MANAGEMENT OF FAECAL SLUDGE IN DEVELOPING COUNTRIES

By Xanthe Cross
Master Student at The University of McGill, Canada. xantheboo@gmail.com[1]

ABSTRACT

Faecal sludge management (FSM) is essential in order to complete the entire sanitation chain and ensure the safe disposal of faeces in order to break the faecal-oral transmission route for enteric pathogens and prevent environmental pollution. This field of study is a hidden problem with both technical and institutional challenges that limit the goal to allow for access to sanitation for all. In order to develop functional and sustainable FSM systems, integration is required between each aspect of the sanitation chain, private-public partnerships need to be incorporated into legal frameworks that should be established to regulate and enforce these systems and the Shit Flow Diagram advocacy tool should be used to view the sanitation chain and its weak links from a holistic point of view.

1.0 INTRODUCTION

Water is integrated into many aspects such as land, health, biology and culture. Water is also intrinsically linked to sanitation, both because we require water for hygienic practices, but also because the developed world has adopted water as a means of transporting human waste (1). Safe water, sanitation and good hygiene are all required to create better quality of life and improved health in any community (2).

Currently, there are 1.6 to 2.5 million deaths annually from diarrheal-related diseases and poor sanitation, with most of these victims being children under the age of 5 years (2). Faecal sludge (FS) has a high content of nutrients (when combined with urine), which could lead to contamination of water if not properly managed (3). The nutrient contamination occurs both by an increase in nutrients that is normally a limiting factor in the water, but also because FS has a high oxygen demand that depletes the water source of dissolved oxygen (3).

Sanitation, as defined by Mara et al., is the safe disposal of human excreta, which means both safe in terms of human contact and hygiene as well as in terms of final disposal of the faecal matter after defecation (2). The aim of the sixth Sustainable Development Goal is to provide access to safe water and sanitation for all by the year 2030 (4). This goal is in place because improvements to sanitation have been shown to generate social and economic benefits (2). Social benefits are seen through improving quality of life for all and in providing a safe toilet space for women, which encourages equality (2). Economic benefits are realized by decreases in illness so as to increase school attendance, work attendance and reduce health system costs (2). Improvements to sanitation are not complete when

[1] Currently interning in the Pollution Research Group (PRG) at the University of KwaZulu-Natal, Durban, South Africa

onsite toilet facilities are built. There is a sanitation chain that ends with the safe disposal of faecal sludge that needs to be addressed so that funding and maintenance can be provided to ensure sanitation is sustainable (3).

In the development of improved sanitation in the past, a focus has been taken on looking solely at access and not at the entire chain which includes conveyance, treatment and final safe disposal process or resource recovery (5). This focus has limited the success of access to sanitation achieving true social and economic development. Faecal sludge management deals with the sludge from on-site technologies so that they are treated before entering into the environment for disposal or reuse (3). This paper aims to explore the problems and potential solutions around faecal sludge management (FSM).

2.0 SETTING THE SCENE

Most of the developing world is lacking significantly in improved sanitation, with approximately 2.6 billion people in this position (2). The sanitation that does exist is largely on-site technology with little thought given to the sludge management of these systems (3). Figure 1 shows the areas of the world that require sludge management systems due to the implementation of pit latrines, septic tanks and pour flush toilets that are usually designed with a pit (6).

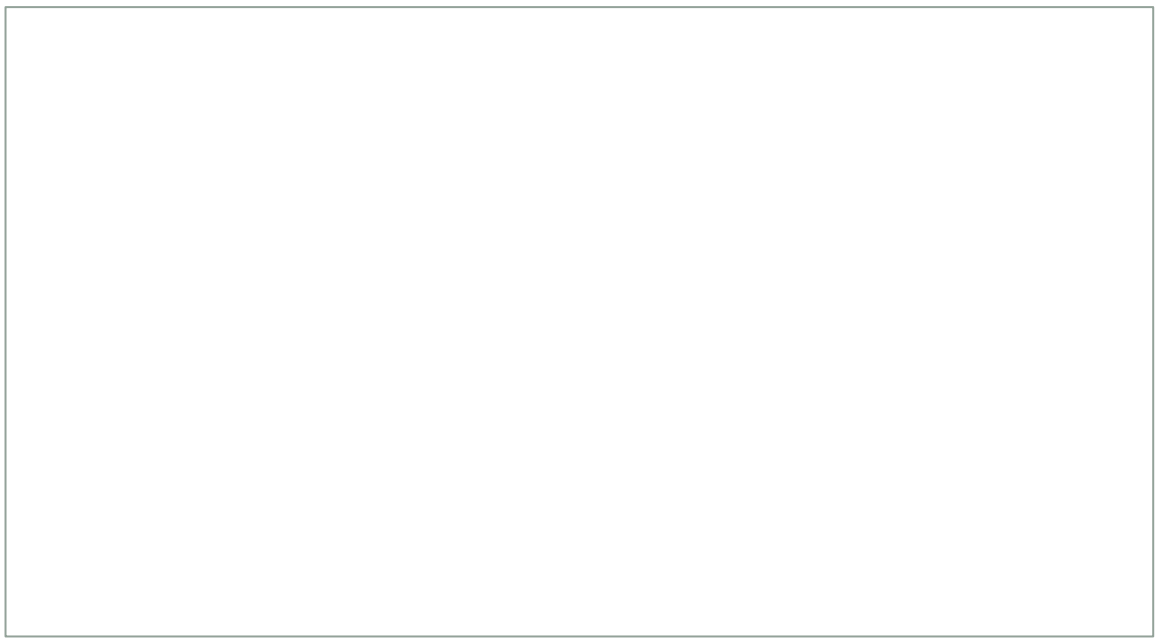

Figure 1: Percentage of population that are served by various toilet technology across the world (3)

Sludge collection is mainly discharged untreated into the environment via open drains, irrigation fields or directly into surface water (3). Illegal dumping from trucks that collect faecal sludge occurs regularly, and a single $5m^3$ truck of sludge is equivalent to 5000 people defecating in the open (3). The consequences of untreated waste being released into the environment are excess nutrients in the surface water leading to eutrophication, increased costs in health, increases in child mortality rates, decreases in nutrient absorption due to diarrheal diseases and low

economic and social development from the lack of social capacity that is produced (3).

Faecal sludge management (FSM) is not an attractive topic for politicians and funding groups to support (2), and it is also not a high priority for engineers and municipalities (3). Because of this, or perhaps leading to this, FSM is invisible to policymakers and is generally a hidden and severely lacking area of the already marginalized field of sanitation (7).

Recently, on-site technology has been seen as a long-term solution where it was previously seen as a temporary solution before sewer access could be achieved (7). It has been found that decentralized technologies such as ventilated pit latrines, urinary diversion toilets, pour-flush toilets with septic tanks are more sustainable solutions for low-income areas, especially since the cost of FSM has been shown to be five times less expensive than conventional sewer-based solutions (3).

The full sanitation chain and the detailed on-site sanitation chain are presented in Figure 2. In sewerage systems the emptying and transport is done by the sewer network, whereas in on-site systems the toilets are emptied by mechanical suction or manual excavation to be transported to treatment by road (7).

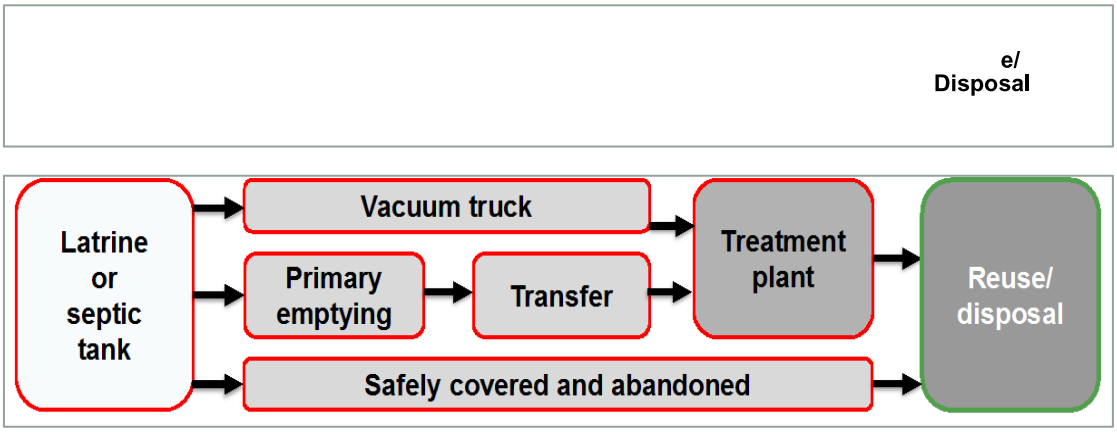

Figure 2: (top) Sanitation Chain, (bottom) Detailed on-site sanitation chain (7)

Many low- and middle-income countries, such as South Africa, have been short-sighted in their efforts to build ventilated pit latrines without a maintenance or service plan (8). If the full sanitation chain is not set up and maintained, the result is large amounts of untreated faecal waste entering the environment which leads to pervasive contamination of the surrounding areas (3).

3.0 THE CHALLENGES

The challenges in faecal sludge management (FSM) are most severe in poor urban areas where there is limited space for individual toilets and more users and therefore more waste accumulating in a shorter period of time. In these areas there is higher risk of public health problems due to the high density of the living area, limited access to mechanized pit emptying, land tenure issues (especially in informal settlements), financial constraints and regulatory problems (9). The challenges can be divided into technical and institutional areas.

Technical Challenges

The sanitation chain is often broken at weak links such as lack of access for pit emptying trucks in narrow streets of informal urban areas, lack of sludge disposal points, household users not being able to pay for a pit emptying service and other funding for the truck operators around hauling the sludge over long distances to the treatment facilities (3). Even in developed countries, where sludge is produced from wastewater treatment plants and sent to land fill sites or for reuse as a fertilizer (10), the full chain needs to be ensured in order to make sure that pollution is not simply transferred to the land or water in other areas (11). Without proper management of the sanitation chain, faecal sludge is often left to accumulate in poorly designed pits or discharged directly to surface water or storm drains which leads to public health and environmental health issues (3).

The toilet structure itself has problems with maintenance and unless implemented with good user engagement and training it has often been found to be used for purposes other than its intended one (2). These purposes include firewood storage, as a goat's shed or simply as a solid waste dump (2). A study done on 12 developing countries by the Water and Sanitation Program of the World Bank found that household containment for sludge was generally inadequate, which led to full pits being abandoned and left as a risk to the health of the environment and community (7). Another problem found was that many toilets are constructed without thought given to the sludge collection access points, making sludge collection impossible due to technical constraints such as being sealed shut or being placed in the center of the home (7).

On the sludge collection step in the chain, toilets are often constructed without any consideration of the distances to the treatment plants or sludge disposal sites (3). Pit latrines contain the wiping material used after defecation such as newspaper, cardboard, toilet paper or water as well as the sanitary items often discarded in pits by women; in addition pits are often used for disposal of solid waste (8). All these items cause blockages in the suction pipes used to empty the pits (8). While suction tankers have the advantage of being quick, efficient and relatively clean, they have problems with blockages. They require additional water to increase the viscosity of the sludge for suction (i.e. additional costs) and they are often too large to maneuver through the narrow streets of peri-urban settlements (8). While there are other methods of emptying pits, they each have their own set of problems making no one solution the ideal. Manual emptying can be hazardous to the worker's health and is a slow process despite being cost effective (8). Small hand carts that have manual pumps allow easy access through urban areas, but are also prone to blockages and require sludge dilution before suction can occur, which increases the volume of the sludge being removed and therefore requires more trips to empty a significant number of pits due to limitations of storage capacity on a cart (8).

Once the sludge has been collected, the issues around where to take it arise. Many developing countries face problems with illegal dumping by private services, into the sea, wastelands, landfills or surface waters (7). This is due to the industry being largely unregulated and the fact that FS treatment plants are usually situated on the outskirts of the city and are therefore expensive to get to (3). There is little

communication between the private companies that collect the waste and the municipal treatment plants with regards to treatment capacity and planning of infrastructure development. This often leads to capacity problems in accepting the sludge for further treatment. There is a lack of data from sludge collection in informal settlements particularly, that allow for planning with regards to treatment capacity (7). There is also a lack of treatment facilities dedicated to sludge treatment in developing countries (7). With treatment of faecal sludge already a problem, these countries are far from developing reuse potential of the nutrient rich sludge. In the study done on 12 developing countries' sludge management systems, only 2 were found to have mechanisms for formal reuse of treated sludge, and neither of these are profitable (7).

Institutional Challenges

In order to keep the sanitation chain in full service, funding is required, along with responsible parties, to maintain and manage the process. Most FSM is unplanned and develops out of informal private service providers who are quicker to recognize the permanence of this field, but that are not regulated (7). Municipal policy is largely focused on sewerage and requires updating to include the long-term solution of sludge management (7). Municipalities should cover the cost of emptying peri-urban pits as it falls under the city planning jurisdiction, and it would make it easier to perform a single sweep of pit emptying at regulate intervals; but there are lower costs associated with manual pit emptying contracted directly from the household user and large scale municipal programs are complex and require more control (8). Often the question of who is responsible is not addressed when implementing toilet solutions, despite the fact that the type of sanitation solution depends strongly on who would be responsible, i.e. the capacity of the community and the municipality (8).

In most industrialized countries there are policies in place that restrict the use of sludge as a fertilizer on agricultural land; this restricts the drive to reuse faecal sludge as a nutrient source in agriculture (11). This lesson from industrialized countries should be used as a guide to prevent the limitations on the reuse of faecal sludge.

A major challenge with the management of faecal sludge is a lack of data on the sanitations systems in place in developing areas. There is also a lack of knowledge on appropriate sanitation designs for developing regions. Because sewerage has been viewed as the ultimate end point in the past, there is technical bias towards these methods through education, training and practice, which has led to limited data and research in the field of FSM (7). FSM is a growing challenge in rapidly growing urban areas of developing countries and so is a relatively new field of study (7).

4.0 PATHWAYS TO A SOLUTION

Despite being a new field of study, FSM is gaining recognition for how important it is in the sanitation chain (3). The importance of managing the nutrient cycle and making sure that the nutrients from our food end up back in the land is becoming more important as resources become more limited due to population increase. A lesson that can be taken from the developed areas of the world is that water-borne toilets are not the ultimate answer to the sanitation dilemma. As many in

industrialized countries are coming to see, flush toilets are unacceptable, and that reuse of human faeces allows for prevention of pollution along with a positive impact to the environment (12). While there may be challenges around managing the sanitation chain, faecal sludge managements should be embraced as it is a pathway to sanitation solutions that reduce potable water usage for waste removal and has the potential to reconnect the concepts of human waste, nutrient cycling and efficient land use.

More recently there have been developments in other resource recovery techniques from human waste, such as biogas from anaerobic digestion, pyrolysis, gasification, incineration and co-combustion to produce biofuel or protein production through the use of black flies (3). Sludge resource recovery should be designed and planned on a local level depending on the heavy metal and pathogen content as well as cultural and social factors around the reuse of human waste (3).

There are specific areas of improvement that would lead to better faecal sludge management strategies such as integrated management principles, development of legal and costing frameworks, private-public partnership strategies and the use of decision-making tools such as the Shit Flow Diagrams (SFD). Each of these will be discussed.

Integrated Management Principles

Integrated management principles could be taken from the field of Integrated Water Resource Management, such as the integration of human society with land management, water quality standards and agricultural regulations or energy and fuel regulations in order to allow for the incentives into the reuse of faecal sludge for more productive and potentially financially sustainable fields (13). On-site toilet type influences the amount of water in the faecal sludge and would lead to decisions around the appropriate equipment to remove and transport the sludge or the appropriate on-site dewatering techniques to reduce the volume of the sludge before transportation (3). This could also be viewed from the reverse, where the end use of the faecal sludge requires specific wetness contents and pathogen levels which can be controlled by toilet type, sludge storage and treatment (3). Integration is encouraged between all levels of the sanitation chain in order to allow for a holistic view on the entire sanitation solution.

The use of stakeholder engagement is recommended as means to include all key players along the sanitation chain and to promote educational campaigns to teach those involved about the problems with solid waste in sludge collection and the importance of final treatment and disposal of faecal sludge (3). This is especially required when on-site sanitation is very user reliant. Stakeholder engagement would encourage sustained interest in the success of the system, allow for clearly defined responsibilities and coordination of the various stages of the chain and provide a platform for feedback to improve solutions (3). Integrated management also encourages an increase in involvement of women as head of the user household (13) and a means to lead to functional toilets and maintenance aspects within a community.

Improved knowledge around faecal sludge management and education on appropriate technology and management techniques is required in the engineering fields in developing countries. The Faecal Sludge Management guidebook by Strande, Ronteltap and Brdjanovic is a good publication that covers the entire sanitation chain process, including technical and institutional guidelines (3). The relative newness of this field also implies that there is much to development on in terms of technology and insight into the sanitation processes along the chain.

Technical solutions need to be developed in order to counter some of the existing problems, but technology should not be considered in isolation as it is inherently connected to the management and non-technical processes (3). While there are mechanized and hand pumps that have been developed for ease of pit emptying such as the Motorized and Manual Diaphragm Pump, the Trash Pump, the Pit Screw Auger and the MAPET (Manual Pit Emptying Technology), there are ranging problems around pumping of non-biodegradable wiping material and solid waste in the pits that cause blockages, limitations in access to different sizes of pits, varying size of the storage and pump capacities and the use of parts that are not locally sourced making repairs expensive and difficult (3). The manual technology of the Sludge Gulper, which is built from low-cost, local materials and the motorized Gobbler that can empty high viscosity sludge, are two technologies that have overcome a lot of these problems (3). The technology and methodology around wastewater sludge treatment is a well-established field of study as it is an area that reveals opportunities for financial incentives around reuse, and is more directly linked to the preservation of public health; but there are significant difference in faecal sludge and wastewater treatment sludge characteristics that need to be considered when transferring the technologies and techniques (3). In order to better develop local expertise and increase research into faecal sludge management, it is advised that collaboration between universities, NGOs and research centers is developed (3).

In order to overcome the weaknesses in the sanitation service chain, a sustainable FSM plan needs to be designed that uses a systems level approach and addresses the responsibilities and funding requirements to be taken at each step in the chain (3).

Legal and Costing Frameworks

The institutional frameworks (defined by laws, contracts and regulatory documents) need to be set up based on local situations, as there is no single solution that works in all areas (3). The private sector needs to be considered in these frameworks and will be discussed in more detail further on, as they are an important element in the collection and transport portion of the sanitation chain (3). The regulatory framework that is developed will need to take into account the risks to human health at all stages of the sanitation chain on a city-wide scale, and consider who is responsible at each stage and how these regulations will be enforced (3). There can be penalties set up for failure to meet the regulations, and permits and licenses will help to distinguish adherence (3). Enforcing roles need to be clearly designed for each stakeholder with sufficient resources made available to the institution in charge to enforce regulations and auditing systems need to be set up from the planning stage in order to keep all roles in check (3).

In setting up and enforcing these frameworks strong commitment from the government is needed, as is does require dedicated funding and training strategies. In the FSM planning stage, operation and maintenance needs to be built-in, in terms of costing, responsibilities and scheduling (3). Sanitation authorities should encourage worker training and certificates through incentives, as this ensures effective service providers that perform well technically, allow for limited environmental impact and conduct safe work (3). Financial management by each organization included in the sanitation chain needs to be sound and transparent, including clear tariff and price breakdown and well-planned funding and cost recovery plans (3). While there may be limitations to direct and full cost recovery, the frameworks should aim to try to move towards a system that has less waste of resources like nutrients (12), and move towards gaining agricultural, energy and sanitation linkages.

Built into these frameworks, the costing and roles for monitoring and record keeping should be addressed (3) as this leads to more informed decision-making in the long-term.

Private-Public Partnerships

The private sector has responded more quickly than policymakers, to the gap in sludge management that has appeared from the permanence of on-site sanitation solutions, and they have been practicing sludge management for over 20 years (7). The removal of faecal sludge is a household level problem that falls into the private sector realm of responsibilities, but the FSM chain is part of the public interest that requires regulations, authority and enforcement (3). In light of this, it is clear that the promotion of private-public initiatives and the inclusion of private sector companies in the framework and planning of FSM are essential.

Regulations, licenses and permits need to be established for the private sector vehicles and for the operations that they perform to ensure that the full sanitation chain is sustained and no illegal dumping occurs (3). In doing this, it is essential to insure that there is competition among private sector companies in order to reduce the push for profit seeking and ultimately reduce the pit emptying price to the user (3).

An example of where the private and public sector have worked in conjunction with one another successfully is in Marikina city in the Philippines where the water utilities and the city municipality work together to do a 5-year cycle sludge removal program (3). At the time of removal, the city supports the private sector organizations by sending trucks into the areas where the sludge removal will occur to announce (by loudspeaker) the private companies in order to encourage more households to acquire this service (3). The public sector workers are equipped with information about the pit removal techniques and prices, and are available on the day of removal to help in any way that they can (3). This has resulted in 95% compliance with sludge removal in the areas where this occurs (3). The combination of integration between private and public initiatives, dissemination of information along with the private cost structure and compliance with regulated standards

generates a working system that is supported by both the public sector and the household users.

Shit Flow Diagrams

A tool that has been developed out of the Water and Sanitation Program's study is the Shit Flow Diagram (SFD) (7). While the name of this tool was initially termed the faecal waste flow diagrams when it was developed, the Sustainable Sanitation Alliance altered the name to a more catchy, slightly provocative title, which may have had the intention of making this tool more prominent and recognized. The development of the SFD tool is an initiative funded by a Bill and Melinda Gates foundation grant (5). It is being developed by the WSP, GIZ-GmbH, SANDEC, the Water@Leeds research group from the University of Leeds, WEDC and CSE (5). The aim of this advocacy tool is to allow for the gathering of data surrounding the sanitation chain and to generate an easily accessible, visually clear representation of where the problems in faecal sludge management lie in any given city. In doing so, this tool aims to create an enabling environment to bring about beneficial reform in these developing cities (5). The guidelines to using this tool and generating a SFD for any city are still in the early stages of development (5).

A SFD is the graphic representation showing the pathways of the faeces produced by the contributing population. An example of a SFD that was produced for the city of Dhaka in Bangladesh can be seen in Figure 3. These diagrams are not precise, scientific tools; they represent public health hazard (not risk); and are based on the contributing population rather than volume of faecal sludge (7). They are meant as a communication tool that would support decision-making around the faecal sludge system (7). The pathway of faeces from creation to disposal helps to identify risks and weaknesses along the sanitation chain (7). The data used to create a SFD and the accompanying Service Delivery Assessment Scorecard is verified with the stakeholders involved, and each diagram is altered to be appropriate to the place, scope and availability of data (7).

The Service Delivery Assessment Scorecard is a tool that analyzes the enabling environment such as the level of management of budgeting, policy and planning (7). And example of the scorecard produced for Dhaka in Bangladesh is shown in Figure 3. The scorecard generates a score from the worst case to the best case (0 to 3) based on questions around the city's enabling environment, development of services and sustainability of services (7). The outcome of the scorecard is that the city is classified as having poor, basic or improving FSM (7) which gives a overall indication on the level of investment and focus that are required in order to meet the goal of having a fully sustainable and functioning FSM system.

These advocacy tools are recommended because they allow for insight into the often over-simplified and misunderstood field of FSM (7). Gathering data in order to develop the SFD and the scorecard allow for identification of data gaps and reveals areas in the service that are bottlenecking or hidden (7). In developing a tool that looks at the entire sanitation chain a holistic view is forced, which allows a clear understanding of the scale of the problem (7).

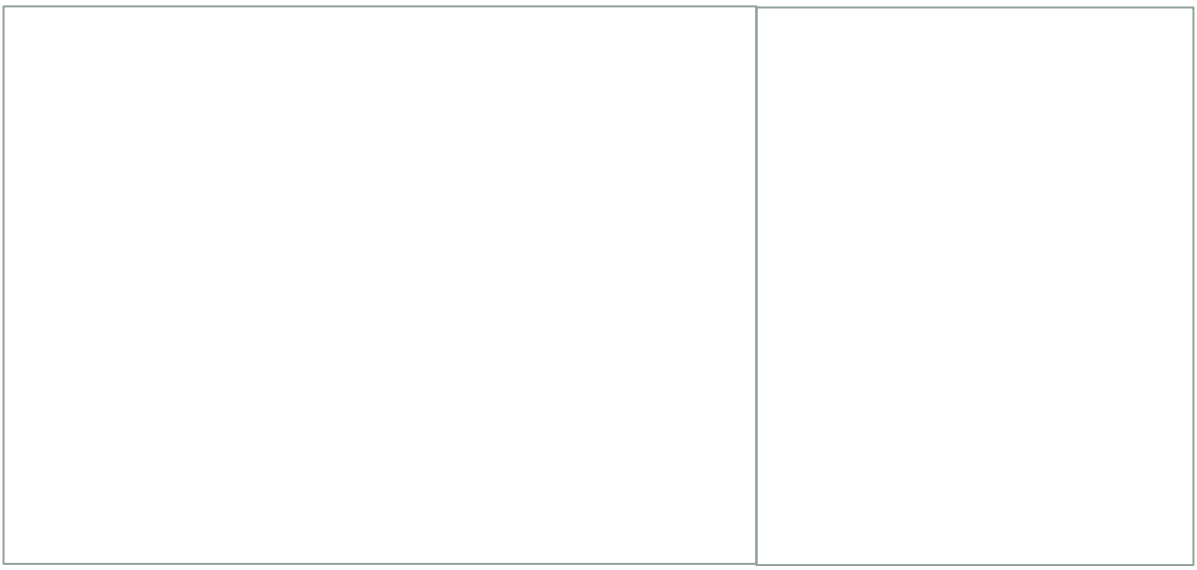

Figure 3: Shit Flow Diagram and Service Delivery Assessment Scorecard developed for Dhaka, Bangladesh (7)

These tools form a baseline of the city's problems that can be compared with an updated SFD to note real progress and assessment of implemented initiatives. They also allow for justification of budget requests (7). Stakeholder engagement is incorporated to some degree in the SFD, as the data collection involves verification and validation from stakeholders (7). This tool could also be used as a bridge between private and public decision as it presents the sanitation chain as a common map on which clear areas of responsibility can be agreed upon.

Market and business models from the private sector could be developed alongside these public management tools in order to reduce the gaps that currently exist. These gaps include the extent of economic value of public health and the financial and environmental benefits from good management of faecal sludge and reuse (7). SFDs could be improved to include volumetric analysis and financial aspects to create a more managerial tool. They could be used to assess the predicted outcome of decisions if it were made into a more dynamic model. It will be interesting to watch as the SFD tool develops and is assessed through practice.

5.0 CONCLUSION

The next step in terms of advancing towards a sustainable FSM plan in developing countries is action and regulation implementation in key areas addressed by the SFD. Pricing structure and regulation of the FSM chain is essential as it allows for a sustainable system. The use of private-public partnerships would allow for more structured tariffs and more resilient service providers while allowing for a citywide holistically managed sludge collection and disposal system. With the development of a structured and regulated faecal sludge management plan, the goal of access to truly improved sanitation for all could be achieved in a sustainable way.

6.0 REFERENCES

1. J. Benidickson, The Culture of Flushing: A Social and Legal History of Sewage, UBC Press, Vancouver, (2007)
2. D. Mara, J. Lane, B. Scott, & D. Trouba, “Sanitation and Health”, PLoS Medicine, *7* (11), p.1-7, (2010)
3. L. Strande, M. Ronteltap, & D. Brdjanovic, (ed.), “Faecal Sludge Management: Systems approach for implementation and operation”, IWA Publishing, UK, (2014)
4. United Nations Department of Economic and Social Affairs, Sustainable Development Goals, Retrieved 13-11-2015, from Sustainable Development Knowledge Platform: https://sustainabledevelopment.un.org/?menu=1300, (2015)
5. Sustainable Sanitation Alliance, Shit Flow Diagrams: SFD Promotion Initiative, Retrieved 07-11-2015, from SuSanA: http://www.susana.org/en/forum/96-shit-flow-diagrams, (2014)
6. D. Mara, Low-cost Urban Sanitation, John Wiley and Sons, London, (1996)
7. WSP, “The Mising Link in Sanitation Service Delivery: Review of Fecal sludge Management in 12 Cities. Water and Sanitation Program”, WSP, (2014)
8. D. Still, N. Walker, & D. Hazelton, “Basic sanitation services in South Africa: Learning from the past, planning for the future”, Water Research Commission, (2009)
9. M. Schouten, & R. Mathenge, “Communal Sanitation Alternatives for Slums: A case study of Kibera, Kenya”, Physical and Chemistry of the Earth, 35, p.815-822 (2010)
10. S. Smith, “Management, use, and disposal of sewage sludge”, Waste management and Minimization, p.1-10 (nd)
11. A. Bresters, I. Coulomb, B. Deak, A. Bernard Matter, L. Spinosa, & A. Utvik “Sludge Treatment and Disposal: Management Approaches and Experiences”, European Environment Agency, Copenhagen, 7, (1997)
12. J. Engels, Humanure is no laughing matter, Retrieved 07-11-2015, from Permaculture Research Institute: http://permaculturenews.org/2015/11/06/humanure-is-no-laughing-matter/, (2015)
13. J. Adamowski, C. Zyla, E.G. Cuenca, W. Medema, M. Clamen, & P. Reig, “Integrated and Adaptive Water Resource Planning Management, and Governance”, Water Resources Publication, Colorado, (2013)