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Household pit emptying and reuse practices in rural Cambodia

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Abbreviations

CDHS	Cambodia Demographic and Health Survey
ESC-BORDA	Environmental Sanitation Cambodia-Bremen Overseas Research and Development Association
E&T	emptying & transportation
FSM	fecal sludge management
GRET	Groupe de Recherches et d'Echanges Technologiques
HH	household
iDE	International Development Enterprise
IDI	in-depth interviews
JMP	Joint Monitoring Program
MPWT	Ministry of Public Works and Transport
MRD	Ministry of Rural Development
NSDP	National Strategy Development Plan
OHS	Occupational Health and Safety
ODF	open defecation free
PPE	Personal Protection Equipment
PSI	Population Services International
RWSSH	UNICEF strategy for Cambodia: Right to Water Supply, Sanitation and Hygiene
SaniFOAM	sanitation behavior change framework: Focus, Opportunity, Ability, Motivation
SBCC	social and behavior change communication
SCE	Sanitation in Challenging Environments, project affiliated with Engineers without Borders
SDG	Sustainable Development Goals
SNV	Netherlands Development Organization
SOP	standard operating procedure
UNICEF	United Nations Children's Fund
USD	United States Dollar
WASH	water, sanitation and hygiene
WaterSHED	Water, Sanitation and Hygiene Enterprise Development
WB	The World Bank Group
WSP	Water and Sanitation Program
WWTP	Wastewater Treatment Plant

Glossary List

No	Words	Definitions
1	Effluent	Liquid waste that is sent out from factories or places like septic tank where sewage is dealt with, usually flowing into rivers, lakes, or the sea
2	Sludge	Sludge is defined in the present study as all human waste produced in a latrine including solid fecal waste and urine.
3	alternating twin pit latrine	A new technology designed latrine with a series of pits connected to one other. This would avoid easily filling rate in the future.
4	fecal waste	Solid extracia
5	pathogens	Any small organism, such as a virus or a bacterium that can cause disease
6	On-site treatment	Onsite wastewater treatment systems are used to treat wastewater from a home or business and return treated wastewater back into the receiving environment. They are typically referred to as septic systems, because most involve a septic tank for partial treatment
7	Dump site	The location of a dump, especially a garbage dump or a place where wastewater is discharged.
8	Wastewater treatment plant	Wastewater treatment is a process used to remove contaminants from wastewater or sewage and convert it into an effluent that can be returned to the water cycle with minimum impact on the environment, or directly reused.
9	Sludge Reuse	The practice of using sludge for agriculture purposes including discharging to increase top soil nutrition
10	Sludge disposal	The practice of discharge sludge into the lake or landfilling
11	Sludge treatment	Biological/chemical waste water treatment reduces the solved and unresolved pollutants existing in the waste water.

Definitions

Fecal Sludge Management (FSM)

Fecal sludge management refers to the collection, transport and treatment of fecal sludge from pit latrines, septic tanks or other on-site sanitation systems.

Latrine pit seen above ground.
Source: PSI Research Team



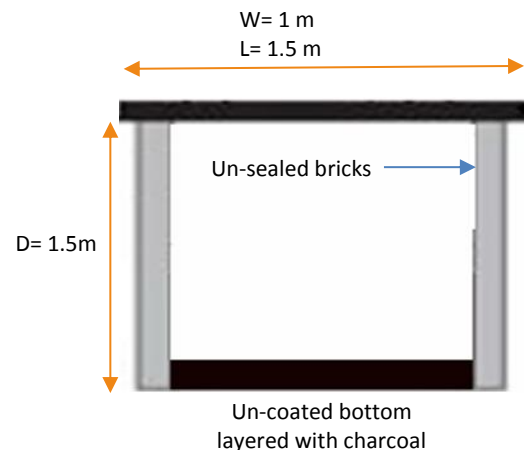
Pour-flush latrine connected to pit

A pour-flush toilet that is connected to a pit holding feces in the ground. The pit is a cylinder-shaped container constructed with concrete rings. It is usually partially above ground. In a twin pit containment system, the first pit is usually sealed and contains sludge while the second pit has an unsealed bottom that allows liquid to infiltrate into the soil.

Pour-flush latrine connected to tank

A pour-flush toilet that is connected to a tank holding feces in the ground. The tank is rectangular cube-shaped and constructed with bricks. The brick walls can be coated or uncoated. The bottom is usually unsealed and layered with charcoal.

Illustration of a latrine tank. Source: PSI Research Team



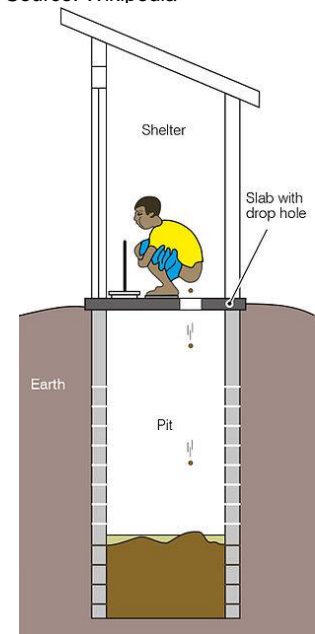
Traditional pit latrine

A traditional pit latrine is a type of dry toilet that operates without flush water and is placed above a single pit that contains sludge in the ground.

Pit emptying vs. partial emptying

A household having “conducted pit emptying” only when a significant amount of feces and liquid is emptied from the latrine containment system, allowing for further use of the latrine for at least a year. The definition of pit emptying includes manual emptying, vacuum truck emptying and pumping machine emptying. The definition excludes partial emptying methods which only allow for temporary use of the latrine, such as draining the containment system by connecting a pipe or removing liquid with buckets.

Illustration of a traditional pit latrine.
Source: Wikipedia



Pit filling rate

Volume of fecal waste produced by an average household member every year (liters/person/year).

Executive Summary

Context

Poor sanitation and hygiene practices remain a significant challenge for Cambodia. Almost half of the overall population (40%, JMP 2015) and a majority of the rural population (50%, JMP 2015) still practice open defecation. One of the persistent challenges related to poor water, sanitation and hygiene is stunting, which continues to prevail in Cambodia, especially in rural areas and among the poor. Under the Sustainable Development Goals (SDGs) announced in 2015, there is now a focus on the whole sanitation service chain from containment through to disposal. The challenge is therefore not only to promote universal toilet coverage across Cambodia but also to develop practices, services and infrastructures in order to manage fecal sludge safely and effectively along the sanitation service chain.

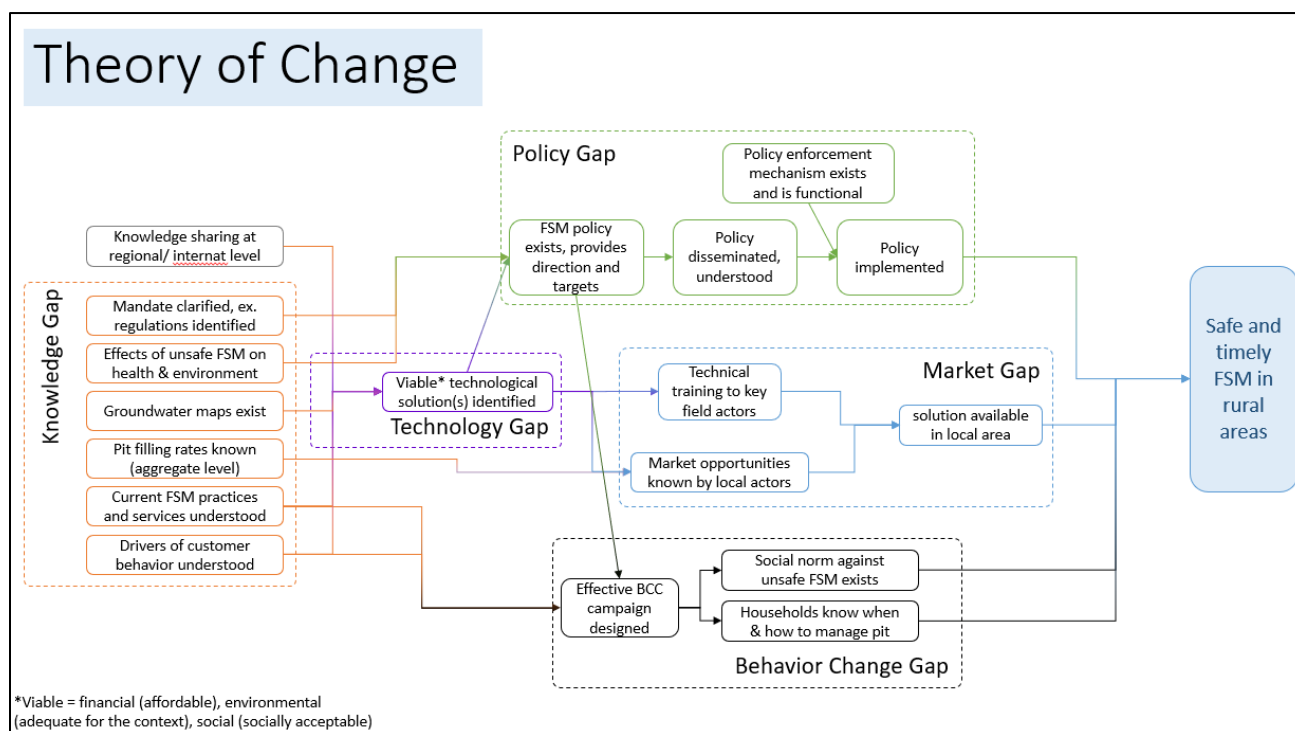
In 2015, more than 75% of households in Cambodia rely on on-site sanitation systems which generate fecal sludge and wastewater that must be managed safely. Fecal sludge consists of variable amounts of contaminated wastewater and partially-digested feces, urine, and can include solid waste or other materials. In Cambodia, the access to fecal sludge management services and the quality of these services are limited, especially in rural areas where the rapid uptake of latrines from 3.8% latrine use in 2000 to 38.58% (2015, JMP) is leading to fast growing needs for FSM services whereas those are affected by factors such as household socioeconomic status, geographical areas, and technology options.

Purpose of study

The purpose of this study is based on a request of the Ministry of Rural Development to identify the behavior change gap as illustrated in FSM in rural areas theory of change (**Figure 1**). Thus, the main purpose of this research study is to understand current practices of pit emptying and sludge reuse in the rural context of Cambodia and to find drivers and barriers of these pit emptying and sludge usage behaviors. The study is designed with a purpose to track the aspirations, motivations, and barriers impacting such practices in the rural context. It is expected to complement existing literature of FMS pit emptying and sludge reuse due to this unprecedented data collection, covering a large sample of over 600 households in the field of FSM management and practices in Cambodia, drawing from diverse perspectives of households, and related institutions across three geographical areas (flood-prone, plain, and highland).

Findings from this study is to produce a set of recommendations that can be an informed choice for the Ministry of Rural Development (MRD) to design a rural FSM national guidelines. The Findings from this study would also provide a key input for WASH sector of Cambodia with a comprehensive information and analysis as a catalyst to understand the views of FSM behaviors and practices from stakeholders, individual households and private sectors for developing innovative solutions to address issues of FMS management and practice in the rural context.

Figure 1: Theory of Change for FSM in rural areas



Summary of Key Findings

Current practices and behaviors of pit emptying and sludge use are the core purposes and tracking aspirations, motivations, and barriers impacting such practices is also another key areas of the study. The following are the key summary of responses with core research questions of the research.

The level of knowledge among rural households on pit emptying and sludge reuse. Perceiving “every important” perceptions of pit emptying is very high among pit emptying practice and non-pit emptying practice.

- 98% of all rural households **considered pit emptying to be very important** when the latrine is full. A bit more percentage of the rural households with behavior of pit emptying when is full were more likely to empty the pits. 82% of rural households with pit emptying practice compared to that 78% of rural household with non-pit emptying practice acquired pit emptying to be pivotal. 60% of the households with pit emptying knew the methods of self-conducted pit emptying.
- Missing understanding of pit that has never been full is widespread** among the rural households, especially among households with non-pit emptying practice in the past. 80% of the households with non-pit emptying practice in the past was not aware of their pits when are to be full. Only 28% of other households with non-pit emptying practice in the

past knew the methods of self-conducted pit emptying. This can be suggested that there is significant positive connection between knowledge of self-conducted pit emptying and the practice of emptying the pits.

- **Knowledge of pit to be full are easily to recognize among the rural households.** 86% of rural households were capable of identifying when pit is full based on latrine malfunctions. Such malfunctioned latrine is understood to be un-flushable, pungent smell emitting, and liquidated leaking. 71% of the rural households had a concern with the latrines filling up in near future.
- On average, **rural households are expected that latrines can be functional in about 9 years.** Such filling rate is also depending on the latrine usage within the family members¹.
- **The majority of the rural households have a commonly understanding from the previous practices that sludge is used.** 68% of the households have been practicing of sludge reuse. Such practice has been acquired from some formal trainings and others have learnt from other households, drawing experiences from the Khmer Rouge when the sludge had been used for rice cultivation in order to increase high yields.

The current practices of rural households in relation to pit emptying and reusing sludge.

Low percentage of rural households conducting pit emptying can be associated to the socio-economic factor despite widely knowledge of pit emptying.

- From the survey, 34% of **all rural households had practiced of latrine emptying.** Only 12% of all households with current latrine filling up removed the sludge from the pits. Rural households with multiple-pit latrines are more likely to conduct pit emptying than the households with the single-pit latrines. This can be associated with the socio-economic factor since households that installed multiple pits to their latrines are less likely to be ID Poor card holding households; therefore, they are likely to pay for pit emptying services.
- Paid pit emptying is more popular than self-conducted pit emptying practices. Among total rural households conducted pit emptying, 54% of the households paid for pit emptying services. With about the same figure, 46% of the rural household had self-conducted pit emptying.
- **Pit emptying practices differ by geographical areas.** In flood-prone challenging environment, rural households commonly conducted pit emptying with own pumping machines (46%) or hired/borrowed pumping machines (36%). 51.7% of households in the non-flooded and 57.1% of highland areas used vacuum truck services for pit emptying.
- **Pumping machine emptying was also commonly practice in the rural areas.** There is a market potentially for vacuum truck services in the non-flooded and highland areas

▪ ¹ Cambodian rural context, on average, has about 5 members living with the same household. It is not to mention the shared households living close to the premise of the latrine.

because there is strong evidence that pumping machine was dominated in those areas. Overall, vacuum truck and pumping machine emptying were the two most popular pit emptying practices in the rural areas.

- Safe handling during pit emptying is a concern. All observed service providers had direct exposure to feces without proper protection equipment. There were no basic medical and hygiene sanitation materials on site.
- Although rural households acquired knowledge of sludge is reusable, small proportion of the rural household is reused it nowadays. Only 7% of the rural households have been reusing sludge. It is understood that rural households with the practice of self-conducted pit emptying are likely to reuse sludge for nurturing young trees, vegetables and rice cultivation for increased high yields. With high proportion (61%) of those sludge usage does not stock sludge prior to reuse.

The decision maker of conducting pit emptying within rural households. Cambodian culture has given big part of decision making to the male as a dominant counterpart for socio-economic related matters in life although there have been a lot of development project intervention to raise up the voice of women in some gender related aspects. This has a strong link to the gender dominating role in the FSM management and practices of the Cambodia rural context. As can be seen, 54% of rural household heads played crucial role as the decision makers regarding pit emptying, of which 60% of the rural household head are male according to the survey. Although female was engaged with the decision through interpersonal discussion, they were not impactful to share significant part of decision making for pit emptying practices in the rural households.

Availability and Accessibility of pit emptying services for rural households in highland, flood-prone, and non-flooded areas. There were not many options for the pit emptying practices in the rural areas. About 40% of all rural households knew where to obtain pit emptying services within the premise of the communities. The most available and accessible services were vacuum trucks, with about 38% of all rural households knew where to find vacuum truck service providers. Manual emptiers, pumping machine operators or pumping machine renters were also available, but there was only about 3% of all rural households knew where those services located.

There has been a formidable challenge between affordability and cost of pit emptying services. The actual affordability and willingness to pay for the rural households were in between 13-18 USD per emptying unit of services; while, the actual services charged were on average of 33 USD. The actual price of vacuum truck services was as twice as the price of willingness to pay. Overall, affordability and availability of pit emptying services have posed a significant barrier for pit-conducted emptying.

The key needs, barriers, beliefs and motivations of rural households on pit emptying and reuse of sludge. The key SaniFOAM determinants of pit emptying behaviors are access, availability and affordability of services, households' willingness to pay, skills and self-efficacy, and social norms. Manual emptiers are accessible on a local level but not consistently available across different communes.

- Vacuum truck services are excessively expensive compared to households' willingness to pay and often charge extra when operating out of district-level or provincial towns. Many households that had full latrines but did not conduct pit emptying do not have access to available pit emptying service options, nor do they have the skills to empty or have any emptying equipment.
- Lack of suitable disposal locations for emptied sludge also discourages households from conducting pit emptying. In addition, negative social norms such as community perceptions of pit emptying and the stigma around smelly latrines, as well as positive social norms such as neighbors' emptying practices all play significant roles in swaying pit emptying decisions.
- In terms of reusing sludge, beliefs and social norms can play a huge role in behavior change. Households that identified other households within the community reusing sludge are more likely to engage in similar reuse practices. Households who think sludge reuse is safe for health are also more likely to reuse than those who believe it has health risks.

The gaps between current practices and safe practices of pit emptying. According to field observations and interviews, current practices of pit emptying by service providers did not fulfil Occupational Health and Safety (OHS) requirements. E&T operators did not wear Personal Protection Equipment (PPE) during emptying. There was no established emergency medical support for workers and no first aid kit available on-site. E&T operators usually did not clean up appropriately upon the completion of service. Vacuum trucks were usually not secured with wheel checks while emptying, and operations of the hoses or the valves were not standardized.

Both manual and mechanical E&T operators disposed the emptied sludge unsafely. As found in field observations conducted by the study, manual operators commonly dig a hole in the ground within the areas of the household to bury the sludge with little or no treatment. Also found in field observations, mechanical operators rarely drive their trucks to official dumping sites, but usually discharged the untreated sludge into the local environment or farmlands of households willing to apply it as fertilizer.

Summary of Study Gaps and Limitations

The sample size for pit filling rate calculations was lower than expected. The sample size for highland areas was also limited, especially when after being filtered for the households that reuse sludge. None of the households interviewed used service providers with pumping machines. Future studies can further explore fecal sludge management (FSM) solutions specific to highland areas, pit filling rates for different types of environment and rare FSM service types.

Summary of Recommendations

General Recommendations on On-Site Treatment, Disposal and Reuse of Sludge

For **MRD** and other relevant ministries to develop guidelines serving three distinct purposes:

- Standardize safe operation for all existing FSM practices, including manual emptying, pumping machine emptying, partial emptying, etc.;
- Establish effluent standards and the corresponding levels of treatment required for different receiving environments;
- Establish practical guidelines on safe reuse of sludge in different agricultural settings and quality control of sludge-generated compost products. In addition;
- **MRD** and other relevant ministries should develop FSM guidelines including social behavior change, Occupational Health and Safety guidelines, set safe disposal standards.
- MRD should consider planning a pilot program in select rural areas with the biggest market potential which subsidizes vacuum truck business to provide services with smaller vacuum trucks at cheaper prices.

For **NGO's** active in the WASH sector of Cambodia:

- Continue researching and leveraging Wetlands Work on-site composting solutions or small-scale emptying & treatment solutions that are safe, smell-free and affordable
- Increase uptake of existing solutions that have been successfully piloted at a small scale such as the alternating twin pit latrine and HandyPod to reach more rural communities through social marketing programs, flexible payment plans, etc.
- Equip latrine business partners and service providers with technical knowledge to sell latrine types most appropriate for local environments and inform households about the effects of water infiltration (seasonal, high water table) on pit filling rates.

For **local authorities (Provincial Department of Rural Development and District Administration)**:

- Enforce MRD guidelines by organizing mandatory trainings for all FSM stakeholders (service providers that operate within the community and household representatives) on compliant practices at every stage of the sanitation chain
- Set up reward/punishment mechanism for safe/unsafe disposal of sludge and other practices compliant/incompliant with safety standards
- Run regular spot checks on community practices and vacuum trucks' use of local dumping sites

For **both NGO's and local authorities**:

- Educate households on indicators of full latrine, appropriate pit emptying measures, health risks related to direct exposure to feces or unsafe disposal, and benefits of reusing sludge
- In collaboration with **NGO's**, local authorities can also help vacuum truck business owners develop flexible payment plans that cater to more households with their community, such as installment plans and group discounts.

- Identify innovators among households, local best examples of households managing FSM correctly to act as community influencers
- Devote particular efforts to involve more women in pit emptying decision-making by improving their related knowledge and skills
- Promote positive social norms such as establishing a common goal for the community to “build a safe and healthy environment” through safe emptying and disposal of sludge.

For **pit emptying service providers**:

- Attend safety trainings and follow OHS guidelines during pit emptying operations
- Follow effluent standards and adopt safe on-site procedures in disposal of sludge
- If applicable, share with customers relevant expertise on maintaining latrines and reusing sludge
- Consider branching out into less urban areas, such as smaller towns near rural areas. At these semi-rural branches, vacuum truck business could invest in trucks with lower capacities that operate at lower costs and thus charge lower prices accommodating the needs of individual rural households.

Recommendations on Specific Objectives for Different Geographical Areas

In **flood-prone areas**, it is particularly important to establish guidelines on safe pumping machine operation and standards for subsequent sludge disposal, since rural households there more heavily rely on the pumping machine method. There should also be a ban on flowing sludge directly into surface water during rainy season or flood season. When the behavior change guidelines developed by the government, local authorities and NGO should adopt it on creating social norms against such practices by launching a behavior campaign programs educating the community on related risks to public health. In such areas with high water tables, innovative latrine solutions such as HandyPod developed by Wetlands Work should be further promoted.

In **non-flooded areas and highland areas**, there is relatively more potential for developing the capacity and competitiveness of vacuum truck services. Enforcing guidelines on safe practices such as the alternating twin pit latrine which would be an appropriate on-site composting solution for areas with low water tables and should be further promoted. Further, using pumping machine is also crucial since pumping machine is the second most popular pit emptying option.

Background

In recent decades, Cambodia has made good progress towards the sanitation target set by the Millennium Development Goals (MDGs) and has achieved the water supply target.² Between 1990 and 2015, 76% of Cambodia's population have access to improved water sources, and 42% have access to improved sanitation.³ Despite the impressive improvements, Cambodia still has a long way to go. Access to water supply and sanitation in Cambodia remains below its regional peers'. On average, only 21% of the total population enjoy piped water supply. Poor sanitation and hygiene practices are of particular concern in Cambodia. Almost half of the overall population and a majority of the rural population still practice open defecation. One of the persistent challenges related to poor water, sanitation and hygiene conditions is stunting, which continues to prevail in Cambodia, especially in rural areas and among the poor. As of 2010, 40% of children under five years old remained stunted (WSP, 2015).

The United Nations' Sustainable Development Goals (SDGs) announced in 2015 set substantially higher targets for progressively addressing unequal distribution of resources and achieving universal access to water supply and sanitation by 2030. In addition, while the MDGs focus on reducing open defecation and universalizing improved types of containment facilities, the SDGs focus on the whole sanitation service chain, extending beyond containment to the emptying, transportation, treatment and disposal of fecal waste. The sanitation target under the SDGs is therefore not only to achieve universal coverage of toilets, but also to achieve safe management of fecal waste along the sanitation service chain.⁴ Thus, the lack of FSM solutions in urban and rural setting would present a huge challenge to the timely achievement of the SDG target.

The sanitation service chain is underdeveloped in Cambodia. According to WSP's Regional Service Delivery Assessment, there were only two functioning waste treatment systems in the whole country as of 2013. A few larger urban towns have collection systems with limited capacities, mostly combined drains instead of proper waste treatment systems. On a national scale, the treatment of fecal sludge is estimated to be around only 2%. There is no legal framework for fecal sludge management on national or local levels.

Fecal Sludge Management (FSM) Demand and Practices in Rural Contexts⁵

The sanitation service chain is beginning to form in rural areas, which gives rise to growing demand for FSM services. Since 2009, the WASH sector in Cambodia has been actively promoting latrine coverage in rural areas through sanitation marketing⁶ and behavior change campaigns. Since 2010, these efforts along with other initiatives have contributed to the purchase

² WHO and UNICEF. (2015). Progress on Sanitation and Drinking Water – 2015 update and MDG assessment. Geneva: WHO and UNICEF - Joint Monitoring Program.

³ World Bank's Pit Emptying Research Express of Interest

⁴ World Bank Group. 2016. Fecal Sludge Management: Diagnostics and Guidelines for Service Delivery in Urban Areas. World Bank, Washington, DC. © World Bank. <https://openknowledge.worldbank.org/handle/10986/24722> License: CC BY 3.0 IGO.

⁵ Source: World Bank's Pit Emptying Research Express of Interest

⁶ <https://www.ideglobal.org/story/sanitation/>, <http://www.watershedasia.org/sanitation-marketing/>

and installation of nearly 500,000 latrines. The latrines are on-site sanitation options based on containment systems located within the dwellings of households. The latrines are mostly pour-flush models directly connected to pits or tanks. Overall, by 2014, 69% of rural households in Cambodia had access to improved sanitation facilities (CDB, 2017). Almost 100% of the rural households with improved access have a pour-flush latrine to either a soak-pit or a tank (WSP, 2015). This translates to an estimate of 1.32 million rural households with potential demand for safe FSM services. Therefore, the important next step in improving sanitation is to address the removal and disposal of fecal sludge in a safe environment and timely manner.⁷

To develop sustainable solutions along the sanitation service chain, it is important to understand what current practices and demands are and why they exist. FSM rural areas is a relatively new topic for Cambodia with limited prior research. Most studies have focused on the supply side of fecal sludge disposal, including potential business models for sludge removal services, technological options for reducing latrine sludge such as applying lime, among other service-provider solutions. Research on the demand side of FSM is lacking, especially on FSM practices and needs in rural areas.

Drawing on previous research on FSM service characteristics and urban practices, we expect the following barriers to improving FSM behaviors in rural areas: insufficient knowledge of the need to conduct emptying safely, shortage of pit emptying services, low affordability for services even when they are available, aversion to touching or reusing human fecal waste, etc. Previous study suggests that households in rural areas commonly practice manual emptying, done by the households themselves with rented pumping machines or done by hired manual emptiers. Households often mention reusing the removed sludge on their own fields (Pedi et al. 2014). This study seeks to confirm the key factors influencing rural households' pit emptying and fecal sludge reuse behaviors and to construct a more comprehensive view of common practices in rural areas. A recommended action plan is formulated based on analysis of the findings to advise MRD and private-sector stakeholders to look deeper into the practices of a safe sanitation when the rates of latrine coverage increase and/or latrine pit is full.

Situational Analysis

The study provides the opportunity to understand current rural FSM, particular the FSM regulation and institutional arrangement and attention with innovative private-sector solutions and safe practices. The analysis also helps to understand associated risks and benefits of sludge reuse and disposal that had examined as scientific evidence for the discussions of safe practices.

Institutional Responsibility and Policy and Legislative Review (for FSM). FSM policy and planning has yet to be developed. The regulatory framework and mandates of responsible ministries are not well defined in particular the division between urban and rural. There is a sub-decree recently issued to illustrate the responsibilities of the government in addressing urban sanitation solutions; however, the focus is more on wastewater treatment infrastructure and

⁷ <http://www.cawst.org/blog/bydate/2016/09/fecal-sludge-management-in-5-minutes/>

drainage constructions. No regulation has been formulated by the government in supporting the FSM in city level or rural areas. In the review, the absence of clear roles and responsibility in each agency has resulted in vague mandates of MPWT, MRD, or MoE. The roles and responsibilities of the ministries in relation to sanitation are shown in Table 1.

Table 1: Ministerial roles and responsibilities for sanitation

Institutions	Functions relating to FSM
Ministry of Rural Development (MRD)	MRD's department of rural health care, is in charge of provision of on-site sanitation facilities, and hygiene practices through behavior change program and maintaining household surrounding environment through awareness raising.
Ministry of Public Works and Transport (MPWT)	MPWT's Sewerage Management Construction Department (SMCD) in charge of management of drainage system and wastewater treatment plant system. In some areas in Siem Reap, the wastewater treatment unit collaborates with private vacuum truck to collect and transport wastewater from non-sewer connected households and dispose into the treatment facility.
Ministry of Environment (MoE)	MoE is the lead Government institution with a broad mandate to lead on pollution and protection issues, and to cooperate with other ministries on these. It has taken the lead on waste management, and other related issues.

In the National Strategy Development Plan (NSDP) of 2014-2018, FSM solutions are not reflected in the priority agenda of the government. Ministry of Public Works and Transport (MPWT) established a newly formed Sewerage Management Construction Department (SMCD) in charge of management of drainage system and wastewater treatment plant system⁸. FSM is directly or indirectly one of the mandates of by MPWT, which gives licenses to vacuum trucks, and/or by the Ministry of Environment, which grants special licenses for vehicles transporting or discharging effluent exceeding 10m³ per day and manages official dumping sites (GRET, 2011).

However, recently MRD has embraced the FSM as a new topic for rural sanitation mandate and is mentioned in the National Action Plan for Rural Water Supply, Sanitation and Hygiene (RWSSH) 2019-2023 to fulfil its commitment to Cambodia Sustainable Development Goal (CSDG) targets on safely managed sanitation .

Rural FSM Chain Actors

The following are the potential groups involved directly or indirectly with the FSM:

Households

Rural households are the potential to demand for pit emptying from private sludge emptier or self-conducted pit emptying. Typically, the rural households are looking for pit emptying services from

⁸ Sub-decree on management of drainage system and wastewater treatment plant system. issued on December 25, 2017

private suppliers or they are hiring equipment for self-conducted pit emptying practices. Some rural households are practising the sludge reuse.

Manual E&T Operators (Manual Pit Emptiers)

Majority of manual pit emptiers were part-time service providers to remove sludge. 50 manual emptiers were identified in Phnom Penh, 2 in Kampot, but none in Siem Reap. In urban areas, many manual emptiers were construction workers. In rural areas, manual emptiers were not commonly identified, but information of service providers spreaded from one to others.

Mechanical E&T Operators (Vacuum Trucks)

Vacuum trucks have dominated the pit emptying market in the rural context where households can be contacted. There were approximately on average from 1 to 4 vacuum trucks per business operation. They were usually family-based companies providing services for households, hotels and restaurants for pit emptying. They mainly operate in urban areas (Figure 2) but also travel to some rural areas, charging extra by distance. Volumes of the trucks are varying by city, from 3m³ in Siem Reap to 5-8m³ in Phnom Penh and Kampot. There is no formal registration or licensing for these businesses. Vacuum trucks have normally discharged sludge into the nearby environment or to some authorized sites without a proper treatment.

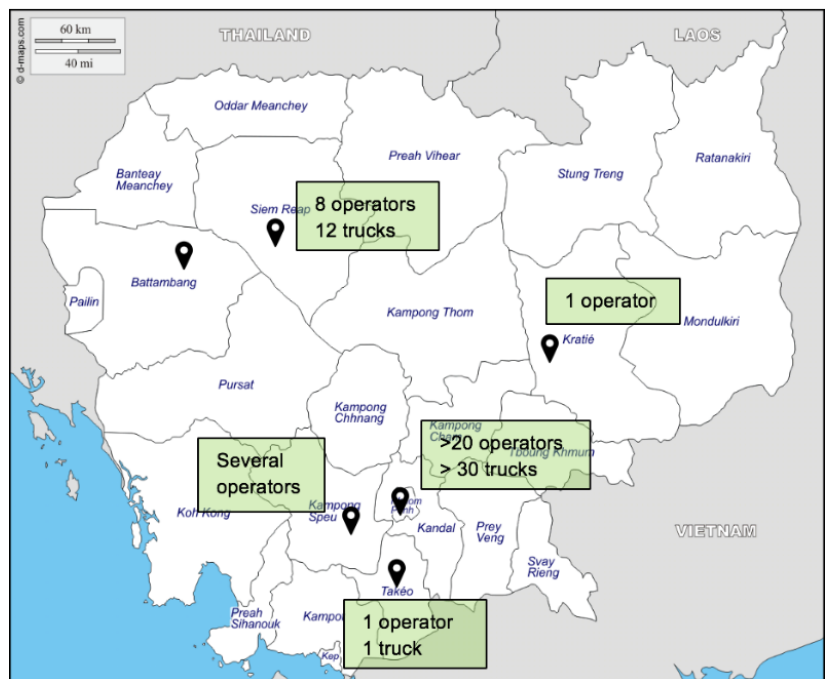


Figure 2 Distribution of Vacuum Truck E&T Operators in Cambodia

Pumping Machine Renters

Pumping machine rentals are FSM-related business specific to rural areas. The rural households were looking for the rented pumping machines for a cheap price to empty pit latrines, but mostly the practice from this small-scale services for pit emptying does not have a proper equipment to security and health safety measure.

Sludge Re-users

Down the value chain, some small farmers re-use removed sludge as fertilizer. Sludge reuse

practices are highly informal and difficult to track. Some urban E&T operators have reported that they occasionally resell emptied sludge through personal contacts to farmers in rural areas to use as fertilizer for rice crops, but no concrete evidence for these practices has been found.

Official Dumping Sites

There are several official sites in urban areas for private E&T operators to dump fecal waste at a certain cost and are scarce in the provincial levels. In Phnom Penh, there are three official wetland dumping sites that has charged about 1.5 USD per trip. In Siem Reap, there is a designated site to dump fecal sludge at a wastewater treatment plant which has built with supports from international donors and operated by the Wastewater Treatment Unit of the Provincial Department of Public Works and transport. The cost for that dumping is at 30 USD per monthly. There is no official dumping site in Kampot.

In all three cities, there are not official or legal recognized dumping sites in any rural areas. Although dumping sites located in urban areas are theoretically viable disposal options for vacuum trucks, it is unlikely that vacuum trucks providing services in rural areas would return to the cities to dispose of emptied sludge. It is most probable that most of the emptied sludge in rural areas from vacuum trucks or from manual emptiers is discharged into the environment (i.e rivers, streams, or wetlands) nearby without regulation.

Vacuum Truck Operation

Vacuum truck business mostly operates at small scales. Each business is equipped with on average 1-4 trucks. These businesses adopt “aggressive” marketing strategies in urban areas, distributing many promotional leaflets every year and painting the business’ telephone numbers on poles and sign boards. For example, in Phnom Penh, 31 vacuum trucks have distributed 7.4 million leaflets, amounting to about 180 leaflets per truck distributed to each potential client (GRET, 2011).

Vacuum truck business mainly provides services in urban areas. Business also provide services to peripheral rural towns, where they charge additional costs proportional to the distance the trucks travel. Service prices are thus often excessively expensive, and there is a shortage of professional vacuum trucks providing affordable services to rural households.

Existing data on urban customers show that service satisfaction for vacuum truck services is extremely high, ranging from 96% in Phnom Penh to 98% in Siem Reap (GRET, 2011). Vacuum truck operations are timely, fast and clean. Despite the fact that most households are satisfied with vacuum truck services, 58% of the households would not call the same operator again. It seems that there is no “fidelity” in the vacuum truck pit emptying service sector, and every service is provided on a competitive way for one time only.

Details about vacuum truck business scales, service fees and corresponding official dumping sites in the cities they operate in are presented in **Table 3** below:

Table 2 Overview of Vacuum Truck Business and Official Dumping Sites in Three Major Cities

	Phnom Penh	Siem Reap	Kampot
Average size of vacuum trucks	5 - 8 m ³	3 m ³	5 - 8 m ³
Avg. vacuum truck emptying fee per service	USD 36	USD 20	USD 75
# of private vacuum truck business in city	19	6	1
# of trucks run by vacuum truck business	31	8	1
# of trucks owned by public utilities	5	1	0
What is the official dumping site of the city?	Wetlands	WWTP	N/A
What is the dumping fee vacuum truck business have to pay? (USD)	USD 1.5/trip	USD 1.5/trip	N/A
Price of second-hand 5 m ³ truck	USD 12,000 – 20,000		
Price of imported brand new truck	USD 200,000		

Rural FSM Practices

Pit emptying is either practiced by rural households themselves or by mechanical or manual emptiers. Many households remove fecal sludge manually by themselves or through manual service providers. Some households reuse emptied sludge on their own fields.

One previous study conducted interviews with households that installed and adopted latrines about their plans for addressing the issue of a full latrine in the future (Pedi et al. 2014). When asked what they would do when their latrine pit fills up, about 40% of installed adopters indicated that they would have someone in their family manually empty the pit, 29% indicated that they plan to hire someone to empty the pit with a mechanical pump, and 22% stated that they would hire someone to empty it manually. Most installed adopters (69%) plan to spread the pit contents directly on their field as fertilizer. One respondent mentioned a specific procedure for emptying and preliminary treatment - that he would empty in dry season, first cover the sludge with ash first and make the family refrain from using for two weeks, then mix the sludge with cow dung, and finally take it to the field after one month.

Another study conducted by WaterSHED provides preliminary understanding of behavioral drivers of current FSM practices in rural Cambodia.⁹ The study drew on 40 semi-structured in-

⁹ 2018 WASH Futures Conference and Training Handbook.
<http://washfutures.com/wp-content/uploads/2018/03/WASH-Futures-2018-Handbook.pdf>

depth interviews with households, local authorities and religious leaders based on EAWAG's RANAS (Risk, Attitude, Norm, Ability and Self-regulation) framework for systematic behavior change. Findings show that rural households do not have enough information about the risks of unsafe FSM, the filling rates of their pit, or any safe alternatives. They strongly prefer professional pit emptying services for avoiding bad smell and transportation of sludge. They associate risk with physical contact with sludge but not with disposing sludge into agricultural sites and commonly value sludge as fertilizer. The study recommends FSM interventions focused on creating social norms against unsafe FSM, developing safe and smell-free alternatives, and raising awareness.

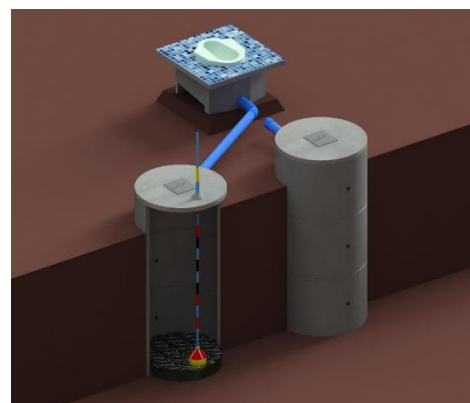
There is a general lack of FSM technologies or affordable and safe services at scale in rural areas. While manual emptying is available in some communes or villages, many households live in communities with no available manual emptiers and consider manual emptying obsolete. Vacuum truck services are better known across rural communities but generally excessively expensive and often unavailable on a local level. Prices of pit emptying services are often disproportionately higher than the capital investment of installing an additional tank or adding concrete rings to the original pit.

Households are often disincentivized to conduct pit emptying due to the unavailability and high prices of pit emptying services and the lack of skills and equipment to practice pit emptying independently. Some households resort to alternative solutions such as adding an additional tank or partially draining the containment system. Existing sanitation options are not conducive to safe pit emptying. Most households install latrines with one pit or two separate pits linked in series. Owners of these latrines have to deal with fresh wet sludge when the pits fill up, leading to increased risks.

Potential FSM Solutions

As latrine coverage increases and demand for follow-up sanitation solutions grows in rural areas, the WASH sector of Cambodia has been developing FSM solutions specifically tailored to rural situations. Recognizing the absence of pit emptying services available at scale, WASH sector actors have mainly focused on on-site treatment and disposal.

- **iDE** piloted the sales of alternating twin pit latrines. The product is a set of concrete rings with a lid and a PVC pipe that is connected to the original latrine underground structure. The pipe leading to the full pit is disconnected and capped off to allow the sludge to dry and be composted while the other pit fills. Before closing off the old pit like this, a solution of hydrated lime is mixed into the sludge by the service provider to accelerate the drying and treatment process. Treatment of sludge with hydrated lime was previously tested by the organization to have positive effects such as reduction of odors and pathogens. Although biological testing on the efficacy of sludge treatment over time in alternating pits has yet to be completed, iDE's twin pit design



that the sludge should be safe to handle and use as plant fertilizer within 1-2 years. The pilot program delivered 157 alternating pit latrine products at \$45 USD to households and met demand stronger than that of pour-flush pit latrines, indicating the product's market potential in broader rural contexts

iDE has also undertaken research since 2016 to understand pit filling rates by measuring seasonal changes of water and sludge levels in pits. This research study uses a low-cost pit gauge device that allows for convenient reading of pit content over time. The aim is to establish pit filling rates so that researchers can measure the frequency and impact of latrine overflow to better understand the environmental risks it poses at the household level. The pit gauge device was installed as a component of the pilot alternating twin pit model with the goal of nudging households to plan in advance for FSM needs.

Targeting affordability of pit emptying, iDE intends to scale two mechanisms to enable poor households to purchase improved sanitation options. The first is a subsidy mechanism using the ID Poor program providing a discount on poor households' latrine purchases. The second is a supply-side financing mechanism that trains local latrine business to assess customer credit and offer payment instalment options.¹⁰

- **WaterSHED** shares the WASH sector consensus that business models for emptying and centrally treating fecal waste are not viable. High transportation costs due to low population density and high liquid levels in waste are among the major constraints. Instead, the organization focuses on marketing solutions that extend the life span of the pit latrine system, including promoting the purchase of an extra pit during the initial purchase and encouraging latrine business partners to target existing consumers with the offer of a second pit approximately two years after the initial purchase. WaterSHED also designed and piloted programs to engage commune-level government authorities and encourage female participation in rural markets.

WaterSHED also proposed an on-site disposal solution similar to a modified arborloo waste management system: sludge would be buried in a hole near the latrine system and covered with leaves and soil, where a small tree can then be planted. The goal is to promote this simple on-site disposal option and offer related safe-handling instructions at a local level by engaging local authorities. In addition, researchers have investigated an innovative waste digestion solution using black soldier fly larvae. The practicality of this solution as a business model has yet to be tested.

- **SNV** has been developing twin offset pi latrines that allow pits to be used alternately while the full pit composts the sludge. Current research is focused on refining the model with an effective method to separate the two pits. Another solution that has been explored is a latrine model connected to biogas reactor. No report from SNV has been published about FSM practices of their latrine users.

¹⁰ "Fecal Sludge Management – Innovations and New Learnings" E-Discussion.
<http://www.cwashfund.org/learning-events/e-discussion/fecal-sludge-management-innovations-and-new-learnings-0?page=1>

- **GRET** promoted Public Private Partnerships at the commune level between 2006 and 2010 as part of its PACEPAC project, which aims to improve the wellbeing of rural populations in Cambodia by planning and developing community water and sanitation services. The pilot projects include the development of a sludge treatment plant and septic management services to introduce technical sludge treatment options into the market. GRET also aims to restructure the private market of latrine emptying services to control the quality of services provided and manage their environmental risks. There are no current updates available for these projects.

- **Wetlands Work** focuses on developing waste treatment options for households in extreme environments such as areas with permanently or seasonally high groundwater tables and flood-prone regions. Their “HandyPod” treatment system consists of two treatment stages sized for different numbers of people using the latrine. The system relies on gravity flow and a retention period for anaerobic and aerobic microbial activity. The first stage provides several days of septic containment of wastewater, which then flows by gravity into the



HandyPod treatment system installed under a floating house.
Source: Wetlands Work

second stage of three-day containment with naturally occurring microbes feeding on the wastewater and especially the pathogens in it. HandyPod isolates and treats wastewater efficiently with no unpleasant smells or sights, mosquitoes or chemicals, and basically requires no maintenance efforts other than FSM. Within a 1m³ volume of ambient water, the discharge from the system is recreationally safe to swim in. HandyPod has been introduced to floating schools and households in ten communities on Cambodia’s Tonle Sap Lake.¹¹ Wetlands Work is developing FSM protocols for the HandyPod; recent (2018) test plots during the rainy season indicate that *E. coli* in shallow 3m long sludge/soil ditches reach normal ambient soil concentrations in less than 4 months. Such ‘composted sludge’ may be appropriate for use in home gardens.

¹¹ <https://wetlandswork.com>

Safety Evaluation of Current FSM practices

The diagram in **Figure 3** provides an overview of how fecal sludge from on-site sanitation systems is managed along the sanitation chain in urban areas. It shows that 99.8% of excreta flows are unsafely managed. Private-sector E&T operators provide mainly vacuum truck services that are unregulated and uncontrolled. Almost none of the emptied waste reaches the treatment stage. The waste is either dumped unsafely in domestic dwellings or transported to be dumped into the local environment such as into rivers and wetlands. Land downstream of the dumping sites is often used extensively for agriculture. The inflow of largely untreated wastewater and fecal sludge into water used for crop irrigation is of great public health concern.

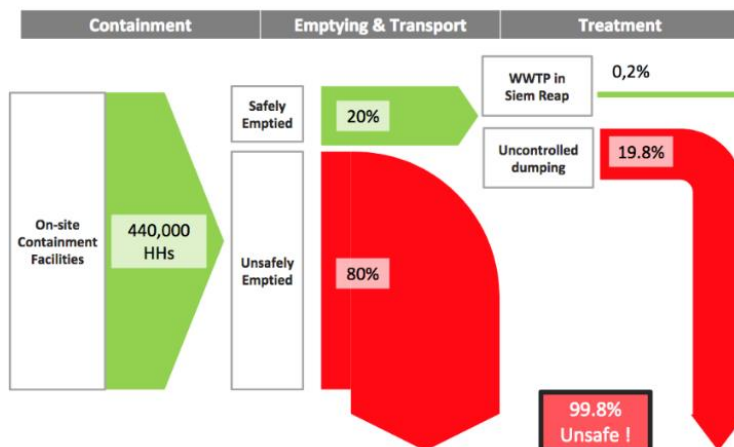


Figure 3 Quick Safety Evaluation of FSM in Urban Areas

Occupational Health and Safety (OHS) Guidelines for FSM Service Providers

No OHS guidelines for FSM service providers have been published by the Cambodian government. SNV has worked out OHS guidelines for FSM workers in Bangladesh that can inform the development of similar guidelines in Cambodia's WASH sector.¹² In general, E&T operators providing FSM services in rural Cambodia need to be aware of personal safety and health issues. They should be encouraged to undertake regular health checks and to always use Personal Protection Equipment (PPE) during practice. They should also be aware of the environmental and health impacts of different sludge disposal methods and engage in compliant practices. OHS guidelines have been generated in the SNV study for manual emptying and mechanical emptying, respectively.



Service providers have direct exposure to feces without protection materials. Source: PSI Total Market Approach

¹² Repon et al. (2015). Occupational Safety and Health Guidelines for Fecal Sludge Management. SNV Netherlands Development Organization, Khulna, Bangladesh. http://www.snv.org/public/cms/sites/default/files/explore/download/guideline-occupational_safety_and_health_guidelines_for_fsm_0.pdf

Benefit and risk sludge reuse

Benefit of sludge reuse. Fecal sludge from rural latrines, if treated properly, can be a constant and reliable supply of soil additives and irrigation water in agricultural settings. Reuse of sludge has major environmental benefits. The discharge of non-treated sludge into the environment and especially into natural water bodies can cause severe degradation of the soil and the water ways due to the presence of pathogens as well as organic and inorganic pollution. Proper reuse of sludge would address the transport challenge for rural areas with on-site treatment at the household level and direct application of safely treated sludge to the cultivated farmlands. Sludge reuse has the potential to eliminate risks along the rural FSM chain by tackling the problem of unsafe on-site disposal. To facilitate sludge reuse, on-site treatment solutions such as the alternating twin pit design, the wastewater garden, anaerobic technologies such as HandyPod, or biogas reactors must be further developed and evaluated to optimize the outcomes of treated effluent.

Risk of sludge reuse. It is also important to recognize the risks and limitations of reusing sludge. Even after proper treatment, recycled water can still contain microbial pathogens and viruses that might infect humans. In the case that on-site treatment system functions inadequately, the influence of heavy metals in partially treated wastewater needs to be considered. Quality issues of recycled water used for irrigation can negatively affect both food crop and the end users of the crop. Social attitudes around crops irrigated with reused sewage effluent might also hurt the market value of the crops.¹³ Finally, promotion and maintenance of on-site treatment options in rural communities requires collaboration between social enterprises and local authorities.



Sludge reused on plantation near rural household.
Source: PSI Total Market Approach

¹³ Simon Toze. (2006). Reuse of Effluent water - Benefits and Risks. Agricultural Water Management, Volume 80, Issues 1–3, Pages 147-159.

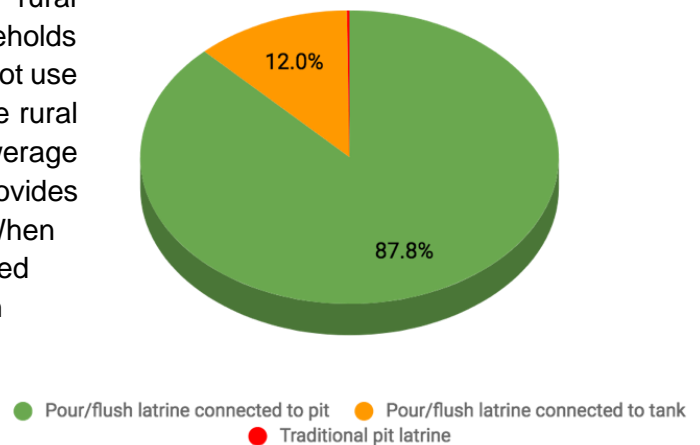
Findings

Latrine Characteristics

Types of latrines and uses

Pour-flush latrines connected to a pit or a tank are the most common latrine models owned by rural households. Only a negligible number of households owns a traditional pit latrine (dry pit) that does not use any water to flush down the waste. None of the rural household latrines are connected to a sewerage system. Neither of the pit nor the tank model provides any composting or treatment of the sludge. When the pit or the tank fills up, sludge must be removed from the containment system or drained to an additional pit or tank. This gives rise to demand for pit emptying or modifications to the original latrine containment system.

Figure 4: Types of Latrine Owned by Rural Households



On average, each latrine is shared by 5.4 users. 57% of rural households used latrines for multiple purposes such as bathing and washing clothes. 43% of the latrines owned by rural households are used for defecation only. In multifunctional latrines, the grey water from bathing and washing clothes usually flows directly to the surface outside the latrine containment system.



The average filling rate of latrines is calculated to be **140 liters/person/year**, which is the average amount of sludge accumulated within the containment system by a person in a rural household every year. Based on this figure, a pour-flush latrine connected to pit with the average volume of **2.6 m³** and **the average number of 5.4 users is estimated to be full 3.4 years after initial use**. This figure is also helpful for future studies to generate specific pit or tank filling rates based on the specific type of containment system and the soil environment.

Pour-flush Latrine Connected to Pit

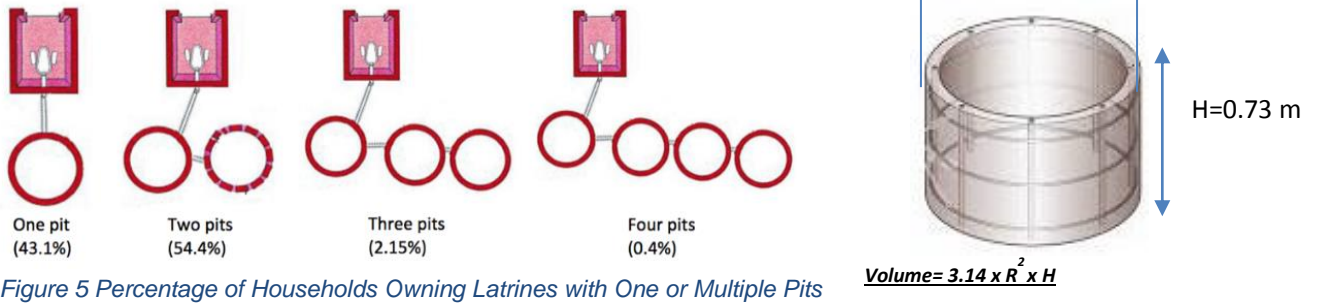


Figure 5 Percentage of Households Owning Latrines with One or Multiple Pits

The most commonly owned type of latrine is the pour-flush model connected to pit. About 88% of 632 households reported that they own this model (**Figure 5**). This type of latrine uses on average three liters of water per flush. It is connected to a pit in the ground which collects feces without treatment. The pit is a cylinder-shaped containment system constructed with concrete rings. The concrete rings and the bottom of the pit can be sealed or unsealed.

The average volume of a latrine pit owned by rural households is calculated to be 2.6m^3 based on data gathered on diameters and heights. Most households have single or twin pit latrines (**Figure 5**). Using alternating pits was not found in this study. Based on field observation, the two pits were connected in series.

Table 3 Percentage of Households Owning Latrines with Different Numbers of Concrete Rings

Number of Concrete Rings	% HHs	Average Volume (m ³)	Estimated Filling Time (Year)
1-3 concrete rings	46.1%	1.5	2
4-6 concrete rings	48.3%	2.5	3.3
7-9 concrete rings	4.7%	3.8	5
>9 concrete rings	0.9%	5.4	7.1

Table 4 Percentage of Twin Pit Latrines with Pit One or Two Sealed

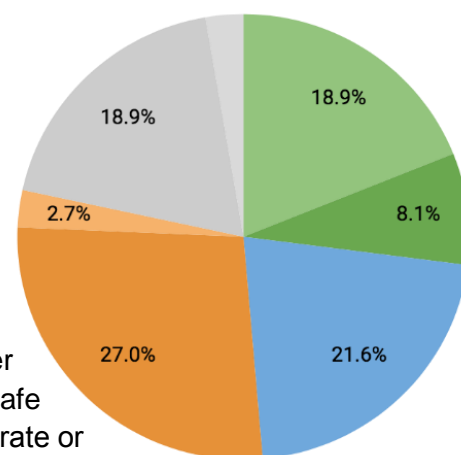
Description	Pit One	Pit Two
Pit has holes on concrete rings	65.4%	69.2%
Pit is joint sealed	77.2%	70.4%
Pit is sealed with cement at the bottom		
Bottom is entirely sealed	72.7%	78.3%
Bottom is partially sealed	0.4%	0.6%
Bottom is not sealed	24.8%	18.6%
Don't know	2.2%	2.5%

Among the few households that reported having three or four pits, most only added the third or fourth pit after the original single or twin pit system filled up. Most households' latrines have 1-6 concrete rings (Table 3). On average, each latrine is equipped with a total of 5 concrete rings with estimated filling time of about 3.3 years. The number of concrete rings is an indicator of the total volume of the pit(s) of a latrine, which is constructed with stacked concrete rings. The more concrete rings it has, the greater volumes of sludge a latrine containment system can hold and correspondingly the longer time it takes to fill up.

Since the majority of rural households have twin pit latrines, the twin pit model was studied more in depth in terms of sealing of the two pits. As shown in Table 4, the majority of twin pit models have both pits' concrete rings joint sealed. About three quarters of twin pit latrines have both pits entirely sealed with cement at the bottom. Notably, a quarter of the twin pit latrines have the first pit ("Pit One") unsealed at the bottom and one fifth have the second pit ("Pit Two") unsealed at the bottom). Depending on the soil environment, leaving pits unsealed at the bottom likely leads to more infiltration of the liquid content of sludge into the ground.

Figure 6 Additional Connections to Primary Latrine System

- Additional tank
- Additional pit
- Surface water
- Own rice field/garden/land
- Others' rice field/garden/land
- Other
- Don't know



Among the 557 households that own pour-flush latrines connected to pits, 6.6% reported that they connect their primary pit system to other places for disposal or further containment. Many of these connection methods can be seen as unsafe alternative solutions to pit emptying that decrease the latrine's filling rate or partially empty the pit when it is full. Some households added tanks or pits to

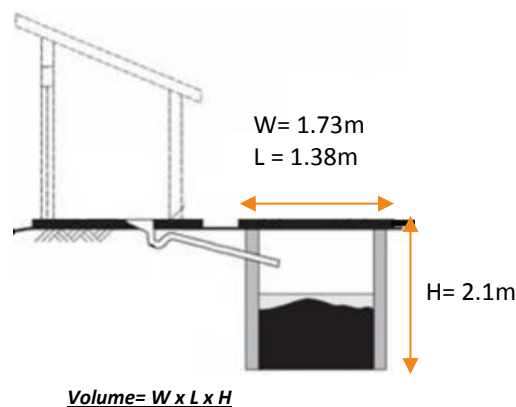
expand the capacity of the containment system. A majority of households connected pipes to their latrine pits that constantly direct liquid content of the sludge to rice fields or surface water. The effluents are untreated and directly discharged into agricultural lands or the local environment (Figure 6).

Pour-flush Latrine Connected to Tank

12% of the households reported owning the pour-flush model connected to a tank. This type of pour-flush latrine functions similarly as the previous model but is connected to rectangular cube-shaped tank rather than pit. The walls of the tank are constructed with bricks and can be sealed or unsealed. The bottom of the tank is usually unsealed and covered with charcoal, allowing for more infiltration of sludge into the ground.



Latrine Tank Seen Above Ground.
Source: PSI Research Team



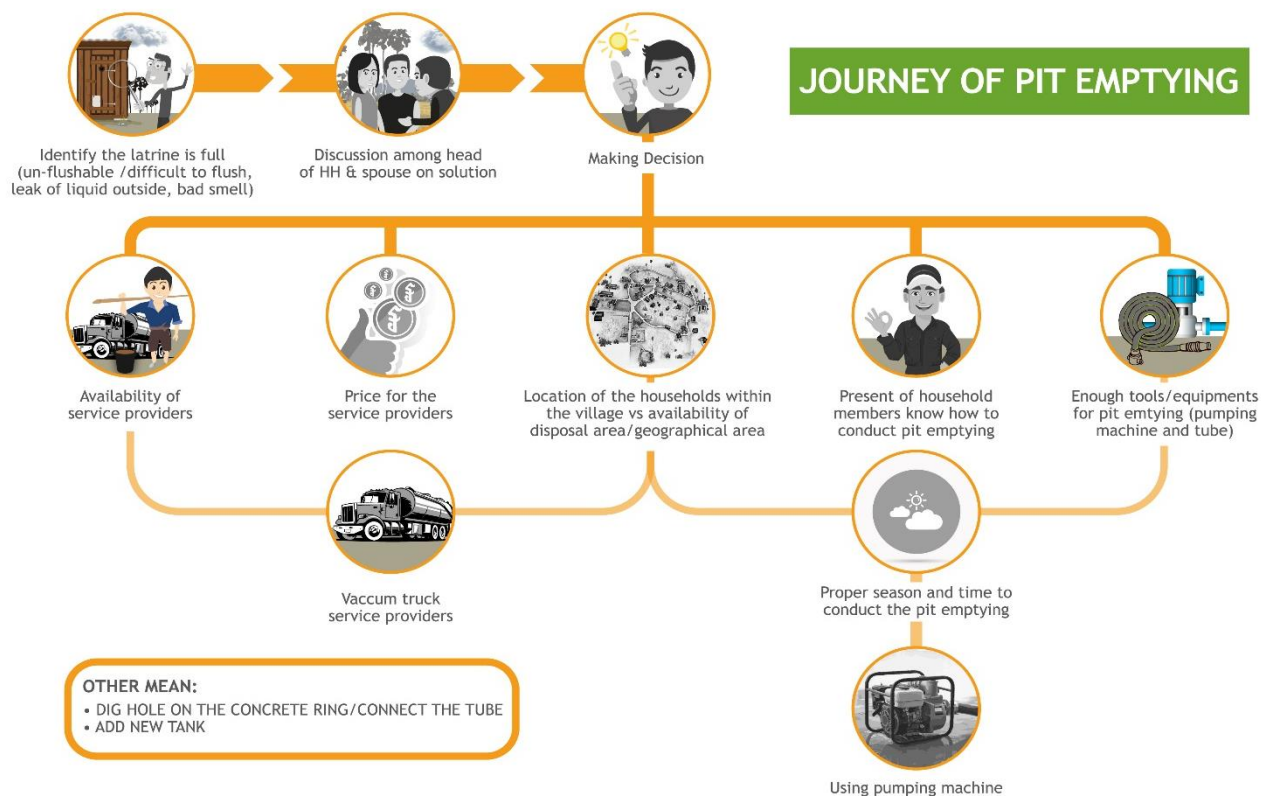
The average volume of tanks connected to latrines owned by rural households is calculated to be 5.66m^3 based on data gathered on tank lengths, widths and heights. The capacity of an average tank is more than twice the capacity of an average pit in terms of sludge containment.

Latrine Types by Socio-economic Status

There is difference in the relative popularity of the two latrine models across wealth quintiles. The percentage of rural households that own pour-flush latrines connected to tank rises steadily as the wealth quintile moves from poorest (8.9%) to richest (23.8%). The richer the households, the more likely that a higher percentage of them own pour-flush latrines connected to tank.

This socio-economic difference in the proportion of households that own the tank model vs. the pit model might be explained by different characteristics of the two latrine models. Because the pit is constructed with stacked concrete rings, the cost of installing the pour-flush latrine connected to pit is largely a function of the number of concrete rings. As shown in **Table 4**, households that purchase the pit model have a wide range of number of concrete rings to choose from and thus have more flexibility in controlling how much they pay for the latrine. On the other hand, the pour-flush latrine connected to tank provides less such flexibility. The tank is not sold by component parts such as concrete rings but rather must be purchased and built as a whole. The tank is also higher in average volume than the pit. Households that purchase the tank model have less power to control the cost of the latrine based on their affordability. Therefore, the pour-flush latrine connected to pit might appear a more desirable option for poorer households, while a higher proportion of richer households would choose the pour-flush latrine connected to pit.

Current Practices of Pit Emptying and Barriers



The pit emptying decision-making process is mapped out above to illustrate how pit emptying perceptions and knowledge turn into practices and outcomes. The “journey of pit emptying” begins with the household’s identification that their latrine is full and needs to be emptied. The head of household and their spouse engage in a discussion about how to address the issue. Depending on the availability of disposal area, the household either tries to find a pit emptying service provider or to conduct the emptying independently. Other important factors the household considers are availability and price of the service provider as well as their own skills and equipment.

Overview

34% of rural households had past experience dealing with a full latrine (**Figure 6**). Most of them addressed the issue by emptying the containment system to different extents.

As shown in **Figure 7**, more than 60% of these households removed some amount of sludge from the containment system. Households that “emptied pit for long-term

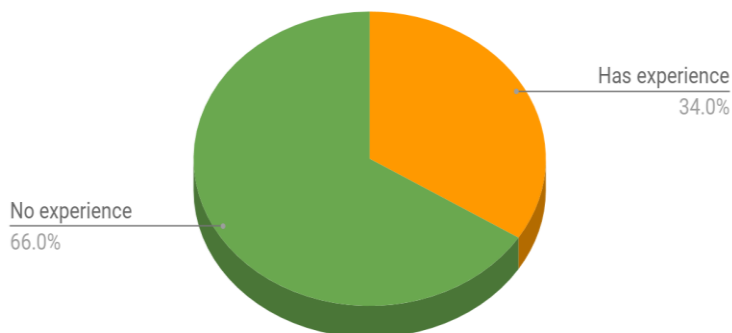


Figure 7 Household's Experience with Full Latrine

use” removed all feces and liquid content from the latrine through vacuum truck services, manual emptying, or pumping machines. The percentage of households that conducted such pit emptying was somewhat over 30% across all geographical areas.

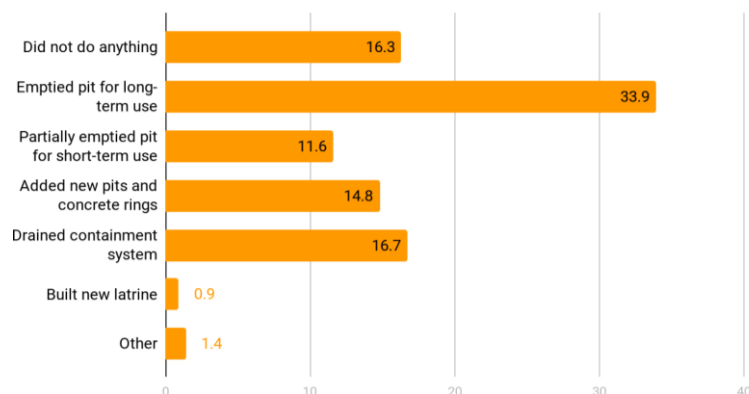


Figure 8 Actions Undertaken by Households to Deal with Full Latrine

flow sludge out to open spaces when rain or flood comes.

Households that “drained containment system” connected their latrine containment system to a pipe through which liquid flows to nearby rice fields or other open areas. This practice poses high risks to the environment and to public health as it allows wastewater to flow into open surface areas without any treatment.

15% of rural households that had experience with full latrine chose to extend their latrine containment system by adding new pits or concrete rings instead of emptying. This choice is especially common in flooded areas, where 46% of the households extended their latrine containment system compared to 9% in non-flooded areas and 23% in highland areas.

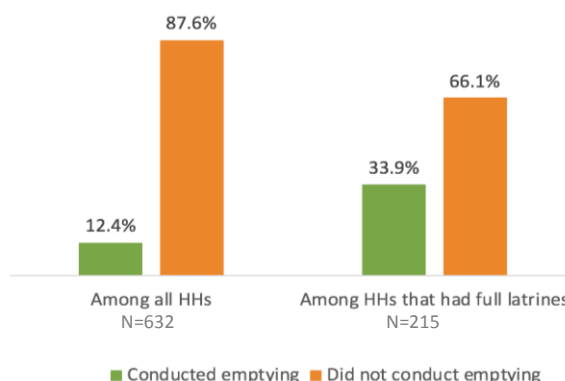


Figure 9 Percentage of Households That Have Conducted Pit Emptying

Few households chose to build a new latrine or engage with other practices. Notably, 16% of rural households that experienced full latrines did not do anything to address the issue. They would refrain from use of the latrine and passively wait for the level of sludge to fall when dry season comes.

Overall, 12% of rural households have conducted pit emptying, which is defined in the present study as the emptying of a significant amount of sludge for long-term use of the latrine (**Figure 9**). The percentage rises to 34% among the subset of rural households that reported ever experiencing their latrines being full, while the other 66% did not conduct pit emptying that allows

for long-term use but rather resorted to other means to make the latrine function again in the short term.

In addition to geographical factors, socioeconomic factors also seem to be at play in terms of household's decision to conduct pit emptying or not. Households with multiple-pit latrines are significantly more likely to conduct pit emptying than those with single-pit latrines, a difference that turns out to be driven by the households' wealth. 88% of the households that owned single-pit latrines have ID poor, while the percentage is significantly lower for households that own multiple-pit latrines. Households that own multiple-pit latrines generally tend to be able to afford more sanitation products and services compared to households with single-pit latrines, and therefore are more likely to purchase pit emptying services or equipment.

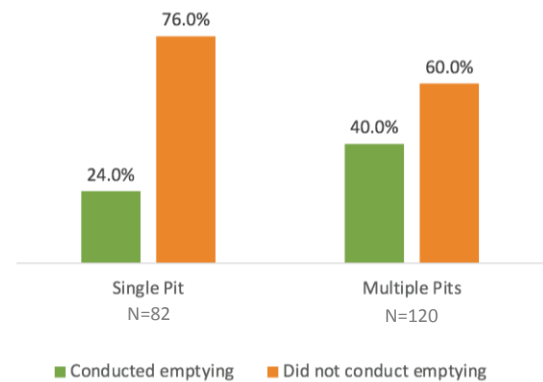


Figure 10 Percentage of Single or Multiple-Pit Latrine Owners That Have Conducted Pit Emptying

Common Pit Emptying Practices

Among rural households that have conducted pit emptying, 54% of them hired some type of service provider. The other 46% of the households had skilled household members conduct the pit emptying (Figure 11). The most popular pit emptying practices are hiring vacuum truck service provider and using household's own pumping machine.

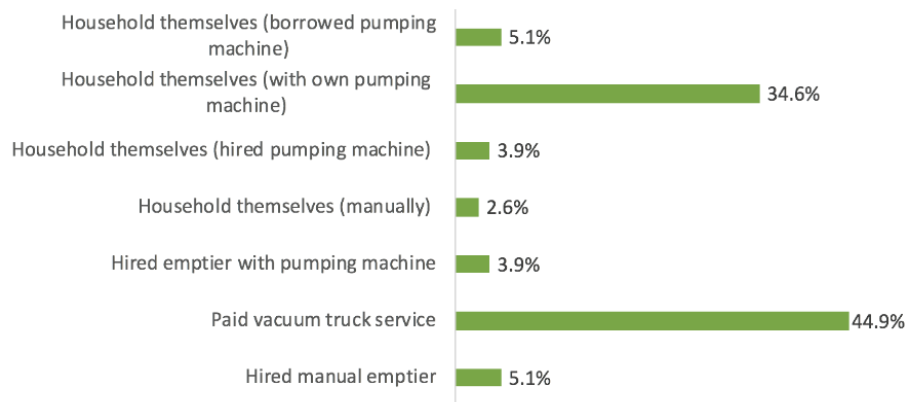


Figure 11 Pit Emptying Solutions Commonly Chosen by Rural Households

Previous understanding of rural FSM needs was that pit emptying services provided vacuum trucks are extremely rare and usually dismissed by households due to high prices. Survey results from the present study show quite the contrary. Across geographical areas and socioeconomic statuses, almost half of all rural households that conducted pit emptying have chosen vacuum trucks as their pit emptying solution. Vacuum trucks appear to be a competitive and desirable option in the rural FSM market.

Popular pit emptying practices differ by geographical areas

In flood-prone areas, commonly rural households (45.5%) conducted self-pit emptying with pumping machines. Hiring a service provider to empty with pumping machine (18.2%) or

borrowing/hiring a pumping machine to conduct emptying independently (36.4%) were also popular practices. On the other hand, none of the households in flood-prone areas sought vacuum truck services or engaged in hired or independent manual emptying.

In non-flooded and highland areas, a majority of households (51.7% and 57.1%, respectively) used vacuum truck services. Using their own pumping machines to empty independently is the second most common option (33.3% and 28.6%, respectively). In contrast to flood-prone areas, little or none of the households in either non-flooded or highland area hired a service provider that operates pumping machine or used a hired or borrowed pumping machine to conduct emptying independently, while some households in non-flooded areas (5%) or highland areas (14.3%) hired service providers to conduct manual emptying.

Analysis of Pit Emptying Decisions in SaniFOAM Framework

SaniFOAM behavioral determinants that significantly influence pit emptying decisions are access and availability, skills and self-efficacy, willingness to pay, and social norms. **Table 7** compares the characteristics of three main pit emptying options and examines what motivates or discourages households from choosing each of them.

Pumping Machine is highly accessible and inexpensive. Many households already have the equipment and operating skills from agricultural practices. It is the most popular option: more than 35% of households that have conducted pit emptying choose to use their own or a hired pumping machine (**Figure 12**). Pit emptying with pumping machine is usually conducted during rainy season for avoidance of bad smells and convenience of disposal. Sludge emptied with a pumping machine is usually disposed on-site into nearby farmlands and other open areas open areas. For this reason, households located on the outskirts are more inclined than households located at the center of a crowded village to use the pumping machine because they have more space available for disposal.



“People prefers doing it at night time because no one can see it and the shelter is not crowded. It also helps to avoid breaching the strong smell to other people.”

“It (Pit emptying with pumping machine) is similar to pumping water to rice fields. We need to pour some water and stir the sludge with a long stick first, and then we pump. That's it.”

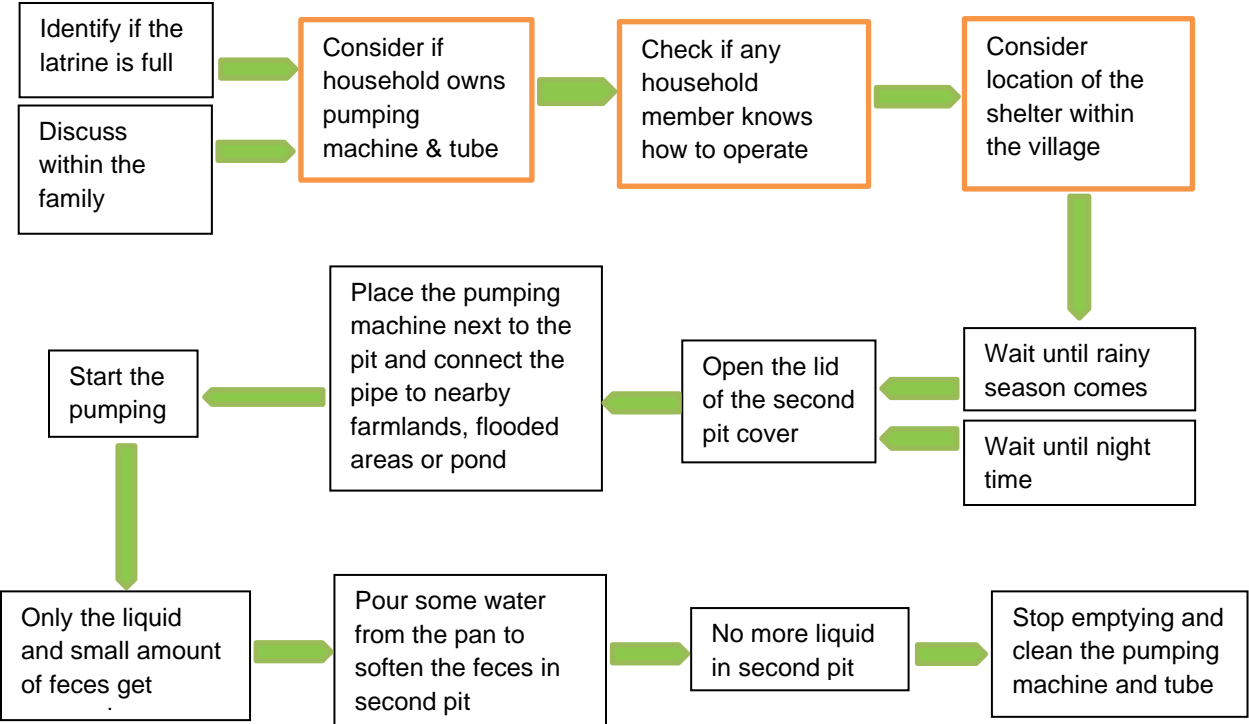


Figure 12 Process of Pit Emptying with Pumping Machine

Manual Emptying varies in access and availability depending on the specific rural community. Manual emptying is rarely conducted by the household themselves because it is considered dirty job. Service providers are rare and mainly operate in their local communities without travelling to provide services elsewhere. Manual emptying is more expensive than pumping machine but cheaper than vacuum trucks. The strong smell and unhygienic nature of manual emptying makes it undesirable in terms of social norms. Only 3% conducted manual emptying by themselves, and only 5% used manual emptying service providers.




Vacuum Truck is only available in district-level or provincial towns and charges extra when travelling to further to areas. It is the most expensive option, but the service is convenient, clean, and quick and the level of customer satisfaction is high. 45% of all rural households that conducted pit emptying chose to hire a vacuum truck service provider. Vacuum truck services are more popular in non-flooded and highland areas. Promotion of vacuum truck services is rare in rural areas. Most households obtain the service after seeing vacuum trucks provide service to other households in the village.



“I saw the vacuum truck come to my village to provide service to other households. My latrine was full, so I asked them to vacuum mine too.”

“Vacuum trucks only come when there are many households buying the service. If only one household calls, they won’t come.”

Table 5 Comparison of Pit Emptying Options

	Pumping Machine	Manual Emptying	Vacuum Truck
Overview	 <p>Used to pump mostly liquid from an easily accessible pit of the latrine. The pumping machine, if owned by household, is normally used for pumping water into rice field. It is usually done at night during rainy season.</p>	 <p>Usually conducted by service provider. Latrine is fully emptied of all sludge and liquid.</p>	 <p>Only conducted by service provider. Latrine is fully emptied of all sludge and liquid.</p>
Motivators	<p>Practice is inexpensive - most households already own the pumping machine and only pay for the gasoline.</p> <p>Practice is easy to carry out - usually a household member is skilled to do it, and the emptying only takes 30 minutes.</p> <p>The household is located where there is open space to dispose the sludge.</p> <p>Other options are inaccessible - long distance from district or provincial town.</p>	<p>Manual emptying operators are present in the community.</p> <p>There is mistaken perception that no other service is available - that the vacuum truck only provides services to more than one household.</p> <p>Service is relatively inexpensive - cheaper than vacuum truck.</p> <p>Emptied sludge is available for reuse.</p>	<p>No household member has skills or equipment to conduct pit emptying.</p> <p>Household has seen other households obtain vacuum truck services.</p> <p>Household does not have space to dispose the emptied sludge from using other emptying options.</p> <p>Service is clean and quick - no risk of breaching smell to neighbors or visitors.</p>
Barriers	<p>Only the second pit of the latrine can be pumped. Only the liquid content of sludge gets removed.</p> <p>The emptying is temporary and has to be conducted each year for latrine to continue functioning.</p> <p>There is lack of surface water or</p>	<p>There are few manual emptiers in the community.</p> <p>Constant strong smell might be breached to neighbors during emptying.</p> <p>There is limited space to</p>	<p>Service is only available in district or provincial towns.</p> <p>Service is very expensive - about \$33 per emptying on average.</p>

	<p>rice field nearby to dispose the pumped liquid.</p> <p>The smell might be breached to neighbors during the pumping.</p> <p>They need to wait until rainy season.</p>	<p>dig a hole for disposing emptied sludge.</p> <p>Household is unable to cover the hole used to dispose emptied sludge.</p>	
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Barriers to Pit Emptying and Alternative Solutions

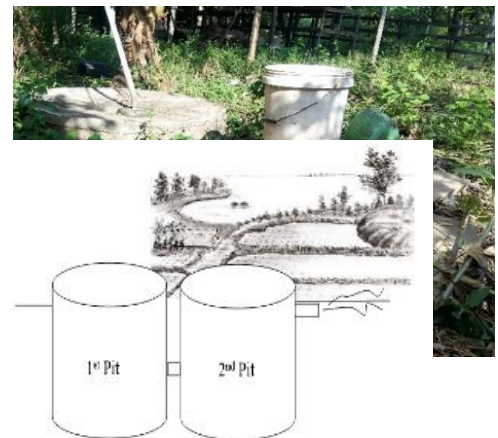
Based on the findings, there are some barriers for households to empty pits and explore alternative options within or outside their community.

- 66% of the households that had full latrines decided not to conduct pit emptying. **Barriers to making the pit emptying decision include lack of knowledge and skills, lack of disposal area, low affordability for services and equipment, and negative social norms.**
- 75% of households that have not conducted pit emptying have the misperception that their latrine would never be full. Only 37% of the households that did not conduct pit emptying know where to find pit emptying service providers in their community.
- Many households find vacuum truck service too expensive and do not have access to other service options. There is a popular misconception that service providers would only come for multiple households, which further discourages individual households from seeking services. At the same time, many of these households do not have the skills, equipment OR manpower to conduct pit emptying by themselves.

These barriers are closely linked with the key determinants of pit emptying in the SaniFOAM framework, which will be explained in detail in the next section.

Households that decide not to conduct pit emptying commonly resort to the following alternative solutions:

- **Partial emptying** is the practice of household that opens the lid to remove liquid from the latrine containment system. It is most commonly used in non-flooded areas and by households that own twin pit latrines, for whom it is relatively easy to open the second pit. Small amounts of liquid are removed with buckets and usually reused for agricultural purposes. Households are aware that the practice only allows for temporary use of the latrine. After removing a few buckets of liquid, the household is able to use the latrine for two or three days until it stops functioning again and the same process must be repeated.



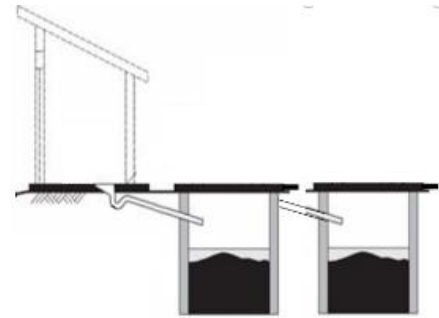
- **Draining containment system** is the practice of making a hole on the concrete or connecting a pipe from the latrine containment system to flow sludge to rice fields and other open areas. Households that adopt this practice are able to use their latrine for longer periods of time and often do not resort to any more solutions. They perceive additional benefits that the effluent can be rich fertilizer for their land. However, the effluent can also emit strong unpleasant smells, especially when the wind blows.



“When the latrine cannot flush, I tell my son to make a hole on the concrete to flow the liquid out...and I use this liquid to water the crop.”

“Before I usually take the liquid out by hand, but now I just flow it through a pipe to fields.”

- **Building additional tank** is the practice of expanding the capacity of the latrine containment system by installing an additional tank. The additional tank is connected in series with the original containment system. Liquid is released from the previous pit when the sludge reaches the level of the connecting tube. The tank has unsealed brick walls and uncoated bottom layered with charcoal, a design that allows for more infiltration of liquid into the soil and lowers the filling rate. At \$30 USD, the tank is similar in price or cheaper than most pit emptying services. Households think it is a reasonable price since the additional tank can contain more sludge for many years. The practice is currently not widely adopted but only seen in flood-prone areas where it is commonly recommended by local masons. Households that do adopt the practice are highly satisfied with the outcome.



“I have added this tank for around a few years and there is no sign of it filling up at all. In dry season, I open the lid and do not see any liquid inside. I can see some during wet season.”

“If we empty it (the latrine), we would have to do it again and again but if we add a tank like this, it lasts for another 10 years since it does not fill up easily.”

- **Directly flowing sludge out** is a practice unique to flood-prone areas and especially households near river banks. When the flood season comes and when water level of the river rises, the household would open the lid or twist open the tube at the near bottom of the containment system to flow the sludge directly into the water. It is common practice within communities of flood-prone and river areas to flow out sludge like this every year. Such regular practice ensures that their latrine never needs to be emptied.

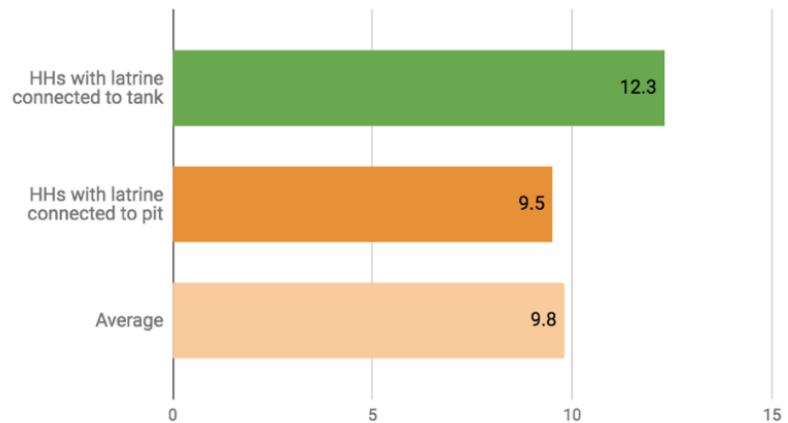
In general, most of the popular alternatives to pit emptying are unsafe FSM practices that involve discharging untreated sludge containing pathogens, viruses and other contaminants directly into food crop fields, surface waters, plantations and other surface areas.

Key Determinants of Pit Emptying Decisions

Attitudes and Beliefs towards Pit Emptying

On average, households perceive their latrine to last for 9.8 years before the containment system fills up and sludge must be removed. Compared to the average filling time calculated from the average filling rate of latrine (3.3 years), the households' perception of their latrine's filling time tends to be overly optimistic. An implication is that some households would find their latrine to be full without previously expecting or planning for the situation.

Figure 13 Perception of Latrine Life Span Before Latrine Fills Up (Years)



Owners of tank models perceive their latrines to be significantly more long-lasting before filling up than owners of latrines connected to pits (**Figure 13**). The comparison is consistent with previous findings on the higher average volumes of tanks compared to pits.

This figure suggests that households' demand for pit emptying or some kind of partial sludge removal arises about a decade after their initial purchase of the latrine. Given that latrine coverage has significantly grown in the past decade and continues to grow, rural demand for FSM can be expected to keep rising in the foreseeable future.

Almost all rural households perceive pit emptying of full latrine as important. The households are aware of latrine is full when flushing becomes difficult. Most households value pit emptying for two main reasons: more than 80% reported that they simply need to make the latrine function again, and more than half are motivated by the desire to control bad smells.

17% of the households reported that they want to make their household area looks clean to themselves and visitors. About 13% of the households think it is important to empty full latrines in order to prevent diseases. Interestingly, 5% mention that they simply don't have land to flow the latrine content out into the open, suggesting that they see it as acceptable practice to flow out feces during rain or flood.

Knowledge on Latrine Characteristics

Knowledge is the most basic prerequisite for making the decision to conduct pit emptying. The household decision maker uses their knowledge to identify if the latrine is full and to evaluate pit emptying as a solution. In some cases, knowledge about latrine characteristics is also important. The household decision maker would consider if the bottom of their latrine containment system is sealed to determine the necessity of emptying.

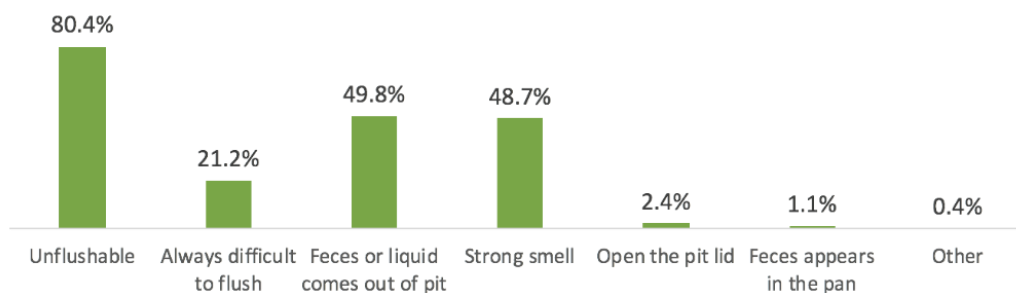
Most of the households reported that they are able to identify if their latrine containment systems are full. The main indicators used to make such judgments are latrine malfunctions such as the latrine being difficult to flush, leaking contents, or emitting strong smells (**Figure 14**). These indicators are commonly identified in quantitative surveys as well as qualitative interviews.



“I tried to flush the toilet with water, but the feces were still there and could not be flushed down anymore.”

“When my latrine is full, there would be bad smells from the bleached areas because when we flush the toilet the pit content would come out.”

Figure 14 Main Indicators to Identify Full Latrine



In qualitative interviews, owners of twin pit latrines reported that they would be able to identify if their latrine is full because liquid leaking out of the second pit through holes on the lid would be visible. Sometimes households would open the lid of the second pit and directly observe the level of sludge. Owners of twin pit latrines never check the first pit since they know it is designed to stock sludge and would be inconvenient to open.

There is no significant difference in how households identify full latrine across geographical areas.

For 80% of the households, knowledge on identifying full latrine comes from past experiences of their own or their neighbors and relatives'. The other 20% rely on guessing to estimate when their latrine would fill up. Few households reported attending related workshops or training before (Figure 15).

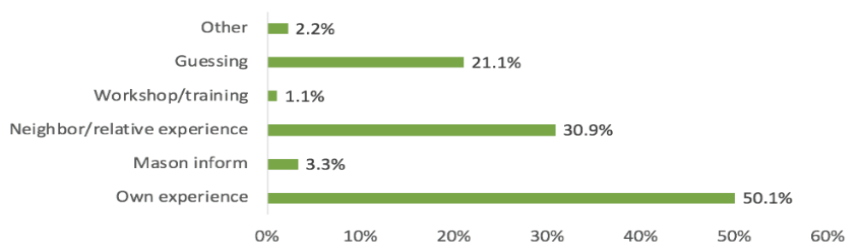


Figure 15 Sources of Knowledge on Identifying Full Latrine

Roles and Decisions on Pit Emptying

A majority of households reported that the head of household or the spouse is the decision maker on whether the latrine should be emptied. Most of the households identified their heads of households to be male. Gender does not turn out to play a significant role in the decision-making process, as no significant difference was found between the pit emptying decisions of households with male heads and households with female heads.

Social Norms

Social norms significantly influence the household's pit emptying decision. The decision maker is less likely to prioritize pit emptying if the household lives in a community where few members conduct pit emptying. Only 11% of rural households think it is common to practice pit emptying within their community. 80% of rural households know only a few or no households that have ever conducted pit emptying.



“Here in this community, people are not concerned with pit emptying because if the pit is full, they just lift the lid, take the liquid out and use it on plantations.”

Sanctions and Enforcement of Pit Emptying

96% of rural households perceive no bans or restrictions from local authorities regarding pit emptying. Sanctions influence the pit emptying decision mainly through the household's own concern about their neighbors' judgments if they do not conduct pit emptying. Especially in crowded shelters, the household worries that the bad smell from full latrine and the leakage from the pit to the surface would affect their neighbors. Some of the households mentioned receiving complaints from neighbors as penalty for not conducting pit emptying. The household does not want to breach the smell and lose their household's face.



“I decide to empty the latrine because I am afraid when there are visitors and when our latrine is full, it will be difficult to use it. I am also afraid of breaching the smell to my nearby neighbor.”

“The water from the pit has bad smell especially when the wind blows. Our neighbor never blames us face to face, but they might blame us behind.”

Affordability of Pit Emptying Services

Even faced with a range of options, the household might decide not to conduct pit emptying because they cannot afford the services. Vacuum truck services are generally considered expensive by rural households. Prices vary from 90,000 KHRs (22.5 USD) to 120,000 KHRs (30 USD) depending on the number of customers. In the case that one truck cannot fully empty, the household would have to pay double. Pumping machine service is cheaper than vacuum trucks but still considered pricey.



“It cost me 90,000 KHRs for each time the truck came to provide the service, and for my latrine the vacuum truck needed to come twice. I spent 180,000 KHRs in total for the pit emptying at that time.”

“There is the service provider in Chambak Commune who uses the pumping machine to empty the pit. The cost is 80,000 KHR each time. It is expensive.”

Skills & Self-Efficacy to Conduct Pit Emptying

At least two (usually male) skilled members of the household are required in order to conduct pit emptying independently. Households are discouraged from conducting pit emptying when they do not have the skills and/or equipment to empty by themselves. Households that reported having household members who know how to empty are more likely to conduct pit emptying and especially with pumping machine compared to households with no such resources.

Location of the Household

Beyond the SaniFOAM framework, where the household is located in a rural community also influences the household’s decision to conduct pit emptying or not (**Figure 16**). Location of the household determines the availability of disposal areas, which in turn determines the range of possible pit emptying options. 93% of rural households reported that there is no properly designated area for them to dispose the sludge after they conduct pit emptying. On-site disposal happens in farmlands. Thus, households located in the middle of a crowded village have very limited options for pit emptying. Because they are far from rice fields and other disposal areas, using pumping machine or draining the containment system are not viable options. Vacuum trucks are often considered too expensive. The only choice left for households in this situation is to extend the containment system with additional concrete rings or tanks.

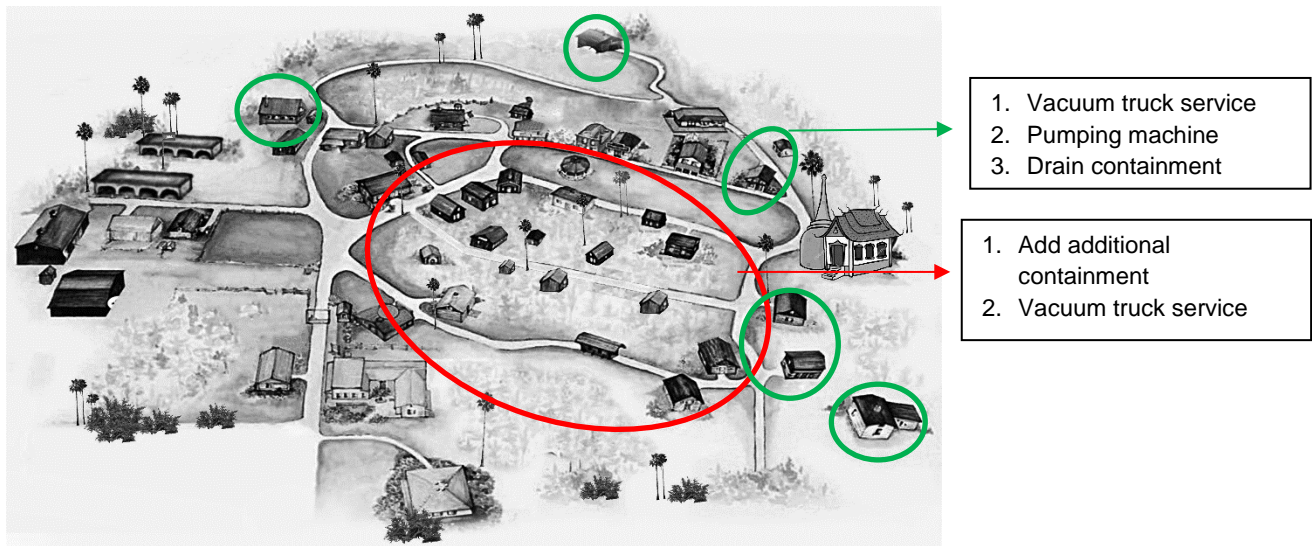


Figure 16 Household Location and Pit Emptying Options

“How can we manage pit emptying with pumping machine? We’re not like that household just next to the rice field. For us, we need a very long pipe that is about 200 or 300 meters. We cannot afford that.”

On the other hand, households near the outskirts of the village have more pit emptying options to choose from. Most of these households find it most affordable and practical to use pumping machine since they are located near available disposal areas.

Personas of Pit Emptying Doer vs. Non-Doer

Personas of a typical pit emptying “doer” – a household decision maker that decides to conduct emptying – and a typical pit emptying “non-doer” were generated from qualitative interviewees’ profiles. Fake names and personal information are used for each persona.

Doer



Vibol is the head of household in a family of five. He is 34 years old. His family does not have ID poor and is relatively well off in his village. One day, Vibol discovers that the latrine cannot be flushed any more. From his past experience, he knows that both pits of the pour-flush latrine that the family uses are probably filled up. He notifies his wife of the situation, and the two of them discuss how they want to deal with the full latrine. Although Vibol knows how to manually empty the latrine, he is reluctant to do it because he thinks it is inconvenient and dirty. Having \$30 USD on pit emptying service the last time their latrine was full, Vibol and his wife decide that they are willing to pay a service provider to conduct the pit

emptying again. Vibol remembers that he has seen a vacuum truck company from a nearby provincial town provide services to his neighbor in the village. On the next day, he calls the vacuum truck company to request a truck to come in the afternoon. He is satisfied with the cleanliness and quickness of the service. He ends up paying \$33 USD for it, and the latrine is now functioning again.



Non-Doer

Dara is also the head of household in a family of five. He is 32 years old. His family is not so well off and has ID poor. The family purchased their first latrine 9 years ago – a pour-flush latrine connected to a single pit. They have never considered what they would do when the pit fills up. One day, Dara’s wife goes to the latrine to wash clothes and smells something really unpleasant. She realizes that liquid is leaking out of the lid of the latrine pit, which is the source of the bad smell. She tells Dara and they decide that their latrine is full, and the pit needs to be emptied. However, no one in the family even knows how to begin with the pit emptying. They don’t know anyone in their village that could be paid to manually empty the pit for them. Dara does know about vacuum truck services, but since they’re far from the provincial town, he does not think any company would send a truck just for one household. No one in the village really knows or cares about pit emptying. In order to continue using the latrine, Dara and his wife end up deciding to connect a pipe from their pit to the nearby rice field. The sludge flows out into the land as fertilizer, and they are glad to find that they can use the latrine again.

The Pit Emptying Service Market

About half of the households that conducted pit emptying chose to pay for some type of pit emptying service. There is an existing pit emptying market and making this market more efficient and services more affordable benefits both sides: consumers obtain more desirable pit emptying services at cheaper prices, while providers face more stable and robust demand. Furthermore, standardized operations reduce the health risks associated with pit emptying. In order to eventually reach sustainable market-driven solutions, the first step is to understand how the market currently functions.



“I really want to empty my latrine, but I cannot have it because it is not like the urban area. We do not have the service provider like that.”

Consumer Knowledge

What do consumers know about the services?

40% of rural households know where to obtain pit emptying services. The percentage rises to 62% among the subset of households that have conducted pit emptying. The percentage drops to 37% among the subset of households that have not conducted pit emptying. There is a significant difference in knowledge of pit emptying services between “doer” households and “non-doer” households.¹⁴ The best-known pit emptying service type is vacuum truck. 38.4% of all households are aware that vacuum trucks provide emptying services. Again, “doer” households are more likely to be aware of vacuum truck services than “non-doer” households.

The discrepancy in knowledge between doers and non-doers highlights the need to promote safe pit emptying services. The current lack of consumer knowledge creates inefficiencies in the market, where households with demand for pit emptying services are not connected with the supply of such services.

Access/Availability of Services and Households’ Affordability

Are services accessible and available? Can consumers afford them?

Table 6 shows that all services involving human labor are significantly costlier than equipment rental. Since pumping machine is relatively easy to operate, many households would rather rent the equipment at a significantly lower rate and do the emptying themselves than hire someone to do it at a much higher price.

Table 6 Average Distance and Price of Each Pit Emptying Service Type

Type of Service Provider	Average Distance (KM)	Average Price
Manual emptier	11	147,727 R (36.9 USD)
Vacuum truck	20.4	159,473 R (39.8 USD)
Hired emptier using pumping machine	4.7	117,142 R (29.3 USD)
Pumping machine rental	1.1	17,676 R (4.4 USD)

- **Manual emptiers** are closer to consumers since they operate on a more local level. However, manual emptying services are disorganized and extremely rare. Even in communities with manual emptiers, demand and supply can still misalign due to negative social norms around the job. Consumers worry that asking a worker to provide manual emptying services might be construed as insulting.
- **Vacuum trucks** are farther from consumers by more than twice the distance compared to other local service providers but the best-known option among rural households. They are organized business reputed for the cleanliness and efficiency of service. Vacuum

¹⁴ A “doer” household is a household that has conducted pit emptying. A “non-doer” household is a household that has not conducted pit emptying.

trucks are highly visible when providing service in a village, which encourages households with pit emptying demand to seek the service on the spot.

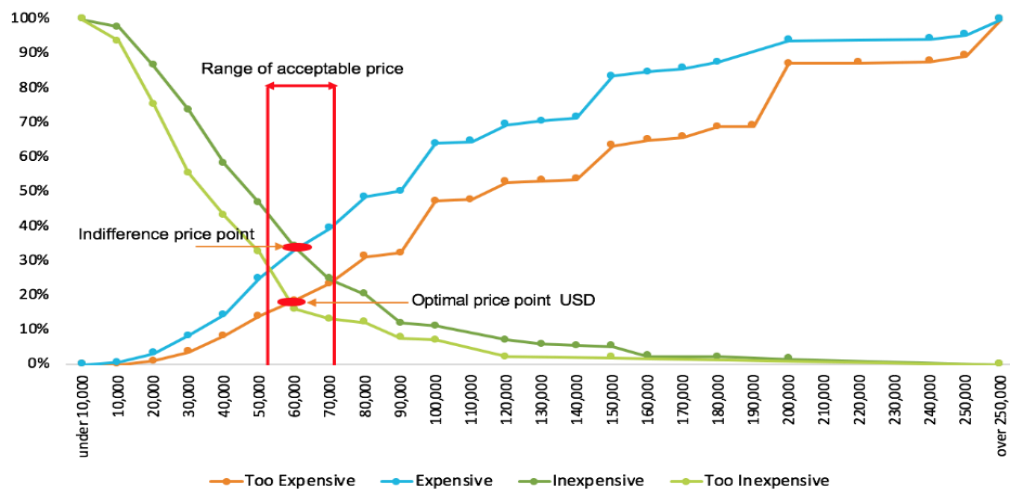
- **Service providers using pumping machines** have only been identified in flood-prone areas where the pumping machine method is most popular. They operate at the commune level. None of the households interviewed in the present study reported hiring service providers that use pumping machines.

Willingness to Pay

Even if households can afford the services, are they willing to pay for them? What prices would they accept instead?

In the general absence of affordable and safe pit emptying services at scale, vacuum truck has the most potential to expand in the rural pit emptying market. Vacuum truck service's relatively

Figure 17 Willingness to Pay for Vacuum Truck Emptying Services Among All Rural Households



high availability, satisfactoriness and organized business models are its advantages. However,

Table 7 Willingness to Pay for Vacuum Truck Services by geographical areas

Geographical Area	Optimal Price Point	Acceptable Price Range
Flood-prone	79,000 Rs (19.8 USD)	60,000-90,000 Rs (15-22.5 USD)
Non-flooded	57,000 Rs (14.3 USD)	49,000-69,000 Rs (12.3-17.3 USD)
Highland	75,000 Rs (18.8 USD)	59,000-84,000 Rs (17.8-21 USD)

the biggest problem with vacuum trucks is that it's too expensive for rural households.

Table 8 Willingness to Pay for Vacuum Truck Services by geographical areas Wealth Quintile

Wealth Quintile	Optimal Price Point	Acceptable Price Range
Poorest	60,000 Rs (15 USD)	50,000-70,000 Rs (12.5-17.5 USD)
Poor	59,000 Rs (14.8 USD)	49,000-70,000 Rs (12.3-17.5 USD)
Medium	60,000 Rs (15 USD)	50,000-78,000 Rs (12.5-19.5 USD)
Rich	62,000 Rs (15.5 USD)	52,000-78,000 Rs (13-19.5 USD)
Richest	75,000 Rs (18.8 USD)	60,000-92,000 Rs (15-23 USD)

To understand the acceptable price range for vacuum truck service, each household was asked to provide four numbers: vacuum truck service price that they would find too expensive, expensive, inexpensive, and too

inexpensive, respectively. The graph above (**Figure 17**) shows the percentage of households that put different prices into each of these four categories. The acceptable price range for all households was found to be 52,000-72,000 Riels (13-18 USD). The prices that households find acceptable are less than half the current average price (33 USD) charged by vacuum truck service providers.

The same analysis was conducted on different geographical segments and wealth quintiles of the study population. Acceptable price ranges appear to vary by geographical areas and socioeconomic statuses. Households in flood-prone areas and highland areas are willing to pay more than residents of non-flooded areas (**Table 7**). Richer households are willing to pay more than poorer households (**Table 8**).

Service Provider Profiles and Practices

How are pit emptying services operated? What are the target client groups of each type of service provider? How do they dispose of the emptied sludge?

From qualitative interviews, we created service provider profiles of one typical manual emptying business and one typical vacuum truck business (**Table 9**). Each type of service provider faces a unique set of challenges.

Challenges for vacuum truck service providers:

- Competition. There are 4-5 other vacuum truck business in the province.
- Disposal of sludge. They sometimes need to ask for permission from local authorities to use dumping sites.
- Time sensitiveness. Some clients are inaccessible during rainy season.
- Equipment: the tube's length is sometimes not enough to reach a latrine located far inside a household dwelling where trucks can't enter.
- Health risks. There are concerns about health problems resulting from constantly being exposed to strong and bad smells.
- Price and value. Consumers complain about high prices and do not value the work.
- Irregular working hours. Business hours are completely based on calls from clients, and sometimes services have to be provided late at night.
- No proper regulation or license (operating guidelines) for vacuum truck to follow any standard operation procedure. Lack of supports in the private market for wastewater or sludge vacuum business.



Challenges for manual emptying service providers:

- Lack of recognition. Not a lot of people know about their service availability beyond the villages or the commune.
- Social norms. Some clients refrain from asking for services to not appear to “look down on” the service provider.
- Tools. Some households do not have the necessary tools that the service provider requests for the emptying.
- Safety hazards. The service provider faces the risk of explosion from reacted gas when the pit lid is opened.



Table 9 Service Provider Profiles

	Manual emptying provider	Vacuum truck provider
Business/work	Engage in multiple works such as construction worker or laborer. Provide manual emptying service based on call.	Pit emptying service is the core business. Provide service in both dry and rainy seasons.
Station	In village	In provincial town
# of members	2	2
Coverage area	Nearby villages	Areas within the province
Price	\$5 per concrete ring; +\$2.5 for households far from station	\$30 per trip for 3m ³ truck; \$50 for 5m ³ truck; +\$10 per 10 km for households more than 20 km from station
Arrival time	Immediately upon call	Around 3-4 hours after call
Duration of service	3-4 hours	30 minutes
Types of clients	Familiar households around nearby villages or friends of previous clients	Mostly guesthouses, restaurants and hotels in urban areas
Average # of clients	3-4 per month	3-4 per day
Tools	Bucket, hoe, shovel, gloves, crowbar	Crowbar, tube, tap, small bucket

Disposal Area	A hole is dug in the ground for disposal of sludge near the household. Additional cost is charged if the service provider does it and if the hole is farther than 30m from the latrine. The service provider advises the household to apply preliminary treatment to the sludge such as adding cow dung, kitchen waste and other compost materials.	The service provider pays for disposal into official dumping sites in certain provinces. In other provinces they ask for permission from local authorities to dump into rice fields of households that want fertilizer.
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Safety Evaluation of Service Provider Practices



None of the service providers observed in the field wore any protective masks, boots or gloves during vacuuming or emptying. Some sludge would spill out during manual emptying. Operators did not wash their hands or bodies with soap afterwards. All operators had direct exposure to sludge without wearing PPE. Unsafe pit emptying among service providers is an issue that needs immediate attention.

Current Practices of Reusing Sludge and Barriers

Reusing sludge is an important alternative to unsafe disposal and an under-researched component of the FSM chain. Reuse of sludge by agricultural households, when done properly, can be a solution to the environmental risks of unsafe disposal methods currently employed by pit emptying service providers.

Overview

16.5% of all 631 households that participated in the quantitative surveys identified that there is a household in their neighborhood reusing sludge for some purpose. Most of the identified households dump sludge in their tree plantations or rice fields as fertilizer (**Figure 18**).

7% of the households reported that they currently reuse sludge. Among households that have practiced pit emptying, 7.7% currently reuse sludge. Statistical analysis indicates that pit emptying does not significantly increase the likelihood of reusing sludge. The percentage of households that reuse sludge among households that have and have not conducted pit emptying is not significantly different.

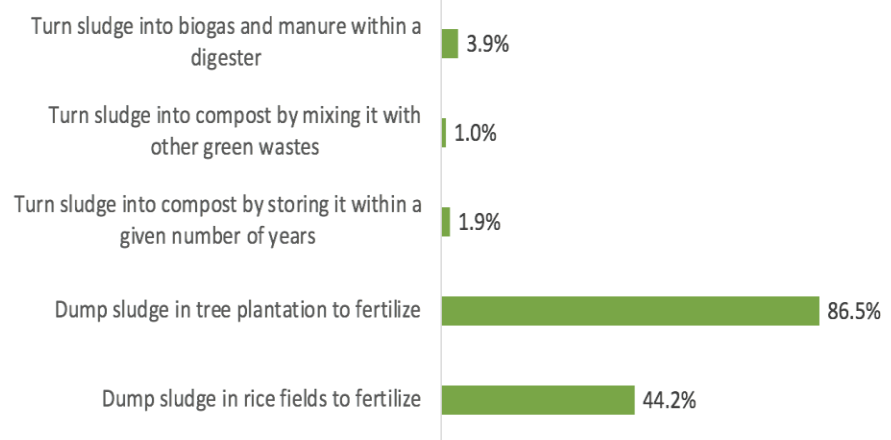


Figure 18 Sludge Reuse Purposes of Identified Households

Households that have experience reusing sludge in the past are significantly more likely to reuse sludge currently than households with no past experience. In addition, households that mentioned seeing other households within the community reuse sludge are significantly more likely to reuse sludge themselves. The findings suggest that promotion of safe reuse of sludge can have ripple effects within a community.

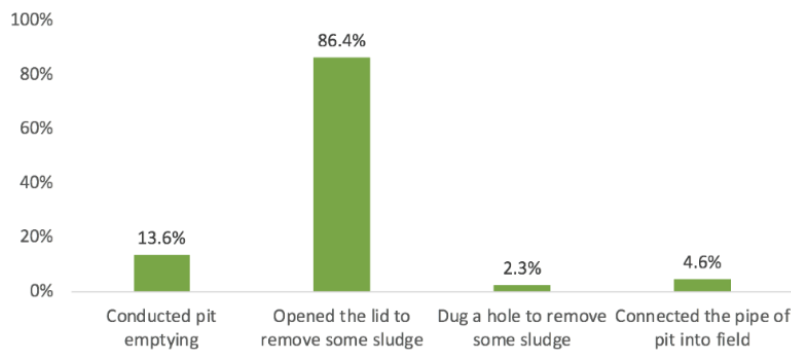


Figure 19 Ways of Obtaining Sludge for Reuse

Households' purposes of reuse are consistent with those of other sludge-reusing households they identified in the community, mainly to fertilize rice fields, vegetables fields or tree plantations. Almost all sludge-reusing households sourced the sludge from their own latrines. Most households did not conduct any thorough pit

emptying but rather opened the lid of latrine pit to remove whatever amount of sludge they needed for reuse (**Figure 19**). Most households do not have designated spaces to store the removed sludge to be reused. There is uncertainty if the sludge is almost immediately reused or rather placed in open areas around the fields for some period of time before reuse. A majority of the households directly reuse the sludge on their tree plantations or rice fields without any treatment. Most other households simply mix the sludge with water before reuse (**Figure 20**). There is a general lack of awareness and practice to apply proper treatment to reused sludge.

Across the three types of geographical areas, sludge is most commonly reused in non-flooded areas where 21% of 415 households reported ever reusing sludge, compared to 9% of 118 households in flooded areas and 12% of 98 households in highland areas. No identifiable variation was found in sludge reuse experience across socio-economic groups. Analysis on geographical or socioeconomic differences in more specific sludge sourcing, storage or treatment behaviors was limited by the extremely small sample size of households that reuse sludge.

Knowledge on Sludge Reuse

In quantitative surveys, 68% of all households reported that they know sludge is reusable. Their knowledge mainly comes from seeing other households reuse and experiencing reuse in the former Khmer Rouge regime. Some households also reported learning from other villagers in the community, discovering by themselves, or learning from NGO programs (Figure 21).

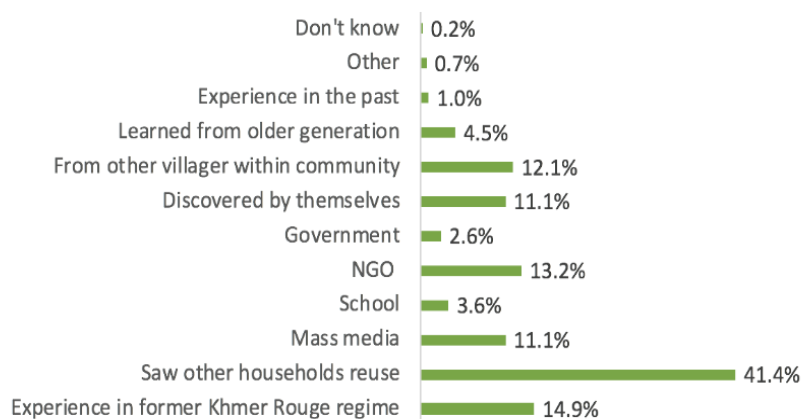


Figure 21 Sources of Knowledge on Sludge Reuse

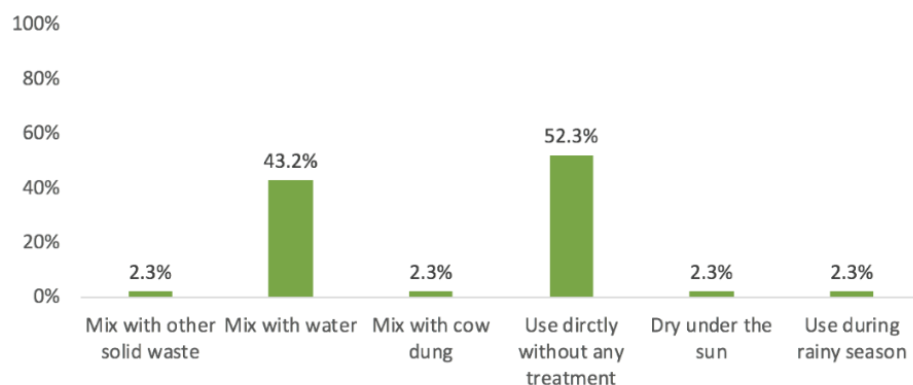


Figure 20 Treatment of Sludge Before Reuse

Similar sources of knowledge were emphasized in qualitative interviews. Some interviewees mentioned that they knew sludge as “the No.1 fertilizer” back in agricultural groups in Khmer Rouge time. Some interviewees have much experience with sludge reuse that allows them to quantify the effectiveness of sludge as fertilizer. They noted that the yield per acre would double and the soil would remain rich for a couple of years after applying reused sludge because it is just “so rich of fertilizer.”



“I used to be part in fertilizing group, during Khmer Rouge regime. Sludge is known as the No1 fertilizer. We need to collect the feces and mixed with soil from termite mounds, dry it first and deliver to drop into the rice field.”

Social Support for Sludge Reuse

Support programs for sludge reuse are effective but in need of further promotion. These programs are mainly aimed at raising awareness of the viability of reusing sludge for agricultural purposes. Only 6% of all households knows of such a program within their community. Only 6.5% of households have received some sort of training on sludge reuse. Nonetheless, programs aimed at raising awareness have been effective at promoting behavior change among the few households exposed to them. We found a significant difference between sludge re-users and non-re-users in terms of knowledge of such support programs. In other words, households aware of a program in their community encouraging sludge reuse are significantly more likely to actually practice it.

Attitudes and Belief towards Sludge Reuse

Perception of health risks related to reusing sludge is highly varied among households. Many households perceive no risk at all, while sizable proportions of households perceive risk levels ranging from low to high (**Figure 22**). Households living in flooded areas reported higher risk perceptions than households in other geographical areas. In terms of socioeconomic status, households in the poorest two quintiles perceive higher health risks in reusing sludge.

Perception of the health effects of sludge reuse is an important determinant of reuse behaviors. Households that perceive sludge reuse to be safer for human health are significantly more likely to practice it than those that perceive it to be riskier. Again, further development of awareness-raising programs

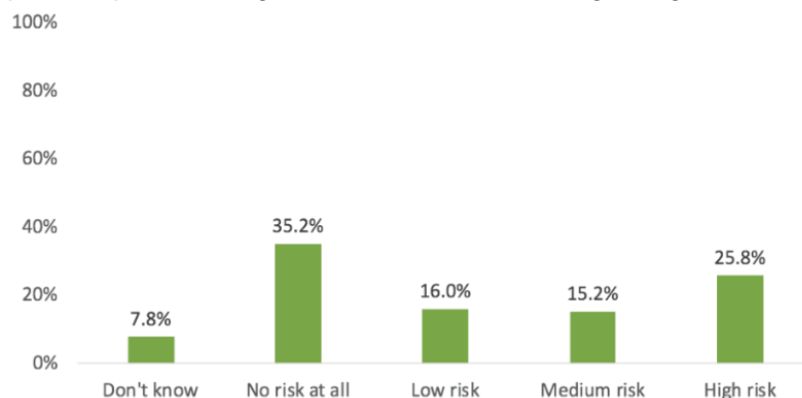


Figure 22 Perception of Health Risks Related to Reusing Sludge

can help establish consensus on the benefits and risks of sludge reuse and help households make informed decisions about whether to practice it.

Discussion and Conclusion

The findings confirm the previous assumption that there is a general lack of safe and affordable FSM solutions at scale in rural Cambodia. A majority of rural households neither know where to obtain pit emptying services nor have the skills or equipment to do it themselves, and thus are less likely to conduct pit emptying. Access/availability, social norms, affordability/willingness to pay and skills & self-efficacy are the main underlying determinants of rural households' pit emptying behaviors. Among rural households that do conduct pit emptying, vacuum truck services and pumping machines are the most popular options. Contrary to previous understanding, vacuum trucks appear to be a desirable and competitive option in some segments of the rural FSM market despite their high prices. Following pit emptying, decisions to reuse sludge are further influenced by the households' knowledge, the social support they receive, and their attitudes & beliefs. Practices along the FSM chain are generally unsafe and unregulated.

Future development of rural FSM in Cambodia should primarily focus on behavior change safe management and disposal of fecal sludge in rural areas, safe and affordable on-site solutions that households can adopt independently, while also exploring improved vacuum truck services for areas with relatively more market potential but requires operating standards, license and regulation. Development and implementation of solutions should always be guided by the key behavioral determinants to optimize outcomes in specific rural contexts.

Safety measure is required for pit emptying practices across all geographical areas. The private sectors and self-conducted pit emptying practice have identified risks associated health, which required a lot of more attention for the future precaution of both health-related risks and environmental damage. This requires trainings and capacity development for all stakeholders about the practices of sludge empty and technical support to service providers for such prevention measure.

Developing a regulation for sludge reuse, transportation and pit emptying to increase the precaution of health associated risks and to embrace MRD's ambitious goals of Universal access by 2025, it is vital important to adopt regulation/policy that can help to avoid conversion rate of sanitation in the rural context. Identified issues of sludge disposal into the nearby fields/dump sites are the evidence that the MRD's ambitious goals could be affected that has impact on conversion rate. This requires a lot of attention on the adoption of the legal framework/regulation and institutional capacity building to address such conversion rate issues. Wider attention from the national and local levels would bring the better coordination to address the issues of fecal waste disposal issues that need to have both adoptions of legal framework and strategic intervention. At the same vein, role and responsibilities need to be set up for a clear channel of structure and systematic intervention at national and provincial levels.

Lack of the official and unofficial dump sites identified from the survey is the key issues for future FMS practice and safety measure for health associated risk prevention. Many private or family based enterprises for pit emptying did not understand and know where sludge dump sites for dumping of the collected sludge and wastewater from vacuum trucks. Increasing understanding among those enterprises and allocating dumping sites or areas for wastewater treatment plant are important for addressing the issues of discharged pathogens into the fields.

Standard and minimum care of safety measure could strengthen the future FSM practices in the rural setting. Such measure would allow all levels of the Government and related stakeholders to be capable of addressing pit emptying practices and of increasing effective behaviors change intervention.

There is a lack of safe and affordable practices of the FSM at scale in rural Cambodia. A majority of rural households neither know where to obtain pit emptying services nor have the skills or equipment to have self-conducted performance of pit emptying. Willingness to pay and the cost of vacuum trucks are varying that does not meet the equilibrium. The rural households need the services at the lower price and the service providers demand at the high cost for pit emptying.

Recommendations

- 1) The future development of rural FSM in Cambodia should focus on promoting safe and affordable on-site solutions such as alternate latrine pits (twin pits) that households can adopt independently, while also exploring improved vacuum truck services for areas with relatively more market potential.
- 2) FSM in rural areas behavior change guidelines should be developed addressing the key behavioral determinants to optimize outcomes in specific rural contexts; addressing social norm towards unsafe practices including pit emptying, sludge reuse, and disposal.
- 3) Regulation/legal framework/policy and strategies development should be another main priority for addressing the issues of sludge reuse, transportation and treatment for control of private sector, economic incentive, investment, coordination, behavior change and financial mobilization; MRD and MPWT should start a dialogue to identify FSM solutions in different areas and coordinate institutional mandates and capacity.

Following table 11 gives some more details of relevant recommendations for the FSM practices in the rural context of Cambodia;

Table 11 Summary of Recommendations

Recommended Actions	Actors	FSM Chain Stage	SaniFOAM Determinant
Promote existing on-site treatment options such as the alternating twin pit latrine or cheap treatment materials such as lime that can be directly applied to emptied sludge. Increase desirability of such products in the market with financing mechanisms such as offering installment plans for ID Poor households.	MRD, NGO and latrine business	Containment	Access / Availability Affordability / Willingness to pay
Develop OHS or safety guidelines for service providers or households practicing manual emptying, vacuum truck emptying, and pumping machine emptying.	MRD and relevant ministries	Emptying & Transport	Sanctions & Enforcement
Monitor and develop capacity of vacuum truck business in areas with the most market potential. Launch pilot program with smaller and cheaper vacuum trucks offering flexible payment options such as group discounts or installment plans.	MRD and NGO	Emptying & Transport	Affordability / Willingness to pay
Establish effluent standards for different receiving bodies of water and fields. Develop guidelines on safe reuse of sludge in different agricultural settings and quality control of sludge-generated compost products.	MRD and relevant ministries	Disposal, Reuse	Sanctions & Enforcement
Follow OHS guidelines in service operations and observe safe disposal standards.	Service providers	Emptying, Disposal	Access / Availability
Organize public awareness and training programs on the necessity of regular pit emptying, the risks related to unsafe FSM practices and the benefits of sludge reuse. Identify innovators among households, local best examples of households managing FSM correctly to act as community influencers.	NGO and local authorities	All	Social Norms Social Support
Hold mandatory or highly encouraged training sessions on safe handling compliant with MRD standards (to be published) during emptying, disposal and reuse as well as on-site treatment methods available within the community.	NGO and local authorities	Emptying, Treatment, Reuse, Disposal	Skills & Self-Efficacy Social Support
Continue researching safe, smell-free and affordable on-site FSM solutions. Validate solutions with reliable laboratory testing of treated waste.	NGO	Containment, Treatment	Access / Availability
Promote positive social norms with social marketing campaigns establishing community goals of “build a safe and healthy environment” through safe emptying and disposal of sludge.	NGO and Local authorities	Disposal	Social Norms

Annex 1: Research Methodology

The SaniFOAM Framework

Research objectives for this study were designed around SaniFOAM, a framework that analyzes sanitation behavior through Focus, Opportunity, Availability and Motivation.

- “Focus” stands for defining *what* behaviors should be improved and *who* the target population is. This study focuses on pit emptying practices of rural households.
- “Opportunity” refers to the household’s *chance* to engage in pit emptying. This depends on external factors such as the existence of service providers in their accessible proximity, quality of the services, and any implicit or official promotion of pit emptying in the community.
- “Ability” refers to the household’s *capability* of actually engaging in the behavior of pit emptying. This depends on internal factors such as their knowledge of available resources, their specific pit emptying skills, how they make decisions in the household, whether they perceive the services as affordable, etc.
- “Motivation” represents the final incentive for households to take money out of their pocket for pit emptying rather than for some other consumer good. This depends on people’s attitudes and beliefs, values, consumption priorities, acceptable price ranges, etc.

Research Structure based on SaniFOAM Framework

Framework		Key Research Questions and Corresponding Answers
Opportunity	Access/ Availability (***)	What pit emptying options are available and accessible for households in rural communities? <ul style="list-style-type: none">- Vacuum truck and pumping machine emptying are most consistently available and accessible across geographical areas.- Manual emptying is inconsistent in access and availability. Many households regard it as obsolete practice.

	<p>Product Attributes</p>	<p>What are the characteristics of each pit emptying option and rural households' respective levels of satisfaction?</p> <ul style="list-style-type: none"> - Vacuum truck services, while more costly than rural households are willing to pay, are widely satisfactory due to their quickness and cleanliness. - Pumping machine is relatively inexpensive, accessible in terms of required skills and equipment, and thus also widely satisfactory. - Manual emptying is only slightly less expensive than vacuum truck services and sometimes perceived as undesirable by households because it is not so clean and takes a long time.
	<p>Social Norms (***)</p>	<p>Is it a common practice to conduct pit emptying and/or reuse sludge in the rural household's community?</p> <ul style="list-style-type: none"> - Perception of how much the household's community cares about pit emptying significantly affects the likelihood of practicing pit emptying. - Most households do not regard as common practice to conduct pit emptying or reuse sludge in their community.
	<p>Sanctions/ Enforcement</p>	<p>Are there legal frameworks to regulate pit emptying and sludge reuse?</p> <ul style="list-style-type: none"> - No household perceives any existing sanctions or enforcement on their pit emptying and sludge reuse behaviors.
<p>Ability</p>	<p>Knowledge</p>	<p>Do households recognize the necessity of pit emptying and the viability of sludge reuse?</p> <ul style="list-style-type: none"> - About 80% of all households think it is very important to conduct pit emptying when their latrine is full. - 60% of households that have conducted pit emptying know how to practice it by themselves. 28% of the other households that haven't conducted pit emptying know how to conduct pit emptying independently. - More than 60% of rural households reported knowing that sludge is reusable.
	<p>Skills and Self-efficacy (***)</p>	<p>Do households know how to conduct pit emptying themselves or to choose the most suitable pit emptying option?</p> <ul style="list-style-type: none"> - Most households reported not having the skills to conduct pit emptying by themselves. Many of them also lack technical knowledge about their own latrine or have misperceptions about service options that hinders evaluation of the most suitable pit emptying option.

	Social Support	<p>Are there any programs or community members that encourage pit emptying and sludge reuse?</p> <ul style="list-style-type: none"> - No programs encouraging pit emptying have been identified. In fact, a majority of households do not perceive that their community cares about pit emptying. - About 5% of rural households identified community-level programs that aim to raise awareness of the viability of reusing sludge. Households with knowledge of such programs are more likely to reuse sludge.
	Roles and Decisions	<p>Who is the decision maker regarding FSM in the household?</p> <ul style="list-style-type: none"> - About 55% of households reported that head of household is the decision maker for the household's FSM-related practices. In some households, the head of household and the spouse jointly make decisions. 60% of these heads of household are male. - Statistical analysis shows no significant gender difference in household's pit emptying decisions.
	Affordability	<p>What is the household's affordability for different pit emptying options?</p> <ul style="list-style-type: none"> - Rural households can most easily afford the pumping machine, which usually only costs the rented price or the gasoline price. - Given that rural households' willingness to pay is ranged at 13-18 USD for vacuum truck services, it can be estimated that a sizable proportion of households cannot easily afford either vacuum truck services (avg. 33 USD) or manual emptying (avg. 30 USD).
Motivation	Attitudes and Beliefs	<p>What are households' perceptions of pit emptying needs and sludge reuse practices?</p> <ul style="list-style-type: none"> - A majority of all rural households think it is necessary to conduct pit emptying when their latrine is full, mainly because they need to continue using the latrine. About 75% of the households that have not conducted pit emptying have the misperception that their latrine would never be full. - Households are divided in perception of the level of health risks associated with reusing sludge. Overall, about 70% of households perceive sludge reuse to have at least low levels of risks.
	Values	<p>Do people think it is important to conduct pit emptying and why?</p> <ul style="list-style-type: none"> - A majority of households agree that pit emptying express the values of their family to the community. A majority also think it is

		important because pit emptying maintains their good relationships with neighbors.
	Willingness to Pay	How much are people willing to pay for pit emptying services? <ul style="list-style-type: none"> - Rural households are willing to pay 13-18 USD for each pit emptying service provided by vacuum trucks. In contrast, the average actual price charged by vacuum truck service providers is 33 USD. There is a mismatch in consumers' willingness to pay and market price.

This research study employs both quantitative and qualitative research methods.

- Quantitative surveys were carried out through face-to-face interviews and focus on uncovering current behaviors of rural households related to pit emptying and reusing sludge.
- Qualitative in-depth interviews (IDIs) were conducted to gain further insights into the households' needs, barriers, beliefs and motivations related to pit emptying and reusing sludge. In addition, on-site observations of pit emptying services were undertaken to triangulate and confirm information collected through surveys and IDIs. Three households, one receiving manual emptying services and two receiving mechanical services, were observed to understand pit emptiers' existing practices, the safety standards and households' service satisfaction.

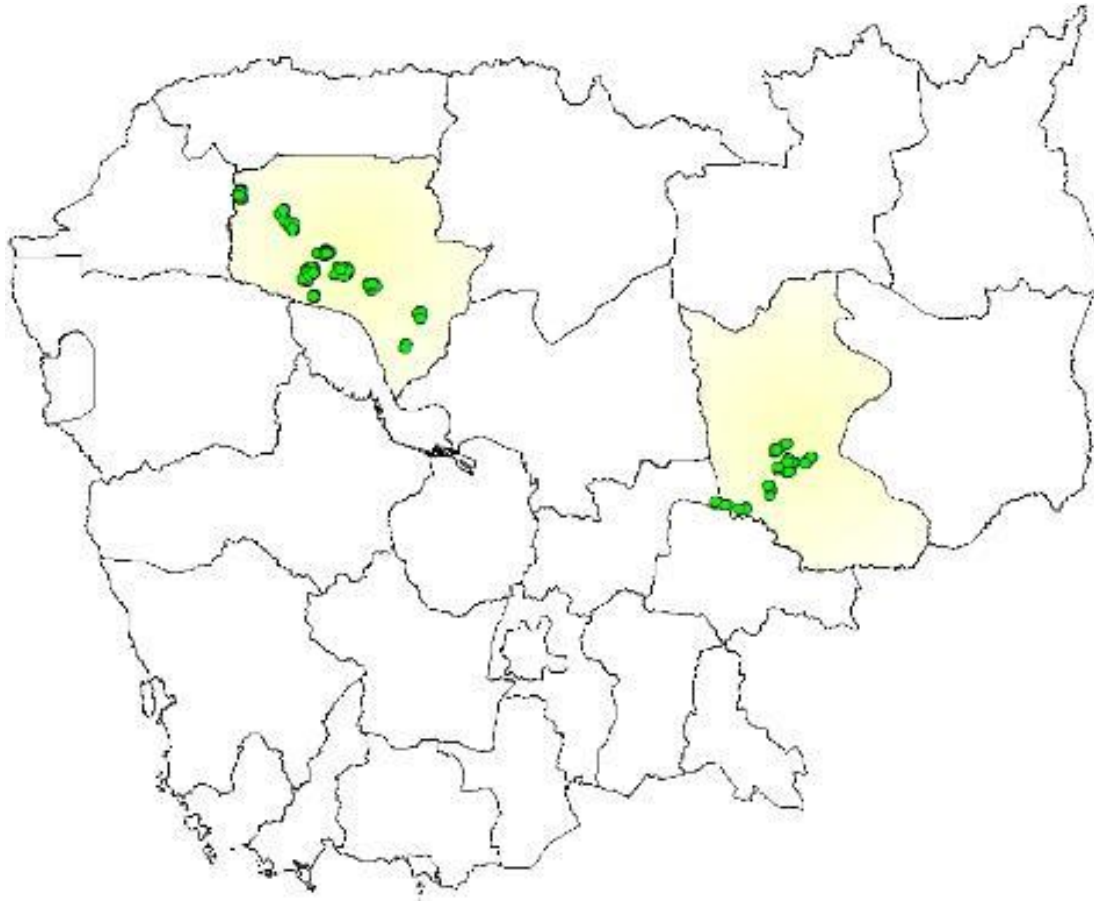
Table 10 Overview of Quantitative and Qualitative Methodologies

	Quantitative Methodology	Qualitative Methodology*
Content	Surveys conducted through face-to-face interviews	IDI's and field observations
Study Population	Participant is considered eligible for interviews if: <ul style="list-style-type: none"> • Their household is located in selected areas • Their household owns a latrine that has been in use for 5+years 	<p>"Doer" household selection criteria:</p> <ul style="list-style-type: none"> • They live in selected areas • They have experience with pit emptying practices in the past year, either by themselves or by hiring service providers <p>"Non-Doer" household selection criteria:</p>

		<ul style="list-style-type: none"> • They live in selected areas • They have never had experience with pit emptying in the past 5 years 		
		E&T operator selection criteria: <ul style="list-style-type: none"> • Individual or licensed/unlicensed business providing manual or mechanical pit emptying services 		
Study Areas	Flood-prone areas (selected villages from Siem Reap and Kratie provinces) Non-flooded areas (selected villages from Siem Reap) Highland areas (selected villages from Kratie) *Both Siem Reap and Kratie are high ODF provinces			
Sample Size	In total 633 heads of households responsible for latrine construction and management:	416 HHs from non-flooded areas	24 heads of households	12 Doers
		118 HHs from flood-prone areas		12 Non-doers
		99 HHs from highland areas	4 E&T operators	1 manual emptier
				3 mechanical emptiers

*During qualitative interviews, researchers also identified households who have had experience reusing sludge and conducted IDI's with them to understand more about their practices

Sampling Procedure



Multi-stage cluster sampling was applied to a sampling frame created from population information in the National Housing and Population Census of 2014. First, different numbers of clusters (communes) were selected from each study area using the Probability Proportional to Size (PPS) sampling method.¹⁵

For non-flooded and flood-prone areas, 5 villages were selected from each commune using the same sampling method. Then, 9-10 eligible households were selected at random from each village using systematic random sampling. For highland areas, 4 villages were selected from each commune, among which 8-9 eligible households were selected for quantitative survey interviews using systematic random sampling. In the case that a selected household does not meet the eligibility criteria, the next eligible household in line was used as replacement. In total, 633 households from 74 villages across 20 communes participated in the quantitative study.

When arriving at selected villages, the data collection team updated their information about the village's geography by asking the chief of the village to do the following: 1) draw a map to confirm that all households in the village were included for the systematic random sampling process; 2)

¹⁵ see *Annex 1* for list of selected communes

ask for household information for skip interval calculation; 2) ask for permission to collect data within the village.

While visiting selected households, enumerators first asked to conduct interviews with the heads of households. In the case that the head of household was not available, another adult member of household who knows the most about the household's pit emptying practice was interviewed. In the case that enumerators could not find any eligible respondent due to unavailability or absence, they checked back at the household for another two times during the study period before moving on to find replacement.

Participants for qualitative IDIs were selected from the quantitative samples. In the case that the desired respondent type was not available in certain villages and communes, household respondents were selected from neighboring villages and communes in the district. A snowball approach was used to reach more potential participants through established connections. Similarly, the qualitative data collector found pit emptiers to interview mainly by asking chiefs of studied villages as well as IDI participant households to refer any eligible candidates that they know of.

Four participant households were selected for field observations from the households receiving IDIs. The households selected must own a latrine for household usage which has been in use for more than 3 years, and they must be willing to be observed while receiving a pit emptying service paid.

Study Tools

- *Structured questionnaire translated into Khmer language (local language)*: Designed around the research objectives to understand pit emptying practices through the SaniFOAM framework and in context of the entire FSM chain.
- *Monitoring sheet*: Used to help enumerators keep record of interviews and report back to the supervisor on a daily basis
- *Android smartphones*: Used for data collection. Electronic data collection forms were preprogrammed with automated skip patterns and range checks to prevent errors and ensure a high level of accuracy. The database for data collection was developed using CSPro 16.1 and uploaded to the mobile devices via CSEntry.
- *Semi-structured discussion guide*: Used as general agenda for in-depth interviews with households and pit emptiers, which allows for flexibility to dig deeper into specific lines of inquiry.
- Audio tape recorders for recording interviews
- Observation checklist
- *Cameras*: Used to record key observations with participants' consent and without revealing the identity of participants outside the research team.
- *GPS Waypoints Navigator App*: Used to measure the distance between consumer households and service providers' locations

Data Collection

Data collection started on April 26th, 2018 and ended on May 5th, 2018. Enumerators and supervisors were trained to follow standard operating procedure (SOP) to ensure consistency of implementation across data collection teams.

Personnel

Four-person teams consisting of three team members and one supervisor were tasked with collecting quantitative data over the period of 12 days. Two teams were assigned to each province. Enumerators completed on average 4~5 interviews per day.

Two qualitative interviewers were tasked with conducting IDIs and observations over the period of 6 days. Qualitative data collection was supervised by the Qualitative Researcher in the research team.

Quality Assurance

Supervisors did regular spot checks and conducted back-check interviews if needed to make sure that the quantitative data was accurate and complete. Data was uploaded from the mobile devices to an assigned server at the end of each data collection day, where core researchers conducted additional spot checks at random.

The supervisor for qualitative study was present at more than three IDIs and provided feedback to make sure they were conducted appropriately and consistently. Comprehensive field notes were received and checked by the supervisor within 24 hours after each interview.

Data Analysis

Quantitative data was cleaned and analyzed using Stata 14.0 (© StataCorp, College Station, TX). All data were analyzed in accordance with the tabulation plan developed by research team. Descriptive statistics by geographical areas, wealth quintiles and gender were generated to give insights into attitudes and behaviors across different regions and groups of people. Bivariate analysis using logistic regression was conducted to examine the key determinants of pit emptying practices. Particular attention was given to map the household decision-making process of pit emptying and the role gender plays in it.

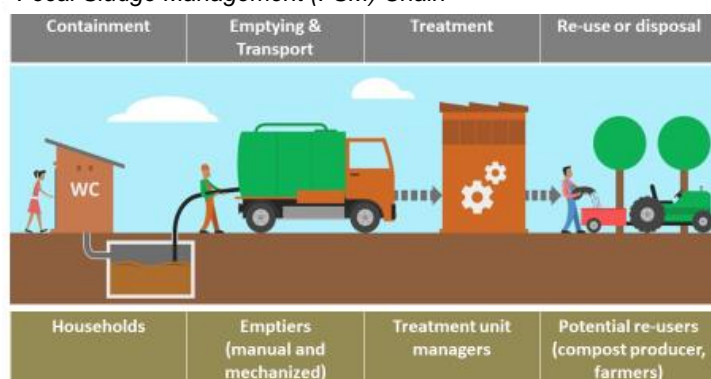
All interview recordings were transcribed into English. Transcribed data were summarized in a matrix developed by field researchers. Any new practices and determinants that emerged in the conversations were further analyzed in context of related quantitative data and in relation to the main behavioral determinants. Original field notes and memos were incorporated into the analysis as needed.

Annex 2: List of Consulted Informants

No.	Name	Institution
1	Pom Chreay	Ministry of Rural Development
2	Chanto They	Ministry of Rural Development
3	Sophy Som	Ministry of Rural Development
4	Virak Chan	World Bank
5	Bopha Seng	World Bank
6	J. Dumpert	WaterAid
7	Khanndarith Sin	GRET Cambodia
8	Lyn McLennan	WaterSHED
9	Jimi Metcalfe	Sanitation in Challenging Environments, EWB
10	Mary Claire	Sanitation in Challenging Environments, EWB
11	Piseth Kim	Sanitation in Challenging Environments, EWB
12	Shona Fitzgerald	Sanitation in Challenging Environments, EWB
13	Bronwyn Powell	SNV
14	Sodany Saing	SNV
15	Majel Kong	WaterSHED
16	Visal Cheng	WaterSHED
17	Taber Hand	Wetlands Work
18	Champa Sok	Wetlands Work
19	Lach Long	WASH Skill Development
20	Sokunthea Rith	WASH Skill Development
21	Tyler Kozole	iDE
22	Sam Treglown	UNICEF
23	Oum Sopharo	UNICEF
24	David Dietz	ESC-BORDA

The FSM Chain

Fecal Sludge Management (FSM) Chain



FSM Chain	Key Research Questions
Containment	<ul style="list-style-type: none"> • What is the average pit filling rate (m³ of sludge/user/year)? • Are households able to identify if their latrine is full? • What have households done to address the issue of a full latrine?
Emptying & Transport	<ul style="list-style-type: none"> • What are common practices of emptying & transport? • What are the barriers and motivators of pit emptying & transport behaviors? • What is the gap between current emptying & transport procedures and safe procedures?
Treatment	<ul style="list-style-type: none"> • Are households aware that sludge needs to be treated before reuse? • How do households treat sludge before disposal or reuse, if at all? • What treatment options for rural situations are currently available or being developed?
Reuse or Disposal	<ul style="list-style-type: none"> • Where is sludge being disposed? • What are current practices of reusing sludge in rural settings? • What are the risks and benefits of sludge reuse for agricultural purposes? • Are there any support/training programs that encourage sludge reuse and promote safe handlings?

Annex 3: List of Consulted Documents

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