

Chapter 7

Marketplace and sales

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Chapter objectives

The aim of this chapter is to guide the reader in assessing sanitation end-market conditions that determine production and services in the IFSVC as well as explore some of the characteristics of this market, why its potential has not yet been realized, and some of the ventures that are bringing about change.

7.1 INTRODUCTION

It is only relatively recently that sanitation began to be considered to a marketplace where sales of products and services can be made. Historically, in many countries it was considered to be a public good which should be provided by the state. While governments do still have an important role to play, it is now widely accepted that the private sector also has a key role in meeting sanitation needs and can do so profitably and sustainably. The emerging sanitation marketplace is large, diverse, complex and underdeveloped, but represents a huge opportunity for business, for improved public health, for resource recovery, and for reducing human impact on the environment. In this chapter we will explore some of the characteristics of this market, why its potential has not yet been realized, and some of the ventures that are bringing about change. Although global estimates are not readily available, the commercial case for the sanitation market has now been made in several countries ([Toilet Board Coalition, 2020a, 2020b, 2020c](#)) and for new technologies such as the Janicki Omniprocessor ([Gates Foundation, 2017, 2018](#)). With 2.3 billion people, about 30% of the world's population, still to access decent sanitation ([JMP, 2017](#)) the potential for market growth in all sanitation-related goods and services must be very large. Furthermore, there is a huge potential market for resources – water, energy and nutrients – which can be recovered from the ‘waste’ collected from sewers (wastewater) and on-site sanitation systems (faecal sludge), and for the associated plant and equipment. Globally there is a marked lack of capacity to manage and treat both types of waste, particularly in developing countries ([Harada *et al.*, 2016](#); [WWAP, 2017](#)). Thus, the potential for recovery and reuse is very high, as is the potential to reduce harmful pollution and disease caused by direct discharge of untreated waste into the environment.

The future development and impact of the sanitation market and of the Integrated Functional Sanitation Value Chain (IFSVC) are thus closely intertwined. The IFSVC can be viewed as a series of market-based transactions taking place within and between the different stages, and involving different customers and suppliers, different products and services, and differing motivations for purchase and sale. For the concept to be realized, value should be added at each stage and accumulated along the chain, with every part of the chain aligned to and serving the overall goal of reuse and recovery. Equally, revenues should flow in the opposite direction, providing the incentives for value creation and covering the costs of the transactions involved (Figure 7.1).

The current reality falls short of this ideal for a number of reasons that will be explored in this chapter, although recent innovations in market development, wastewater reuse, container-based sanitation and reuse product technology are bringing it closer. However difficult, achieving an efficient IFSVC is important for several reasons:

- (i) economically, it should reduce the cost burden of sanitation;
- (ii) environmentally, it should reduce harmful pollution caused by dumping waste, enhance resource reutilization and reduce pressure on scarce resources; and
- (iii) socially, it should drive increased access to decent sanitation, and the associated health benefits, for the underserved.

Making markets work effectively and sustainably is critical to achieving this vision. This necessitates private-sector involvement and there has been a growing recognition over the past decade of the essential role that the private sector can play in delivering the benefits of sanitation and meeting the Sustainable Development Goals (SDGs). However, significant barriers and constraints remain, and different innovations are being explored to overcome them and make markets work more effectively. In this chapter we examine progress, what has been learnt, and opportunities for the future. The focus will be on attempts to drive universal access to safely managed sanitation through market-based sanitation and at the same time realize the vision for the IFSVC.

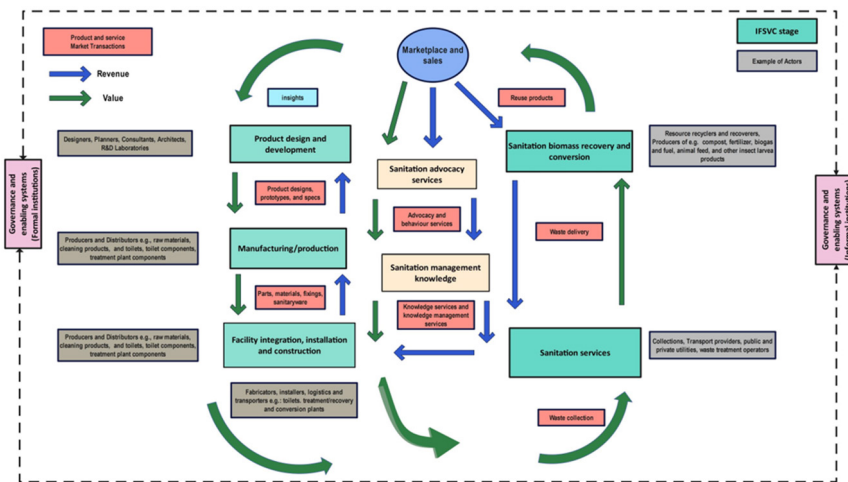


Figure 7.1 IFSVC: revenue and value flow, market transactions and actors. (Diagram by author, after Koottatep et al. 2019).

7.2 MARKET LANDSCAPE

7.2.1 Sanitation market

At its simplest the sanitation market is where demand meets supply, where buyers or customers meet suppliers and a transaction related to sanitation provision takes place. This is conducted by the sanitation enterprise (or in some cases a public utility) which arranges for promotion, production, distribution, sale, and delivery of the goods or services through its operations. There are many different sub-markets, characterized in terms of size (number of customers or products sold), value (revenue from sales), segments (different groups of customers with similar characteristics who share the same desire for a particular product), and the available products or services and their prices and perceived value. As an example, the 'toilet' market is one major segment, but it can be further sub-divided by location (e.g., urban/rural), by type (e.g., household, communal or public), by product type (e.g., container-based vs on-site treatment) and so on. Other major segments include sewered and non-sewered, 38% and 62% of the world's population respectively (JMP, 2017), and the sanitaryware market, estimated to be worth \$32 bn and growing, driven by developing countries (Business Wire, 2020).

The sewered market predominates in countries and regions with more mature developed economies (e.g., EU, USA): the value of the market is difficult to estimate as tariffs typically cover combined water and sanitation services, but the figure of €37bn for the total production value in the EU is indicative of its size (Schouten & Van Dijk, 2007). In developing countries, where non-sewered (on-site) sanitation is the dominant type, the market value is also very large: detailed analyses of India, Kenya and Nigeria by the Toilet Board Coalition estimate the 2021 values of the sanitation economy in those countries alone to be \$97.4bn, \$3.2bn and \$15.5bn respectively (Toilet Board Coalition 2020a, 2020b, 2020c). The toilet economy, which includes household, public and community toilets, operations and maintenance and auxiliary products, is by far the greatest sector currently. The circular economy, comprising the market for reuse products, is relatively small at present. To some extent this reflects the dominant paradigm in the sanitation sector for the past 20 years, which has been toilet provision. The concept of reuse, essential for the IFSVC, is relatively recent and the associated technologies, markets and business models are still being explored.

The sanitation market is poised for significant growth, much of it in developing and emerging economies, and much of it driven by growing wealth and the ambitions of the SDGs to provide universal access to adequate sanitation: as noted above around 2.3bn people still do not have access to decent sanitation (JMP, 2017). This should enhance sales of toilets and on-site waste collection and treatment systems, as well as cleaning products. The gap in wastewater and faecal sludge capacity is being recognized in countries such as India and will drive investment in new technology and plants. Production and sales of reuse products will increase, driven by improved technology, market forces (e.g., resource scarcity) and government legislation. Product innovations will open new and valuable markets: the Bill & Melinda Gates Foundation estimates the market potential for their portfolio of 'Reinvented Toilets' to be around \$6bn (Gates Foundation, 2017, 2018). It is striking however that as yet there is no actual market for raw faecal sludge or other 'toilet resources'; the emergence of significant global demand for this as a feedstock, with a concomitant value in dollars/tonne, will signal the integration, full functionality and widespread operation of the IFSVC. If the value is high enough it could lead to a new paradigm in sanitation, one where instead of being a cost burden, it becomes value creating, offering the prospect of lower charges and better products and services for customers providing the raw material for subsequent transformation.

7.2.2 Sanitation marketplace and the IFSVC

How does this marketplace of sanitation goods and services map onto the IFSVC? Conceptually, within the IFSVC, individual marketplace transactions should be connected and add value at each stage to achieve the overall purpose of optimal reuse and recovery of sanitation resources. The model implies an alignment of market transactions from stage to stage with each one adding value in exchange for revenue. The customer for one product or service becomes the supplier to the next, with the reuse customer being the ultimate driver of demand. However, at present the customer for an individual product or service is rarely buying into a joined-up, safely managed sanitation value chain. Indeed, the reuse customer is presently not the dominant driver of market transactions further back in the chain. Other customers, often sitting outside the chain, and not necessarily connected to later stages, can interrupt value and revenue flows as shown in [Figure 7.2](#).

This reflects the fact that, for good reasons, the focus of many organisations, both private and public, is and has been the provision of toilets, with less thought being given to completing the chain and adding value at every step. However, the purchase or provision of a new toilet does not mean that the new owner will then have access to related sanitation services or markets further along the chain. Nor does it mean that the value of the waste it collects will be recovered at a later stage. As we will see later, for the domestic customer it can appear as a very fragmented marketplace. At present, sanitation product and service providers rarely span the whole chain and operate it as an IFSVC. More typically each stage of the IFSVC is made up of different types of enterprise that may or may not supply customers in a later stage. The wide range of different enterprises active in the IFSVC has been comprehensively summarized by [Kootatép *et al.* \(2019\)](#) and is mapped onto the IFSVC conceptually in [Figure 7.1](#).

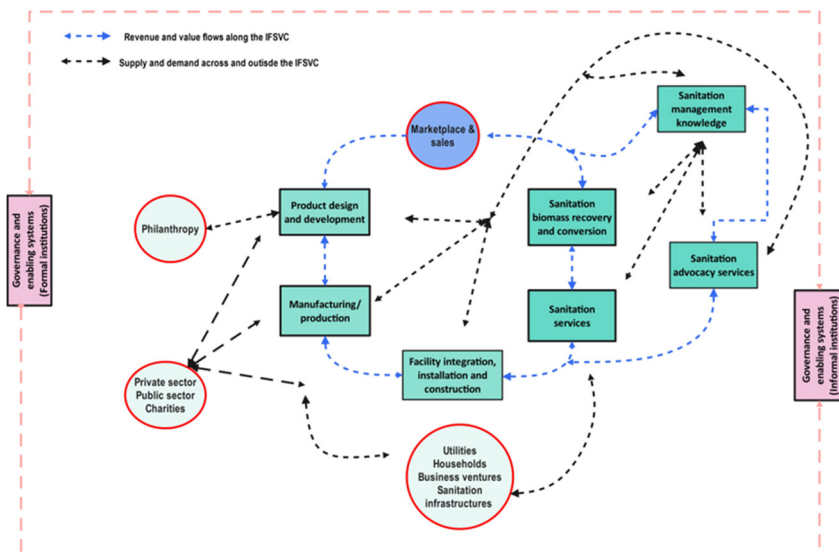


Figure 7.2 Sanitation marketplace and the IFSVC: internal and external demand. (Diagram by author, after [Kootatép *et al.* \(2019\)](#)).

Although [Figure 7.1](#) recognizes that public utilities have an important role to play and can be considered as enterprises if they are charging market-based fees, it is to be expected that private enterprises will dominate within the IFSVC and its associated market transactions. Although there is a view that sanitation is a public good and there is evidence that private-sector involvement will not necessarily improve access to services for the poor ([De Oliveira, 2018](#)), there is a growing acceptance that the private sector does have important roles to play and that its contribution will be necessary to meet the SDGs ([Mason *et al.*, 2015](#)). [Sparkman and Sturzenegger \(2016\)](#) also recognized this trend and highlighted some of the benefits of a market-based approach involving private-sector providers, which include:

- (i) greater sense of ownership by the end customer if they are investing their own resources;
- (ii) continuous improvement in quality of goods and services due to greater accountability of, and competition between, providers;
- (iii) greater focus on what people actually want and are willing to pay for;
- (iv) greater potential for sustainability due to reduced dependence on outside aid; and
- (v) greater potential for self-scalability due to incentives to seek growth and new customers.

Businesses can therefore contribute not just value to the IFSVC but also to the sustainability of service delivery. For the IFSVC to function optimally, each enterprise must be able to achieve its full market potential, that is, efficiently create and meet demand, and have incentives to participate in value creation. However, they sit within a complex system, that, along with market reality and market forces, will influence how far they can go to achieving that goal.

7.2.3 Market system

Marketplaces and enterprises do not operate in isolation: they sit within a broader market system which supports and influences it through a broader context and range of actors such as government institutions, investors and so forth. Market rules will apply which also affect business operation. [Figure 7.3](#) illustrates how IFSVC enterprises are influenced by the wider environment and external enablers and supporters (based on [Agarwal *et al.*, 2018](#), and [Koottatep *et al.* 2019](#)). For market potential to be realized effectively an entrepreneur must identify the target customer, create and produce a product they want to buy, activate demand through sales and marketing, and develop a model to deliver the product to the customer. As shown in [Figure 7.3](#) these activities take place within the broader market system, which includes enablers, supporters and the external environment. Here the latter is taken to include factors that influence businesses directly and the broader context in which they have to operate. For sanitation this system is quite complex and involves a range of different actors including NGOs, utilities, regulators and other government bodies, policy makers, builders, manufacturers, designers, philanthropists, donors and investors. Some of the constraints to its effective operation are considered later in this chapter in the section on market failures.

NGOs have historically played a major role in sanitation provision; their role, as we will see later, is now changing in some cases towards facilitating market development. Non-sanitation businesses such as property developers, architects and builders may influence the design and choice of sanitation system used in homes, factories and offices. Academics study market dynamics and opportunities and support new policy development and market development. Scientists and technologists develop improved products and services, some of which may enable new markets for existing or start-up enterprises. Finance providers help with purchases and help entrepreneurs to grow their

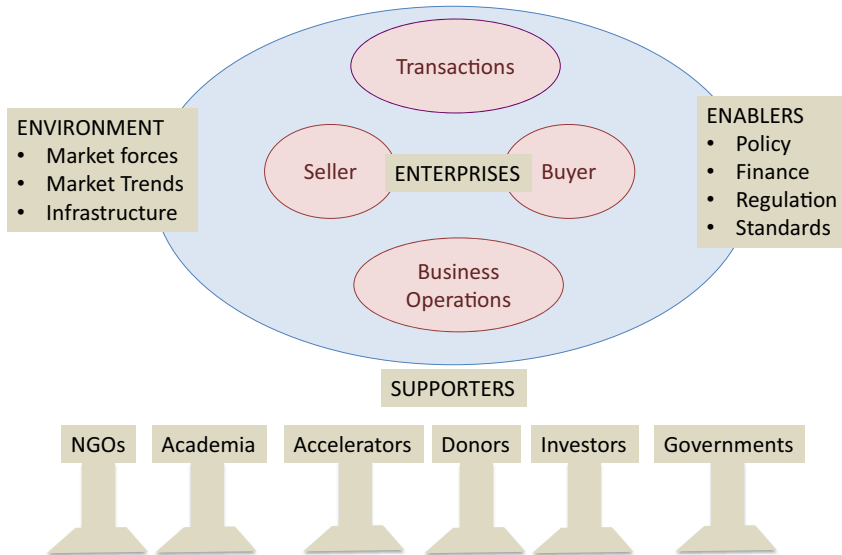


Figure 7.3 The market system: wider influences on IFSVC enterprises.

businesses. Philanthropy has a role to play too in supporting new ventures, developing and introducing better products and services, and learning how to make the marketplace work. The actions of each of these players are not necessarily coordinated, leading to market complexity and the potential that they will work against, rather than with, each other.

Governments play a particularly important role. Sanitation has historically been viewed as a public good although this does not mean that governments have taken complete responsibility for an end-to-end provision of sanitation as a social service. It does mean, however, that in most countries it is viewed as a government responsibility to ensure that sanitation is safely managed for all its citizens. How this is discharged, for example through policy, regulation and direct interventions such as subsidies, can have a positive or negative effect on the market.

The market and business viability are also influenced by the environment in which they operate. This can include broader factors such as infrastructure (affecting, e.g., movement of goods), as well as others that affect businesses more directly, such as finance availability, laws and regulations, and availability and process of raw materials (Agarwal *et al.*, 2018).

7.2.4 Sanitation market status

The market transactions and enterprises at the heart of the IFSVC are thus part of a much larger system and influenced by it. This market-led approach is however a relatively recent trend, especially in developing countries, and is not yet well established. So what is the current status? The position in developed countries is exemplified by the UK where sanitation is largely delivered by connection to sewers and waste treatment in large, centralized plants. Since privatization in 1989 these are maintained and operated by what are effectively private monopoly companies (derived from previous regional public utilities) within a market framework designed and regulated by an independent

government-established regulator (Ofwat, 2020). The cost is borne largely by fees charged to individual households, offices and other premises connected to the network. In the past the focus of sewage treatment has largely been on safely treating it and disposing of residual sludge either by landfill or at sea. More recently the value of sludge for use in agriculture or in energy production has been recognized and there has been a shift towards reuse and recycling, encouraged by the regulator (Ofwat, 2015). External factors, such as demand for clean energy, and scarcity of water and other natural resources such as phosphorus are also driving greater recovery and reuse of energy and nutrients from wastewater and sludge treatment. Recovery and reuse potential from wastewater is highest in urban areas (WWAP, 2017). The market for biogas globally is predicted to grow from \$25.5bn in 2019 to \$31.69bn by 2027; currently the main biogas installations are in the US, Germany and the UK (Fortune Business Insights, 2020). Water is being recycled directly or indirectly for drinking or for irrigation, and phosphorus recovery is now getting closer to being economically viable (WWAP, 2017).

Unlike many other markets, consumer choice is somewhat limited for the majority of users in developed countries where sanitation is sewerled: there is likely to be only one local provider. Those consumers who are off-grid have somewhat more choice in terms of the range of septic tanks available for purchase and there is also competition between private service providers for emptying tanks and transport to treatment plants. The market for sanitaryware is however highly developed and competitive: although the basic functionality of toilets has changed little (except in Japan, where very innovative features have emerged in the last 30 years), designs are constantly changing to keep pace with fashion and trends in interior design. By contrast, in developing countries, the focus in sanitation has been ending open defecation. In regions such as Sub-Saharan Africa and Central and South Asia only a minority of end users are connected to sewers, mostly in urban rather than rural areas (JMP, 2017). The majority of rural households and low-income urban households are off-grid and have no real prospect of being connected to sewers. Installation of sewer lines in rapidly growing cities is simply too expensive and difficult, so even wealthier families may not be able to get a connection and have to rely on septic tanks. Connection to a sewer does not of course guarantee safely managed sanitation if there is not adequate provision for waste treatment, as is the case in many countries. Likewise, there is nothing wrong with on-site sanitation so long as excreta are disposed of safely *in situ* or safely removed and treated off-site. The latest JMP figures, while noting a lack of data on excreta management, suggest there is a long way to go to achieve universal safely managed sanitation (JMP, 2017).

Typically, sanitation markets aimed at low-income customers are focused on provision of toilets – generally septic tanks and latrines along with superstructure and fittings – and emptying and transport services by small-scale entrepreneurs. Public services may also be available although utilities tend to focus on the sewer network and operation of treatment plants. Management of faecal sludge and septage has not kept pace with increased coverage. Regulations may have been adopted from developed countries and not aligned with the dominant local non-sewered form of sanitation. There is low treatment capacity and reuse is still on a very small scale: in India alone something like 72 000 tonnes of faecal sludge are dumped in the environment every day without treatment or value recovery (Sivaramakrishnan, 2019). This is a key issue for the IFSVC: a flourishing and high-value market for reuse products is critical to drive the chain.

Sanitation markets in such countries are fairly embryonic, limited and fragmented relative to their potential. A report in 2015 concluded that ‘sanitation markets that meet the needs of poor rural consumers are virtually non-existent’ (DumPERT & Perez, 2015). This may reflect the fact that the off-grid market was viewed as an interim step on the way to fully sewerled sanitation, instead of a viable and acceptable alternative in its own right. However, recognition is growing that it is precisely these markets which need to

be developed if universal access to safe sanitation is to be achieved. This is beginning to happen as the underlying market failures and barriers to growth are better understood and new business models and interventions are explored. Standards for product and service performance will also contribute to the development of the market as they will provide reassurance to customers of the quality of their purchase, build trust and encourage product use, which is crucial to achieving the health impact of sanitation.

7.3 MARKET FAILURES

At present, sanitation markets in developing countries, particularly those serving the majority with on-site facilities, lack capacity: that is, goods and services are not being provided in sufficient quality and quantity. This can be broadly attributed to market failures due to external events, information asymmetry or imperfect competition (Tremolet, 2012). Looking along the value chain and across the market system in more detail, specific failures and constraints can be identified using a number of different approaches, including economic analysis (Tremolet, 2012), qualitative research (Murta *et al.*, 2018; Scott *et al.*, 2018; Sy *et al.*, 2014), mixed methods (Muhkerjee *et al.*, 2019; Tsinda *et al.*, 2015), expert interview/literature review (Sparkman & Sturzenegger, 2016), workshops (Mulumba *et al.*, 2014) and case studies (Agarwal *et al.*, 2018). The conclusions from these studies are summarized in Table 7.1 using the market system framework of Agarwal *et al.* (2018) where the environment is broken down into the business environment and the broader context; it is not an exhaustive list but will exemplify the wide range of issues in the market.

Many of these failures fall under the heading of 'information asymmetry', a category which applies in other sectors such as climate change (Andrew, 2008). As concluded by Dumpert and Perez (2015) information flow to market actors is often the missing link in the value chain, due to poor communication and misperceptions: consumers are unaware of products because suppliers don't promote them, and suppliers think there is no demand from consumers. Others relate to the intrinsic market attractiveness in terms of business viability, competition, market rules and access to finance. Another critical factor is coordination and alignment of public- and private-sector players and interventions.

In addition, there seems to be a damaging combination of weak demand coupled with a fragmented supply chain. The lack of demand seems to be more related to lack of focus on products that people want to buy as opposed to the products being unaffordable. Indeed, there is evidence that if the products are designed to meet key wants and needs, and are of good quality, then people are willing to invest in improved sanitation. Willingness-to-pay studies are a key part of evaluating new products and can be a guide to likely demand, as well as indicating the trade-offs that customers are willing to make in terms of price vs product attributes. Dumpert and Perez (2015) in a comprehensive review of the sanitation market in countries across the world noted that low-income consumers – contrary to common beliefs – value quality and are willing to pay for high-quality products even if lower-cost alternatives are available. In this sense, in some cases the challenge may be not so much about increasing demand *per se* but about finding ways to enable such consumers to purchase products designed for them and to which they aspire, for example, through financing. Agarwal *et al.* (2018) also noted the importance of addressing *ability* as well as *willingness* to pay and in addition to microfinance mention the use of 'market-compatible' subsidies such as incentives to credit providers. Perhaps the single greatest factor influencing the IFSVC is the relative lack of a significant market for reuse products, which is influenced by the relative lack of treatment capacity, weak demand for reuse products, lack of awareness of its potential and regulatory factors. Currently the flow of revenue along the chain originates largely

Table 7.1 Market system failures along the IFSVC.

Failure/Constraint	Causes
Core Market	
Weak demand	Not providing products people want and offering products they do not want Lack of market segmentation Lack of promotional activities and low awareness of products and services Limited access to finance
Limited availability products/ services	Weak, fragmented supply system
Lack of entrepreneurs	Lack of access to finance and training Lack of market attractiveness
Inadequate market structure	Lack of skills and training of service providers, presence of illegal operations, no economies of scale
Poor revenues for small-scale operators	Lack of awareness of reuse opportunities
Lack of attractiveness of reuse markets	High transport costs, consumer perception, limited financial value of reuse products,
Business Environment	
Barriers to entry/ entrepreneur participation	Public utilities may hold monopoly but be unwilling to provide services to poorer customers Lack of access to capital Lack of transparent regulatory framework Lack of representation for start-ups to influence policy
Distortion by subsidies	Ineffective targeting or over-liberal use
Governments invest in expensive solutions	Lack of awareness of cheaper solutions
Financial value of reuse products fluctuations	Changes in external factors, for example, energy prices
Inhibitory market rules	Lack of alignment with market functions
Broader Context	
Poor infrastructure	Insufficient cross-sectoral action due to poor planning
Challenging physical environments	Difficult terrain, physically dispersed population

from household customers for sanitation goods and services (Figure 7.2). For the IFSVC to flourish this needs to be matched or exceeded by a flow of revenue from customers in other markets for reuse products.

7.4 MARKET DEVELOPMENT INNOVATIONS

The challenges outlined above are almost certainly incomplete but are not insurmountable. Recent work has shown that there is considerable scope for many of the actors in the market system to intervene to improve its efficiency and develop the core market for sanitation goods and services. Innovation across the IFSVC, not just in products but in delivery models, marketing approaches, financial interventions, is vital for improved

service delivery (DumPERT & Perez, 2015) and indeed for the market to develop into a viable, sustainable means of delivering sanitation at scale. Because the private sector has only recently become engaged with sanitation and many of the players are SMEs, often lacking the necessary business skills, market development has been slow and few market-based sanitation enterprises have achieved significant scale (Agarwal *et al.*, 2018). Help is at hand however as many of the other actors in the sanitation market system are starting to innovate and play leading roles in its development.

7.4.1 Role of NGOs

Historically NGOs in the sanitation sector have been implementers, acting as providers of goods and services for underserved populations. There is a growing realization and trend for them now to act as facilitators of market systems, helping them to develop and become self-sustaining (Text Boxes 7.1 and 7.2 below).

Box 7.1 WaterSHED's Market Systems Approach in rural Cambodia

WaterSHED have taken a market systems approach to delivering sanitation to rural customers in Cambodia, deliberately playing a facilitation role with the ultimate aim of exiting once the market has become self-sustaining – the 'hands off' strategy (Jenkins *et al.*, 2019). Over a period of roughly 10 years, they went from research and development, to scale-up, and finally to strategic phase-out – while enabling well over 200 000 rural families to purchase a toilet. The approach involved multiple interventions across the sanitation market system, engaging with consumers, local businesses, local NGOs, lenders, community leaders and higher levels of government across the market system. WaterSHED worked closely with academics and another NGO, Lien Aid, to design their strategy (Pedi *et al.*, 2011); a key initial intervention was to carry out very detailed market research into demand for toilets in rural areas and in parallel understand the supply chain in the same districts. User-centred design was employed to develop an affordable and desirable latrine product. Demand data were used to encourage local suppliers with appropriate capacity to take up production of the new design. Market activations were then carried out village by village with the help of local community-based independent promoters and village leaders to create sales which were then fulfilled by the local entrepreneurs. In effect they created a replicable micro-market system to encourage local suppliers to deliver sanitation products and meet locally generated demand. The transition to a self-sustaining market involved ongoing monitoring, identifying success factors and gaps in the market system, expansion to new areas and continued focus on making WaterSHED's role obsolete (Jenkins *et al.*, 2019). Initially WaterSHED acted through local market facilitators who brokered relationships between key actors in the system. This transitioned to a more business consultancy relationship, which kept the risk of creating dependency low. A key challenge was to find a more sustainable way to activate demand. One solution was the *civic champions* leadership development program, based on the recognition of the potential role commune officials could play in demand generation: this program trained and motivated local government officials, in part through peer-to-peer learning. Later iterations were led by the Ministry of Interior. In 2018 WaterSHED moved into its final phase to support provincial government staff and the Ministry of Interior to take over its roles in market system facilitation and work towards universal access. Complete exit was planned for 2020 (Jenkins *et al.*, 2019).

Box 7.2 PSI's Market development approach in rural India: the 3SI project

Like WaterSHED, PSI and the 3SI project team began by analysing the sanitation market landscape in rural Bihar, which at the start of the project (2012) had a high rate of open defecation. This enabled them to identify four key market failures which they sought to tackle through the 3SI (Supporting Sustainable Sanitation Improvements) project. They also played the role of facilitator with the aim of creating a self-sustaining market system: it required the team to think as a viable business has to think, but work through actors who could sustain it into the future. The process involved iterative market testing and evaluation of possible solutions, then strengthening the wider market infrastructure, particularly in terms of finance and supply chain (Singh *et al.*, 2017). The four key market failures were the lack of an affordable and aspirational product, a fragmented supply chain which was difficult and costly for consumers to navigate, a lack of finance for customers and entrepreneurs, and a prevailing acceptance of open defecation. Each of these was addressed through the 3SI project and integrated within a scalable business model. The final product addressed key customer concerns about frequency of emptying, quality and price. It offered a standard, basic model of good quality at an affordable price with a pit which would not fill up quickly and a superstructure which could be customized depending on the available budget. The fragmented supply chain – there were as many as 30 different actors in Bihar across the value chain – was a major factor deterring potential customers from purchasing a toilet. Customers also wanted to deal with certain market actors they could trust. This was tackled through an ‘aggregation’ approach: selected entrepreneurs dealt with all the individual suppliers necessary to build a toilet and became a single point of contact (Turnkey Solution Provider) offering a complete installation service for would-be purchasers. While attractive on paper, this did not work out as well as hoped, for either the customers or the entrepreneurs. A further iteration took account of the reality that customers wanted to oversee construction themselves and were prepared to source some of the materials: this blend of DIY and one-stop shop was much more successful and was focused on entrepreneurs (concrete ring manufacturers) for whom sanitation was a core market. As with WaterSHED, working out a market activation strategy was important: demand existed but was latent. Several models were tested and that of sales facilitator (promoting awareness and generating sales interest) worked better than sales agent (actually taking orders). Alongside salaried sales promoters, local champions (‘toilet motivators’) played a key role in generating community interest. While not explicitly sales agents they played a role very similar to sales agents in convincing families to make a purchase and they did facilitate toilet sales and received a commission on each toilet sold. They were key in delivering the behavior change campaign. Figure 7.4 illustrates sales activity in action. Bringing in a sustainable source of finance was crucial to oil the wheels of the market system: the project was able to demonstrate successfully to MFIs that loans would be repaid and to establish methods for assessing the creditworthiness of entrepreneurs. The project acted as a demonstrator of what works, building a solid foundation in terms of sales (around 220 000 by 2017), trained entrepreneurs (759) and loans provided (37 175 to households and 251 to enterprises). The transition to sustainability was through helping entrepreneurs to strengthen their own supply chains, encouraging them to take over payment and responsibility for demand creation via sales facilitators and toilet motivators, and through helping to mobilize further credit.



Figure 7.4 The 3SI Project – sales activity in progress (image credit, Kiran Thejaswi).

What these examples show is that sanitation market systems can be made to work even for low-income customers but need patience, detailed market analysis, creative and targeted interventions, multiple iterations, and external soft funding to allow proof of concept of key elements of the mix.

7.4.2 Role of start-ups

In the above examples NGOs acted as market facilitators with an endgame of exiting and handing over to entrepreneurs and other actors in the market system to sustain product and service delivery. Entrepreneurs themselves, through innovative start-ups, also have a key role to play by experimenting with delivery models and new ways to capture value along the IFSVC. In particular, in the past 10 years a number of enterprises have been exploring the potential of container-based sanitation (CBS), which represents an attempt to marry improved service provision with collection and transport of the raw material and its conversion to reuse products that increase business revenue. Their main target is the urban poor, who are poorly served by other types of service, and their activities span the IFSVC. Different approaches in terms of waste collection, revenue models and reuse products are being explored (World Bank, 2019). While such businesses do not currently recover all their costs (Remington *et al.*, 2018; Russel *et al.*, 2019; World Bank, 2019) and require external funding to sustain their operations, there are different approaches to accommodating or reducing this requirement. Some level of ongoing subsidy may be acceptable and justified from public funds: however, there is also scope to increase service charges as the businesses become better known and established, and to seek cost reductions and efficiencies (World Bank, 2019). In addition, were the values in terms of environmental, health and economic impacts of waste to value businesses taken into account, this would make a material difference (Parker *et al.*, 2020).

Revenue can also be increased through innovation in value recovery technologies (Diener *et al.*, 2014) and finding new markets for reuse products where demand is high

but demonstrating their potential at scale is important. One such innovative technology, included in the analysis of [Diener *et al.* \(2014\)](#), is the use of BSF larvae to process faecal waste ([Banks *et al.*, 2013](#)) and convert it into protein and oil, which can be further converted into animal feed (e.g., Sanergy's KuzaPro, see Chapter 2) and a variety of products, for example, biodiesel ([Nguyen *et al.*, 2018](#)) respectively. This technology has been the subject of an at-scale study in Durban, South Africa, to explore its business and technical viability ([Grau & Alcock, 2019](#)). The study brought together in a public–private partnership the eThekweni municipality, who wished to explore the potential of this reuse technology to deal with toilet waste, and The BioCycle, who had done much of the early proof-of-concept work on nutrient recovery from faecal waste using BSF larvae and wished to test its potential on a bigger scale. KwaZulu Natal University was also involved and the implementing agency was Khanyisa Projects. With funding for capital expenditure from the Bill & Melinda Gates Foundation, a plant was designed, built and operated at a scale of 2–3 tons/day for several months. Food waste was included as well as faecal waste in the feedstock.

This study provided valuable data on key parameters such as conversion efficiency, allowing for a more reliable projection of capital and operating costs within a business model for the existing plant. Assuming an upgrade of the facility and operation to a cycle of 12 tons per day of 50:50 faecal sludge:food waste, the projected loss based on sales of protein and oil was found to be \$9 per ton ([Grau & Alcock, 2019](#)). This is coming quite close to achieving profitability and the authors identified several routes to enhancing profitability. The learning from the study will enable the eThekweni municipality to make more informed decisions about future waste management processes. The BioCycle conclusion was that to be commercially viable, scale would be a prerequisite, specifically for the farming of the fly (biological capacity) and that simple cross-subsidization would not be sufficient ([Lewis, 2022](#), personal communication). Another key insight was about the patience required to take such new technologies to the point where they can viably operate at scale: the period from the initial lab work ([Banks *et al.*, 2013](#)) to the Durban study ([Grau & Alcock, 2019](#)) spanned some 9 years (2010–2019): perhaps another 5–10 years will be required.

The learning from this and other research, and how it is taken forward and applied, is vital to increase the impact of value recovery processes on sanitation.

A further idea of the size of the gap that remains is provided by a detailed economic and financial analysis of a trial of Sanivation's fuel briquette process in a refugee camp linked to a CBS service ([Parker *et al.*, 2020](#)). This is outlined in [Box 7.3](#) and [Figure 7.5](#).

Since that study, Sanivation have taken several important steps towards addressing these challenges and bridging the gap. Firstly, they have scaled their technology by developing a product called 'superlogs' which is suitable for large industrial customers such as tea producers, flower farms and dairy producers with a large firewood furnace. They are currently operating at >200 tonnes/month. Secondly, costs of production are less because the process is more automated, at a bigger scale, and uses a cheaper more abundant co-ingredient (sawdust). Thirdly, it is a more favourable market: because the earlier 'superballs' were mostly sold at a household level, distribution costs were too high at the scale they could achieve. Finally, Sanivation have recently learnt that their products reduce greenhouse gas emissions in comparison with the fuels they replace and may thus be eligible for carbon credits of \$12–70 per tonne of product.

This type of market and product innovation by entrepreneurs will drive integration along the IFSVC: as demand for the end product grows and capacity to produce it has to increase, so will demand grow for the feedstock (i.e., faecal waste) and the products and services needed to collect and transport it safely. As further and even more economically attractive biomass conversion technologies become available (see Chapter 2), the incentives to operate a fully integrated IFSVC will increase. However as highlighted above, action from other actors can help to create an enabling environment for the

Box 7.3 The benefits and challenges of waste to value innovation

Sanivation's mission is to increase access to safe and cost-effective sanitation services in urbanizing communities and refugee camps. Their core innovation is a waste treatment process which takes faecal sludge, combines it with other organic waste, and turns it into briquettes which can be burnt as fuel. The briquettes are safe to handle as pathogens are destroyed during the manufacturing process. Both the first-generation briquettes ('superballs') and the second generation 'superlogs' have significant customer advantages over the fuels they are designed to replace, that is, charcoal and firewood respectively (Parker *et al.*, 2020; Sanivation, 2020). At Kakuma refugee camp in Kenya, Sanivation piloted a CBS service linked to production and sale of fuel briquettes: 500 toilets were in use and being serviced and peak sales of 11 tonnes/month of briquettes achieved, in a context where a certain amount of free solid fuel was distributed to camp residents. An economic and financial analysis was undertaken to understand the underlying cost structure and revenue potential, as well as to study cost-effectiveness in comparison with two other sanitation options. Overall, the revenue from briquette sales did not cover the operational costs and there was a gap of some \$122 per toilet per year, similar to the net cost of burying the waste in landfill without treatment. However, this does not take account of the non-monetized benefits in terms of environmental, health and employment impacts. Placing an actual value on these is complex but not impossible and perhaps could be part of a wider sustainability assessment when making choices about sanitation provision. The cost-effectiveness analysis showed that the Sanivation model was less cost-effective than pit latrines and urine-diverting double vault (UDDT) toilets where the waste went to landfill. However, either a 25% saving in costs or a 67% increase in revenues brings the Sanivation model in line with UDDT. Can this gap be closed? Savings could undoubtedly be made through process and material improvements, and scale of operations. Revenue could be increased if distribution challenges were overcome. More difficult to achieve are realizing the full value of all the benefits of the approach and establishing a more level playing field with respect to competition – for example through regulation to ensure that all sludge is made safe prior to disposal and that firewood and charcoal are sustainably produced. So, the challenges of delivering the vision for the IFSVC are not purely economic or technical and within the control of the entrepreneur.

markets to flourish. Recently a number of CBS businesses have joined forces to promote this approach and influence the enabling policy environment (Russel *et al.*, 2019).

7.4.3 Role of governments

Governments have very significant roles to play in encouraging and enabling greater private-sector involvement and market development (Dumpert & Perez, 2015; Mukherjee *et al.*, 2019; Sparkman & Sturzenegger, 2016; Tremolet, 2012). Among the innovations being advocated and explored in different countries are:

- (i) more targeted subsidies, aimed at enabling access for the poorest households;
- (ii) framing and enforcing regulations to encourage safe disposal and reuse;
- (iii) providing technical assistance on options available;



Figure 7.5 Sanivation's Superlogs being used in an industrial boiler at a flower farm in Naivasha, Kenya (image credit: Sanivation).

- (iv) framing and enforcing regulations to support fair competition and adherence to service standards;
- (v) supporting small-scale entrepreneurs;
- (vi) improving infrastructure, including treatment facilities and roads; and
- (vii) targeted social marketing campaigns to create demand.

While regulations are needed, analysis in India ([Mukherjee *et al.*, 2019](#)) suggests that over-regulation can negatively impact business viability. Likewise, [Dumpert and Perez \(2015\)](#) concluded from a global survey that government policies can have a positive influence on the market, but that direct interference should be avoided. Governments cannot act in isolation: there needs to be an interaction between legislation, available markets and products of suitable quality, as highlighted by [Christodoulou and Stamatelatu \(2016\)](#) in an overview of how legislation is being used to encourage more sustainable forms of sewage sludge management in several different countries. Japan is one of the pioneers in this respect, with a series of legislative and innovation efforts aimed at minimizing sludge production and maximizing the recovery of energy and nutrients, such as phosphorus ([Christodoulou & Stamatelatu, 2016](#)). Legislation was passed in 2015 to require sewage operators to use recovered biosolids as a carbon-neutral source of energy (UNESCO, 2017) in an effort to double the amount of energy recovered. Legislation is not the only tool being deployed: financial incentives in the form of feed-in tariffs and measures to encourage investment in new technologies for energy recovery were also introduced ([Christodoulou & Stamatelatu, 2016](#); [WWAP, 2017](#)).

Encouragingly, [Christodoulou and Stamatelatu \(2016\)](#) found a general shift in legislation favouring realization of the value of energy and nutrients in sewage sludge, and they have set out some guidelines for such frameworks which balance human health

and safety with the desire to achieve economic, environmental and social impacts. Governments can also play a key role in helping new enterprises prove, scale and commercialize their innovations in the sanitation market. In Australia, the government agency ARENA (Australian Renewable Energy Agency) has provided significant funding to the Hazer Group to support the construction and operation of a new facility to demonstrate its process for converting sewage-derived biogas into hydrogen and graphite at a large (100 tonne per annum) scale. This is in line with Australia's increasing focus on hydrogen as an alternative fuel (ARENA, 2019).

7.4.4 Role of philanthropy

Once a role for the private sector is established then multiple actors, not only NGOs and governments, can play a role to develop the markets. Philanthropic organisations such as the Bill & Melinda Gates Foundation have a deliberate strategy to encourage market development through market-making grants. This has involved patient support for initiatives such as 3SI and learning the lessons from them, which included that reaching the poor through markets is possible, understanding their wants and aspirations is critical, and working within the prevailing local market system is essential (Rosenboom, 2017). As mentioned above, philanthropy also plays a key role in developing new technologies to the point where they are proven at scale: commercial investors are likely to be reluctant to bear this kind of risk and since scale is a key part of achieving commercial viability, it is vital that such risks continue to be addressed by philanthropic grants. In addition to supporting technical development of their portfolio of 'Reinvent the Toilet' technologies, the Bill & Melinda Gates Foundation also conducted market analyses to identify key areas of opportunity for them in a number of key market segments: this also provides encouragement to potential commercial partners to become engaged. These analyses can be viewed on the Bill & Melinda Gates Foundation Open Research Gateway.

7.4.5 Role of multi-national corporations

Large companies bring resources, knowledge and capacity of working at very large scale, understanding of consumer-based markets and technical and business model innovation expertise. There is growing interest in promoting the role that the private sector can play in the development of the sanitation market among a number of multi-nationals, as evidenced by the establishment and membership of the Toilet Board Coalition, which includes three major corporations with global reach, Kimberly-Clark, Unilever and LIXIL.

Alongside their mentorship role within the Toilet Board Coalition's Accelerator Program for start-ups, such companies are also conducting their own direct exploration of new markets, often through partnerships with other organisations. It was announced in 2018 that LIXIL would partner with the Bill & Melinda Gates Foundation to apply such commercial skills to bear on preparing for a market test of a household 'reinvented toilet' (3BLMedia, 2018). LIXIL had already become directly involved in new products and business model development through the design, development and marketing of the SATO pan, which has had a significant impact worldwide (see Chapter 2 for more information).

Unilever, one of the world's leading manufacturers of toilet cleaners, is partnering with UNICEF to enable more people to have access to toilets: so far they have helped over 16 million such individuals. They have also launched a toilet cleaner aimed at low-income households in India, which represents a growing market as a result of the Swachh Bharat Mission (Unilever, 2017). Unilever has also contributed to the development of new business models such as Clean Team in Ghana (Narracott & Norman, 2011) and has set up the

Transform fund with the Department for International Development in the UK to provide finance and mentoring to innovative businesses. Major utility and waste management companies also have significant roles to play, particularly in leading the development of the recovery and reuse markets. Veolia is one such company: perhaps responding to demand created by stricter legislation in many countries regarding waste disposal and reuse, it offers customers in local authorities and industry globally the plant and equipment for biogas production from sewage sludge (Veolia, n.d.). This reduces the environmental impact of the operators and provides an additional potential income stream.

7.4.6 Need for coordination

It is thus becoming clearer how each individual actor in the system can best work and deploy their skills and resources to support market development. What then becomes vital is that their actions, interventions and incentives are coordinated with the common aim of enabling the market to grow and become self-sustaining. NGOs can work as market makers, supported by philanthropy and other funders, demonstrating viable business models to the point where private enterprises can take over and run them; innovative entrepreneurs can test new products and service delivery models in the market financed by grant-making organisations until they can attract commercial investment; governments can review and design policy and regulations to encourage and support the private sector; investors and finance providers can provide resources to households and enterprises to support individual purchases and improvements in capacity.

7.5 TOWARDS AN IDEAL MARKET

The sanitation market system is far from ideal at present, but much has been learnt about what is wrong and many initiatives are underway to drive improvements. It is possible to think in terms of designing the ideal market. After all, this is the function of the regulator in countries like the UK. It will not be a blank sheet of paper and will have to start with the system imperfect as it is, but it is possible to envision what an ideal market system would look like and then consider strategies to get there. In functional terms the characteristics of this ideal market system would align with the aims of the IFSVC, namely:

- (i) Every customer along the chain is able to purchase the products and services they want (and aspire to) at an affordable price.
- (ii) Each step of the chain/market transaction is performed to high standards of public and environmental safety.
- (iii) Each step of the chain/market transaction realizes the maximum potential for value creation.
- (iv) Each step of the chain/market transaction facilitates optimum recovery of resources and minimizes waste.
- (v) Each step of the chain/market transaction is supported by the business environment and wider context, including policy and regulatory factors.
- (vi) Each actor in the chain recognizes their role and contribution and is incentivized to do so.
- (vii) Effective partnerships between key players are built and new possibilities created.
- (viii) The overall chain is working at the required scale for commercial viability and optimal health and environmental impact.

Two ways to make this happen could be considered. The first is that current efforts by different actors individually and through working together will continue to address

key issues and opportunities for improvement. While valuable, these are likely to be incremental, unless there is a concerted effort by all the players at a large enough scale, such as a major city, to create, evaluate and demonstrate a viable market system. The second is that some kind of disruptive innovation will occur which dramatically alters the economic incentives at one or more stages of the chain. An example of this would be a novel high-value end product for which market demand and value was such that the need for faecal waste as a raw material drove backwards vertical integration along the IFSVC. This integration would involve all elements of the chain: toilets would be redesigned not just for consumer appeal, but also to preserve the raw material ingredients; collection and transport would be optimized for the same purpose; and treatment facilities would be redesigned to make the necessary conversions.

Such a strong market pull does not exist at present, but there are already signs of what it could look like as a result of valuable marketplace experiments and learning. Further research in economics and science and technology would be welcome to help frame the next round of business exploration and discovery. Economically it should be possible, using the data already in existence from different business models on the costs of operation along the IFSVC, to estimate the market value needed to drive backwards vertical integration sustainably. This will set the challenge and the target for science and technology, for example through the continued exploration of the potential of bioconversion (Chapter 2).

7.6 Take action

- (I) Explore the sanitation marketplace in your city and show actors, activities and interactions within the market.
- (II) Visit your chamber of commerce to find out the existing sanitation businesses and the chain linkages between them.

7.7 Journal entry

- (I) Determine the sanitation market status in your locality and country and the economic value addition at local and national levels.
- (II) What are the sewered and non-sewered sanitation markets? Where is each predominant?

7.8 Reflection

- (I) Consider the enterprises and actors involved in the marketing, sales and distribution/supply of sanitation products and services.
- (II) With the aid of a diagram illustrate the linkages and interactions between the players that participate in the marketplace and sales.

7.9 Guiding questions

- (I) What are the three main reasons for achieving an efficient IFSVC?
- (II) What is a sanitation market and sanitation market system?
- (III) What are the estimates of the sanitation economy in India, Kenya and Nigeria?
- (IV) What is the implication of these estimates for sanitation markets in these countries?
- (V) What is sanitation market failure and what implication does it have for the IFSVC?
- (VI) Why are marketing and sales considered to be a primary duty of the IFSVC?

7.10 Tools

Tools have been developed to explore the market attractiveness of different reuse options and tested in five different cities (Andriessen *et al.*, 2017). A tool is also available to estimating and valuing the resources which could be recovered from municipal waste streams (Ddiba *et al.*, 2016).

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REFERENCES

- 3BLMedia (2018). LIXIL to pilot household reinvented toilets in partnership with the Gates Foundation. <https://www.3blmedia.com/News/LIXIL-Pilot-Household-Reinvented-Toilets-Partnership-Gates-Foundation> (accessed 2021)
- Agarwal R., Chennuri S. and Mihaly A. (2018). Scaling Market-Based Sanitation: Desk Review on Market-Based Rural Sanitation Development Programs. USAID (WASHPaLS), Washington, DC.
- Andrew B. (2008). Market failure, government failure and externalities in climate change mitigation: the case for a carbon tax. *Public Administration and Development*, 28, 393–401, <https://doi.org/10.1002/pad.517>
- Andriessen N., Schoebitz L., Bassan M., Bollier S. and Strande L. (2017). Market driven approach for faecal sludge treatment products. In: Local Action with International Cooperation to Improve and Sustain Water, Sanitation and Hygiene (WASH) Services, R. J. Shaw (ed.), Proceedings of the 40th WEDC International Conference, Water Engineering and development Centre, Loughborough University, pp. 1–6, 24–28 July 2017. Available at: https://repository.lboro.ac.uk/articles/conference_contribution/Market_driven_approach_for_faecal_sludge_treatment_products/9589361/1 (accessed 2020)
- ARENA (2019). World-first project to turn biogas from sewage into hydrogen gas. <https://arena.gov.au/news/world-first-project-to-turn-biogas-from-sewage-into-hydrogen-and-graphite/> (accessed 2021)

- Banks I. J., Gibson W. T. and Cameron M. M. (2013). Growth rates of black soldier fly larvae fed on fresh human faeces and their implication for improving sanitation. *Tropical Medicine & International Health*, **19**, 14–22, <https://doi.org/10.1111/tmi.12228> (accessed 2020)
- Business Wire (2020). Global sanitary ware market (2020 to 2025) – technological advancements present lucrative opportunities. <https://www.businesswire.com/news/home/20200615005245/en/Global-Sanitary-Ware-Market-2020-2025--> (accessed 2020)
- Christodoulou A. and Stamatelatou K. (2016). Overview of legislation on sewage sludge management in developed countries worldwide. *Water Science and Technology*, **73**, 453–462, <https://doi.org/10.2166/wst.2015.521>
- Ddiba D. I. W., Andersson K. and Rosemarin A. (2016). Resource Value Mapping (REVAMP): A Tool for Evaluating the Resource Recovery Potential of Urban Waste Streams. Discussion Brief, Stockholm Environment Institute, Stockholm.
- De Oliveira A. (2018). Market solutions and inequalities in sanitation services access in Brazilian cities. *Theoretical and Empirical Researches in Urban Management*, **13**(4), 28–42.
- Diener S., Semiyaga S., Niwagaba C., Muspratt A. M., Gning J. B., Mbeguere M., Ennin J. E., Zurbrugg C. and Strande L. (2014). A value proposition: resource recovery from faecal sludge – can it be the driver for improved sanitation? *Resources, Conservation and Recycling*, **88**, 32–38, <https://doi.org/10.1016/j.resconrec.2014.04.005>
- Dumpert J. and Perez E. (2015). Going beyond mason training: enabling, facilitating and engaging rural sanitation markets for the base of the pyramid. *Waterlines*, **34**, 210–226, <https://doi.org/10.3362/1756-3488.2015.021>
- Fortune Business Insights (2020). Biogas Market Size, Share and COVID-19 Impact Analysis, Report ID: FBI100910. <https://www.fortunebusinessinsights.com/industry-reports/biogas-market-100910> (accessed 2021)
- Gates Foundation (2017). Bill & Melinda Gates Foundation Open Research Gateway, J-OP market landscape – India. <https://gatesopenresearch.org/documents/3-1698> (accessed 2021)
- Gates Foundation (2018). Bill & Melinda Gates Foundation reinvented toilet expo overview. https://www.fsmttoolbox.com/assets/pdf/Reinvented_Toilet_Expo_Overview_2018.pdf (accessed 2021)
- Grau M. and Alcock N. (2019). Viability of A Black Soldier Fly Plant for Processing Urine Diversion Toilet Faecal Waste. Gates Open Research. <https://gatesopenresearch.org/documents/3-1665> (accessed 2021)
- Harada H., Strande L. and Fujii S. (2016). Challenges and opportunities for faecal sludge management for global sanitation. In: Towards Future Earth: Challenges and Progress of Global Environmental Studies, T. Katsumi and S. Hashimoto (eds.), Kaisei Publishing, Tokyo, pp. 81–100.
- JMP (2017). Progress on Drinking Water, Sanitation and Hygiene: 2017 Update and SDG Baselines, WHO & UNICEF, Geneva. <https://washdata.org/sites/default/files/documents/reports/2019-05/JMP-2017-report-final.pdf> (accessed 2020)
- Jenkins M. W., McLennan L., Revell G. and Salinger A. (2019). Strengthening the sanitation market system: WaterSHED's hands-off experience. All Systems Go Symposium, IRC, 2019. <http://watershedasia.org/wp-content/uploads/Strengthening-the-sanitation-market-system-WaterSHED%E2%80%99s-Hands-Off-experience.pdf> (accessed 2020)
- Koottatep T., Cooney P. E. and Polprasert C. (2019). Regenerative Sanitation: A New Paradigm for Sanitation 4.0. IWA Publishing, London, UK, chapter 6.
- Mason N., Matoso M. and Smith W. (2015). Private Sector and Water Supply, Hygiene and Sanitation, ODI Report, Overseas Development Institute, London, UK. 74pp.
- Mukherjee A., Arya P., Desgupta S. and Chhabra S. S. (2019). Bridging the Gap: Opportunities for Private Sector Participation in Faecal Sludge and Septage Management. Centre for Policy Research, New Delhi, India, <https://doi.org/10.13140/RG.2.2.22926.72006>
- Mulumba J. N., Nothomb C., Potter A. and Snel M. (2014). Striking the balance: what is the role of the public sector in sanitation as a service and a business? *Waterlines*, **33**, 195–210, <https://doi.org/10.3362/1756-3488.2014.021>
- Murta J. C. D., Willetts J. R. M. and Triwahyudi W. (2018). Sanitation entrepreneurship in rural Indonesia: a closer look. *Environment, Development and Sustainability*, **20**, 343–359, <https://doi.org/10.1007/s10668-016-9883-7>

- Narracott A. and Norman G. (2011). Clean Team, a human-centred approach to sanitation: initial trials in Ghana. WSUP Practice Note. <https://www.wsup.com/content/uploads/2017/08/PN008-ENGLISH-CleanTeam.pdf> (accessed 2021)
- Nguyen H. C., Liang S.-H., Li S.-Y., Su C.-H., Chien C.-C., Chen Y.-J. and Huong D. T. M. (2018). Direct transesterification of black soldier fly larvae (*Hermetia illucens*) for biodiesel production. *Journal of Taiwan Institute of Chemical Engineers*, 85, 165–169, <https://doi.org/10.1016/j.jtice.2018.01.035>
- Ofwat (2015). Water 2020 Regulatory Framework for Wholesale Markets and the 2019 Price Review. Appendix 1. Sludge Treatment, Transport and Disposal: Supporting Evidence and Design Options. Ofwat, London, UK. https://www.ofwat.gov.uk/wp-content/uploads/2015/12/pap_tec20151210water2020app1.pdf (accessed 2020)
- Ofwat (2020). Water Sector Overview. Ofwat, London, UK. <https://www.ofwat.gov.uk/regulated-companies/ofwat-industry-overview/> (accessed 2020)
- Parker J., Hakspiel D., Foote A. and Woods E. (2020). Waste to Value Sanitation in Kakuma Refugee Camp. UNHCR, Geneva. <https://wash.unhcr.org/download/waste-to-value-sanitation-in-kakuma-refugee-camp/> (accessed 2020)
- Pedi D., Jenkins M., Aun H., McLennan L. and Revell G. (2011). The ‘hands-off’ sanitation marketing model: emerging lessons from rural Cambodia. In: *The Future of Water, Sanitation and Hygiene in Low-Income Countries - Innovation, Adaptation and Engagement in a Changing World*, R. J. Shaw (ed.). Proceedings of 35th WEDC International Conference, Water Engineering and Development Centre, Loughborough University, Loughborough <https://wedc-knowledge.lboro.ac.uk/index.html> 6–8 July 2011. <http://wedc-knowledge.lboro.ac.uk/index.html> (accessed 2020)
- Remington C., Jean L., Kramer S., Boys J. and Dorea C. (2018). Process cost analysis for the optimization of a container-based sanitation service in Haiti. Proceedings of 41st WEDC International Conference, Nakuru, Kenya. <https://www.oursoil.org/wp-content/uploads/2018/07/Process-cost-analysis-for-the-optimization-of-a-container-based-sanitation-service-in-Haiti.pdf> (accessed 2020)
- Rosenboom J. W. (2017). Developing markets for sanitation. SuSanA and BEAM Exchange Webinar 12. <https://www.youtube.com/watch?v=ReZTD8XCOGU&feature=youtu.be> (accessed 2020)
- Russel K., Hughes K., Roach M., Auerbach D., Foote A., Kramer S. and Briceño R. (2019). Taking container-based sanitation to scale: opportunities and challenges. *Frontiers in Environmental Science*, 7, 00190. <https://doi.org/10.3389/fenvs.2019.00190> (accessed 2020)
- Sanivation (2020). Superlogs Overview. <https://sanivation.com/approach> (accessed 2020)
- Schouten M. and van Dijk M. P. (2007). The European water supply and sanitation markets. In: *Water and Liberalisation: European Water Scenarios*, M. Finger, J. Allouche and P. Luis-Manso (eds.), IWA Publishing, London, pp. 11–35.
- Scott P., Forte J. and Mazeau A. (2018). Barriers and opportunities for SMEs: a study of the wider market system in Ghana. <https://www.issuelab.org/resources/28424/28424.pdf> (accessed 2020)
- Singh S., Singh A., Sharma V. and Sinha B. (2017). PSI White Paper Building a sustainable market for toilets: lessons learned from rural Bihar, India. https://www.psi.org/wp-content/uploads/2020/07/India-Sanitation-Report_FINAL.pdf
- Sivaramakrishnan S. (2019). 120,000 Tonnes of Faecal Sludge: Why India Needs A Market for Human Waste. World Economic Forum. <https://www.weforum.org/agenda/2019/09/how-to-improve-sanitation-in-india/> (accessed 2020)
- Sparkman D. and Sturzenegger G. (2016). Fostering water and sanitation markets in Latin America and the Caribbean, Inter-American Development Bank Report, Washington DC.
- Sy J., Warner R. and Jamieson J. (2014). Tapping the Markets: Opportunities for Domestic Investment in Water and Sanitation for the Poor. World Bank. <http://doi.org/10.1596/978-1-4648-0134-1>
- Toilet Board Coalition (2020a). The sanitation economy in India. <https://www.toiletboard.org/media/65-Sanitation-Economy-Markets-India-2020.pdf> (accessed 2021)
- Toilet Board Coalition (2020b). The sanitation economy in Kenya. https://www.toiletboard.org/media/64-Sanitation-Economy-Markets-Kenya_2020.pdf (accessed 2021)
- Toilet Board Coalition (2020c). The sanitation economy in Nigeria. <https://www.toiletboard.org/media/63-Sanitation-Economy-Markets-Nigeria-2020.pdf> (accessed 2021)

- Tremolet S. (2012). Sanitation markets. Using economics to improve the delivery of services along the sanitation value chain. https://sswm.info/sites/default/files/reference_attachments/TREMOLET%202012%20Sanitation%20Markets.%20Using%20economics%20to%20improve%20the%20delivery%20of%20services%20along%20the%20sanitation%20value%20chain.pdf (accessed 2020)
- Tsinda A., Abbot P. and Chenoweth J. (2015). Sanitation markets in urban informal markets of East Africa. *Habitat International*, **49**, 21–29, <https://doi.org/10.1016/j.habitatint.2015.05.005>
- Unilever. (2017). Two Domestos innovations that will help tackle the sanitation crisis. <https://www.unilever.com/news/news-and-features/Feature-article/2017/two-domestos-innovations-that-will-help-tackle-the-sanitation-crisis.html>
- Veolia (n.d.). When sewage sludge becomes a source of green energy. <https://www.veolia.com/en/solution/sewage-sludge-green-energy-biogas-wastewater> (accessed 2021)
- World Bank (2019). Evaluating the potential of container-based sanitation. <https://www.worldbank.org/en/topic/water/publication/evaluating-the-potential-of-container-based-sanitation> (accessed 2020)
- WWAP (UN World Water Assessment Programme) (2017). The United Nations World Water Development Report 2017. Wastewater: The Untapped Resource, UNESCO, Paris, 198pp. <https://unesdoc.unesco.org/ark:/48223/pf0000247153/PDF/247153eng.pdf.multi> (accessed 2021)