to sell the compost, or commit to purchase an assured quantity of compost. The Local Government Parks and Gardens Department and the fertilizer industry could offer other key partnerships or customer segments. It is often unlikely that a compost producer, who has his/her roots in the sanitation sector, understands agricultural market segments; thus, it can be very strategic to link with such partners familiar with compost users.

Table 18 summarizes some benefits and limiting factors of the Co-composting model.

TABLE 18. BENEFITS AND LIMITING FACTORS OF THE CO-COMPOSTING MODEL.

FINANCIAL IMPLICATIONS		REGULATORY AND MONITORING IMPLICATIONS	
Benefits for emptying operations	N	Requires close monitoring for regulatory compliance	N
Reduces emptying cost to households	N		
Requires subsidy	P	Modification of sanitation codes and policy	Y
Improve cost recovery of FSM	Y		
INSTITUTIONAL IMPLICATIONS		**ENVIRONMENTAL AND HEALTH IMPLICATIONS**	
Requires public sector involvement	P	Reduces indiscriminate disposal of sludge	P
Requires private sector involvement	Y	Concerns of public health and environmental safety	N

Y – Yes, P – Possible, N – No, NA – Not applicable; see Table 3.

9.2.1 Town Cluster Approach Model

A logistical variation to the co-composting model can be applied to a group of towns (or communities) using the cluster approach. Instead of individual FS treatment plants for a small town, a shared plant for several towns could be undertaken. The shared plant should be strategically located within a radius of 25 to 30 km to each town that uses it, so that the transport cost does not dictate viability of the plant. The co-composting treatment plant treats waste generated from these towns/cities and thus requires close coordination between respective towns. The business model cannot rely on one entity, but requires a multi-partnership structure where partners are likely to serve different parts of the sanitation service chain, from emptying septic tanks, MSW collection, transportation of waste and treatment to market development of the reuse product (Figure 31). The different components are likely to involve (multiple actors of the) private and public sector (city authorities), preferably regulated within a public-private-partnership (PPP) arrangement. However, it is recommended that a single public/private entity is contracted to manage all parts of the sanitary service chain jointly by all the towns/cities participating in the setup.

9.2.2 Pull-Push Model

Given the dependence of the co-composting model from at least two waste streams as input and also two possible revenue streams, there can be many variations to optimize the model as presented in section 9.2.1, and also by linking to other models. A key difference is that, compared to waste disposal, compost sale has limits. Also, a very common challenge for entrepreneurs in the conventional MSW compost sector is the optimization of the process flow between material inputs and outputs to maximize revenues and avoid unnecessary treatment and storage costs, especially where the management of FS and MSW is handled by different entities. The pull-push model is from a treatment plant perspective, and tries to mitigate potential supply/sale barriers through incentivizing ('pull') emptying enterprises to deliver the FS for treatment, and simultaneously through a 'push' strategy to develop a sustainable market and supply chain for the enriched compost, which should pay as far as possible the operational costs of an optimized 'pull-push' business model (Figure 32).

The key goal of the 'pull' strategy is to ensure sufficient raw material supply for compost production/sale. The distance (and loss of time in traffic) to transport FS from households to the usually very few disposal sites is a major challenge for truck operators leading to illegal dumping, where the profit earned depends on the frequency of services provided per day. Thus, for the co-composting operator to tap into the FS service chain either investments in own service trucks are required, or there needs to be composting stations closer to the city than any FS dumping site, or decentralized transfer stations that are strategically located (see section *Transfer Station Model*) for other operators to target. The transfer stations could be manned by a 'watchman', where delivery is incentivized ideally by the household fee (payment only against safe delivery receipt) or by paying a fixed amount for delivering FS to the transfer station (see section *Incentivized Disposal Model*); both of which would benefit from specific regulatory measures and contractual agreements. Communication between the different parties is needed to balance the volume of FS arriving at the transfer stations and the volume the treatment plant can absorb.

The 'push' factor is in support of compost sales. An operational breakeven point is possible, and the system can even achieve profits depending on market demand and the value proposition based on the types and quality of compost produced (Otoo and Drechsel Forthcoming). The model will likely require a strategic partner with agricultural market penetration, which can be the public sector (as seen in Sri Lanka) as well as private sector (as seen in India). Especially agro-based commercial enterprises, including fertilizer companies, can play a key role in the 'push' strategy to develop or support the market and supply chain of the FS-based compost product. As mentioned above, an important institutional broker and supporter can be the Department of Agriculture. In many developing countries, compost has to compete with subsidized chemical fertilizer. Therefore, the government could either create a level playing field by providing a price subsidy for compost (as introduced in 2016 in Ghana) or mandate fertilizer companies to sell a prescribed quantity of compost for every bag of chemical fertilizer sold. For example, the Government of India, under the Solid Waste Management Rules, 2016, requires the Ministry of Chemicals and Fertilizers to provide market development assistance for city compost, and ensure promotion of co-marketing of compost with chemical fertilizers at a ratio of 3 to 4 bags: 6 to 7 bags by the fertilizer companies to the extent that compost is made available for marketing to the companies (MoEFCC 2016). The Ministry of Chemicals and Fertilizers provides INR 1,500 (USD 22) per tonne towards market development assistance for existing fertilizer companies, and in due course compost producers and marketing agencies (recognized by the state governments) may also be provided with similar assistance. Table 19 summarizes some benefits and limiting factors of the model.

Case examples of co-composting from Sri Lanka and Ghana

Balangoda, Sri Lanka (Otoo and Drechsel Forthcoming): In Balangoda, Sri Lanka, with a population of about 35,000, a successful co-composting business model is run by the Balangoda compost plant, a public entity owned and managed by the local urban council. The council is responsible for delivering MSW and FS collected from the municipal region to the plant. Desludging of FS from OSSs is carried out on an on-demand basis and households pay about USD 30 for the service. The local urban council undertakes door-to-door MSW collection from households on a daily basis and twice a day from commercial entities. The council encourages waste segregation at source, and unsegregated waste is collected from commercial entities for a fee (USD 0.75 to USD 9 depending on the quantity of waste) while segregated waste is collected for free, which results in most commercial entities segregating the waste at the source. Currently, households do not pay for the MSW collection service. The urban council has set up recycling centers in different parts of the town, and the key role of these centers is to collect recyclable material and deliver it to the plant. To incentivize these centers, the urban council awards points to recycling centers (with 1 point = 1 Sri Lankan Rupee) and points are awarded based on the type of recyclable material and quantity.

FIGURE 31. TOWN CLUSTER APPROACH MODEL.

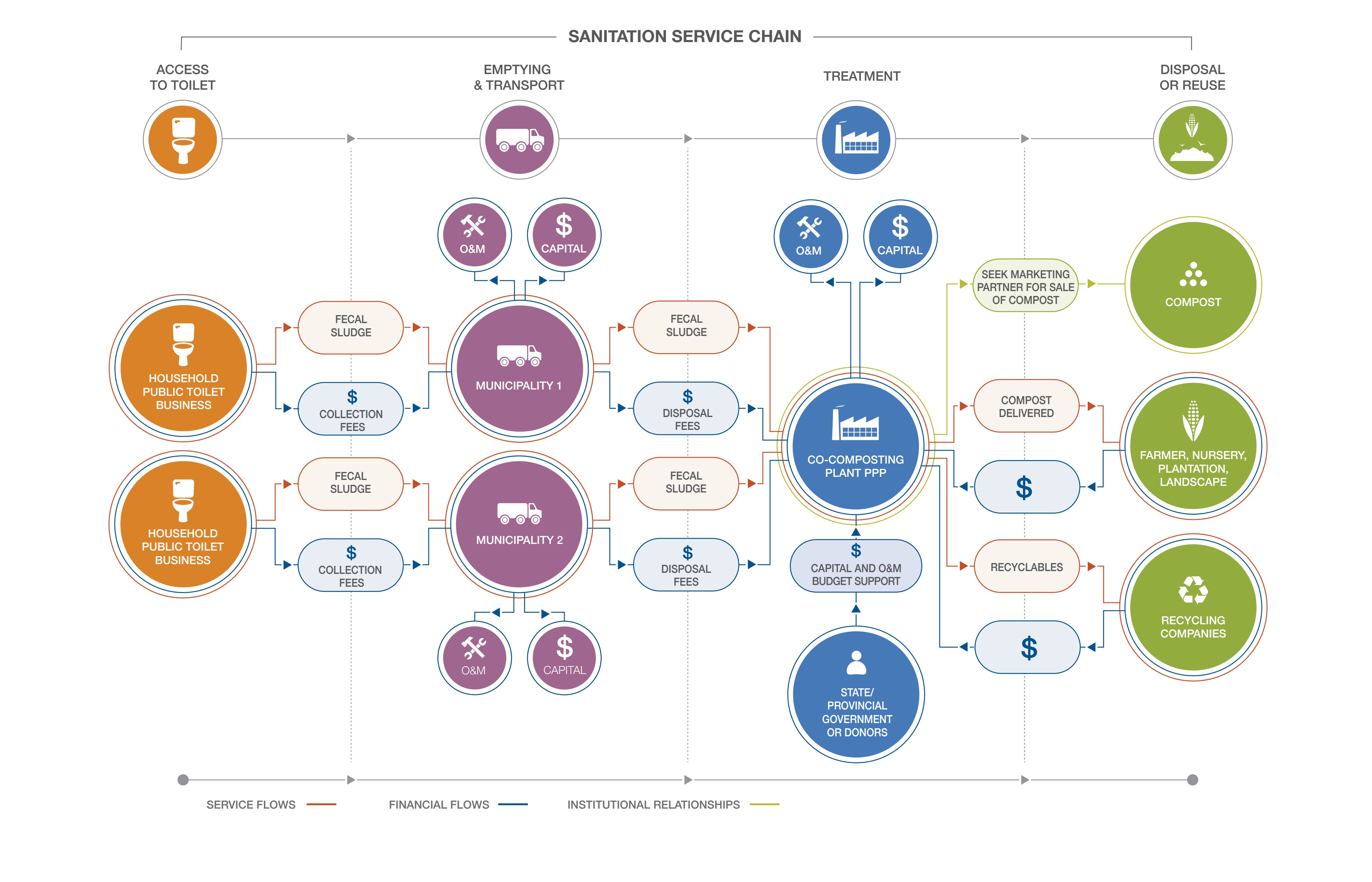


FIGURE 32. PULL-PUSH MODEL.

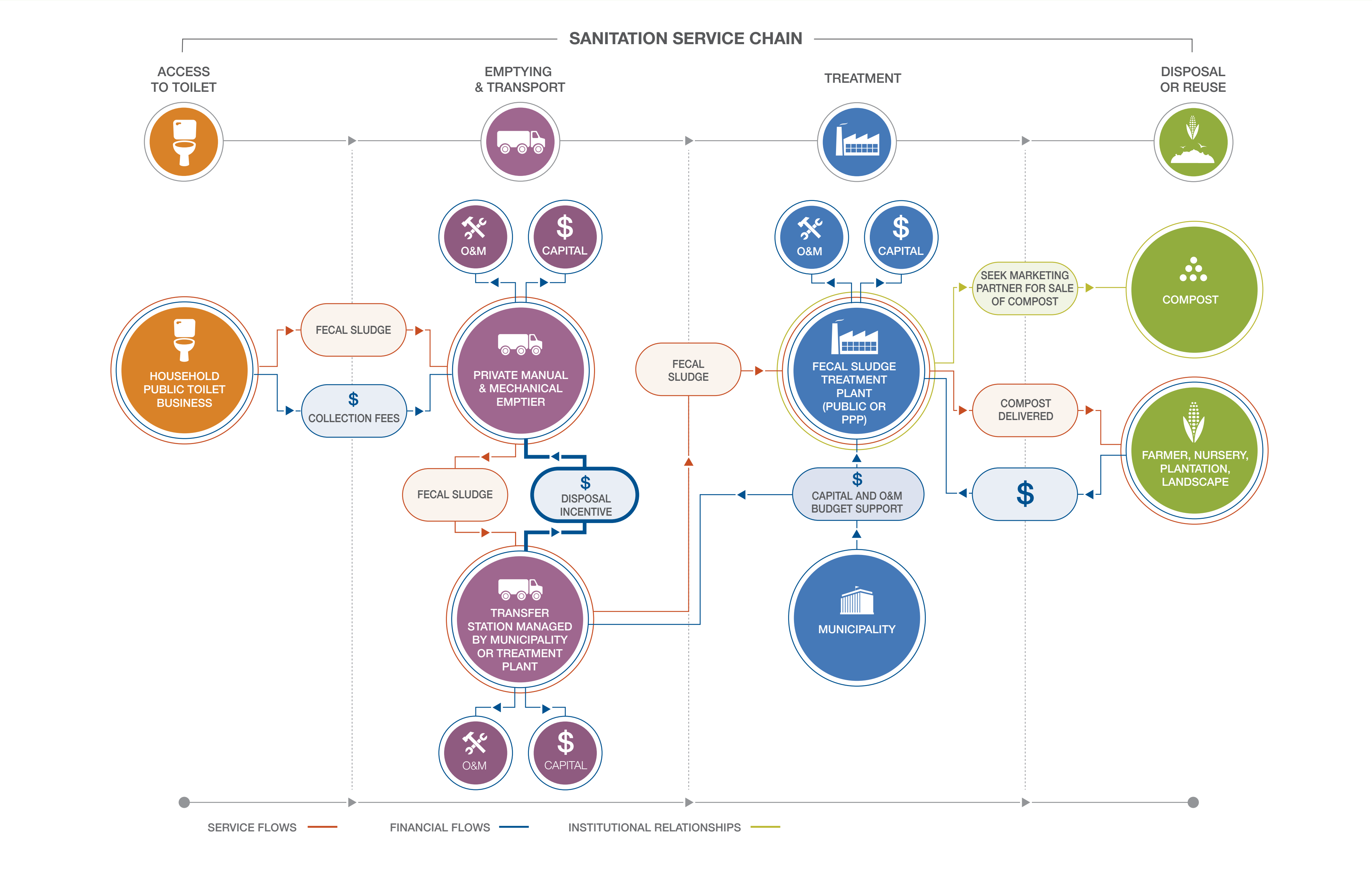


TABLE 19. BENEFITS AND LIMITING FACTORS OF THE PULL-PUSH MODEL.

FINANCIAL IMPLICATIONS		REGULATORY AND MONITORING IMPLICATIONS	
Benefits for emptying operations	Y	Requires close monitoring for regulatory compliance	N
Reduces emptying cost to households	N		
Requires subsidy	Y	Modification of sanitation codes and policy	Y
Improve cost recovery of FSM	Y		
INSTITUTIONAL IMPLICATIONS		**ENVIRONMENTAL AND HEALTH IMPLICATIONS**	
Requires public sector involvement	Y	Reduces indiscriminate disposal of sludge	Y
Requires private sector involvement	Y	Concerns of public health and environmental safety	N

Y – Yes, P – Possible, N – No, NA – Not applicable; see Table 3.

The Government of Sri Lanka provided the required capital under its 'Pilisaru' project for construction of the compost plant. In addition, the plant has partnered with different local universities and received training via LIRNEasia (www.lirneasia.net). The capital cost of the co-compost treatment plant was USD 352,000, with operation costs of USD 1,340 per month and a demand-based production capacity of up to 14 tonnes of compost per day; however, they produce around 420 tonnes of compost annually. Some compost is sold to small farmers (USD 77 to 120 per tonne) in the Eastern Province of Sri Lanka, where soils are sandy and chemical fertilizer proved less effective. Most of the compost is sold in bulk at very low prices to tea plantations and government institutions, such as the Urban Development Authority. Also, the Ministry of Agriculture purchases compost in bulk for landscaping. Recyclable material is sold to recyclable companies based on the prevailing market price, and it is the primary driver for achieving cost recovery and sometimes with marginal profits for the plant.

Safi Sana, Ghana (Safi Sana 2015): Safi Sana is a social enterprise in Accra, Ghana, which started in 2009 to provide a public toilet service and treatment of waste generated in these toilets. The enterprise collects toilet and organic waste from slums in Accra, which is then used to produce organic compost and generate renewable energy. Since 2011, the enterprise has established three communal service blocks (public toilets) franchised to local entrepreneurs for management. The waste from public toilets is collected on an on-demand basis, and organic waste from local food markets and small enterprises are collected and transported on a daily basis to its factory in Ashaiman, where the waste is treated to generate electricity and produce fertilizer. As of 2015, the factory has received 1 tonne of waste per day and there are plans to scale the operations to process 25 tonnes per day from late 2016 onwards. The factory has, as of 2015, constructed a digester 2,500 m^3 in size for stabilizing waste, and producing biogas to generate heat and electricity of around 100 kW. The plan is to sell the electricity to the local power grid at a pre-fixed, feed-in-tariff. Information on the capital and operation cost and revenue sources is not available.

Co-composting model is observed in many developing countries, for example, Vietnam, Bangladesh, Ghana, etc. In Accra, Ghana, IWMI, under a project funded by the Bill & Melinda Gates Foundation, has initiated a PPP (between Accra Metropolitan Assembly [AMA] and Jekora Ventures Private Ltd.) to commission a treatment plant to produce 1,000 tonnes of compost per year from organic waste and FS collected from OSSs in Accra. At the time of writing this report, the plant was under construction and was planning to kick-start its operations by the end of 2016.

10. MODELS COVERING THE ENTIRE SANITATION SERVICE CHAIN FROM TOILET ACCESS TO REUSE

The business models discussed in this section engage in every component of the sanitation service chain – from provision of toilet to households, collection and transportation of sludge to treatment for disposal or reuse. The common factor in the models presented here is the use of Urine-diverting Dry Toilets (UDDTs), which, as the name states, operates 'dry', i.e., without flushing water. The technology is usually capital intensive and depends on subsidies for toilet provision (WSP 2009). Subsidies can be justified where groundwater levels are too high for pits or septic tanks, there is a lack of sewers or water is too scarce to be used for flushing. As UDDTs collect urine and feces separately, there are multiple options for resource recovery (ecological sanitation (ecosan)) for agricultural reuse (WHO 2006; Richert et al. 2010), and the availability of land for local reuse can be an important factor for the financial performance of the UDDT system (WSP 2009).

Therefore, while UDDT systems fit well in rural and peri-urban settings where space (school gardens, backyard farms) for **on-site** waste processing and agricultural reuse is available, the system can also be used in dense urban set-ups based on resource collection, and **off-site** processing and reuse. This, of course, requires a more challenging and complex (institutional) set up.

The business models discussed in this section only look at the more urban **off-site options**, which offer the following value propositions:

- Improved sanitation service to under served (often high density or remote suburban) communities through access to toilets and emptying services.
- An alternative for water-scarce areas or where groundwater levels are too high for septic tanks/pits.
- The provision of high-quality compost and/or nutrients from urine.

10.1 Non-movable UDDT Installation Model

The UDDT business model, where the toilet will be anchored in the household, can be a viable alternative to other toilet types when for physical or logistical reasons pit latrines, septic tanks or sewers are not an option. The UDDT can thus help in saving maintenance costs compared to alternative options for the provision of sanitation services (WSP 2009) with the option to generate revenues from (i) sale (and/or installation) of toilets, (ii) collection and transportation of dried FS and urine on a fee-for-service basis, and (iii) valorization of the collected waste as agricultural inputs. Dried FS can be transformed into a nutrient-rich compost, and urine can be a high-quality liquid fertilizer or if transformed into struvite also solid as fertilizer for use in farming, horticulture, plantations and landscaping (Figure 33).

Valorization of the generated waste products is not only a consideration from an ecological or revenue perspective, but also in view of cost savings to take care of the (potentially costly) accumulating organic waste.

If there is no reuse at the household level, the recovery, transport, further treatment and storage of both separated resources (urine, feces) require a sound process analysis, as both products can have significant logistical costs, especially if the volumes of resource supply, transport, treatment and sales do not align. In general, where a more organic soil ameliorant is needed, the collection of dried feces will have priority. On the other hand, where crop nutrients are in short supply, the nitrogen- and phosphorous-rich urine becomes more interesting. However, even from a few public toilets in central city locations, urine production can be significant, and regular transportation, storage/sanitizing and the handling of excess urine can quickly become challenging, with daily supply easily outpacing seasonal farm demand. The model thus strongly depends on process engineering to align transport volumes, available storage capacity, timing and volume of customer demand, etc., with urine collection and vice versa. The transformation of liquid urine into struvite crystals helps address challenges around its (water) volume and weight, although this comes with its own costs, especially if the magnesium required for struvite production is not locally available. A part of the urine could also be absorbed to enrich the fecal matter compost.

The UDDT business model can be run by one or more private entities or CSOs, including CBOs, with the mission of providing improved sanitation services to the community/residents. Engagement of the government and donors helps in easing initial financing and start-up costs. Financial assistance could, for example, be in the form of price subsidies towards water-saving household applications for households in disadvantaged locations in view of public water supply. In the event that adoption of the UDDT system is initiated by the government under its access to toilet programs, it could outsource the collection and transport service along with treatment to a private entity.

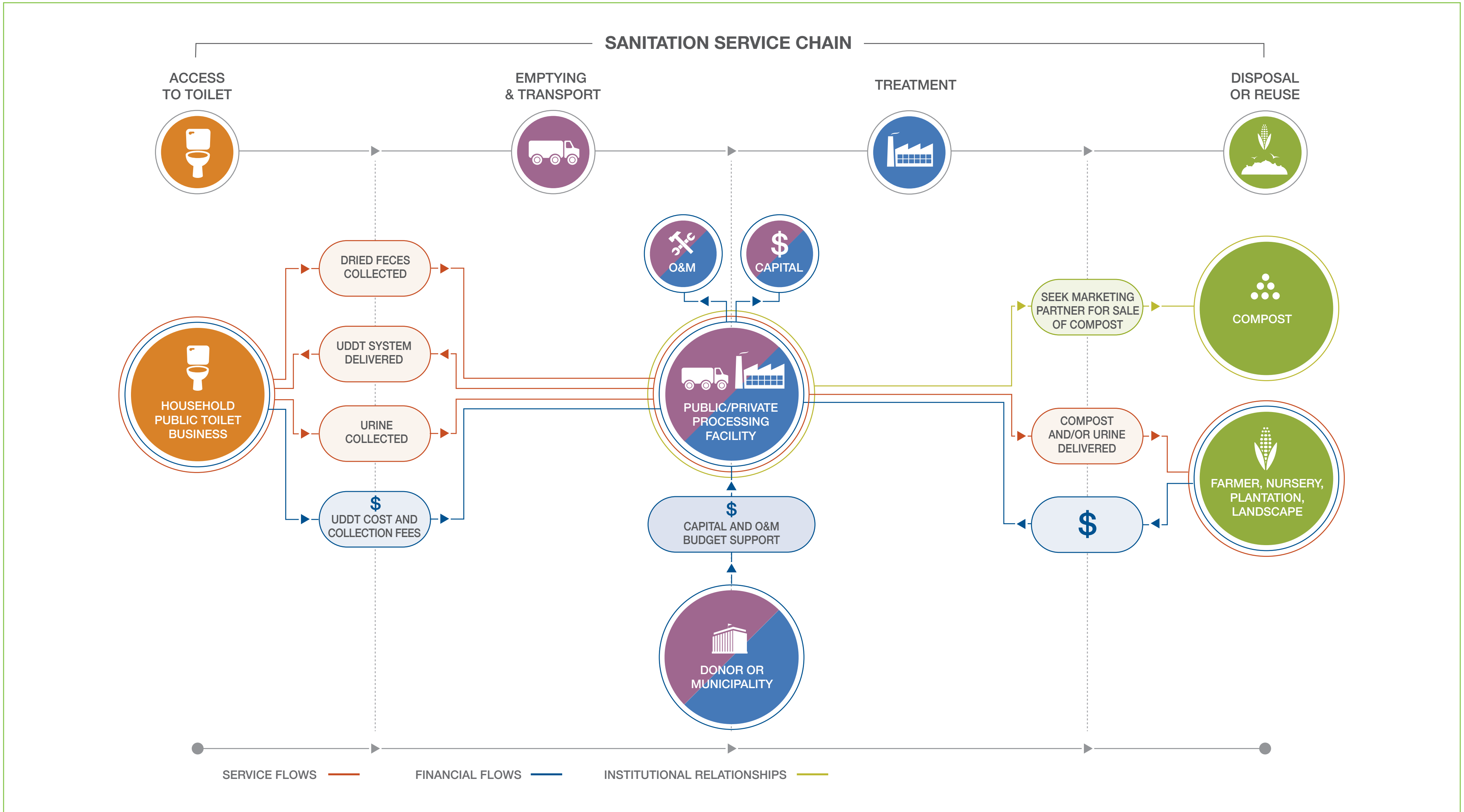
UDDT systems have been set up in many countries, but mostly as subsidized pilots or without a planned reuse component as in the well-known case of eThekwini, South Africa (Roma et al. 2011). With a high-degree of responsibility being placed on residents to maintain their toilets, household buy-in can vary especially where other households don't have the burden of toilet emptying. The possibility of irregular compliance can also lead to concerns of public health and environmental safety (Table 20). In eThekwini, the municipality decided eventually to offer free UDDT emptying[11]. Related impacts on operational expenditures can be leveraged through value adding resource recovery. Where households remain in charge, the overall financial and economic performance of the model remains largely a function of capital costs (WSP 2009).

Case examples from Burkina Faso and Rwanda

ECOSAN_UE, Ouagadougou, Burkina Faso (Dagerskog et al. 2010; Sawadogo 2008; Fall and Coulibaly 2011; WSP 2009): The ECOSAN_UE project was funded by the European Union (EU), in French: Union Européenne (UE), and implemented by Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH, CREPA, and the Office National de l'Eau et de l'Assainissement (ONEA), the national water and sanitation authority, as a pilot from June 2006 to December 2009. The goal of the project was to

[11] http://forum.susana.org/forum/categories/34-urine-diversion-systems-includes-uddt-and-ud-flush-toilet/12708-health-risks-in-connections-with-using-uddts-example-of-ethekwini-in-south-africa#12828

FIGURE 33. NON-MOVABLE UDDT INSTALLATION MODEL.



facilitate access to safe sanitation for the residents of the city of Ouagadougou, and simultaneously provide farmers with a reliable source of nutrients for crop production. In collaboration with the municipality of Ouagadougou, UDDT systems were implemented in four out of 30 urban sectors in the city, covering approximately 1,000 households. The project supported local CBOs to set up household collection and sale of the human waste to farmers. The CBOs received revenue from the collection (about USD 0.7 per UDDT per month) and sale of fertilizer (urine at about USD 10/m^3 and compost feces at about USD 5 per 50 kg bag). The business faced a range of challenges from

TABLE 20. BENEFITS AND LIMITING FACTORS OF THE NON-MOVABLE UDDT INSTALLATION MODEL.

FINANCIAL IMPLICATIONS	
Benefits for emptying operations	Y
Reduces emptying cost to households	P
Requires subsidy	Y
Improve cost recovery of FSM	Y

REGULATORY AND MONITORING IMPLICATIONS	
Requires close monitoring for regulatory compliance	N
Modification of sanitation codes and policy	Y

INSTITUTIONAL IMPLICATIONS	
Requires public sector involvement	P
Requires private sector involvement	Y

ENVIRONMENTAL AND HEALTH IMPLICATIONS	
Reduces indiscriminate disposal of sludge	Y
Concerns of public health and environmental safety	P

Y – Yes, P – Possible, N – No, NA – Not applicable; see Table 3.

social stigma towards product acceptance, provision of subsidy for chemical fertilizer, and decreasing UDDT usage (resource supply) by 41% from 2009 to 2012. Altogether, 21 tonnes of compost and 11,188 jerry cans were sold from 2009 to 2012 constituting about 48% and 74% of waste collected, respectively. The net revenue made by CBOs from the sale of reuse products and collection fees was about 24-43%, and the remaining revenue was earned through a subsidy from the municipality for providing sanitation services.

Rwanda Environment Care, Kigali, Rwanda (Otoo and Drechsel Forthcoming): Rwanda Environment Care (REC) is a private company providing public toilets on a fee-for-usage basis in Kigali City using UDDT systems. The company was established in 2005/2006 with the help of an award of USD 50,000 from the Small Grants Programme of the Global Environment Facility and UNDP, and land was provided by Kigali City Council for the city's first UDDT-based public toilet. The company, while offering toilet services, also provides rental space to shops to trade goods and produces compost from dry feces generated in its public toilets. They also provide technical consultancy services on the design and construction of UDDT systems. REC operates five UDDT public toilets across Kigali City with 48 seats and an average of 4,000 users on a daily basis, producing 0.6 tonnes of feces per day. REC collects feces from all the toilets and transports it to a centralized location for composting and packaging into bags, which are sold at the factory gate to large farmers. The business is earning significant revenue from toilet fees (USD 324 per day), which drives the profitability and complements the revenue from compost sales (2,000 bags of 50 kg each annually, which generates USD 6,300). Also, the composting contributes a minor share to revenue and it helps maintain the overall system, which needs to provide a solution to the accumulating fecal matter. Composting is thus not only a resource recovery mechanism, but a business necessity to reduce the waste volume and facilitate its productive 'disposal'.

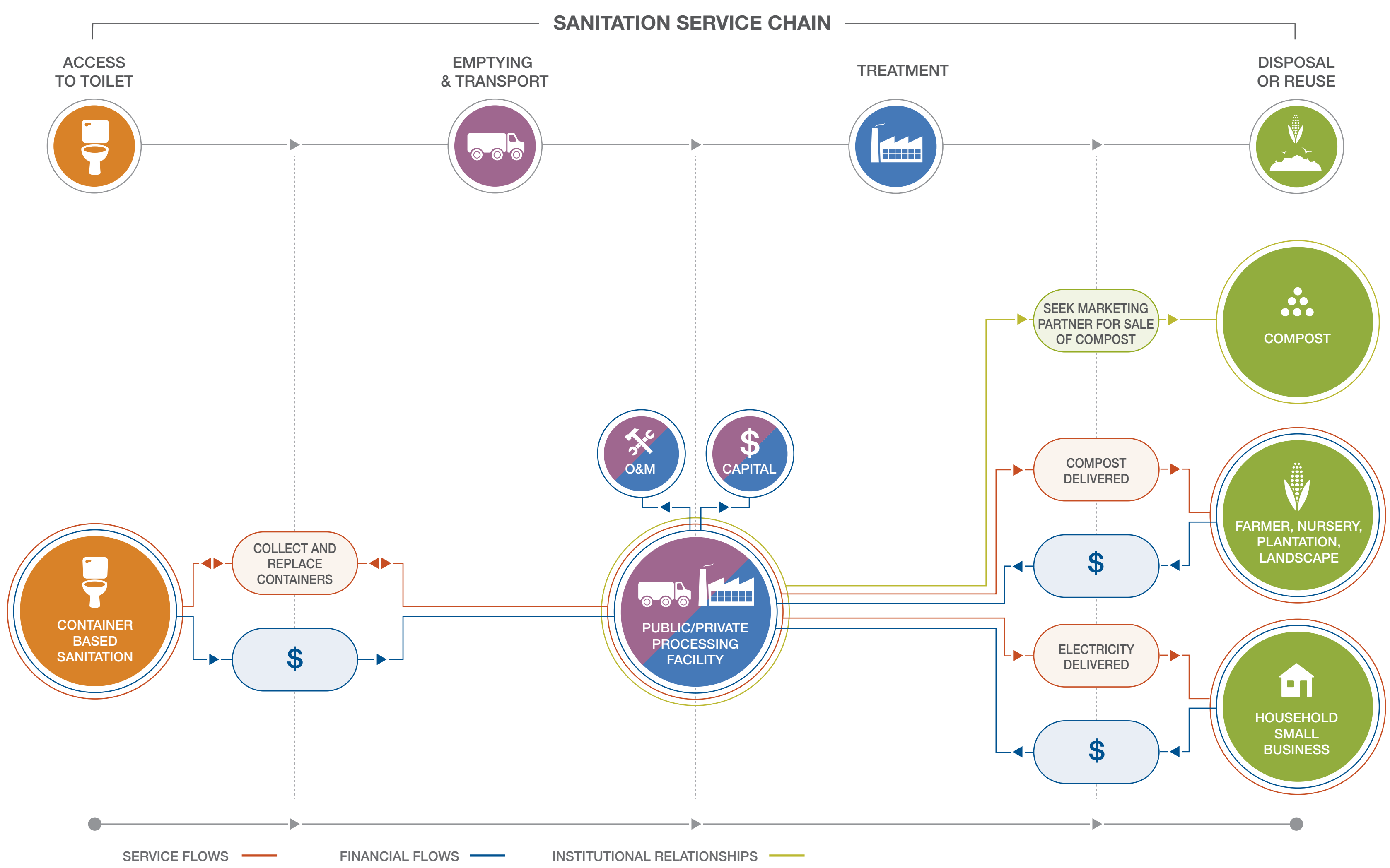
10.2 Container-based Sanitation (CBS) Model

Container-based sanitation (CBS) – in which human waste is captured in sealable containers which are then transported to treatment facilities – is an alternative sanitation option in urban areas where on-site sanitation and sewerage systems are infeasible. These mobile UDDTs can be rented out and placed in any household corner. They require less (vertical) storage space due to frequent collection (exchange) of the inbuilt container which accumulates the feces. The sealed container is instantly replaced, which adds a high level of hygiene (Figure 34). The business can be run either by a public or private entity or CBO, and also on a rental basis. Typical customers do not have access to toilets, water or any alternative emptying service, or no space to bury or use the generated dry feces. Moreover, they are usually renting their homes with limited incentives to invest in fixed toilet systems (Box 10).

BOX 10. CLEAN TEAM.

There are a number of private enterprises that restrict its business to the provision of sanitation services through the rental of mobile toilets. A well-known example from West Africa is the Clean Team, a company established in Ghana focusing on making sanitation profitable for the communities it serves in Kumasi by renting portable toilets to low-income areas, schools, businesses, public toilets and community centers. With support from its founding members Unilever and WSUP, Clean Team is strong in branding and has a different pricing structure for each customer segment it serves. Along with the renting of toilets, it also engages in the collection of waste two to three times per week. The waste collected is transported to the municipal treatment site. In the future, Clean Team plans to convert waste to energy and organic fertilizer (Clean Team Ghana 2015).

FIGURE 34. CONTAINER-BASED SANITATION (CBS) MODEL.



On a scheduled basis (weekly or twice every week), the containers are collected and transported to a central processing facility where the waste is processed. Some of the container-based sanitation providers take the additional step to produce compost, which reduces the waste volume, allows to sanitize the most recent (fresh) fecal matter and enables the production of a soil ameliorant for farming. As stated before, the extra efforts to engage in compost production are not only of ecological value (circular economy), but also help to reduce the (otherwise costly) waste accumulation. An alternative consideration to composting and fertilizer production is energy generation, which could take place at a centralized processing facility for the fecal matter.

From the resources collected, emphasis is usually placed on the feces collected, which requires treatment to safeguard public health, while urine from healthy people is microbiologically safe and the urine collection containers are emptied where possible by the toilet users, also to reduce the overall waste disposal costs.

The business model has high applicability in underserved communities, such as remote areas or slums where access to toilets are issues. The key revenue for the business is from the rental of toilets (and emptying service), complemented by the sale of reuse products. Table 21 summarizes some benefits and limiting factors of the model.

TABLE 21. BENEFITS AND LIMITING FACTORS OF THE CONTAINER-BASED SANITATION MODEL.

FINANCIAL IMPLICATIONS		REGULATORY AND MONITORING IMPLICATIONS	
Benefits for emptying operations	Y	Requires close monitoring for regulatory compliance	N
Reduces emptying cost to households	P		
Requires subsidy	P	Modification of sanitation codes and policy	N
Improve cost recovery of FSM	Y		

INSTITUTIONAL IMPLICATIONS		ENVIRONMENTAL AND HEALTH IMPLICATIONS	
Requires public sector involvement	P	Reduces indiscriminate disposal of sludge	Y
Requires private sector involvement	Y	Concerns of public health and environmental safety	N

Y – Yes, P – Possible, N – No, NA – Not applicable; see Table 3.

Case examples from Haiti, Peru and Kenya

SOIL, Haiti (Sasha Kramer pers. comm. and www.oursoil.org): SOIL is a NGO in Haiti working on the provision of access to sanitation since 2006. SOIL offers UDDTs, and provides collection, transport and treatment of mainly feces to produce compost in two locations in Haiti (Port-au-Prince and Cap-Haïtien). The compost is, in part, sold to farmers, and also used in tree nurseries and reforestation efforts, and large-scale agricultural projects through other NGOs and companies. SOIL works mainly with household toilets and also, to some extent, with public toilets. Independent contractors construct the toilets following the SOIL guidelines. SOIL purchases the toilets from the contractors for approximately USD 25 per toilet and installs them in households that have requested the services. SOIL and the household sign a contract stipulating that the household will pay approximately USD 3-4 per month for a twice weekly servicing of the toilets. SOIL staff then collect the buckets with feces from the households and provide clean buckets with cover material, using a small handcart. The urine is collected in a 1-gallon plastic container and emptied by the users. The buckets are then transported from centrally located collection points to the compost site. SOIL staff operate the composting facilities and sell the compost produced to companies, NGOs and independent farmers. As of July 2016, SOIL served a population about 5,000, although that number was closer to 25,000 following an earthquake emergency response in 2010. The total capital investment from SOIL is about USD 25,000 for a truck, USD 200 per handcart and about USD 150,000 for construction of its treatment facility. According to Tilmans et al. (2015), the (initial) costs of SOIL's small-scale service were higher than those of large-scale waterborne sewerage systems, but economies of scale have the potential to reduce container-based sanitation costs over time.

Compared to its local management cost (about USD 81,000), not to mention its overall program costs (around USD 1 m), direct cost recovery is still modest, with about USD 66,000 in service fees and program revenues (SOIL 2014). To support its social business model, SOIL is seeking alternative revenue streams and has so far been very successful in obtaining external financial contributions to cover both its program costs and local operations. To increase financial viability in the long run, it appears not viable for one NGO to cover operations across the entire sanitation service chain, and SOIL plans to outsource parts of its activities to private entrepreneurs, such as local bucket collection, with the ultimate goal of eventually having the entire sanitation service managed by private sector entities, possibly with the compost sites being managed by the government (or through a PPP).

X-runner, Peru (X-runner 2015; Pires, 2014; SuSanA 2013a; Swiss Re Foundation 2015): X-runner is a social enterprise in Peru providing sanitation solutions to low-income urban households, with the target of providing sanitation services to 550 households in three districts of Lima. X-runner has established an alliance with Separett, one of the world's leading urine separating toilet manufacturers. Their products are well designed to satisfy customers' high demands on appearance, environmental impact, function and quality. The toilets are rented out to households. X-runner's portable dry toilets separate urine and feces, and the latter is collected in a bin lined with a compostable bag. The customers pay an initial fee of USD 35 plus a monthly fee of about USD 13 for waste collection services. The business aims to collect 20 tonnes of human waste on a monthly basis to produce 11 tonnes of compost per month. Gradually, it hopes to achieve scale and reduce the waste collection cost to its customers. As of December 2014, X-runner had tested its compost product, which met the standards prescribed by Austria and Chile. Based on these results, the social enterprise is in the process of establishing a partnership with landscapers for maintaining green zones in the water-scarce regions of Lima, where soils are very poor and lack organic matter.

Sanergy, Kenya (Sanergy 2015; Auerbach 2015): Sanergy is a company in Kenya that designs and manufactures low-cost sanitation facilities called Fresh Life Toilets (FLTs). These toilets are installed close to homes in a community that does not have access to toilets. Sanergy builds a network of operators from the community who become franchise partners, and own and operate sanitation facilities (pay-per-use toilets). The operators are trained by Sanergy to maintain the facility, including removal of filled containers and replacing them with clean empty containers. The FLT operator is responsible for the provision of consumables (e.g., water, toilet paper, soap, etc.) and hence the cost of running the toilets is fairly low. An FLT operator with 50 users per day can earn about USD 800 per toilet per year. Sanergy collects filled containers and transports them to a centralized facility to produce compost and generate renewable electricity. The organic compost is produced through co-composting FS with other organic waste such as sawdust. Sanergy plans to commercially scale up reuse activities. In 4 years of its operations, Sanergy has launched 750 FLTs run by 350 operators in the slums of Nairobi, providing sanitation services to more than 33,000 people on a daily basis. Sanergy ensures removal of 60 tonnes of waste from the toilets per week.

11. WAY FORWARD

The overarching priorities to undertake improved sanitation service delivery from containment through to treatment are to safeguard public health and the environment. The shift in focus from access to sanitation (under the MDGs) to the entire sanitation service chain (under the SDGs) will entail massive investments into the sanitation sector. Given that 2.7 billion people worldwide currently use OSSs, and since this is also the preferred system in many regions (based on logistical reasons, costs or water scarcity), the challenge is extremely ambitious and stepwise solutions are needed (Hutton and Varughese 2016).

A city or town that aims to meet the SDGs should carefully and strategically look into the most suitable approach between improved on-site sanitation systems for FSM and expansion of networked solutions to maximize service delivery at affordable costs. Both systems have advantages and disadvantages, and can largely complement each other, thus OSSs are definitely not an interim solution and require our full attention.

In view of RRR, OSSs offer an easier and safer entry point for nutrient and organic matter recovery for agriculture and landscaping than sewage treatment, with the additional option of a revenue stream to offset some costs along the sanitation service chain. However, resource recovery from on-site as well as off-site systems implies challenges, such as the involvement of new stakeholder groups (e.g. in the agriculture sector), understanding and stimulating secondary markets, and giving attention to social and cultural issues of product acceptance. The earlier the sectors involved get together to jointly address the opportunities that FSM (including RRR) can offer them, the higher the probability of success. With increased water stress, the necessity for the use of renewable energy, and with the increased need for nutrient recycling, resource recovery can play an important role in addressing multiple challenges within and beyond the waste and sanitation sectors.

This report presents a number of different institutional options and business models along the on-site sanitation service chain beyond 'access to toilets', in order to provide options that could stimulate thinking about new or alternative ways to improve on-site service delivery either via private sector involvement or by introducing business-like thinking into the public sector service delivery. The examples also reflect an increasing interest in RRR in support of a green or circular economy.

This report presents business models for FSM from the perspective of interactions between different key stakeholders involved in the provision of FSM services. Implementation of most of these models require well-formulated PPPs, and supporting policy instruments and financing arrangements. Engagement of the private sector in sanitation is still low, and participation is mostly observed in the pit/septic tank emptying component of the sanitation service chain. The treatment component of the chain is dominated by the public sector due to low revenue collected along with low incentives to attract private capital. Private sector engagement is not a panacea for infrastructure development and also not for success, but under the right conditions (e.g., well-balanced risk spreading and appropriate incentives) it can be beneficial to the public, and deliver better and more efficient services. Financing in the form of public funding can be allocated based on results and performance. Trémolet (2011) provides examples of applying results-based financing (RBF) such as cash on delivery aid, output-based aid, advanced market commitments, and conditional cash transfers in the sanitation sector. Appropriate service and output indicators for each business model described in this report can be developed in order to apply RBF for model implementation.

In any given context, additional work is required to understand drivers, incentives and policy measures that influence the success of any business model within the strengths and weaknesses local actors offer. FSM is still in a nascent stage of development, often missing in policies, and with limited empirical evidence and data to analyze the viability of the different business models presented. More work and data are required to specifically assess the financial sustainability of the business models in different institutional environments and with different levels of subsidy. So far, there are only a few cases which have their audited financial statements in the public domain (e.g., SOIL), which greatly facilitates research.

IWMI, under WLE, is undertaking feasibility studies of subsets of the business models described in this report, which will help to build the dialogue and understanding around FSM models further. These feasibility studies will result in the adaptation of the business models presented here depending on local opportunities and constraints. In other projects, IWMI and partners are facilitating PPPs across the sanitation and agriculture sectors, analyzing the need for capacity development. For a long time, companies within the sanitation and waste sectors were paid by the volumes of waste collected, even if the same entity is now producing a compost or fertilizer. The shift in thinking towards multiple revenue streams and increasing independence from the public sector is taking its time. Many waste companies involved in co-composting still consider the value of their work foremost in the reduction of the volume of waste, and not in producing a competitive soil ameliorant. However, with increasing capacity in market analysis and demand for cost recovery, we see many examples of change (Otoo and Drechsel Forthcoming).

Given the increasing number of households served by OSSs worldwide, and potential viable business approaches and solutions available, an increase in the recognition and investments in on-site sanitation services by decision makers is extremely critical for meeting current and future challenges of providing improved sanitation services. Further research support is needed to guide decision makers on the type of on-site and off-site sanitation solutions that are most cost-effective, acceptable and sustainable to a given context and scale of operation.

Changing the ‘business-as-usual’ scenario in the conservative sector of waste and sanitation requires as much efforts in capacity development, and the exploration of strong incentive systems such as investments in infrastructure to build new alliances for successfully addressing the SDGs related to sanitation along with the interlinked targets around water, energy, rural-urban linkages and food security (Andersson et al. 2016).

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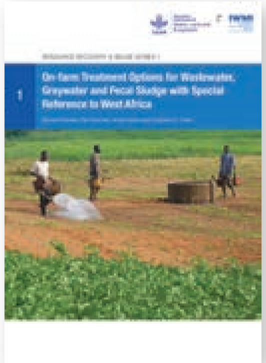


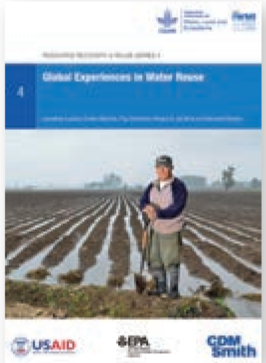
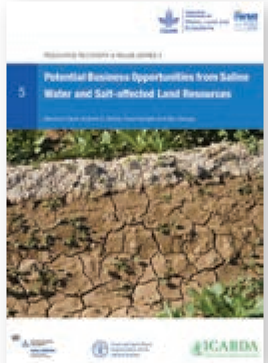
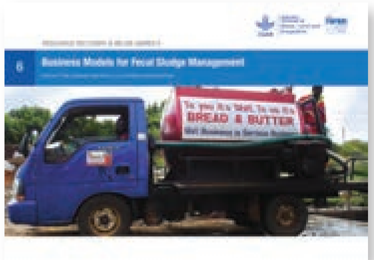
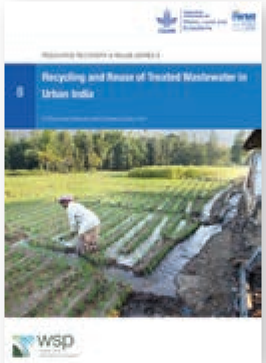

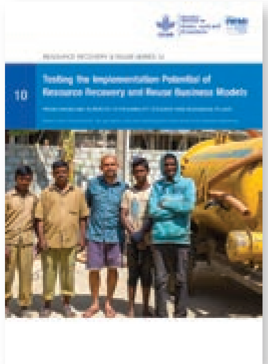

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The **CGIAR Research Program on Water, Land and Ecosystems (WLE)** combines the resources of 11 CGIAR centers, the Food and Agriculture Organization of the United Nations (FAO) and numerous national, regional and international partners to provide an integrated approach to natural resource management research. WLE promotes a new approach to sustainable intensification in which a healthy functioning ecosystem is seen as a prerequisite to agricultural development, resilience of food systems and human well-being. This program is led by the International Water Management Institute (IWMI) and is supported by the CGIAR System Organization, a global research partnership for a food-secure future.

Resource Recovery and Reuse (RRR) is a subprogram of WLE dedicated to applied research on the safe recovery of water, nutrients and energy from domestic and agro-industrial waste streams. This subprogram aims to create impact through different lines of action research, including (i) developing and testing scalable RRR business models, (ii) assessing and mitigating risks from RRR for public health and the environment, (iii) supporting public and private entities with innovative approaches for the safe reuse of wastewater and organic waste, and (iv) improving rural-urban linkages and resource allocations while minimizing the negative urban footprint on the peri-urban environment. This subprogram works closely with the World Health Organization (WHO), Food and Agriculture Organization of the United Nations (FAO), United Nations Environment Programme (UNEP), United Nations University (UNU), and many national and international partners across the globe. The RRR series of documents present summaries and reviews of the subprogram's research and resulting application guidelines, targeting development experts and others in the research for development continuum.

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ISSN 2478-0510
e-ISSN 2478-0529
ISBN 978-92-9090-843-2

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