BUSINESS MODEL 15

Outsourcing fecal sludge treatment to the farm

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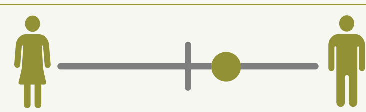
Key characteristics

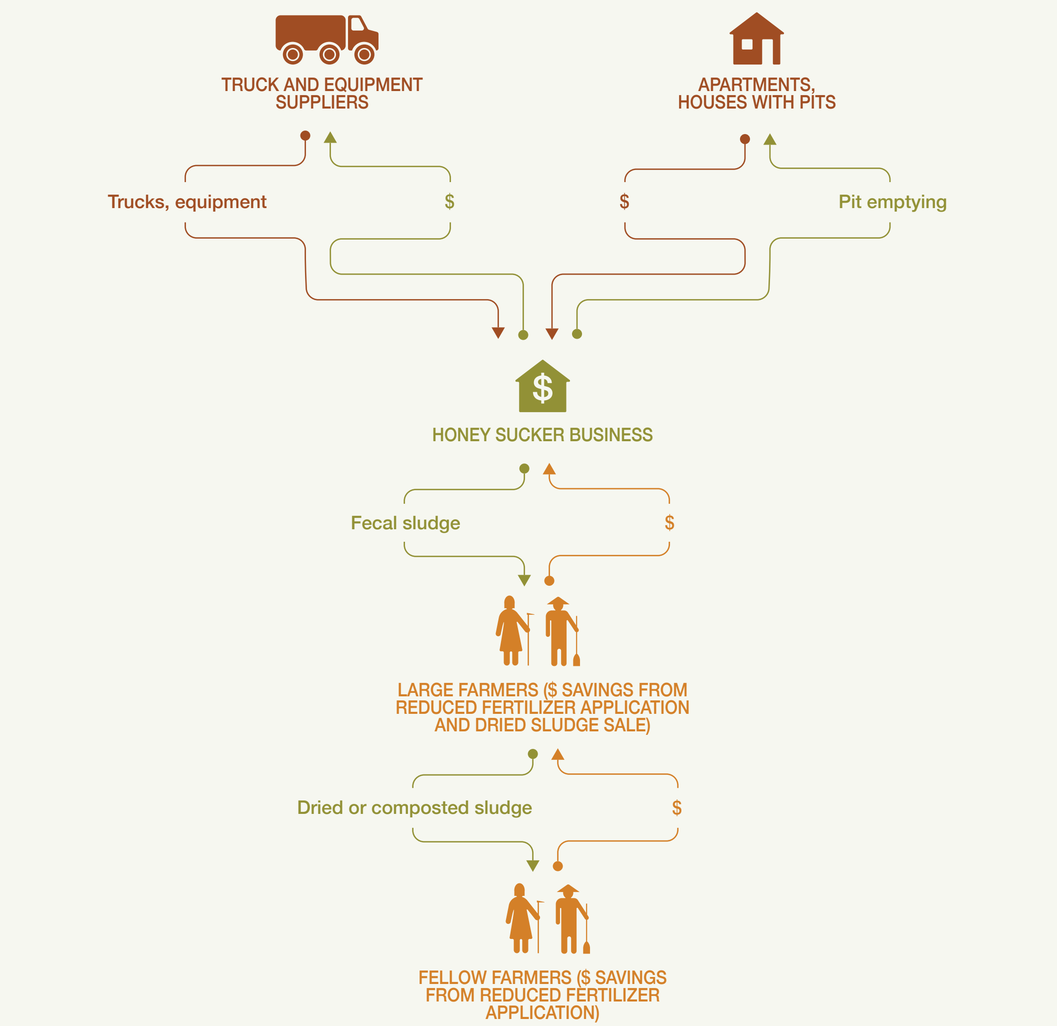
Model name	Outsourcing fecal sludge treatment to the farm
Waste stream	Fecal sludge (FS)
Value-added waste product	Organic fertilizer, waste removal and collection services
Geography	Urban population with no connection to sewerage network and use on-site containment such as latrines or septic tanks with off-site disposal. Dry climate over 3+ months for on-farm sludge drying before application.
Scale of production	Small to medium sized service operation; 20,000 people reached per truck per year (single homes and apartment blocks)
Supporting case in this book	Bangalore, India (with additional lessons learnt from Northern Ghana)
Objective of entity	Cost-recovery [ ]; For profit [X]; Social enterprise [ ]
Investment cost range	Variable but low; depending on fleet size, per truck ca. USD 24,000 (new)
Organization type	Private
Socio-economic impact	Jobs (3 people per truck), reduced disposal costs, agricultural production increase, sanitation improvement, living comfort increase
Gender equity	Primarily more benefits accrue to men who farm crop plantations and male drivers of vacuum trucks who gain from improved desludging and disposal measures 

Business value chain

This business model can be used by private enterprises in smaller and larger towns and cities with a significant share of on-site sanitation facilities like septic tanks and cement pit latrines at households or office/apartment blocks in need of servicing (desludging). In the primary market, the business will collect fees from the household for collecting the fecal sludge (septage). In the secondary market the sludge is sold to peri-urban farms or plantations where the material is treated on-site, potentially composted and used as manure (Figure 196). The value for customers in the primary market is clean removal of fecal sludge to ensure a working water closet and a clean property. On the secondary market, the sludge supports crop growth on even unfertile soils, easily replacing commercial fertilizer, which can represent significant savings for the farmer while reducing the disposal/pollution costs for the city. The truck operator gains significantly economically if the farm is closer than the official dumping site and due to a reversed cash flow: instead of paying a tipping fee, the farmers pay the drivers. This model works best where farmers have no objection to the use of fecal sludge, know how to treat it safely and official dumping sites are far out of town. As farm demand might be seasonal, sludge that cannot be sold to farmers must be legally dumped.

An alternative scenario in the secondary market is that a farmer has multiple partnerships with different truck operators to deliver sludge to the farm. The farmer treats the sludge through sun drying (e.g. over 6 months like in Dwarward, Karnataka) and sells/auctions the treated dried sludge as fertilizer to other farmers. Compared to conventional septage collection from households and disposal in treatment ponds, the model has increased safety issues due to sludge disposal on farm and its possible link to the food chain. On-farm treatment, hygiene and crop restrictions must be strictly managed in this model, unless the fecal sludge is professionally dried and sanitized in a dedicated facility before being sold to farmers.

FIGURE 196. VALUE CHAIN SCHEMATIC – OUTSOURCING FECAL SLUDGE TREATMENT TO THE FARM



This type of business operates in a relatively simple value chain, and has two different markets that rely on each other. The primary market, and the driving force of the business, is the one where people are in need of on-site sanitation service, to clean out pit latrines where houses, apartment blocks, etc. in urban areas have no connection to sewage systems. The secondary market is formed by farmers who are interested in buying the fecal sludge for use on their land, thus saving on fertilizer costs, or for drying/composting and resale to fellow farmers. The business relies on availability of adapted trucks and specialized equipment.

Business model

The primary concept of the business model is to provide on-site sanitary cleaning services to households in the city by collecting fecal sludge from households' pit latrines, and provide nutrient-rich sludge to peri-urban farmers as a form of cheap 'manure' (Figure 197). A private enterprise operates throughout (parts of) the city, providing pit latrine emptying services to households and apartment blocks that have no connection to sewer systems or any other effective on-site sanitation treatment service. The service is based on the operation of fecal sludge emptying trucks that have specialized equipment on board to flush, suck up and store fecal sludge. The overall investment required for this type of business is relatively modest, with major investments required only for buying trucks (ca. USD 24,000 for each new truck, not counting for variation per country). The business makes a contribution to improvements in the environment through reduction of fecal sludge-based pollution in the city and related possible contamination of water bodies. It provides an important sanitation service where sewer systems are not available, and offers an opportunity for farming communities to improve soil quality with minimal investment. The business, however, may be prone to seasonality unless perennial crops are grown, and suffer from ex-legal status. The best business conditions arise where the use of fecal sludge on farms is legal, like the use of manure, but also, where the safety of such business systems is thoroughly investigated and where regulation compliance is monitored and incentivized.

Alternate scenarios

In an alternative, legal (but hypothetical) model the enterprise will be operating with a larger fleet of trucks. This model builds on the possibilities that arise when raw fecal sludge reuse on farms is permitted and regulated. The enterprise is a public-private-partnership in which the private partner, having the materials and equipment as well as operative expertise, gains operational freedom leveraged through its public partner (e.g. a municipal sanitation body or a government-owned operation). Operations will be bound to strict selection of complying farms (monitored), but the enterprise also gains the advantage of economies of scale, enabling the transition to improved value offerings, such as 'eco-friendly fecal sludge removal' or 'guaranteed time of pick-up of fecal sludge'. The enterprise invests in and gains from extensive expertise on fecal sludge removal and pit latrine construction and cleaning knowledge. Competition from micro and small enterprises of the same sort is minimal because of value proposal superiority and operational freedom arrangements. Costs are incurred for monitoring of compliance, also at farming sites in the network. This model strongly reduces negative externalities such as health risk to consumers of farm products, and illegal networks.

Potential risks and mitigation

The business model presented here was designed and optimized based on the analysis of previous studies and a case study. In designing this optimized business model, risks decribed below were addressed. However, risks defined below would continue to remain and are hence acknowledged.

Market risks: Market risks in terms of accessing fecal sludge are minimal, unless there are plans to extend the coverage of the sewer system. Market risks in terms of accessing farm land can occur

FIGURE 197. BUSINESS MODEL CANVAS – OUTSOURCING FECAL SLUDGE TREATMENT TO THE FARM

KEY PARTNERS
- Truck and pump systems supply
- Municipal sanitation office/ department

KEY ACTIVITIES
- Collecting sludge
- Transporting, dumping/on-farm sales of sludge
- Service marketing and base development

KEY RESOURCES
- Truck(s) (capital)
- Labor, 3 per truck
- Driver–farmers network
- Household and apartment base

VALUE PROPOSITIONS
- Provision of a reliable and affordable fecal sludge removal service
- Low-cost high quality manure for farmers, who will save costs for expensive fertilizer.

CUSTOMER RELATIONSHIPS
- Semi-personal (ad-hoc)
- Contractual (apartment blocks)
- On demand or contractual (farmers or through auctioning)

CHANNELS
- Informal, word of mouth
- Telephone marketing
- Trucks, leaflets and banners advertising

CUSTOMER SEGMENTS
- Citizens in single or multiple households
- Apartment blocks
- Farmers

COST STRUCTURE
- Financial costs if and as long as trucks are financed
- Truck maintenance
- Truck fuel
- Labor wages
- Legal dumping fees (for sludge not absorbed by farmers)

REVENUE STREAMS
- Pit latrine emptying fees
- Sludge sales on-farm plus possible savings on transport costs (and tipping fees)

SOCIAL & ENVIRONMENTAL COSTS
- Potential health risk for workers from handling fecal sludge
- Crop contamination risk and associated health risk to consumers if crop restrictions and safety measures are ignored
- Operating ex-legally strengthens other illegal networks

SOCIAL & ENVIRONMENTAL BENEFITS
- Improvement of the sanitary situation for houses and apartment blocks without connection to sewer systems
- Reduced city-internal fecal waste pressure and related health and environmental problems
- Land fertilization where soils are poor and fertilization cost is high

Note: Fecal sludge household collection service (market 1) and safe on-farm use (market 2).

outside the season of fertilizer application, unless different perennial crops are grown which can absorb fecal sludge throughout the year. Market risk in terms of consumer acceptance could become a factor where crops are not mixed in markets.

Competition risks: Competition risk for small-scale business is high, with low new entry barriers.

Technological performance risk: The business relies on availability of specialized trucks and equipment, as well as parts and repair expertise for the same. If such are imported, a real technological risk exists.

Political and regulatory risks: Regulatory risks exist for the business as long as they operate in an ex-legal manner (which is common practice rather than exception). The ex-legal character forms a barrier to enterprise growth and maturation. Legalization of the business and associated regulation and compliance forms a further complexity to this type of business.

Social equity related risks: This business model does per se not create any particular social inequity, but this depends on the type of crops used and the associated gender. As ideally perennial plantation crops are preferred, the model might in many cultures favour men who have better access to land and capital. Also, most truck drivers will be male. Otherwise, the model rather contributes to ensuring that households using non-sewered systems have access to waste collection services. This is because cesspit operators now have 'informal' designated disposal sites and are thus incentivized to provide services to a larger proportion of the population.

Safety, environmental and health risks: Health risks exist for personnel operating latrine emptying trucks. Serious health risks to consumers of farm products exist where the model is employed ex-legally, and sludge handling practices on farms do not follow basic safety recommendations. Risk mitigation options are known and should be sought, like protective clothing for workers and farmers, and monitored farming practices such as crop restrictions, sufficient time for sludge drying and safe sludge application (Table 46).

TABLE 46. POTENTIAL HEALTH AND ENVIRONMENTAL RISK AND SUGGESTED MITIGATION MEASURES FOR BUSINESS MODEL 15

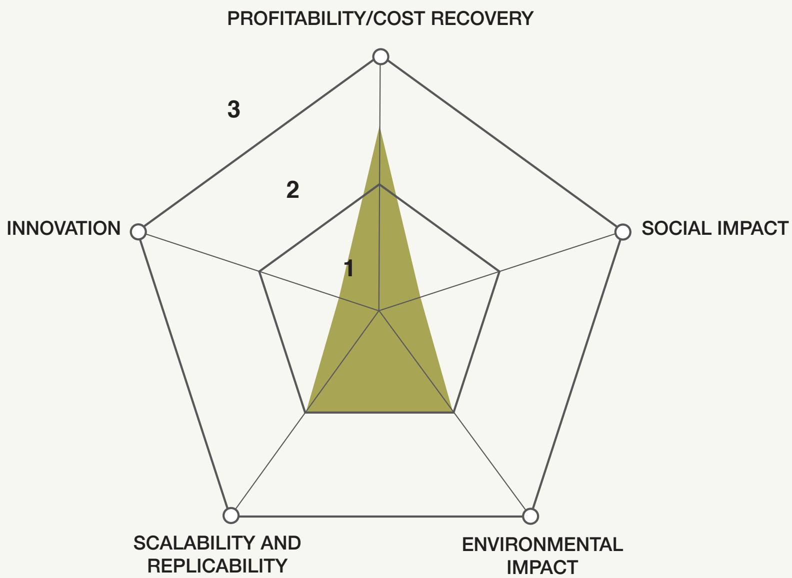
RISK GROUP	EXPOSURE					REMARKS
	DIRECT CONTACT	AIR/DUST	INSECTS	WATER/ SOIL	FOOD	
Worker	HIGH RISK	LOW RISK	MEDIUM RISK	NOT APPLICABLE	NOT APPLICABLE	At farm level, sufficient drying time for the sludge and crop restrictions are recommended, as well as personal protection (gear and hygiene) from sludge collection to farm work See Stenström et al. (2011) and Keraita et al. (2014) for more details on risks and risk mitigation
Farmer/user	HIGH RISK	LOW RISK	MEDIUM RISK	MEDIUM RISK	MEDIUM RISK	
Community	NOT APPLICABLE	LOW RISK	LOW RISK	LOW RISK	LOW RISK	
Consumer	NOT APPLICABLE	NOT APPLICABLE	NOT APPLICABLE	NOT APPLICABLE	LOW RISK	
Mitigation Measures						

Key: NOT APPLICABLE; LOW RISK; MEDIUM RISK; HIGH RISK

Business performance

The business model scores high on scalability, environmental impact and profitability (Figure 198). This business model may thrive in places where sewage services are minimal and where people require affordable, speedy, on-the-spot sanitation services. A strong driver for the business is the large availability of pit latrines that are accessible by truck, and the availability of local vacuum truck

FIGURE 198. RANKING RESULTS FOR OUTSOURCING FECAL SLUDGE TREATMENT TO THE FARM BUSINESS MODEL



manufacturers. There is need for farming activities in proximity with ample (ideally year-round) demand for sludge, like via perennial (tree) crops. Although driving the ease of entry, an ex-legal climate for the business operation also forms the major restriction of business growth, because official marketing systems such as yellow pages and websites are avoided to steer away from penalties. The development of a conducive legal-institutional framework would benefit the industry greatly.

Under the right circumstances, i.e. a legally conducive framework, companies will be able to grow and make use of economy of scale principles. The cost of acquiring new customers then are lower, as well as the cost of accessing and buying finance. In such a situation, this type of business could follow multiple avenues to vertically scale their operations: 1) through the exploitation of their growing specialized knowledge (e.g. of construction details and cleaning ease, efficacy) towards 'smart' sanitary solutions advice and consulting; 2) by bringing customers new quality offers services (e.g. time-guarantee arrival and emptying, guarantee towards eco-friendliness – customers explicitly mention their willingness to pay extra if they can be sure the entrepreneur's handling of the waste is guaranteed to be environmentally safe); 3) by development toward production of safe compost that will allow sales of compost to farmers and companies, and information services to farmers for safe handling and use of sludge for composting and crop growing; and finally 4) by offering maintenance service for 'smart' latrines that are built to fit the housing and offer higher safety, e.g. monsoon times or are easier to clean and empty. For scaling towards eco-friendliness, more emphasis would have to be put on the secondary market, the services to farmers. Stronger relationships, built on solid trust, would have to be developed. In the long run, these businesses would need to spend more effort in design and cleanliness of trucks, the appearance and training of personnel, and increasingly good handling of sludge, to sell their services to increasingly developed and richer communities.

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13. BUSINESS MODEL ON PHOSPHORUS RECOVERY FROM EXCRETA AND WASTEWATER

Introduction

Among the essential plant food nutrients, phosphorus (P) is of particular interest as it is a non-renewable (finite) resource and means of its production other than mining are unavailable. With about 90% of known phosphate rock reserves found in only a few countries, the slowly declining reserves have stimulated a lively discussion ("Peak phosphorus") on sustainable P management and P recovery before it ends in waterways (Cordell et al., 2011; Edixhoven et al., 2014; Sartorius et al., 2012).

According to Latimer et al. (2016), phosphorus (P) recovery in the form of struvite is for now the most established technology for facilitating extractive nutrient recovery at scale during wastewater treatment. Nitrogen-only recovery is also feasible but has not been implemented extensively. Taking this into account, Latimer et al. (2016) estimated that the existing domestic wastewater treatment industry can optimistically bring between 100,000 and 210,000 metric tonnes of P_2O_5/yr (as struvite) and up to 220,000 metric tonnes N/yr to the fertilizer market. Although this corresponds only to 2–5% of the global P_2O_5 and N fertilizer demand, the sector is expected to grow. Moreover, in financially more rewarding niche markets, like fertilizer for ornamental plants, already between 30% and over 100% could be covered.

A particular interesting source for P recovery is human excreta[1]. Each year, the average human excretes up to 500 litres of urine and 50–180 kg (wet weight) of feces depending on water and food intake. Comparing feces and urine, most of the nutrients, i.e. 88% of the nitrogen, 67% of the phosphorus, and 71% of the potassium are found in the urine (Drangert, 1998). For low-income countries, there are three broader options for accessing and recovering P from human excreta, which are in order of increasing scale:

a) Collecting separated urine and feces at source (toilet), for urine use as liquid or crystal mineral fertilizer;
b) Collecting mixed excreta (septage) from unsewered systems, for use as organic fertilizer (fecal sludge composting);
c) Extracting P crystals during or after sewage treatment, for use as inorganic P fertilizer.

a) Collecting excreta before they are mixed with other potentially harmful waste streams appears most straight forward. Given the different nutrient amounts in feces and urine, and also the differences in pathogen loads, an ideal system collects both fractions separated, like in urine diverting dry toilets (UDDTs). The separated products can be safely treated and reused in agriculture ideally directly at household level (gardens). However, where households have no space, means or interest in reusing the produced excreta, collection services can be set up, where – depending on available alternatives – households either pay a fee for being served or receive payment for the provided waste resource. Different models are possible:
   - **Decentralized excreta collection from households with UDDTs**. This has been tried at scale, e.g. in Ouagadougou (see **case example** following) with resale of the recovered and treated resources to farmers. There are very few similar examples yet to promote a particular business model. From a financial perspective, success is so far mixed, especially when the provision of the UDDTs is included (WSP, 2009). Additional challenges, like in the case of Ouagadougou, are the high management overheads to organize excreta collection and distribution as well as the related (urine) transport costs.
   - A related business model is to focus on the **collection of urine from large one-point supply sources** such as sport arenas, youth hostels, prisons, industrial fares, music-, business- or entertainment-parks, universities and colleges, research institutes, etc. which are (or can be

temporarily) equipped with normal urinals or UDDTs. This model avoids the costs of dealing with multiple clients as well as expenditures related to transport and logistics. The Dutch GMB[2] Bioenergy company in the Netherlands runs such a business using the SaNiPhos® process for urine treatment. The plant has been operating since 2010 and sourcing urine from music festivals, treating about 1300m^3 of urine per year. Each cubic meter of urine yields 3–4kg struvite (solid fertilizer) and about 60kg ammonium sulphate (liquid fertilizer). In another Dutch example, Amsterdam's water company (Waternet) and water authority Amstel, Gooi and Vecht recover phosphate in a special phosphate factory since 2013. They targeted Amsterdam's five-day maritime festival in 2015 to harvest about 100m^3 of urine. The expected 140 kg of struvite will be used in three innovative urban greening projects by the Amsterdam Rainproof platform[3]. A significant disadvantage of urine collection is its large water content and related volume and weight. The most common method for reducing the urine volume is through P precipitation (Pronk and Koné, 2010) as used in the examples above which can be catalysed through the addition of magnesium and results in "struvite" which is a soft P-crystal ($NH_4MgPO_4{\cdot}6H_2O$). The process has been piloted in many countries, like in Nepal, and can be financially viable unless magnesium access becomes too expensive (Tilley et al., 2009; Etter et al., 2011). An alternative option could be membrane filtration. Urine collected during a music festival in Ghent, Belgium, has been heated in larger (e.g. solar powered) tanks before passing it through a membrane which separates the nutrients and recovers the water in the urine[4].

b) Where urine and feces are not separated, and collected in latrines or septic tanks, resource recovery can transform the generated and collected septage during treatment into a safe organo-mineral compound fertilizer for example through drying and composting or co-composting (Nikiema et al., 2014). The compound nature of the material with different macro- and micro-nutrients has its own value proposition and business models (Rao et al., 2016). In many developing countries where treatment plants are too expensive, the agricultural use of nutrient rich (composted) sludge from septic tanks can be the most cost-effective option. This does not apply to sewage sludge, which with increasing industrialization has a growing risk of chemical contamination limiting its direct reuse potential. For sewage sludge, other P extraction options exist (see next point).

c) Where households are connected to sewers, and the excreta are flushed away, the process of extracting at this stage nutrients is increasingly complex and costly. However, to protect water bodies from eutrophication and treatment plants from unwanted phosphorus crystallization (valve and pipe damage), a large array of technical options is available to not only remove but recover different percentages of reusable P from wastewater and sludge during or after the treatment process (Egle et al., 2014; Latimer et al., 2016). These technologies have different requirements on the treatment process and energy and not all might be suitable for developing countries. However, especially in larger plants, they offer an important value proposition for saving maintenance costs, next to the generation of high quality Ca or Mg based P crystals with potential for use as fertilizer.

In this section we will describe two examples from the spectrum of opportunities listed above, one as a **case study** (Ouagadougou) and the other as **a model** (**P extraction from sewage treatment**). The Ouagadougou case was selected as a promising but also highly subsidised attempt for going at scale without qualifying yet as a model recommended for replication. The other case is based on P extraction from sewage treatment using the approach of Ostara (Canada) as an example. Given the success of the Ostara model, the example was chosen as a ***business case*-cum-*business model*** based on data from Ostara's operations in Canada, USA, and Europe and application potential also in middle-income countries. It is however important to add that there exist a wide array of other companies, processes and technologies for P recovery with different advantages for different situations and recovery targets (Sartorius et al. 2012; Egle et al., 2014).

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Notes

1 Urine and feces together are called excreta.
2 http://www.gmb-international.eu (accessed November 8, 2017).
3 https://amsterdamsmartcity.com/projects/amsterdam-rainproof (accessed November 8, 2017).
4 http://firstwefeast.com/drink/2016/07/scientists-discover-way-to-turn-urine-into-beer (accessed November 8, 2017).