

concrete casting. According to the study of water supply project of Khulna it was identified that ground water level of foremost shallow aquifer fluctuates from .56m or 1'-9" to 2.16m or 7'1" below ground level (Institute of Water Modelling, 2011). Surveyed pits are constructed



Figure 4.16: map of periodic FS discharge through pipe from sample containments, Source: author

with 6-10 concrete rings which gets six to ten feet deep and directly connected with upper shallow aquifer. It means, FS contained in pits are directly mixed with foremost ground water level. This phenomenon is also mapped in a FS flow diagram (Figure-4.15) in simple diagram with other way of flowing of FS and also mapped in settlement level mapping. Each of the containment has pipe connection to discharge faecal sludge with black water. As containments are connected with pipe towards drains or nearest pond as primary discharge point and containment does not fill up with FS. From this practice people manage to keep their containment functional but it is causing environmental contamination and risk with health of the people.

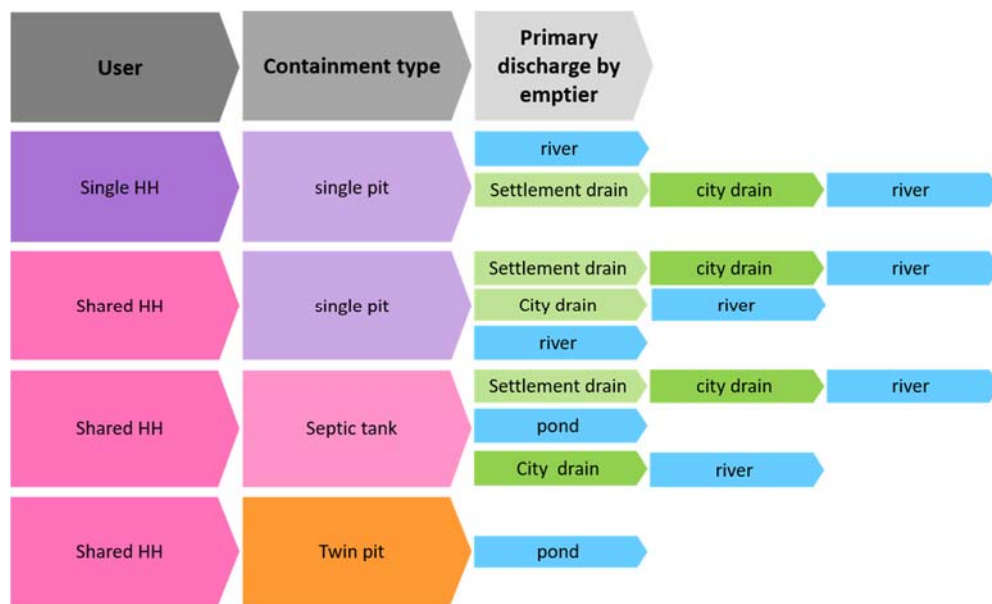


Figure 4.17: findings of emergency emptying and discharge point from sample containments,

Source: author

From objective-1 it is understood that any how FS is going into water. People practice emptying or call manual emptier if somehow blockage happens in connecting pipes. Initially they try to unblock the pipe with their own by pouring buckets of water or using wooden or bamboo stick to prick the blocked pipe. But when they fail to unblock it, they call local emptier or sweeper. The concept of environmentally safe emptying and conveyance defines that, to make the FSM environmentally safe, it is needed periodic emptying of faecal sludge from containment within every three years (Kabir & Salahuddin, 2014; WHO, 2018). But it has not been found among the selected containments except the one at Ranga Mia Goli. From emptier who worked in the settlement for emptying they sometimes entered to the pit to remove the hard sludge with spade and this activity also the criteria of unsafe emptying. The identified primary discharge location discharged by manual emptier are nearest drain of settlement, pond,

to the storm drain, to the river and to the sluice gate (figure-4.17). These practices are also environmentally unsafe. Besides this operational activity of emptier also causes environmentally unsafe emptying. People don't call emptier in day time and manual emptiers works with open bucket and spillage happens in premise while they carry sludge, which practice is also environmentally unsafe.

“sweepers do not work properly every time... often they spill sludge into our streets... intentionally or unintentionally... we cannot tell them anything about it... if we argue with them ... they drop the dirt to the alleys...” – a CDC member (FGD-7) lives the settlement

People informed about dealing with emptier is an important issue, but people became used to it. Sweepers take less money for emptying and widely accepted to the settlement. A manual emptier live in the settlement in ashraf goli. He is very popular in the settlement to unblock the pipe at emergency. Once he was an emptier but now, he does not do that, only repairs the pipes and toilet fixtures and settlement people are very much dependent on him. Sometimes he arranges emptying job calling other manual sweepers and form a team for the work (respondent-41). But they cannot maintain the quality of emptying due to lack of proper emptying equipment. From the interview with vacutug operation manager of CDC, it is informed that vacutug was never used in this settlement because of narrow roads (Figure-4.3). People does not know about it actually. Some respondent said they heard about it but never saw in their settlement (FGD-2,3,4).

“Streets are very narrow the pickup cannot enter into the street.... suppose that it requires minimum 8'...still some roads are big... recently it is widened... but how do you turn it around... again how will it enter because there are burners, extended slabs on the street...”- vacutug manager (respondent-42)

The adaptive growth of household spaces can be seen in this settlement. People extend necessary functional spaces like kitchen and cliff storage over the streets. Which actually make the streets narrower. They often get restrictions from electric service providers or from councilor about extending but without it they cannot manage their all living needs (FGD-7). Peoples of some alley's constructs gates near main roads to create privacy for their alleys (FGD-3). Actually, those alleys have dead ends and gates allows them to use it as like their user needs but these gates also make the streets narrower (figure-4.13). Toilets of these alleys are seen well maintained rather than other alleys which are being used commonly (figure-4.12).

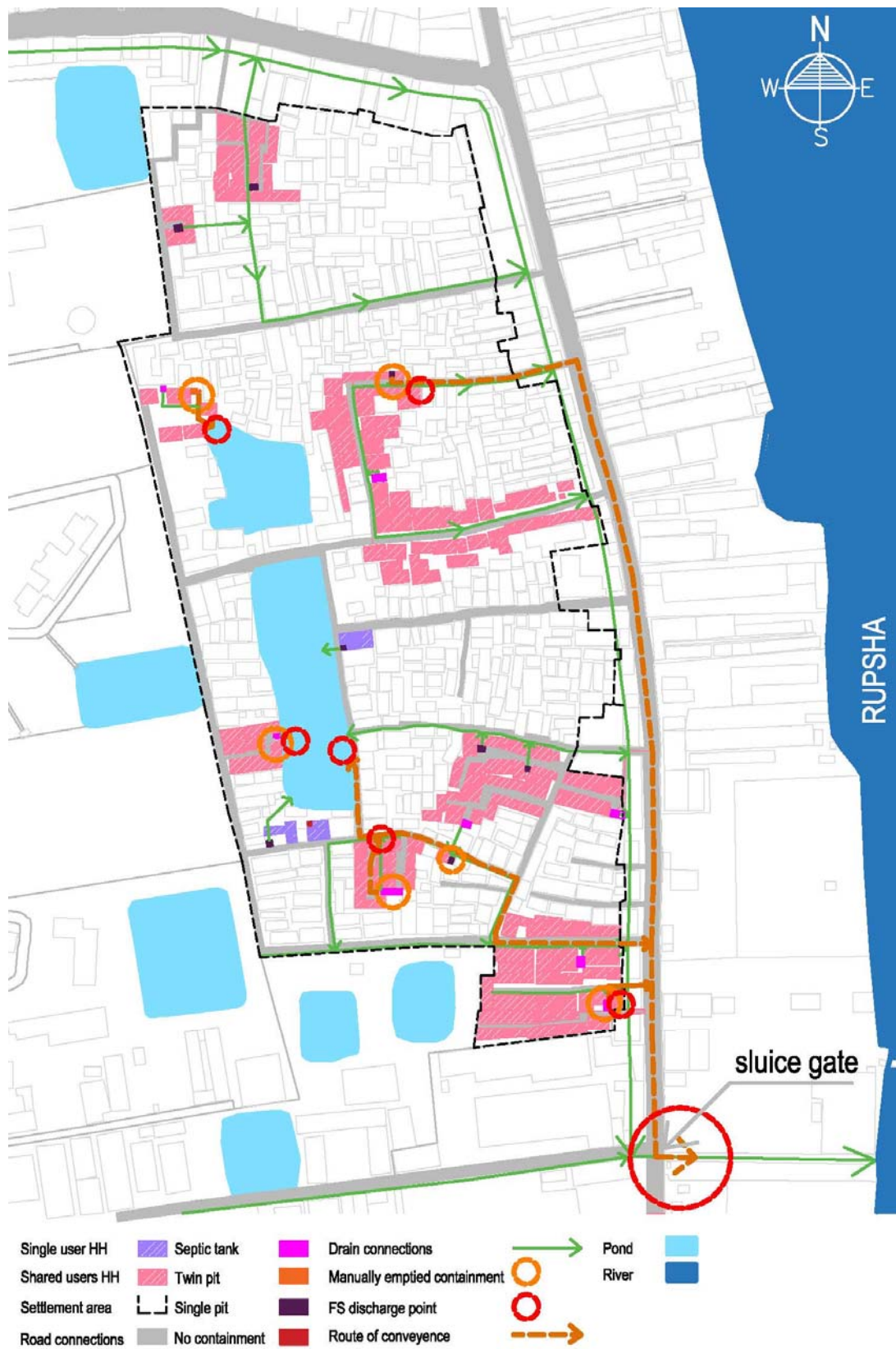


Figure 4.18: map of findings of emergency emptying and discharge point from sample containments (source: author)

4.4 Key Concerns

According to discussions of previous section, it is certain that people do have a management system in against to faecal sludge accumulation. In this section some understanding about their management system can be drawn. Some strengths are visible in their practices; such as: (1) Periodical desludging what is they concerned about most; (2) Periodical monitoring; is the sludge is emitting or not, (3) Alley based organization for their territoriality, (4) Collective payment mechanism and (5) Adaptive to accept changes.

4.4.1 Theme identification

Key concern areas of this research are the FSM practice among the people of informal settlements are environmentally safe or not. In literature review chapter, its been identified that which activities can be termed as environmentally safe. As this thesis is concerned about environmental health; theme identification is necessary here at this section. According previous section discussion, primary discharging points are found as drains, ponds and river which leads FS to water which can place settlement people in severe health risk. From built environmental maps it's been understood that, many discharging points are placed within their settlement and directly related spaces with their daily activity, even their water sources. People of the settlement uses the drain slabs to place their burner and daily cook in that place. Those are same drains in which FS flows. Even some times those drains over flows due to rain or tidal effect of river and water comes out to the alleys people walk and gather daily, as the alleys are only social spaces they have. This situation brings this thesis concern about environmental safety and themes been identified to locate environmentally unsafe practices.

Table 4.1: List of emerging themes of environmentally unsafe practices in faecal sludge management among people and emptiers

containment	<ul style="list-style-type: none"> • not using any means of containment and direct discharge of FS from hanging toilet • using bottom unlined pit that connects FS to water at upper shallow aquifer • connecting pipe to discharge FS periodically to drain which leads to water body • connecting pipe to discharge FS periodically to the pond • people not emptied their containment within three years
emptying	<ul style="list-style-type: none"> • people not using any protective gear while operating any management work • emptiers not using any protective gear during emptying • emptier enters into the containment during emptying • emptiers not using safe equipment during emptying
conveyance	<ul style="list-style-type: none"> • emptiers not carrying FS to safe discharge location • emptiers spill sludges on settlement premises

4.4.2 Identifying influencing factors

In this section, this thesis tried to identify key influencing factors behind environmentally unsafe practices in informal settlement. Data collected from KII and FGDs been analyzed in NVivo and word cloud been generated to find most frequent words from people's perceptions. KII data of NGO personnel, FGD data of CDC members, KII data of emptier and FGD data also been used for triangulation. Data from secondary sources been used to identify key factors where it was necessary. Themes identified in previous section are used as nodes for data analysis in NVivo. Discussions of this section are supported by the table 4.2 which is associated with containment, table 4.3 which is associated with emptying and table 4.3 which is associated with discharging practice. These table presents word frequency as analytical product and related data sources grouped under the themes.

4.4.2.1 People not using any means of containment and direct discharge of FS from hanging toilet

From in-depth interview findings there are some reasons of using hanging toilet presented in table 4.2. Main reasons are found transiency of these population. These people are comparatively newer in the settlement. Users of existing shared toilets were pre decided while those are constructed and newer settlers do not get access to the shared toilets. People are not concern about developing their toilets because they think it is important to expense money to educate their child more than upgrading their toilet and house. They preferred road side shop more than road side toilet, to increase their income. While they decided to build the toilet, they found old habitants are practicing to connect their toilet with the pond and they did the same with their affordability. They did not get toilet from any kind of donations nor CDC and NGO's and they never get offered for receiving toilet. They said it needs a good social network with commissioner's office. As they built their toilet self-funded, it was the cost which was burden to them and sometimes they had loans which they have to pay. These transient people sometimes hear about losing the land from other settlers and that is another reason they don't upgrade their toilets for the fear of loss of money they earn for their family need.

4.4.2.2 Using bottom unlined pit that connects FS to water at upper shallow aquifer

Most of people the settlement uses pit toilet are constructed as bottom unlined pit which causes FS to get touched with water in ground level. Among ten sample containments all are found bottom unlined. People actually follow what is the practice in the settlement and suggested by

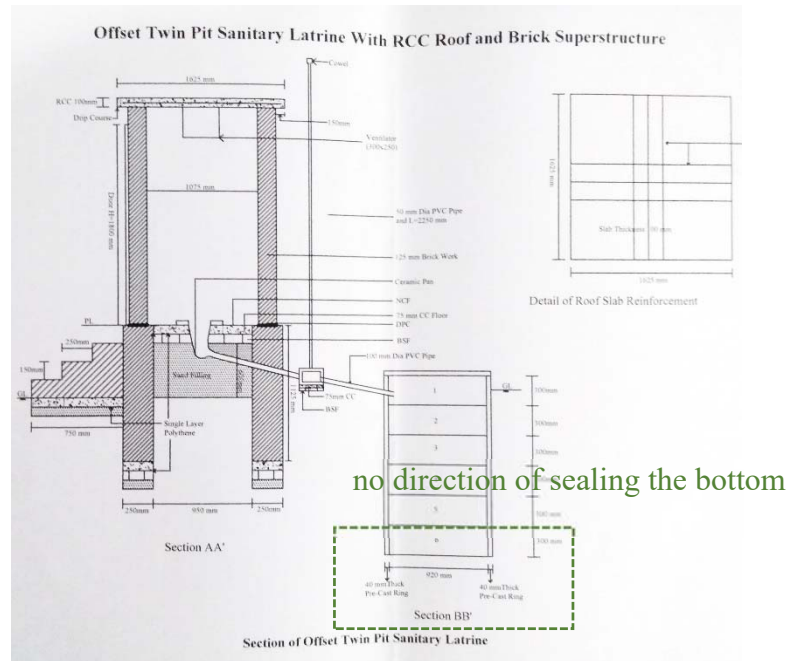


Figure 4.19: twin pit toilet for providing to the informal settlements (source: UNDP) masons. Individual HH who constructed their pit self-funded calls local mason who suggest that practice. Many shared pit toilets are also having bottom unlined pit. These toilets are provided by CDC with membership loan procedure. In construction drawings gathered from secondary data source provided by UNDP personnel, it is observed there are no indication of brick soling or concrete casting for the lining the bottom of the pit. Besides people don't have knowledge about the health and environmental risk of this practice. They only do what is available and easy to construct with minimum cost. From a respondent from individual house gave information that they had to expense almost 16,000/- taka to construct their toilet.

4.4.2.3 Connecting pipe to discharge FS periodically to drain which leads to water body

It is very common practice in the settlement. Almost all the containment which are not connected to the pond are connected to drain and both practices are seen in pit toilets and toilets with septic tank. Actually, it is a city-wide issue. Almost all settlements of Khulna both formal and informal practices the same (Kabir & Salahuddin, 2014). In notun char, people do this to reduce FS accumulation and this is their management technique of their toilet. In the case of pits absence of service-hole. From NGO personnel, it was informed that they don't give the connection to the drain, people make this connection with their own. People says they made the connection when the toilet was constructed. Actually, their view is, they won't take the toilet without pipe connection. During the construction time they influences masons to make that connection. They are not aware of environmental and health consequences which comes

after it. Those issues are unknown to them. If they asked about what can be done, they said they don't have any other option and they relies on it.

Table 4.2: Environmentally unsafe practices associated with containment, source: author		
Data source	Node	Word frequency
respondent (1,2,5)	people using hanging toilets	education network cost transiency income loan practice access tenure
respondent (3,5,9,10,11,16 17), FGD 6	people using bottom unlined pit	available mason knowledge provider practice local
respondent (6- 8,12,14,15), FGD (1-5)	septic tank users connecting pipe to discharge to drain	practice fill-up ^{option} mason manage unknown
respondent (3,5,9-11,16 17), FGD 6	pit users connecting pipe to discharge to drain	unknown mason manage service-hole fill-up ^{option} practice
respondent (3,4,13)	people connecting pipe to discharge to pond	location practice cost no-drain institution awareness road
FGD (1-6) all settlement respondent except (1,2,5)	people containing FS for more than three years	willingness situation bad-smell alley provider payment decision income emptiability networks awareness ability

4.4.2.4 Connecting pipe to discharge FS periodically to the pond

As most of the toilet containments are connected to drains these practices are exceptional. People living near the pond don't have drains with their streets and that is the main reason for connecting containments to the pond. In both type of containments, they do the same. This practice is the result of constrains with the location of their houses. Besides they informed that, if they think to connect their containments to the drain that will cost more. The pond in the settlement is under the supervision of Christian community of the settlement and belongs to Christian service society (CSS) Khulna. People said they never got any resistance from CSS because Christian households also connect their pipes with the pond. In very recent times CSS cleaned the pond and took initiative to grow fish in there and they informed people of the settlement to disconnect their pipe connections but still now they are not forcing about it. People don't know what will they do then. From interviews it is understood that they are not aware of the consequences can come with this degraded pond because they don't use water from the pond. In future, what will happen with the pond will be decided by CSS, there are nothing to from settlement peoples.

4.4.2.5 People not emptied their containment within three years

In notun char, either it is a pit or septic tank, that is containing sludge from very long time. A lot of containment found which are never emptied before. For this particular practice, the most influential factor is the situation. People who did not get into the problem of blockage of the pipe they never emptied the containment. They empty when pit or tank become full with sludge and when they cannot use the toilet. There are quite a few numbers of provider who provided shared toilets with septic tank and pit. Shared toilet with pit provided by CDC with the help of UNDP projects and shared toilet with septic tank are provided by KCC and Nobolok; a NGO. In notun char, the story of alleys is influential factor for the overall FSM context. There is some containment found which are being used by single alley and some are used by two alley people. Some cases are found like, the toilet block is being used by two alleys but using single septic tank. One alley people using two toilet and another using one toilet. In that case, people were initially unaware of the single septic tank. When they became known about it, they reacted. Because it creating decision making problem among them. Because in both alleys number of the house hold is not the same. Often relation between two group gets worse about the toilet use. Sometimes people from one alley gives restriction about bringing guests in their home, because guests will use the toilet which will increase the fill rate of excreta. In that cases it is

observed that, those tanks are emptiable from only one side because there is no service hole in other side of the toilet block which can be accessed from that alley, even the connection of the pipe also ran through one alley only (figure 4.15). These situations create decision making dilemma for taking emptying decision among them. It been observed that toilets used by single alley people are being well maintained comparatively from the toilet used by two alleys. Once when people need to empty their containment, they had to empty faced problems about money collection. When they call sweeper, they take rate of emptying from them and divide it among households. Every house hold pays same for the emptier. But if they had any relational problems among groups, it influences the whole process. Sometimes different groups have different social and political networks. Sometimes comparatively strong groups influence to take control over the toilet. In a case of torik goli, people of one alley was using a toilet block containing two pour flash pans with pit science it was constructed. In very recent time CDC took initiative to repair their toilet but suddenly people from another alley claimed for one toilet and made it constructed as their wills and took a doorway fronted to their street. From that situation the construction of the toilet block got hampered and people using it without doors. Besides of these stories, people of the settlement always keep themselves busy for their income generation. People don't get time to think about their containment management. In most cases women arranges every decision about emptying and completes the whole process. In the case of pit toilets, emptiability of the containment acts a big role on decision making. Because pit toilets which has pits under the pan slab are not actually emptiable. Having no options for emptying the containment at emergency time emptiers had to break the pan slab which adds an extra cost of repairing the toilet. In the case of twin pits top slab of the pit can be removed but it does not come with service hole from providers.

4.4.2.6 People not using any protective gear while operating any management work

People keeps wooden or bamboo sticks in their alleys to unblock the pipes but they don't use any protective gears while they manage the problem. In some cases, they have to remove sludge themselves but they don't keep any safe equipment. When problem arises, they feel dilemma about who will do that work but if they call sweeper, they have to pay for that. They actually don't have skills and knowledge about containments. By pricking with sticks, they often damage to their containment and its fixtures and pipes. Even often they get injured and faces health issues several times. They don't get any options of equipment in shops what they can buy and keep it in their alleys for management works.

Table 4.3: Environmentally unsafe practices associated with emptying, source: author		
Data source	Node	Word frequency
FGD (3,6)	people not using protective gear	<p>knowledge decision situation option dilemma</p>
respondent 41, FGD 8	emptiers not using protective gear	<p>willingness consciousness cost efficiency availability time</p>
respondent 41, FGD 8	emptiers entering into the containment	<p>effectiveness force hard-sludge water manhole containment equipment</p>
respondent 41, FGD 8	equipment used by manual emptiers	<p>shawl kerosin bucket lamp sweep hammer stick spade drum rope bottle mug jerrican</p>
respondent 41, FGD 8	emptiers not using safe equipment	<p>familiarities availability skill efficiency</p>

4.4.2.7 Emptiers not using any protective gear during emptying

From the focus group discussion with emptiers it is found that, emptiers also don't use protective gear while they go for emptying job. Because what is available in market that reduces their efficiency. When they wear any protective dress, they cannot get to work freely and even they don't feel good with it. they claim these are not actually fits with them and needs customization. They have knowledge about health issues but sometimes they have nothing to

do with that. They think protective gear is extra elements which costs extra money, but they work cheap; how they can avail it. Consciousness about health is very low among them. Some have protective gears but often they don't use it, even they don't wear boots also.

4.4.2.8 Emptiers enters into the containment during emptying

Emptying is highly depending on the type of containment. But the most peculiar thing in septic tanks is so called “manhole”. Emptiers perception on manhole is to enter human through the man hole for emptying. In sanitation projects applied by different NGO and authorities’ these holes are mentioned as “Manhole” in drawings (figure-4.27). It is necessary to remove the concept of manhole from documents and may be that will help to change perception of emptiers about it. For that reason, the hole is mentioned as service hole throughout this thesis. It is necessary to establish the concept of service hole for people who take the main challenges of FSM in developing countries.

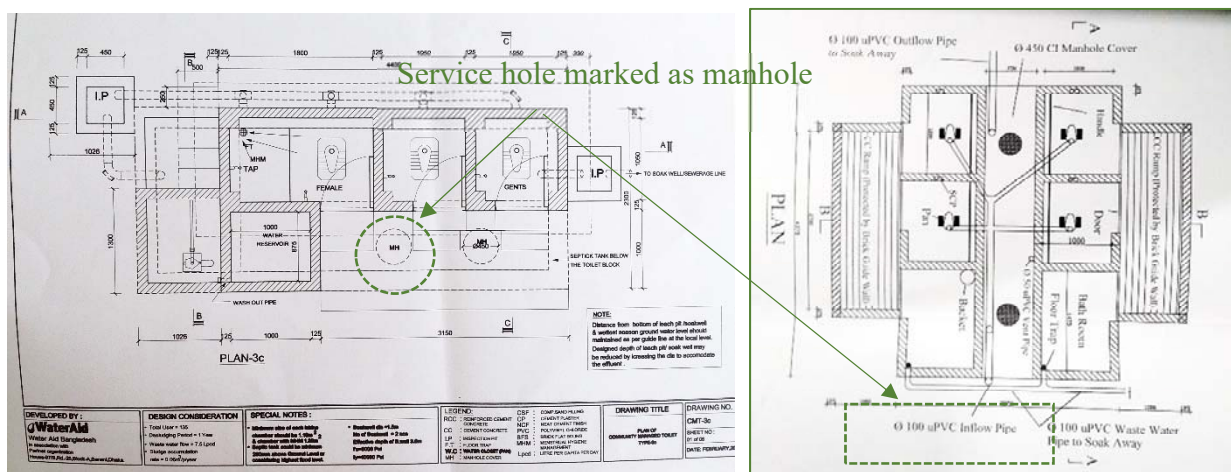


Figure 4.20: shared toilet drawings from NGO (source: Nobolok left; UNDP right)

The type of the containment is the first concern among emptiers. Because they decide how they will operate the emptying job from observing the type and condition of containment and they decide what will be the cost and then they get the contract of that job. They felt the job easier if it is septic tank because about the pit they had to struggle more. Main struggle of emptying they face about the hard sludge. From their observations they have seen, pit sludges are comparatively harder than they get in the septic tanks. However, containment which has not been emptied within three years it becomes difficult to empty, because sludges becomes like soil with time. Hard sludges need spades to remove and more often they need to enter into the pit for spading job. They don't have any better equipment for digging. During their job they need to pour plenty of water to dissolve sludge again, to make it liquid so that they can pick it

up with buckets. Sometimes they do not get water source nearby, because in informal settlements not every household has tubewell in their houses. It causes extra labor. Sometimes they struggle with effectiveness of emptying. when they contract for job full tank emptying, they have to complete that, but during emptying when they find it is hard at that time, they been forced to empty the full tank and sometimes they have entered the pit unwillingly. Sometime they don't contract the job contains hard sludge. From their perception there are no available equipment that can blend sludge with water easily and often struggles with that job which causes some times bad injuries.

4.4.2.9 Emptiers not using safe equipment during emptying

From the common perceptions of emptier they use spade to remove hard sludge, bucket to lift sludge over ground level, rope for binding bucket, drum to carry sludge using van, shawl to remove the service hole cover and some-times they bring hammer to break concrete cover of the tank, mug and bucket to pour water, jerrican to carry sludge to drop sludge to drum and use bottle to carry kerosin oil which used to remove bad smell from working premise. As working at night, they sometimes need kerosin lamp to lit the premise where there are no means of lighting is available. But there are risks for which they are aware about. Because pits having no ventilation pipe contains methane gas which can be ignited with lamp fire. After the work they cleans premise with water and use their own sweep for cleaning. Among this equipment what is missing is safety for the environment and for their own health. Any means of safe equipment are not available for them. They are aware of vacutug but they think it is not their type of job equipment. They think any mechanized emptying machine needs extra skill what they don't have and can't get involved with vacutug? They think they can increase their efficiency if they get any kind of manual machine which can increase their efficiency. They are not familiar of that kind of manual emptying machine.

4.4.2.10 Emptier's not carrying FS to safe discharge location

There is a treatment plant at Rajband of Khulna and that is the only one in the city. It is situated on the land owned by KCC they used for garbage dumping. But it is far from the city and from notun char it is almost 11km. from the information of SNV personnel it is accessible for all emptier but the distance increases the cost and even the location is unknown to the local emptiers. Besides there are no such a place where emptiers can discharge sludge safely. For the lack of available safe discharge sites, they discharge sludge in nearby locations. They struggle to carry sludge for lack of vehicles also. They use the only medium that is van.

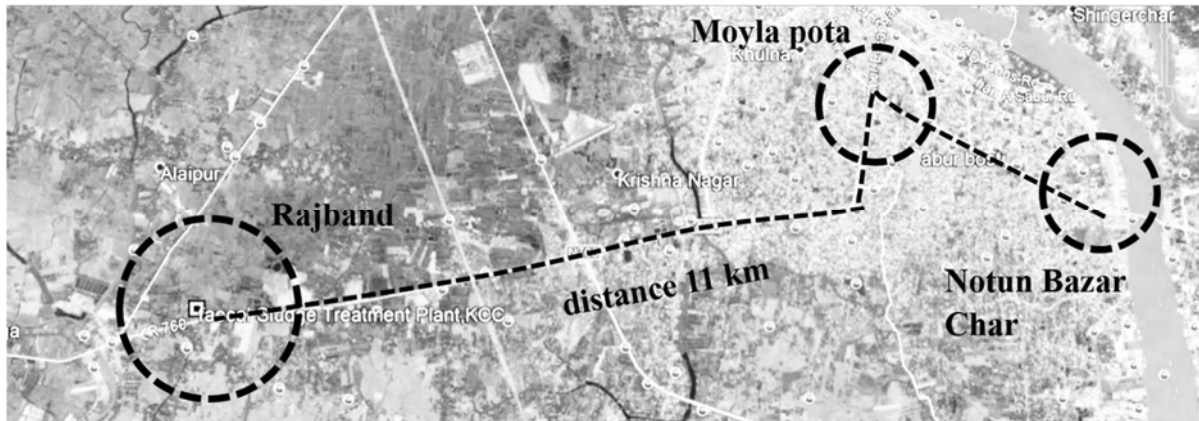


Figure 4.21: distance of treatment plant and settlement (source: author, background google)

Table 4.4: Environmentally unsafe practices associated with discharge, source: author		
Data source	Node	Word frequency
respondent 41, FGD 8	emptiers not transporting FS to safe location	<p>cost distance availability knowledge vehicle</p>
respondent 41, FGD 8	Emptiers perception about FS spillage in premises	<p>topography obstacle behavior medium narrow-road contract night inattention</p>

4.4.2.11 Emptiers spill sludges on settlement premises

In informal settlements emptiers often struggles for narrow roads. Because of narrow roads they cannot take the van nearer to the emptying locations. For narrow roads they put their vans in main roads in forced. But it is the reality of informal settlements. In notun char the narrower road is 1’-6”. For these narrow roads emptiers often needs more mediums to carry sludge to the drum kept over the van. They can’t carry drums without vans. Their small mediums are open buckets, jerricans which cannot be sealed. these open mediums often cause spillage to the street or toilet premises. Further, they spoked about obstacles which are the reality of informal settlements. Settlement people uses the street for multiple purpose. They extend space for kitchen; they extend slabs to the streets for many reasons which makes streets narrower. Also, they use streets for drying their cloths for which they anchor bamboo post. These features become big obstacle in night time and can cause spillage if they become inattentive about it.

Sometimes topography of the road also causes spillage to the premise. Slopes of road and unevenness of roads also causes spillage. Sweepers often go drunk for the work. They drink alcohol to lose their nerve and it also causes inattentiveness. From their perception alcohol helps them to work with extreme bad smell of the sludge. Sometimes toilet users suddenly impose extra work out of their contract and at that situations sometimes they deny and sometimes they don't work carefully. But they act very professionally because they care their job responsibility but sometimes many behaviors from user end, they cannot tolerate when they are drunk, but of-course most of the time they manage the situation.

4.4.3 Factors behind unsafe practices

In this section identified factors been enlisted in three table (table 4.5, 4.6 & 4.7). While identifying the factors, the distinguished steps of typical FSM service chain became overlapped.

Table 4.5: Factors associated with containment and emptying, source: author

People's perception (User and Emptier)	Influencing factor
<ul style="list-style-type: none"> • transiency of living • access interrupted by organization • weak social networks • management varies with alley • acknowledging local product • collection of payment • organizational problem in decision making • influenced by situation • not having service-hole • available construction method & material 	<ul style="list-style-type: none"> • inequity in containment provision
<ul style="list-style-type: none"> • available construction method & material • unknown about risk • no awareness about risk • organizational problem in decision making • influenced by situation • lack of awareness • not informed by provider 	<ul style="list-style-type: none"> • absence of participation
<ul style="list-style-type: none"> • suggested by mason • not interrupted by institution • following common practice • not informed by provider 	<ul style="list-style-type: none"> • lack of environmental concern
<ul style="list-style-type: none"> • emptiability of containment • concerned about fill-up • not having service-hole • obligated by location 	<ul style="list-style-type: none"> • Ignorance of emptiability

This situation indicates that containment must have emptiable attributes, emptying process must be informed with conveyance system and discharge location defines what is needed for conveyance system. Any pre-decided system may not work into the context without being sensitive to these overlapping.

People's perception (User and Emptier)	Influencing factor
<ul style="list-style-type: none"> • emergence of decision • influenced by situation • force-ed by user • knowledge about risk • to lift hard-sludge 	<ul style="list-style-type: none"> • lack of emptying schedule
<ul style="list-style-type: none"> • organizational problem in decision making • access interrupted by organization 	<ul style="list-style-type: none"> • alley and social organization
<ul style="list-style-type: none"> • distant water source • types of containment • topography of settlement • obstacle in alleys • user behavior • difficulties of narrow-road • deviation from contract • dark of night 	<ul style="list-style-type: none"> • constrains of socio-spatial realities
<ul style="list-style-type: none"> • acknowledging local product • available construction method & material • unknown about option 	<ul style="list-style-type: none"> • selecting available option
<ul style="list-style-type: none"> • Comfortable about regular equipment • no familiarity with manual safe equipment • not having proper equipment • no familiarity with manual safe equipment • lack of skill about machines • fear about losing job by machine efficiency 	<ul style="list-style-type: none"> • Unfamiliar equipment
<ul style="list-style-type: none"> • no availability of compatible equipment • reduces work efficiency 	<ul style="list-style-type: none"> • Lacking customizable component
<ul style="list-style-type: none"> • effectiveness of job • conception about manhole • willingness to use • consciousness about risk • knowledge about risk 	<ul style="list-style-type: none"> • Lacking awareness of environmental health
<ul style="list-style-type: none"> • knowledge about safe discharge • cost of transportation • vehicle constrains about transportation • knowledge about safe discharge • cost of transportation • vehicle constrain about transportation 	<ul style="list-style-type: none"> • Lacking transportability

Table 4.6: Identified factors associated with conveyance and discharge

People's perception (User and Emptier)	Influencing factor
<ul style="list-style-type: none"> • lack of availability of land • distance of safe location 	<ul style="list-style-type: none"> • lack of safe discharge site
<ul style="list-style-type: none"> • knowledge about safe discharge • cost of transportation • vehicle constrains about transportation • knowledge about safe discharge • cost of transportation • vehicle constrain about transportation 	<ul style="list-style-type: none"> • Lacking proximal distance of disposal site

4.5 The Way out

To develop a way-out strategy aligned with contextual factors, there are series of issues which needed to be addressed in a single framework. A framework can explain the main theme to be calculated, key factors, concepts or variables and assumed relationship among them (Scott, 2019). But it is also argued that, if factors and variables are presented in the framework better to call it a model (Jabareen, 2009). Several 'frameworks' exist in FSM discourse but models specially for informal settlement are too much oriented in cultural practices of the context and biophysical diversities. That's why none of them can be directly adopted in another context of informal settlement. When a country made development in reducing open defecation with building lots of toilets all around the country, then to work with the second generation challenge it is necessary to understand the first-generation realities with context specific situations. From FSM perspectives, there are lot of identified issues which does not suits with FSM challenges in informal settlements. But acknowledging the challenge can be the idea for developing a new model to resolve. As kim Dovey mentioned informal urbanism as a complex adaptive assemblage which means; in informal settlements there exists a complex adaptive system of growth, conservation, release and re-organization and the system is intermeshed with the chain of whole urbanism (Dovey, 2012); then issues of FSM also connected with whole FSM scenario of the city. As city wide inclusive sanitation concept suggests to initiate adaptive, mixed and incremental approaches for FSM and environmental safety is an unconditional reality to eradicate faecal oral transmission path ways, emerging ideas for model are complex which needed support with multi-stakeholder governance and multi-disciplinary leverage of knowledge. From a social constructivist perspective, all identified factors learned in qualitative manner it is important to give priorities to every factor and need to be addressed. But the difficulty is to present in a simple manner. To address the themes along with various factors, all factors are acknowledged in sub-themes which has been developed from literature

extraction and context-led realities. The emerging model is developed under five main themes which are informed by set of thematic indicators. Key themes along with its indicators been discussed below and then a diagram been proposed to present inter relationship among themes and indicators.

4.5.1 Equitable, Impenetrable and emptiable containment

4.5.1.1 Equitable provisioning

To become sensitive for different skills of social networking of settlement people is important to ensure environmentally safe FSM. Growth and release of informal settlements are influenced by transient nature of population and tenure. Most conserved areas of the settlements are being prioritized by providers because of their increase in socio-political networks whereas less conserved areas are being ignored. It causing the FSM weak and diversifications in people's practices. To include the whole settlement into the system it is needed to ensure equitable provisioning of containment.

4.5.1.2 Participatory installation

Installation of containment is the foremost step to include a settlement in FSM system. But these installations sometimes create socio-spatial issues which affects further management from the people. From the case studies it was informed that, people using toilets in clusters have lack of knowledge about what has been installed in their alleys and how to manage and maintain it. In other side single households are also following only masons' instructions which are not being supervised by any expert professionals. For building knowledge within settlement people about FSM, it is important to increase participatory installation of containments, with the supervision of professionals.

4.5.1.3 Environmentally Impenetrable containment

Pit of the settlements are being installed by self-funded or shared funded with the support of community development committees, city authorities and NGOs. People are unaware of the consequences of environmentally penetrable pits. Even pits installed by providers are also not properly impenetrable. Which is contaminating ground water easily where water level is high. It is necessary to increase professional involvement with constructions and building skills of masons to install environmentally impenetrable containment into the settlement.

4.5.1.4 Emptiability

Containments which will be installed must have some means of emptiability. Installed septic tanks are being found with service holes but pits are installed without means of emptiability. Toilets which don't have separate location for pits are non-emptiable. Because no service hole is made over the pit due to lack of available space. But technical assistance from professionals can help to add service holes with very few structural customizations. Besides which toilet has separate positions for pit has top slab having low reinforcement to bear live loads of emptier and emptying equipment. Often these top slabs get damaged during emptying operations. That's why it is need to proper reinforcement design to carry live loads and service holes with it.

4.5.1.5 Periodical emptying and conveyance

Periodical emptying is inevitable reality for sustaining on-site sanitation systems. Environmental sanitation concept proposes a varied way of sanitation options like decentralized waste water management and faecal sludge management. Most of the means of system needed periodical emptying to be sustained.

4.5.1.6 Participatory schedule making

To make periodical emptying of on-site containments it is important to make schedule of emptying. it is widely promoted in the context of FSM and also it is being campaigned by city authorities and NGOs related with FSM in urban contexts. Schedule making for emptying of containment also needed to implement in informal settlements but needed to be practiced in participatory manner. Capacity of the containment must be studied according to its fill rate and user capacity. Users needed to be informed with fill rate and to let them decide for next schedule of emptying and the whole process can be monitored with a team of emptiers and CDC members. Through CDC there are some management procedures are under implementation like community led garbage management which is widely accepted in the settlement. People of the settlement are managing it with monthly payment basis. For FSM practice it can be also an idea for periodical emptying and payment practice can made running with the schedule. In case of individual households, the fill rate is low and those can made be scheduled for three-year basis, because more than three years of sludge accumulation causes emptying difficult. To make aware with time, each containment can be labeled with the date its next emptying time.

4.5.1.7 Organization based monitoring

Incorporating CDC and user groups the process needed to be monitored. As any practice with FSM is directly related with the environment and community health of the settlement, community-based monitoring must be enabled. As in notun char settlement, the community people live organized in alleys like in Kashem goli, khan saheb goli, torik goli etc. They have own maintenance chain and followings of leadership rooted in their alleys. People maintains these organizations for conservancy of their informal growths.

4.5.2 Adaptive equipment for emptying and conveyance

4.5.2.1 Adaptive technology for socio-spatial realities

Spatial realities of the settlement cannot be ignored for the selection of emptying technology. Emptying technology must be adaptive and mixed, as it is mentioned in city wide inclusive sanitation concept. Spatial reality of the settlement are narrow roads, narrow access to the service holes which been found also in notun char settlement. Width of streets varies from 1'6" to 12'0". Besides emptiers needed to use safe equipment which separates FS from their body contact. Considering these two necessities, small size scalable manual emptying pump can be selected for operation. From literature study it was identified that, manual pit emptying technology (MAPET) and gulper pumps are easy to use and can be carried in narrower streets. At the same time, selection of conveyance medium is necessary. Due to narrow streets, obstacles of streets, variation in topography can cause spillage in the settlement premises, it is important to select properly sealable containers for conveyance. To carry the containers in narrower streets size of the container must be selected according to street width and at same time small size push carts also needed to be selected. As in Notun char bosoti, the narrowest street is 1'-6", push cart size must be customized according to the widths. It is needed a comprehensive study to understand the road widths and containment location; for selecting compatible push cart and container can be carried. Besides, existing equipment of emptiers needed to be studied to enhance the efficiency and safety of the equipment's. in many literatures and also found in notun char, people perception of emptying time is night, because of the problem of bad smell. Emptying in day time is an important issue for safe emptying. Manual hand powered pumps do not spread out too much smell. Besides emptiers has their own mechanism to reduce bad smell. Community organizations needed to be motivated to empty their pit at day time to ensure efficiency and safety of emptying. also, there is a need for safe

tool for working at night and battery powered light must be the safe tool for night time rather than kerosin lamps.

4.5.2.2 Locally produced and maintained

Human powered emptying needed to be produced locally. To make it inexpensive and available in markets. Which can maintain locally with minimum cost. MAPET and gulper can be produced locally. It is also necessary to ensure the use of machines in the context. Purchasing capacity of the machine can be varied by emptiers economic ability. Interest free loan can be added for purchasing the machine will make easier to purchase the machine by emptiers.

4.5.2.3 Familiarization and skill development

With the market adoption of equipment, it is necessary to familiarize emptier with equipment. Skill development is important to ensure the use of safe emptying equipment. There are examples of skill development program in cities of Bangladesh and even in Khulna. These programs will help emptiers to gather knowledge about environmentally safe emptying and the use of equipment.

4.5.3 Adaptable Health safety kit

4.5.3.1 Availability of customizable components

The use of protective gear is largely been ignored among emptiers and people. Compatibility and availability of protective gears are main reasons. Hand gloves, mask, dress, boots and caps are found as protective gears in FSM context, which are not available, not customizable with user and costly from emptiers perception. So, to ensure health and environmental safety it needed to increase availability in market with minimum price, customizable with user preferences and promotion is needed.

4.5.3.2 User based awareness building

To increase the use of protective gear it is necessary to increase awareness among users. Community people who manages FS themselves and emptiers needed to be informed about the use of protective gear. Group workshop with community people and emptier groups can be done for user-based awareness building.

4.5.4 Proximal safe discharge location for all

4.5.4.1 Inclusive allocation

Ensuring safe discharge location is inevitable for sustaining environmentally safe emptying conveyance. Inclusive allocation of land is needed to ensure discharge of FS safely. The treatment plant of Khulna is far from the city and it adds extra cost for emptying and conveyances. The plant is occupying 1.3 acre of land and cost of construction was 1.90 crore BDT (240,000 USD). But according to respondent, it is getting far less than its capacity of FS processing per day. From Notun Char Bosoti the location is being very far and for manual emptiers its been costly for transportation. Decentralized transfer station with holding tank projects can be implemented near locations of settlements, where emptier can easily discharge their collected FS from informal settlements. Vacuum tankers provided by city authorities can collect FS from tanks periodically and carry it to the treatment plants. It will also help to increase discharge rate of FS in treatment plant also. Decision of selection for appropriate land can be made in participatory manner. These transfer stations will help not only for informal settlements but also can be solution for formal settlements also. In the case of notun char bosoti emptiers discharges FS near sluice gate and there is available land for constructing FS transfer station.

4.5.4.2 Optimized Infrastructure

Optimization of cost in infrastructure building is necessary for efficient system. There is necessity of calculating total FS accumulation of the settlement for constructing holding tank. City authority is working with mobile transfer station as vacuum tanker for vacutugs of CDCs but still could not able to decisions about payment distributions between vacutugs and vacuum tankers.

4.5.4.3 Reuse for refund

Reusing FS is not widely accepted but it is been started in Bangladesh. From sakhipur co composting plant of Tangail is producing Sakhi Compost fertilizer for agriculture initiated by sakhipur municipality and water aid. Costs of infrastructural development can refund with similar type of initiatives. Upgrading these reuse policies can be taken to encourage people to enter into the chain of environmentally safe faecal sludge management in urban context.

4.6 The Model

The model been proposed according to the key themes discussed in previous section. The model locates key themes and key indicators within a framework. Necessary variables been identified which can be varied according to different informal settlement contexts. These variables been presented in table showing linkage with indicators and key themes of the model.

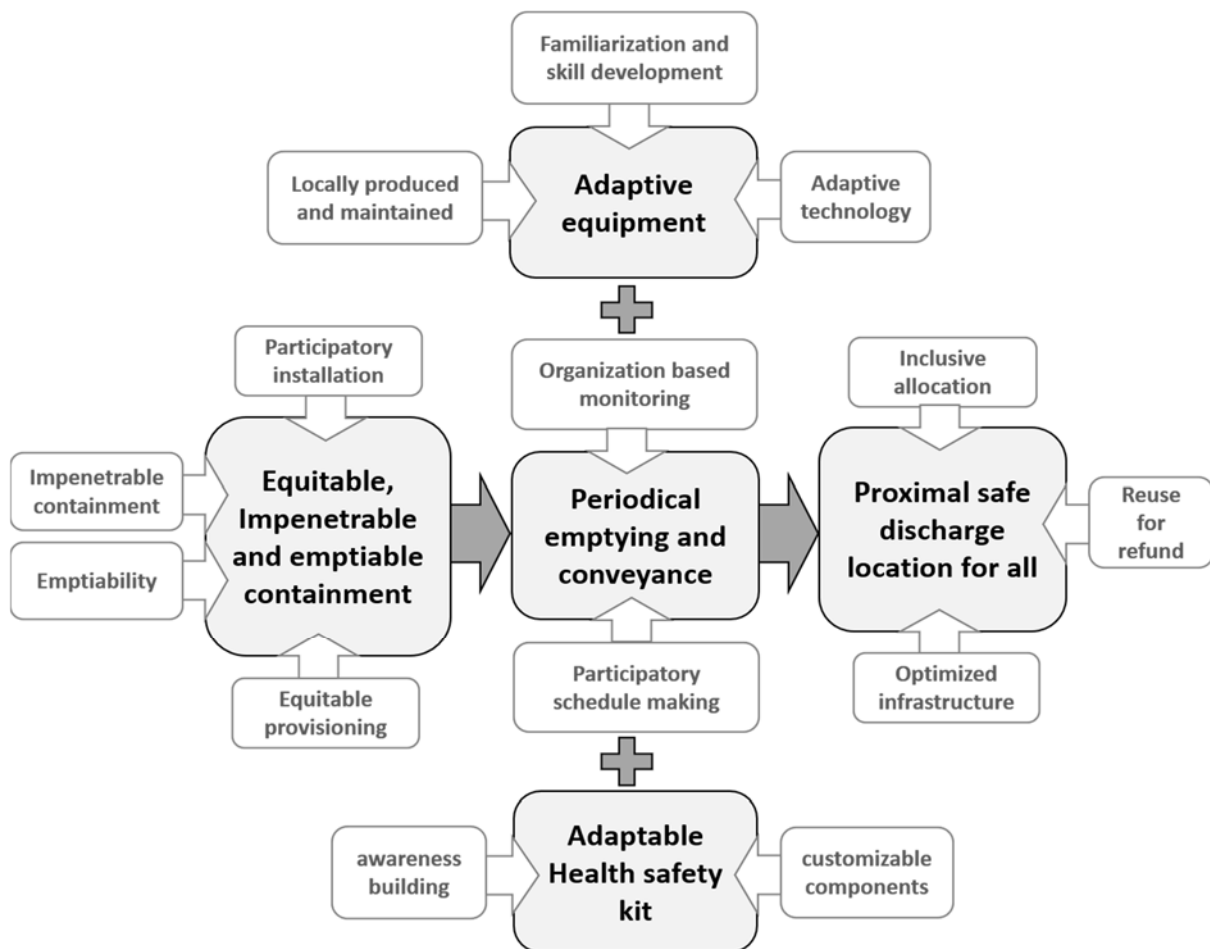


Figure 4.22: The model (source: author)

Table 4.7: list of indicator and variables of the model

Themes	indicators	Variables
Equitable impenetrable and emptiable containment	equitable provision	<ul style="list-style-type: none"> • finding transient population • containment allocation • separate containment • separate service hole
	participatory installation	<ul style="list-style-type: none"> • participation of organization or individual • participation of professional • participation of CDC • participation of local mason • participatory inauguration
	impenetrable containment	<ul style="list-style-type: none"> • pit above upper shallow aquifer • sealable pit ring module • only black water dischargeable pipe
	emptiability	<ul style="list-style-type: none"> • Technical assistance for pit • pit dislocated from pan slab • service hole for top slab
periodical emptying and conveyance	organization based monitoring	<ul style="list-style-type: none"> • informing environmental activities • ensuring network with CDC
	participatory schedule making	<ul style="list-style-type: none"> • enlisting containment • graffiti of emptying schedule • monitored by organization & CDC
adaptive equipment	Adaptive technology	<ul style="list-style-type: none"> • road width mapping • weight of equipment • manual equipment (MAPET, Gulper etc.) • optimized push cart • sealed container for FS carriage • efficient blending equipment
	locally produced and maintained	<ul style="list-style-type: none"> • incorporating local industries • technical assistance
	familiarization and skill development	<ul style="list-style-type: none"> • promotion of equipment to manual emptiers • training program
Adaptive health safety kit	Awareness building	<ul style="list-style-type: none"> • training program • caring manual challenges
	Customizable component	<ul style="list-style-type: none"> • safety wears • locally tailored
proximal safe discharge location for all	inclusive allocation	<ul style="list-style-type: none"> • identifying nearest available public land • settlement wise distribution
	optimized infrastructure	<ul style="list-style-type: none"> • calculating FS accumulation at settlement level • scheduling vacuum tanker with KCC • designing optimized transfer station with holding tank
	reuse for refund	<ul style="list-style-type: none"> • developing co-compost process • locating socially acceptable use

5 Chapter Five: Conclusion

Chapter Five: Conclusion

The research has identified influencing factors of current FSM practices in informal settlement. These factors attributed to develop an emptying model for environmentally safe faecal sludge management in informal settlements. The initial challenge was to identify the factors especially from FSM context of informal settlement. The research has identified the FS flow diagrams which presents how faecal sludge is being discharged to the environment periodically and at emergency time. AS flow of FS is invisible and cannot be explored only with observations. In that case interviews with people, local emptier and CDC members helped to develop the maps and FS flow made visible through built environmental plans and sections.

5.1 Answer to the research question

The research was initially intended to learn FSM from people of informal settlements and to develop an emptying model from that learning. The investigation has gone through the process of collecting and analyzing the contextual evidence from people's perception and intensive observations.

From background analysis the research found current challenges of FSM in informal settlement along with sanitation condition. Then the formulation of the study organizes the overall structure of the thesis to find out how people deal with faecal sludge in such densified settlement of 854 households. From their practices it is identified that what they do with their own management system is not environmentally safe. Further the research tries to find influencing factors of unsafe practices and find out role of people and emptiers from their perception about that management system. Finally, this research tries to develop concepts to form a model of emptying based on people's practices and influencing factors. The developed model based on practice and factors tries to reflect all necessary initiative can be taken to transform existing FSM into an environmentally safe quality.

5.2 Learning from peoples FSM practices

Primary objective of this study to learn from current FSM practices from informal settlement. Primary learning from peoples FSM practices are strengths they hold within their community to manage FS accumulation. Some strengths are visible in their practices; such as: (1) Periodical desludging what is they concerned about most; (2) Periodical monitoring; is the sludge is emitting or not, (3) Alley based organization for their territoriality, (4) Collective payment mechanism and (5) Adaptive to accept changes. But the weakness are risks with environmental health as it was presented in table 4.1.

5.3 Factors behind environmentally unsafe practices

The second objective this study was to find out influencing factors which causes environmentally unsafe practices among people and emptiers who worked in informal settlements. While identifying the factors, the distinguished steps of typical FSM service chain became overlapped. This identification indicates that containment must have emptiable attributes, emptying process must be informed with conveyance system and discharge location will define what is needed for conveyance system. Any pre-decided system will not work into the context without being sensitive to these overlapping. Identified influencing factors are:

Table 5.1: Identified factors overlapped in the chain

associated with containment and emptying	inequity in containment provision
	absence of participation
	lack of environmental concern
associated with emptying and conveyance	Ignorance of emptiability
	lack of emptying schedule
	alley and social organization
	constrains of socio-spatial realities
	selecting available option
	Unfamiliar equipment
	Lacking customizable component
	Lacking awareness of environmental health
associated with conveyance and discharge	Lacking transportability
	lack of safe discharge site
	Lacking proximal distance of disposal site

5.4 The context sensitive model

The influencing factor triggered the thesis towards the development of a context sensitive emptying model. Because FS challenges itself a context specific challenge, which varies with biophysical diversity of settlements and people practices. No single model can be implemented in everywhere. In the case of informal settlements, the problems are more acute and varied. But people of these settlements can break conventional taboos and social customs. To fight with poverty, they adaptive informal solutions according to situations. The create organizations for their own survival and what they accept are the clue for developing a solution for bigger problems. Within social constructivist paradigm this research tries to learn from people and identified how the problems can be addressed. Practices became the clue for developing solutions and factors became the challenge to resolve in this research. Finally, the model been developed in final objective of this research which has been shown in a simple diagram in figure 4.22. To implement the model an adaptive co-management process is needed to deal

with its various aspects. The model is concerned about all identified contextual factors and located stakeholders, activities and processes that can make an environmentally safe FSM for informal settlements. The proposed model has five major themes. Each theme has individual set of indicators and variables which been presented in table 4.22. Variables of the model can be changed according to biophysical diversity, socio-spatial reality of different informal settlements. But the model can derive results in adopting technical solutions and management. The output result from model will vary according to context. Figure 5.1 presents a result for Notun Char settlement, which locates main technological needs for environmentally safe emptying and conveyance of faecal sludge.

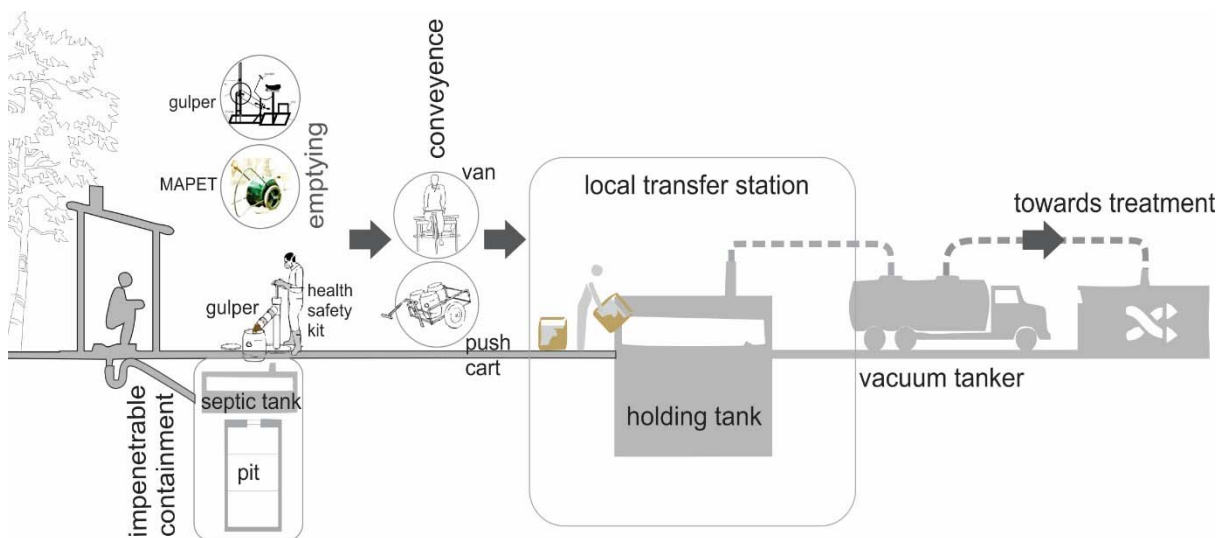


Figure 5.1: technological components of model (source: author)

5.4.1 Limitations of the model

The model is focused on informal settlement and manual emptying of FS. In Bangladesh manual emptying is very depended on Harizan community. As the model addresses manual emptying but social condition of manual Harizan community did not addressed in this model. emptiers of Harizan community plays vital role in FSM. In many informal settlements, institutions play effective role on upgradation of the settlement. In Notun Char, CSS has an impact as they represent Christian community people and owner of lands. But this thesis did not addressed role of institutions.

5.5 Further Research Opportunities

This research always had a focus to create a varied research opportunity for FSM context of informal settlements which was largely been ignored in conventional models adopted in different cities. The whole model has different parts that needed further research on every aspect. Under the main themes sub themes are discussed in detail in previous section. Where every field of analysis are needed further research among multi-disciplines. Variables which been identified in the model needed further multi-disciplinary research for social adaptation, technological performance and management procedure.

5.6 Conclusion

Informal settlements are faces of those realities what a country could not able to address. People living in urban informal settlements; because maybe they lost their own land due to climatic and political shock or they lost their traditional income due the growth of capitalist society and migrated to the cities. The big change could not be addressed in single pinch; but till then the pieces of matters can be addressed with a view that, we want to do something for them. FSM is that kind of piece, but its necessity carries outstanding importance for building a healthy settlement. Looking from bottom of the context can be the answer for why top down approaches are not working. What we do to support the community can also be harmful for them from socio-cultural perspectives and also can harm their relations among social organizations. But those organizations can be the most important opportunity to draw solutions of FSM in those settlements.

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Appendix

1. list of details of respondents

method	respondent no.	population	sex and age	location
KII with single HH toilet user	Respondent 1	settlement	male (34)	Kashem alley
	Respondent 2	settlement	female (26)	Kashem alley
	Respondent 3	settlement	male (55)	school alley
	Respondent 4	settlement	female (52)	khristan alley
	Respondent 5	settlement	female (50)	Kashem alley
KII with shared toilet users	Respondent 6	settlement	male (37)	Sat vai alley
	Respondent 7	settlement	female (37)	hemayet mollah alley
	Respondent 8	settlement	female (60)	Sufi Saheb alley
	Respondent 9	settlement	female (22)	Ranga Mia alley
	Respondent 10	settlement	female (34)	Huzur alley
	Respondent 11	settlement	female (28)	Kulsum alley
	Respondent 12	settlement	female (28)	Hanif sheikh alley
	Respondent 13	settlement	female (55)	Khristan alley
	Respondent 14	settlement	female (68)	Khan Saheb alley
	Respondent 15	settlement	female (60)	Kashem alley
	Respondent 16	settlement	female (38)	torik alley
	Respondent 17	settlement	female (32)	torik alley
FGD 1 at Kashem alley	Respondent 15	settlement	female (60)	Kashem alley
	Respondent 18	settlement	female (33)	Kashem alley
	Respondent 19	settlement	female (30)	Kashem alley
FGD 2 at khan saheb alley	Respondent 20	settlement	male (39)	Khan Saheb alley
	Respondent 14	settlement	female (68)	Khan Saheb alley
	Respondent 21	settlement	female (59)	Khan Saheb alley
	Respondent 22	settlement	female (--)	Khan Saheb alley
FGD 3 at sufi saheb alley	Respondent 8	settlement	female (60)	Sufi Saheb alley
	Respondent 23	settlement	female (58)	Sufi Saheb alley
	Respondent 24	settlement	female (22)	Sufi Saheb alley
	Respondent 25	settlement	female (--)	Sufi Saheb alley
	Respondent 26	settlement	female (25)	Sufi Saheb alley
FGD 4 at Hemayet Mollah alley	Respondent 27	settlement	male (20)	hemayet mollah alley
	Respondent 28	settlement	male (65)	hemayet mollah alley
	Respondent 7	settlement	female (37)	hemayet mollah alley
	Respondent 29	settlement	female (25)	hemayet mollah alley
	Respondent 30	settlement	female (24)	hemayet mollah alley
	Respondent 31	settlement	female (26)	hemayet mollah alley
FGD 5 at Hanif Sheikh alley	Respondent 12	settlement	female (28)	Hanif sheikh alley
	Respondent 32	settlement	female (34)	Hanif sheikh alley
	Respondent 33	settlement	female (--)	Hanif sheikh alley
	Respondent 34	settlement	female (31)	Hanif sheikh alley
FGD 6 at ranga mia alley	Respondent 9	settlement	female (22)	Ranga Mia alley
	Respondent 35	settlement	female (36)	Ranga Mia alley
	Respondent 36	settlement	female (29)	Ranga Mia alley
	Respondent 37	settlement	female (30)	Ranga Mia alley
FGD 7	Respondent 38	CDC member	female (28)	Iaqub alley
	Respondent 39	CDC member	female (37)	Iaqub alley
	Respondent 40	CDC member	female (--)	Iaqub alley
KII	Respondent 41	local emptier	male (45)	main road

KII	Respondent 42	vacutug manager	male (26)	munshi para
FGD 8	Respondent 43	Harizan emptier	male (19)	Harizan Palli
	Respondent 44	Harizan emptier	male (45)	Harizan Palli
	Respondent 45	Harizan emptier	male (33)	Harizan Palli
	Respondent 46	Harizan emptier	male (--)	Harizan Palli
	Respondent 47	Harizan emptier	male (23)	Harizan Palli
	Respondent 48	Harizan emptier	male (--)	Harizan Palli
	Respondent 49	Harizan emptier	male (29)	Harizan Palli
	Respondent 50	Harizan emptier	male (30)	Harizan Palli
KII with NGO/UNDP	Respondent 51	NGO	male (--)	Nobolok office
	Respondent 52	NGO	male (--)	SNV office
	Respondent 53	UNDP	male (--)	UNDP office

2. Form of questioner for KII and FGD of settlement people

(Open ended, Semi-structured questioner for audio recording)

Name:	Age:	Gender: male/female/other	Location:
Containment type:		Organization type: single/1 alley / 2 alleys	
number of populations for FGD:			
<ul style="list-style-type: none"> • How you occupied in this land? • How you manage infrastructural changes for your house? • How did you build or received toilet? • What do you know how it is constructed? • How you manage fill-up of FS? • Why do you connect pipe with the containment to drain? • When did you emptied your containment? <p>(if emptying happened)</p> <ul style="list-style-type: none"> • how did you manage emptying of the containment? • What emptiers did while emptying? • Where emptiers discharges FS? • How did they carried FS to discharge locations? • How you managed the cost emptying? • What do you know about, where to discharge FS? 			

3. Questioner form for KII and FGD of manual emptiers

(Open ended, Semi-structured questioner for audio recording)

Name:	Age:	Gender: male/female/other	Location:
number of populations for FGD:			
<ul style="list-style-type: none">• Where have you worked before for emptying?• What are the conditions of containments if informal settlement?• How people pay for your work?• What do you use for emptying work?• Hou much space you need for emptying work?• How road width required access with your equipment?• Why spillage happens in your procedure?• Why you need to enter in containment?• Why don't you wear protective gear during emptying?• What are procedural differences of emptying septic tank and pits?• How you get the call for job?• What are the locations for discharging FS you use?• Why you discharge in those locations?• Have you ever heard about treatment plant in the city?			

4. Questioner form for KII and FGD of CDC member

(Open ended, Semi-structured questioner for audio recording)

Name:	Age:	Gender: male/female/other	Location:
<ul style="list-style-type: none"> • How long have you been in this job? • which kind of work you do as your responsibility? • What are general works of your sanitation projects? • How your organization provide toilet in the settlement? • How you manage construction of toilets? • What is happening with vacutug in the city? • what is happening with treatment plant of the city? How it is being managed? • How CDC works for FSM? • What were the main considerations of emptiers training program of the city? 			

5. Questioner form for KII of NGO/UNDP personnel

(Open ended, Semi-structured questioner for audio recording)

Name:	Age:	Gender: male/female/other	Location:
<p>number of populations for FGD:</p> <ul style="list-style-type: none"> • How long have you been CDC member? • which kind of work you do as CDC member? • How CDC members work with settlement people? • How people get toilets in the settlement? • What is your role for construction of toilets? • What manual emptiers do in emptying work? • What people do when pit or tank is full? • Why vacutug does not enter to the settlement? • What do you know about waste management of this settlement? • How people pay for your services? 			

6. Prepared settlement map for taking survey field notes (Source: GIS map, KDA)

