Municipalities Network Advocacy on Sanitation in South Asia (MuNASS) Project

Sanitation Situation Report of Lahan Municipality

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Sanitation Situation Report of Lahan Municipality, Siraha, Nepal

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Executive Summary

After Nepal has attained Open Defecation Free Status in September 2019, the country is heading towards long term goal of total sanitation. However, before heading ahead, it is important to have understanding of the current sanitation status. At present, 70% of the population in Nepal rely on non-sewered sanitation system, owing to the economical and geological realities of the country. With such a bigger number relying on non-sewered system, it is important to have proper management of the system so as to assure better health and hygiene of people. The "Municipalities Network Advocacy in Sanitation in South Asia (MuNASS)" project believes that the sustainable sanitation to all can be only achieved when the local government are capable for planning, developing and implementing effective sanitation strategies. As a part of capacity development, the study on FSM status was conducted to assist local government making effective planning and implementation for it.

The municipality is extended to an area of 167.17 sq km with 91,766 population residing in 17,182 households. The study aims at understanding the current status of sanitation in the municipality and hence produce evidence-based data and information for effective FSM planning. For the purpose, methodologies such as literature review of secondary data, in-depth questionnaire survey of households and institutions, direct observation and key informant survey on FSM key stakeholders are conducted. A total of 376 households were sampled at the interval of 42 from 17,239 households distributed in 24 wards with proportionate stratification random sampling. Also, 209 institutions were surveyed.

Lahan municipality was declared as ODF in 2018 itself however survey reveals that 6.6% households did not have toilet. Of those who have toilet facility, majority of them had onsite sanitation system with only 4.3% having offsite system. As of households, majority of the households i.e. 33.2% had single pit constructed out of concrete rings while least of them i.e. 2.4% of households with onsite sanitation system had biogas digester. At institutional level, 30.8% of them had fully lined tank as their containment whereas only 2.4% had their containment connected to biogas digester.

Emptying is an important component to be considered in the sanitation value chain so as to ensure proper functioning of the containment. 65% of the households emptied the containment using mechanical desludging services either from the municipality or private desludging service provider and the remaining used traditional manual scavenging. Emptying was done once the containments were filled. 28% of the containments were emptied once every 3 to 5 years and also 13% of containments were emptied three times a year. 31% had emptied their

containment at least once since the installation and 69% of the remaining have never emptied since their installation as none of these were filled or overflowed reason being most of them newly constructed.

Lahan municipality has been providing desludging services since 2011 but only within the municipal boundary. The municipality has imported a suction tank with a capacity of 4000 liters. Consumers pay the service charge once they get the service and charge depends upon the shape of the containment. The service charge for the rectangular tank is NPR 1500 and NPR 750 for ring containment. Other than municipality, private entrepreneurs are also involved in this desludging business. The cost charged is similar to that of municipality depending upon the shape of the containment. Yet the rate varies.

Last part of the faecal sludge service chain is treatment and disposal/ reuse. In context of Lahan, Municipality does not have any fecal sludge treatment plant and uses its Solid Waste Treatment Plant for the disposal of collected fecal sludge. As for private entrepreneurs, fecal sludge is disposed-off either in farmers' land (as per demand) or into Balan approximately 4 km far away from the main city area.

The study also assessed people's perception of emptying, disposal and its consequences and also their perception of improved management of FS was measured. 58% of households would contact municipality for mechanical emptying while 14% preferred self-emptying. Once collected, 40% of consumers perceived that the collected fecal sludge is applied in the farm, 32% perceived it is disposed in open land and only 24% of them perceived that it is sent to the treatment plant. Regarding perception towards improved FSM, 51% preferred construction of the treatment plant and only 8% of people claimed encouraging reuse option would improve current practices of FSM.

Assessment of the feasibility on FSM reveals that only 3% of FS collected in an anaerobic biogas digester has been treated while 31% of FS collected in the fully lined tank is considered safely managed until it is emptied and rest being disposed of haphazardly to the environment. Quantity of FS is estimated based upon the average size of various containment and their emptying frequency obtained from primary data collected during the household survey. Approximately, 50538 m^3 of FS produced from households alone per year excluding FS from households with an anaerobic biogas digester. In an average 2276 m^3 of FS per year is generated from institutions.

The overall sanitation status of the municipality indicates the urgent need for FSM interventions. The higher portion of containment never emptied indicates leakages and unauthorized open emptying practices into an environment possesses potential threat to human health. Both of which are serious issues and hence the municipality should immediately act on to improve FSM for better environment and human health. Some of the initiatives that the municipality could take for improved FSM could be; formulation of standards of containment and upgrading existing containment, data management and effective monitoring, formulation of regulations for emptying service and finally classification of service delivery area and appropriate treatment facilities.

Abbreviations

CBS	Central Bureau of Statistics
ENPHO	Environment and Public Health Organization
FS	Faecal Sludge
FSM	Faecal Sludge Management
MuAN	Municipal Association of Nepal
MuNASS	Municipalities Network Advocacy in Sanitation in South Asia
NSS	Non-Sewered Sanitation System
ODF	Open Defecation Free
PPE	Personal Preventive Equipment
SDG	Sustainable Development Goal
SFD	Shit Flow Diagram
UCLG ASPAC	United Cities Local Government Asia Pacific

Acknowledgment

We offer our sincere acknowledgement to Mr. Muni Sah Suri, Mayor and Ms. Sariyar Kumari Chaudhary, Deputy Mayor of Lahan Municipality, together with all ward chairpersons and staffs of the municipality for continuous support and valuable feedback during the study. We sincerely thanks Mr. Shatrudhan Chaudhary, a focal person of the MuNASS Project in Waling Municipality for coordinating and mobilizing volunteers during the study.

We would like to acknowledge United Cities Local Government - Asia Pacific (UCLG ASPAC) for financial support of the project Municipalities Network Advocacy on Sanitation in South Asia (MuNASS) and Municipal Association of Nepal (MuAN) for coordination with the municipality. We would like to appreciate Dr. Roshan Raj Shrestha, Deputy Director of Bill and Melinda Gates Foundation (BMGF), Dr. Bernadia Irawati Tjandradewi, Secretary-General, Mrs. Asih Budiati, Regional Project Manager and Mr. Satish Jung Shahi, Communication, Outreach and Knowledge Management Officer of UCLG ASPAC. Similarly, we are very much obliged to Mr. Ashok Kumar Byanju Shrestha, Chairperson, Mr. Kalanidhi Devkota, Executive Director and Mr. Muskan Shrestha, Sanitation Advocacy Specialist respectively from MuAN for their gracious support.

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Also, we would like to acknowledge all the residents from Lahan Municipality without whom the study would not have been possible.

Last but not the least, we are extremely thankful to ENPHO colleagues for their support and cooperation during entire process of Study.

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1 Introduction

1.1 Background

The “Municipalities Network Advocacy in Sanitation in South Asia (MuNASS)” project, focusses on capacity building, implementing national policy and strategy on sanitation particularly focusing on Fecal Sludge Management (FSM) and Non-Sewered Sanitation System (NSS) in line with Sustainable Development Goal (SDG) 6. A limited number of functioning sanitation facilities and appropriate sanitation technologies are main constraint towards achieving the goal. It has increased potential threats towards environmental pollution and human health hazard. Thus, it is always a better to act on preventive approach rather than curative action.

In Nepal, 70% of the population rely on non-sewered sanitation systems. The system is good option owing to economical and geological realities of Nepal. Thus, proper management of the system could ensure better health hygiene of the people. The project belief sustainable sanitation to all can be only achieved when the local government, a major implementing body at the ground are capable for planning, developing and implementing effective sanitation strategies. As a part of capacity development, the study on FSM status was conducted to assist local government making effective planning and implementation for it.

1.2 Objectives

The main goal of the study is to support local government with decision making and planning for better sanitation facilities and services. The major objectives of the study are

i. To understand the current FSM status of the municipality

ii. To produce evidence-based data and information for effective FSM planning, assist in preparing Detail Project Report of FSM, support advocacy and awareness raising initiatives.

1.3 Limitation of the Study

Limitation of the study are

- The study did not cover the sanitation status of the Industries as, there is national provision for industries to manage waste generated in it.
- Assessment of existing policies and institutional set up was not conducted as there is separate activity within the project regarding preparing a municipal policy on FSM.

- Also, financial assessment such as cost-effective assessment on FSM interventions was not performed as it is a totally nonprofit oriented project and responsibility of government to provide safe sanitation. Besides it, there is limited knowledge on CapEx and OpEx of different FSTPs in the country.

1.4 Study Area

Lahan municipality is located in Siraha District in the Province number 2 of south-eastern Nepal. The municipality was formed in the late 1970s through the collaboration of Lahan Bazar, Lahan Goth and Sigarahi Matiyarwa VDCs. In December 2014, the government of Nepal expanded the 10 wards of the municipality into 22 wards. According to the federal structure of the country, adjoining Gadha and Govindapur Malhaniya VDCs were merged and extended to 24 wards. Currently, it is extended into 167.17 square kilometres. It is home to 91766 population residing in 17182 households. The population has increased gradually with rapid urbanization over a period of 20 years. The municipality has evolved as trade and industrial centre from its agrarian economy.

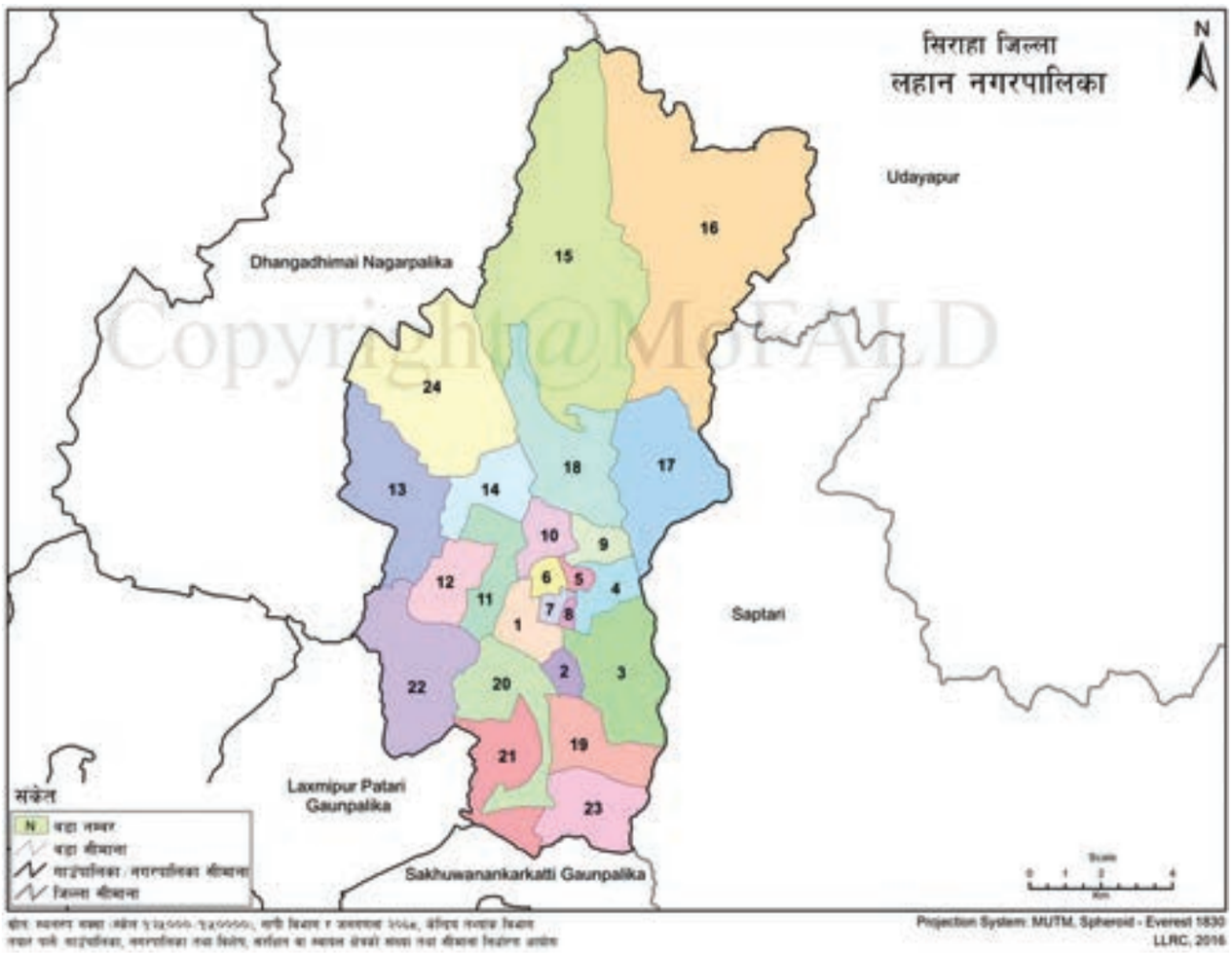

Figure 1: Location Map of Lahan Municipality with its wards boundary

2 Methodology

The methodologies adopted in the study are in a literature review of secondary data, depth questionnaire survey at household and institutional level on existing sanitation status. Also, the key informant survey on FSM key stakeholders is conducted followed by direct observations of the existing sanitation situation.

2.1 Household Survey

The random household survey was conducted in all wards of the municipality through the mobilization of volunteers selected by the municipality. The household survey was conducted using a mobile application "KOBOCOLLECT" after orientation. Two days orientation training was conducted to make volunteer understand the objective of the survey, technical terms regarding sanitation, use of the mobile application and conducting a random sample survey.

2.1.1 Determining Sample Size

The number of households to be sampled in the municipality was determined by using Cochran (1963:75) sample size formula $n_o = \frac{Z^2pq}{e^2}$ and its finite Population Correction for the Proportion $n = \frac{n_0}{1+\frac{(n_0-1)}{N}}$. Where,

Z^2	1.96	At the confidence level of 95%
p	0.5	Assuming that about 50% of the population should have some sanitation characteristics that need to be studied. (This was set at 50% since this percentage would yield the maximum sample size since the percentage of the population practicing some form of sanitation is not clearly known at the intervention sites)
q	1-p	
e	±5%	Level of precision or sampling error
N		Total number of population (households in the municipality)

This is followed by Proportionate Stratification Random Sampling such that each ward in the municipality is considered as one stratum. The sample sized required in each ward is calculated as

$n_h = \frac{N_h}{N} \times n$, where, Nh is a total population in each stratum.

Thus a total of 376 households were sampled at the interval of 42 from 17239 households distributed in 24 wards with proportionate stratification random sampling as shown in table 1.

Table 1: Proportionate Stratified Sample Distribution in each ward

Wards	Households	Sample	Wards	Households	Sample
1	950	21	13	752	16
2	475	10	14	406	9
3	845	18	15	979	21
4	823	18	16	494	11
5	905	20	17	576	13
6	537	12	18	1017	22
7	456	10	19	745	16
8	540	12	20	676	15
9	398	9	21	740	16
10	550	12	22	993	22
11	616	13	23	870	19
12	531	12	24	1365	30
				Total	**376**

2.1.2 Sampling Procedure

To have a more consistent way of identifying, selecting and interviewing the allocated number of households across each ward,a systematic sampling approach was followed and random households are selected for the survey. The steps used are as below.
Steps used:

1. Calculate the ward sampling interval, i.e. the total number of households divided by no. of households to be sampled.
2. Select a random start between 1 and sampling interval using excel function RANDBETWEEN (1, sampling interval).
3. The random start identifies the first households to be interviewed, the second household will be number (random start + sampling interval)
4. Repeatedly add sampling interval to select subsequent households.
5. As a rule, for replacement of HHs that are not available or not consent to the interview, the first household on the left-hand side of the absent household was selected.

2.2 Institutional Survey

Door to door method was applied for Institutional survey. All institutions within the set criteria for selection were surveyed. The criteria for selection are:

1. Educational and financial institutions operated in either its own building or rented building are selected but operating in a single room or flat not selected.
2. All hotels with the provision of residential facilities are selected.
3. Health care center with the provisions of the bed is selected, i.e. small clinics were not selected.
4. Government/ Non-government Offices are selected.
5. Commercial Buildings are selected.

In total 209 institutions were surveyed and descriptions of surveyed institutions are shown in table 2.

Table 2: Descriptions of Surveyed Institution

Wards	Financial Institutions	Hotel/ Home Stay	Commercial Buildings	Educational Institutions	Government/ Non government Office	Community Buildings	Health Care Center	Total
1		2		8	1			11
2				3	2			5
3	2			4	1		4	11
4				5				7
5				2	1		2	5
6				2				
7	2	4	4	2	5	2	1	20
8	1	1		5	1			8
9				1		1		2
10				3	1	1	2	7
11	2			1	1			
12	1			3	1	1	1	
13				4	2			
14				4	4		1	
15				5			1	
16				5	1		1	
17	1			5	2	1	1	
18				7		3	1	
19				4				
20				2				
21				4	2		2	
22				3	1			
23					1	1	1	
24				4	1		1	
Total	**9**	**7**	**6**	**82**	**28**	**10**	**19**	**159**

2.3 Key Informant Interview

Key informant interview was conducted to understand existing sanitation policies of the municipalities, the planning process for developing a sanitation program and on-going programs. Similarly, the interview was focused on the existing service delivery mechanism. Mr Ram Narayan Yadav from the sanitation section was interviewed to get information on desludging service provided by the municipality. Similarly, Mr Shiva Kumar Shah, a private entrepreneur on desludging business was interviewed.

2.4 Data Collection Process

The data was collected by using the KoBo Collect application, which was uploaded into mobile phones through the mobilization of the local enumerators. ENPHO engaged its own staff as supervisors to undertake this survey. The supervisors engaged local enumerators to conduct the household and institutional survey. Enumerators were trained on a questionnaire survey and using KOBO COLLECT. During the training, enumerators have familiarized themselves with questionnaire contents, the flow of questions, mobile data collection devices, and test runs all the devices.

2.5 Data Processing and Analysis

After the fieldwork, all the e-forms submitted in the KoBo dashboard were adequately checked for accuracy and completeness before analysis. The data was cleaned and verified for inconsistency, missing values and errors. After data cleaning, the second step of analysis involved the generation of syntax commands to ensure that variables are transformed appropriately for ease of analysis.

The data processing and analysis entailed the following steps:

- Downloading the data from the KoBo Collect in excel and Performing exploratory analysis to check for accuracy, completeness, relevance and consistency of the critical data elements;
- Performing data cleaning using a set of manipulation commands to ensure that data are aligned to the data analysis plan and the agreed reporting template;
- Descriptive analysis entailed computing frequency distributions; means and cross-tabulations

The data cleaning process is one of the important steps in data processing before its analysis. Data cleaning entails a set of procedures aimed at assessing the sampling protocol adherence, completeness of collected data, accuracy, consistency and relevance of each of the data elements under consideration as well as actual correction of the data with errors for improved data quality.

The process of data cleaning ensures that the errors in data arising from missing data, outliers and other out of range issues are handled in time for better quality results. Following the completion of data collection, the data was cleaned and verified before the analysis and interpretation of data.

3 Sanitation Status

Figure 2: a household toilet in Lahan Municipality

The Lahan municipality was declared ODF zone in 2018. However, the survey showed that 6.6% of households in the municipality does not have toilets. Similar reports was published in national daily paper in 2018 (MyRepublica, 2018). The majority of households have onsite sanitation while 4.3% have offsite sanitation such that toilets are connected to either open-drain or open land. Moreover, toilets in 1.6% of households have been damaged and not used as shown in figure 2.

3.1 Types of Containments

3.1.1 Types of Containments at Household Level

Toilets in 2.4% of households has linked to an anaerobic biogas digester which receives the excreta and flushing water directly from a toilet. The anaerobic biogas digester is designed for the integrated treatment of toilet products, animal manure and kitchen and garden waste. The system is observed in ward numbers 15, 16 and 24 in Khoriyatole, Dhodhana, lagaraha, Mahato tole and Malahanma.

A containment constructed with bricks and cement wall, plain cemented concrete flooring and totally lining without outlet or overflow system is termed as a fully lined tank. The containment is constructed to safely hold the faecal sludge for a certain duration of time and empty regularly. Such a system is observed in 12.2% of the households mostly located at urban clusters in ward number 5, 6, 7, 8, 9 and 10. A septic tank, basically a containment and primary treatment unit at household was observed in 6.1% of households as shown in figure 3, in the same area. While 8.5% of households have a lined tank with impermeable walls and open bottoms.

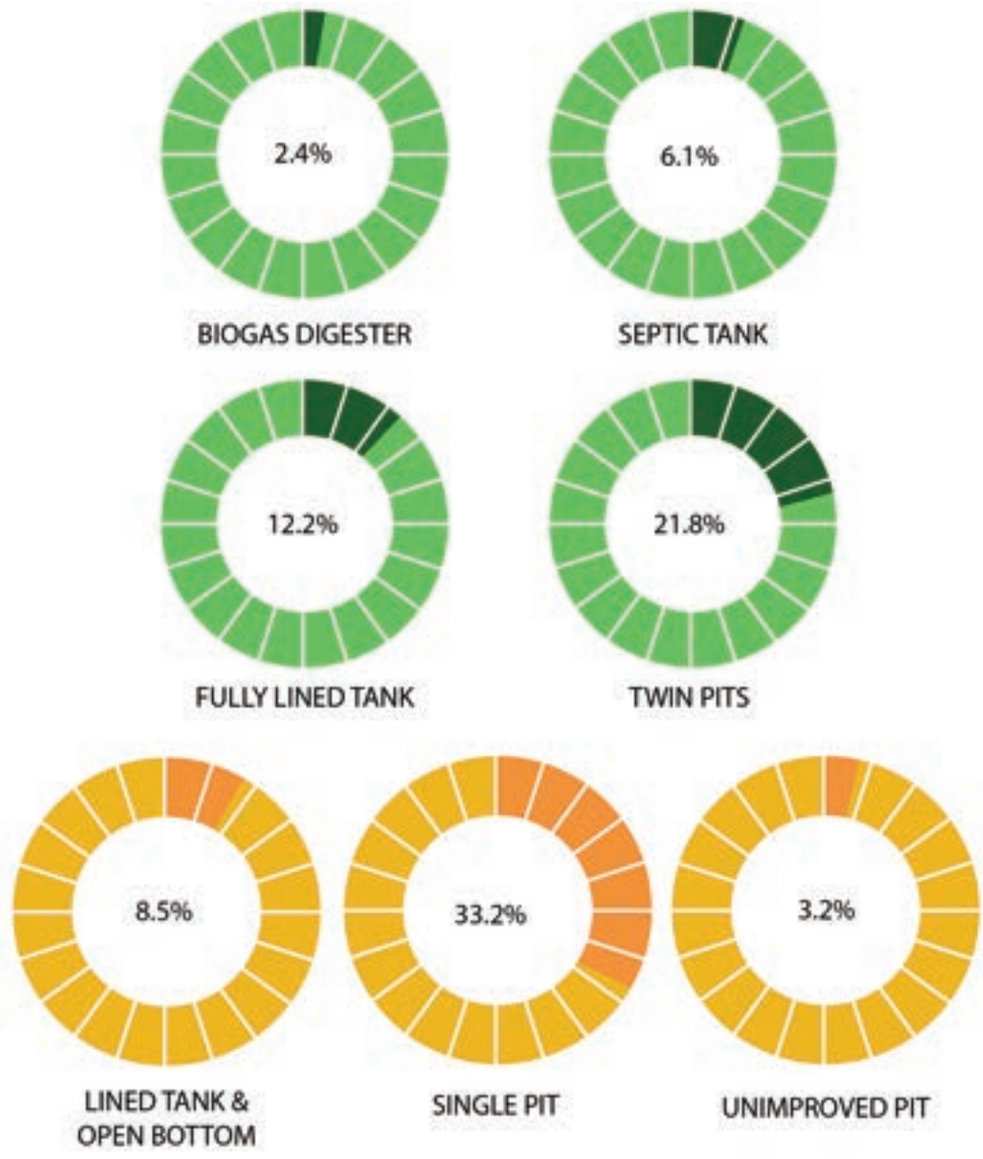

Figure 3: Types of Households Containment in Lahan Municipality

Whereas twin pits and single pits constructed with concrete rings were common in rural areas of the municipality. 21.8% and 33.2% of households have installed such containments. Also, 3.2% of households have an unimproved pit.

3.1.2 Types of Containments at the Institutional Level

Majority of institutions have been established and operated in the core urban area of the municipality. Majority of institutions, 52.2% have connected toilet into either a septic tank or fully lined tank. Similarly, significant institutions have installed unlined tanks with open bottom and pits. Figure 4 shows the types of containments at institutional buildings.

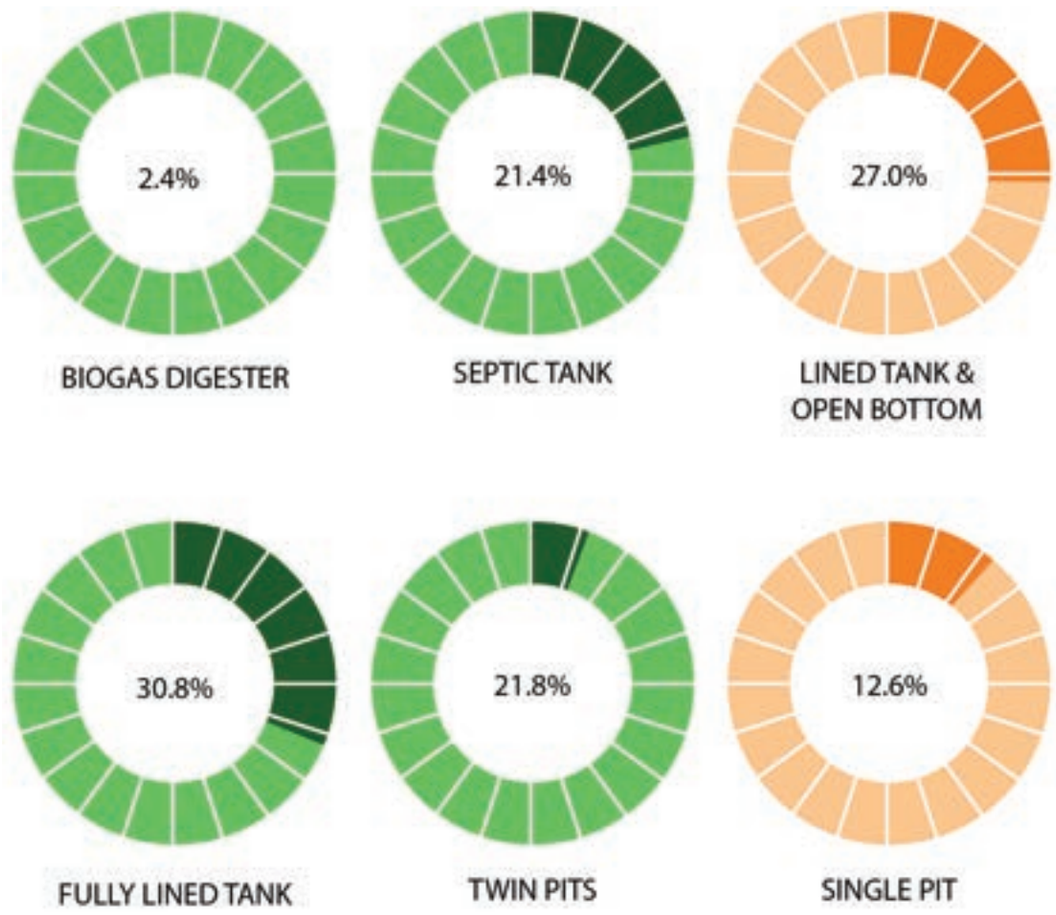

Figure 4: Types of Containments in Institutions in Lahan Municipality

3.2 Sources of Drinking Water

Drinking water in the core urban area of Lahan Municipality has been supplied with pipe drinking water supply schemes since the 1980s. The schemes have been upgraded by JICA and was operated by DWSS till 1998. Currently, the scheme is being operated by Nepal Water Supply Corporation (NWSC) and served only 10 wards of the municipality (MWSS, 2016).

The survey in 2019 showed approximately 30% of the households were benefitted from the water supply schemes and almost 70% rely on hand pumps or tube wells. Data on water quality of ground water is unavailable, however, the risk on water contamination could be estimated with respect to proximity and depth of these water points to containment. Moreover, the risk of water contamination is high in those households which uses lined and impermeable walls but open bottom containment and pit latrines. It was observed 8.68% and 66.42% of households consuming water from hand pumps have installed the lined tank and open bottom and pits (twin, single or unimproved) respectively to collect faecal sludge.

3.2.1 Distance between Water Points and Containments

8.6% of households depending upon hand pumps for drinking water have installed lined tank with impermeable walls and open bottom. Figure 5 shows the per cent of hand pumps at a various horizontal distance of the water point from the containment and its depth. Almost 73% of water points are within the horizontal distance of fewer than 25 feet and depth of 60 feet, which have high risk towards contamination by seepages of faecal sludge from the containment.

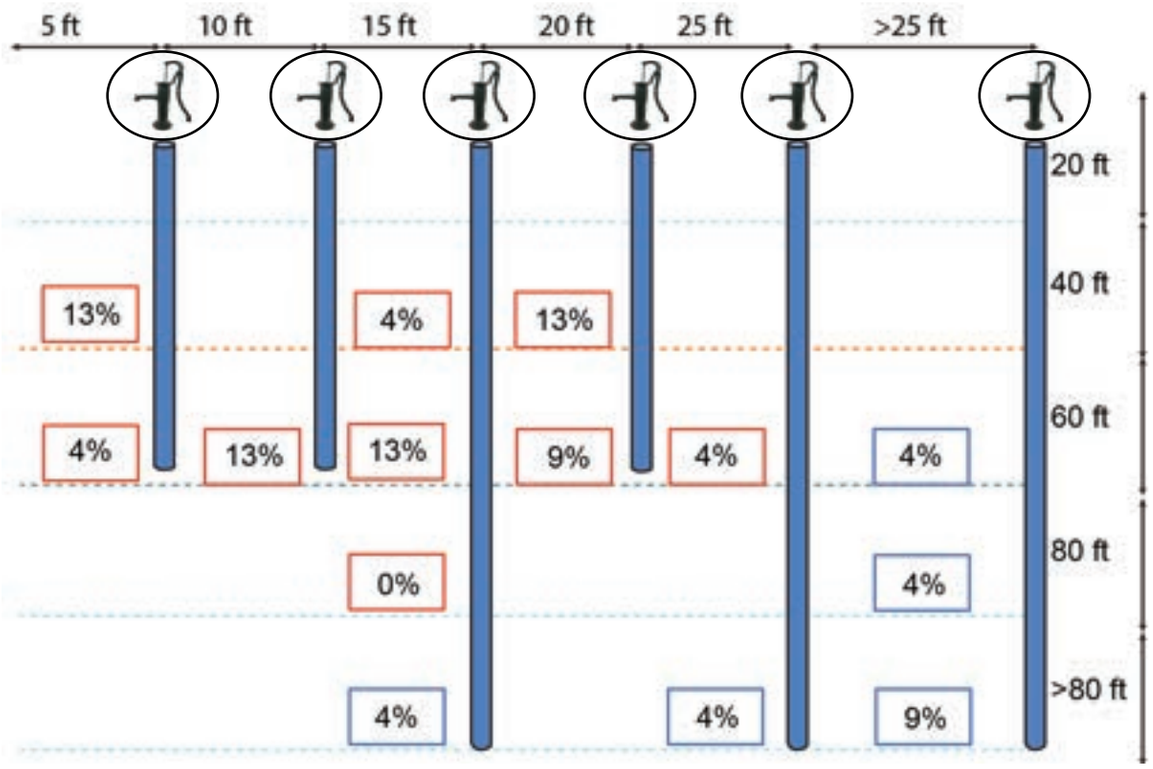

Figure 5 Horizontal distance and depth of groundwater of hand pumps installed in household with lined tank and open bottom containment

Similarly, 66.42% of households depending on hand pump or tube well have installed pit latrines. Approximately, 40% of these water points are within the horizontal distance of 25 feet and a depth of 80 feet as shown in figure 6. Thus, these possess risk towards contamination of groundwater.

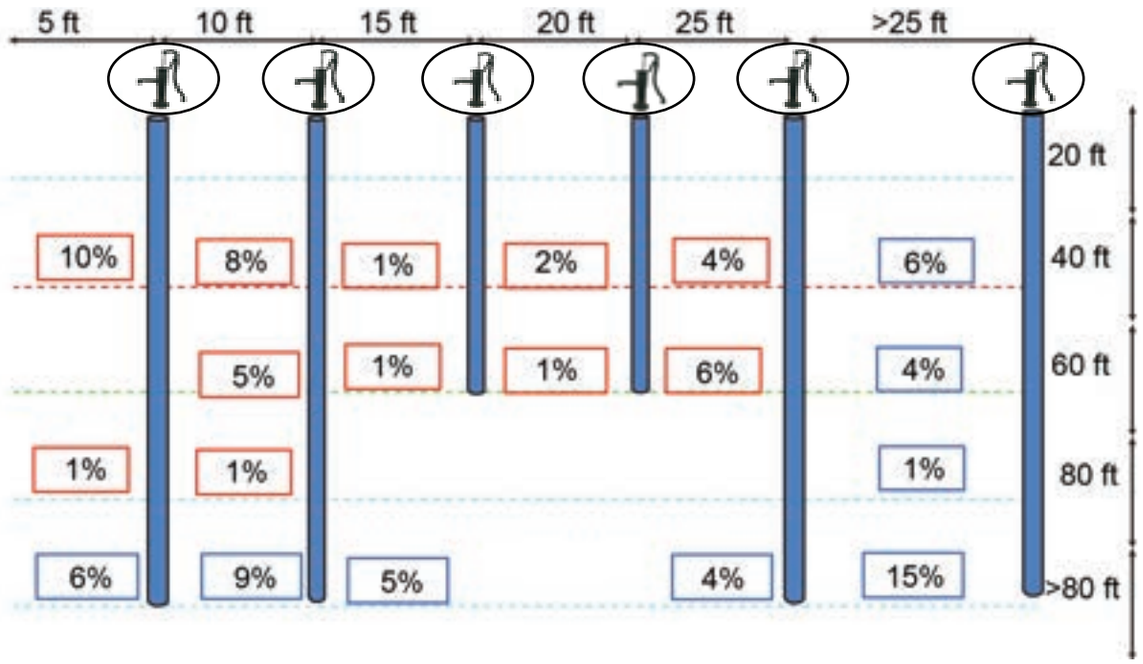

Figure 6 Horizontal distance and depth of hand pumps in household with installation of pits

3.3 Size of Containments

Figure 7 shows the histogram of the size of the containment. The minimum and maximum size is 0.5 m^3 and 46 m^3 respectively. The average size is 6.024 m^3 with 0.44 standard error of mean and standard deviation of 7.9. The skewness value is 2.48 indicating skewed at right. Also, kurtosis value is 6.4 that implies there are significant outliers with respect to average size. Thus, the average size could not be generalized for all the types of containment.

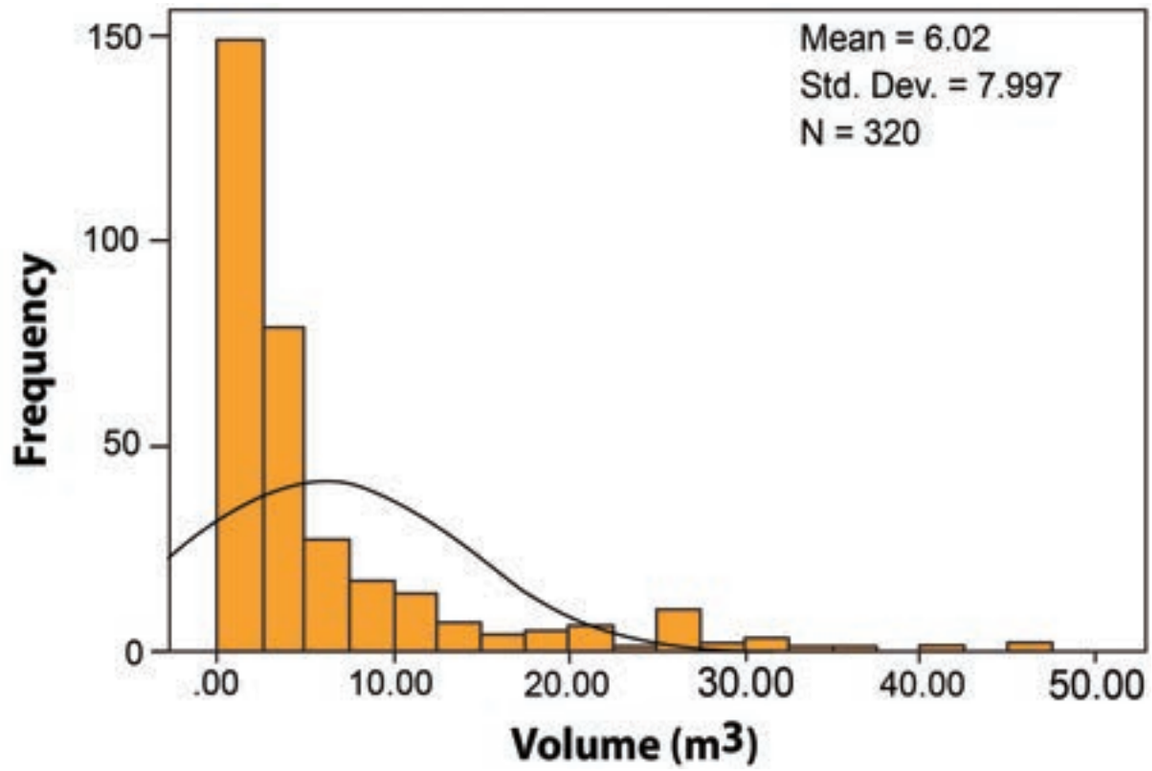

Figure 7 Histogram on size of containments

3.3.1 Size of Rectangular Containment

Figure 8 shows the histogram of the size of the rectangular containments. The average size of the containment is 14 m^3 with a standard error of the mean at 1.01 and a standard deviation of 10.25. The minimum and maximum sizes are 1 m^3 and 46 m^3 respectively. The skewness value is 1.06 which implies right hand skewed and kurtosis is 0.671.

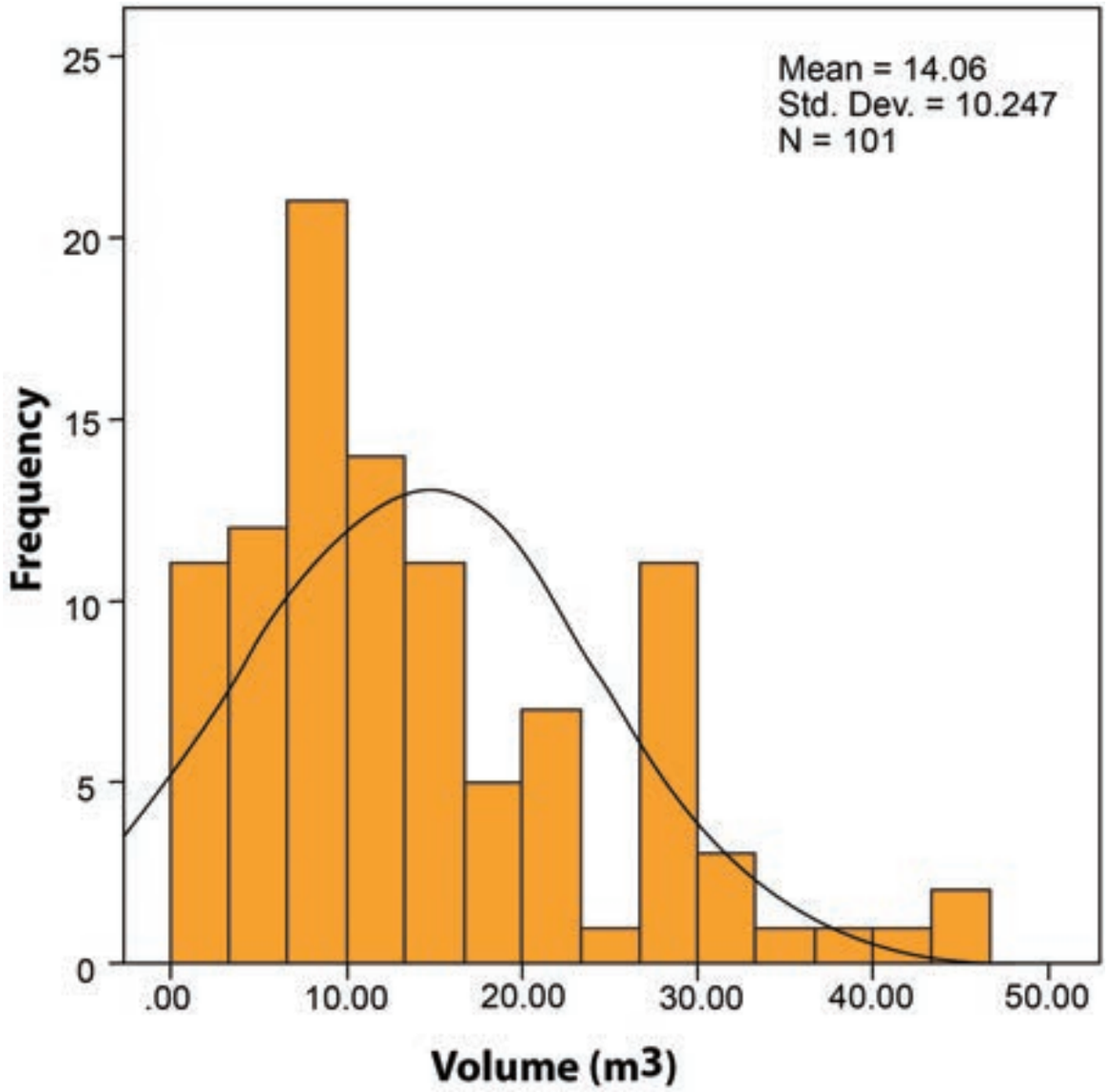

Figure 9 Histogram on size of rectangular containments

3.3.2 Size of Circular Containment

Figure 9 shows a histogram of the size of circular containments which is almost normally distributed with a skewness value of 1.17 and kurtosis of 0.68. The average size is 2.3 m^3 with 0.88 standard error of mean and standard deviation of 1.3. The minimum and maximum sizes are 1m^3 and 7.6 m^3 respectively.

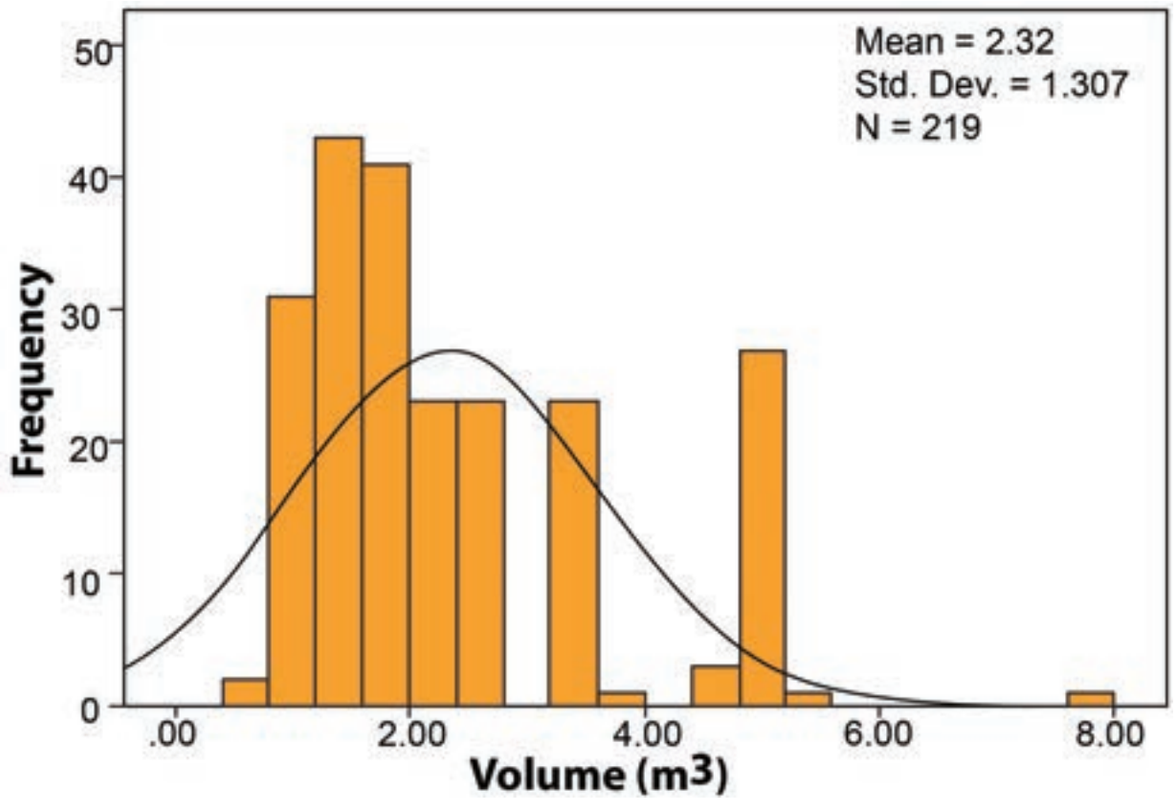

Figure 8 Histogram on size of pits

3.3.3 The relation between Size of Containment and User

Figure 10 shows the relation between the size of the containment and the number of the user. Pearson's Coefficient of the Correlation value is -0.104 with a coefficient of determination 0.011. This implies that there is no significant relationship between the size of the containments and user.

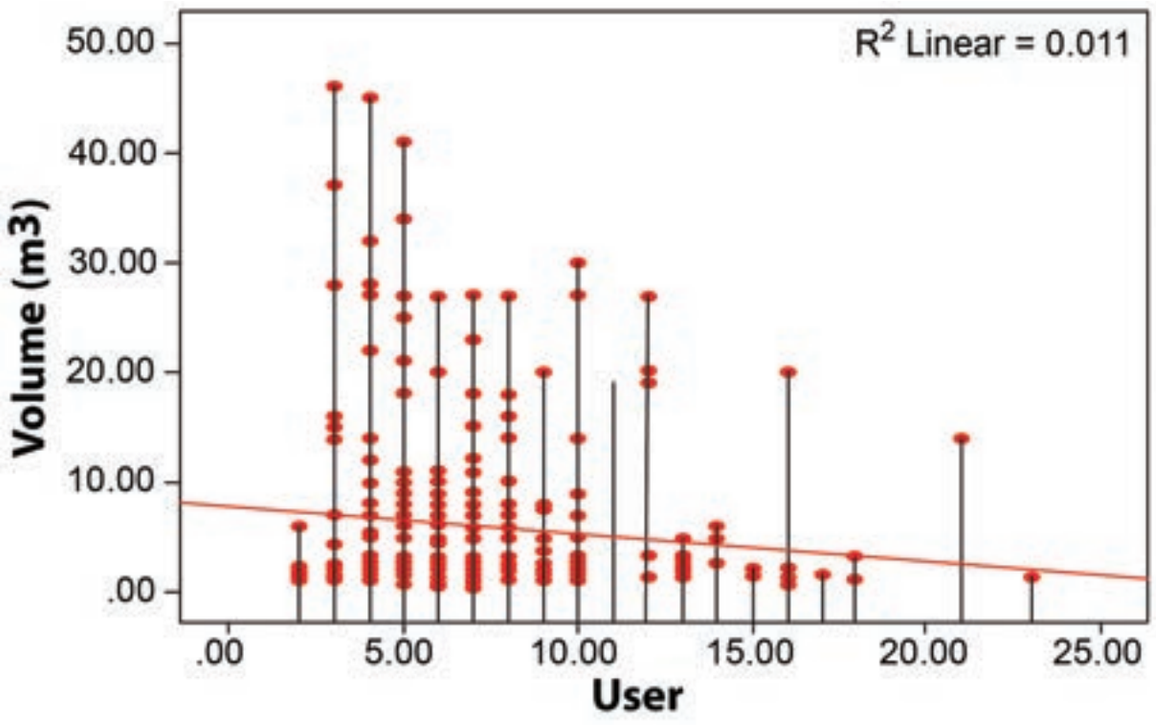

Figure 10 Graph on relationship between size and user of containments

3.4 Emptying and Transportation

Emptying is one of the major components of the sanitation value chain. It ensures the proper functioning of containment basically for the septic tank which functioned well until the volume of sludge is one-third of the total volume of the tank. Also, in other containments, regular emptying prevents overflow of the sludge and blockages. However, anaerobic biogas digester has been designed treated slurry is automatically overflowed from the outlet chamber which is used as manure. Thus, anaerobic biogas digester has been excluded in the analysis.

The data revealed 31% of households have emptied their containment at least once since the installation. Both traditional manual scavenging and mechanical emptying of the containments are practiced in the municipality. In an average 66% of household emptied using mechanical desludging services either from the municipality or private desludging service provider.

3.4.1 Emptying Frequency

Emptying frequency is variable with respect to types of the containment. Generally, containments located in waterlogged and low land area has higher emptying frequencies. It was observed that 28% of the containments were emptied once every 3 to 5 years and also 13% of containments were emptied three times a year as shown in figure 11.

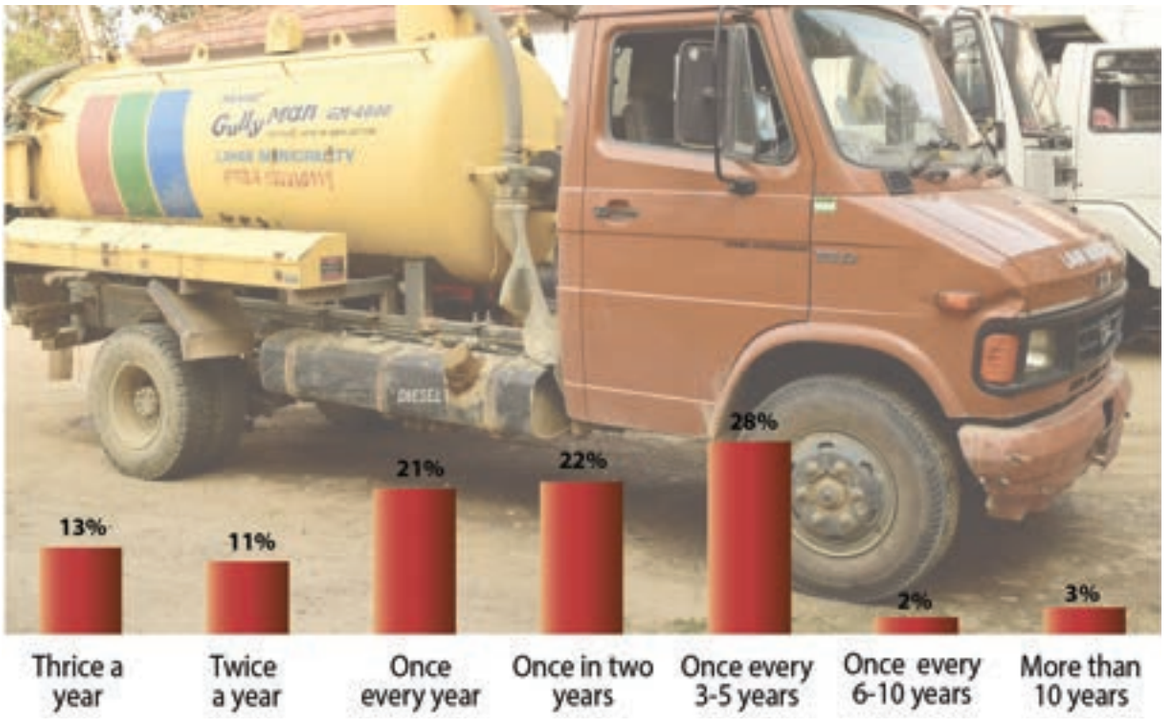

Figure 11 Emptying Frequency of Containments

3.4.2 The relation between Size of containment and Emptying Frequency

The size of the containment determines the emptying frequency. Thus the correlation between the size and emptying frequency was conducted as shown in figure 12. The Pearson coefficient of correlation is -0.4 that is the correlation is significant at 0.01 level (two-tailed). That is smaller the size of containment higher is the emptying frequency.

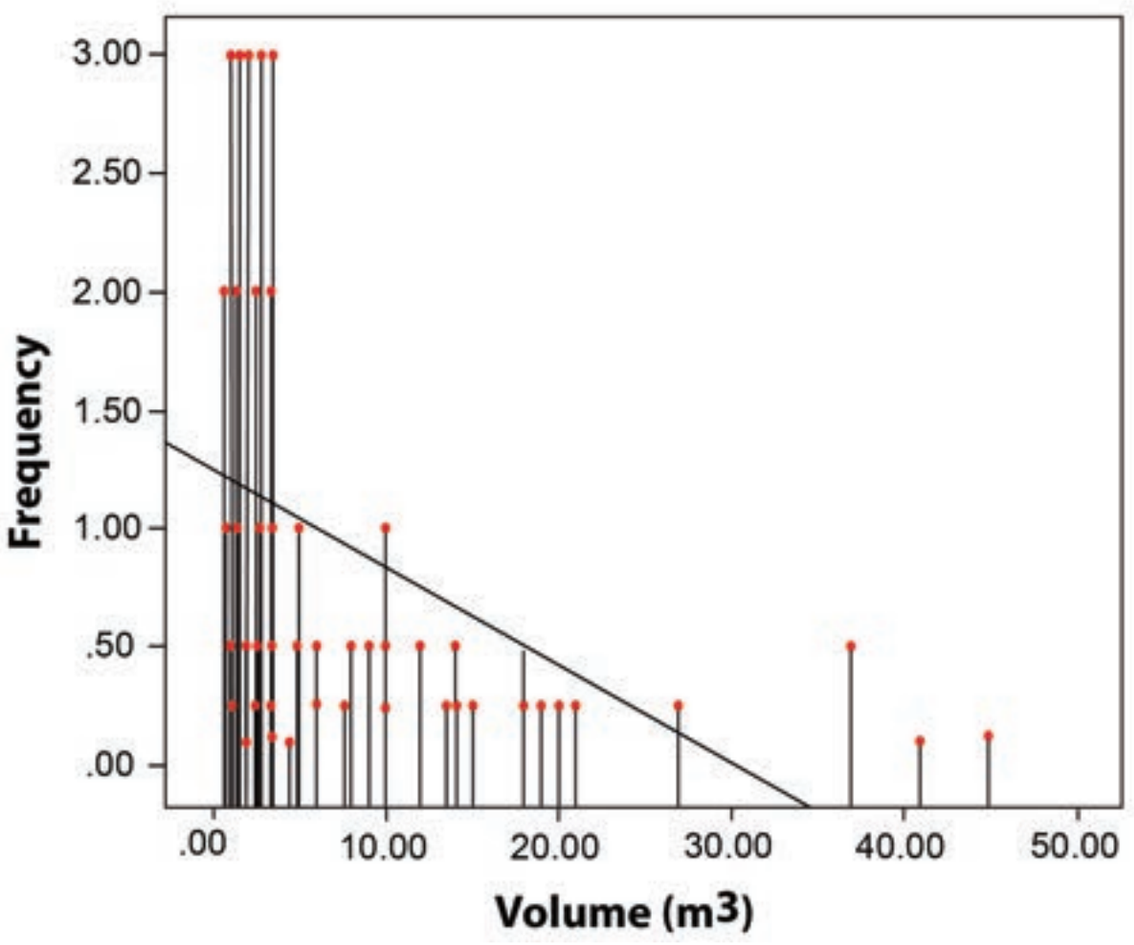

Figure 12 Graph on relationship between size and emptying frequencies

3.4.3 Characteristics of Never Emptied Containment

Almost 69% of the containments have never been filled or overflowed so have not been emptied. The average volume of these never emptied containments with its average users of containment is as shown in table 3. It indicates that size of pits are comparatively small with respect to number users. Thus, it can be assumed there is significant seepages from such containment.

Table 3: Descriptions on Average Size and Number of User of Never Emptied Household Containments

S.N.	Types of Containments	Average Size (m^3)	Average no. of Users
1	Septic Tank	13	6
2	Fully Lined Tank	16	6
3	Lined Tank and Open Bottom	8	6.3
4	Pits	2.4	7

Also, the age of these containments is shown in table 5. It shows that almost 77.78% of the containments were installed only either 2 years ago or within 5 years ago. Thus, it is possible that these never emptied containments have never filled while there may be unauthorized open emptying of the remaining containments.

Table 4: Descriptions of Types of Never Emptied Household Containment and its Age

S.N.	Containment	Constructed Time Period				Total
		0 – 2 years ago	3 – 5 years ago	6 – 10 years ago	> 10 years ago	
1	Septic Tank	0.93%	1.39%	0.93%	0.93%	4.17%
2	Fully Lined Tank	3.70%	5.56%	3.70%	2.31%	15.28%
3	Lined Tank and Open Bottom	4.17%	5.56%	1.85%	1.39%	12.96%
4	Pits	28.7%	27.78%	9.26%	1.85%	67.59%

3.4.4 Emptying and Transportation Services

Lahan municipality has been providing desludging services since 2011. The municipality has imported a suction tank with a capacity to load 4000 litres of a faecal sludge per trip as shown in figure 13. A desludging vehicle is mobilized from sanitation unit of the municipality after it receives demand from the consumer. The consumer pay service charges only after emptying their containment. The service charge for the rectangular tank is NPR 1500 and NPR 750 for ring containment.

At present, the vehicle has been emptying in an average 6 trips of FS per day. Three staffs are mobilized during the emptying and each of them are provided with gloves and mask. These staffs have not received training on effective emptying and health hygiene. They experienced pumping of FS from rectangular tanks is easier than from pit. Additional water has to be added in the pits. Generally, it requires 2 trips to empty rectangular containment in a household while in some cases it increases to 6 trips. However, there is very low demand from institutions.

Figure 13 Municipal Desludging Vehicle

Similarly, Sanjay Safety Tank Sarsafi, an unregistered private desludging entrepreneur has initiated the service in 2018. Currently, the entrepreneur owns a desludging vehicle with a capacity of 5000 litres, shown in figure 14. The desludging vehicle was locally assembled in Lalbandhi. The entrepreneur has invested NPR 6, 50,000 for a tank and NPR 8, 50,000 for a second-hand tractor. The required finances were provided as a loan from Small Farmers Loan and Cooperative Organization at the interest of 14% per annual.

Figure 14 Locally manufactured desludging vehicle operated by private entrepreneur

A driver and two helpers were mobilized for emptying the containment. The driver is paid NPR 12,000 per month whereas each helper receives NPR 5,000 per month with additional incentives of NPR 400 per each trip. General PPE such as gloves and mask were provided to the labour while they lack formal training on the emptying, health and hygiene.

It has been providing services in the entire municipality. In an average, 10 households are served in a month. The service charge for emptying rectangular containments is NPR 2000 per trip while only NPR 250 per ring is charged in containment with concrete rings. The entrepreneur perceived equal and high demand from both households with rectangular and circular tanks even from rural areas of the municipality. The number of trips is higher in institutional containment, he recalled 6 trips from Hotel Darwar located in Lahan Municipality.

3.5 Treatment and Disposal/Reuse

The municipality does not have any forms of the treatment plant for faecal sludge. The FS emptied and transported by the municipality is disposed of in its Solid Waste Treatment Plant located on the river bank. The FS is dumped into a big pits dug in the SWTP site and dried however, no any interventions were carried to manage liquids and leachate as shown in figure 15.

Figure 15 A view of solid waste treatment plant, a pit for disposal of FS and dried FS

Whereas, the private entrepreneur disposed the FS in farmers land on their demand else disposed into Balan approximately 4 km far away from the main city centre.

3.6 People's Perceptions and Knowledge on FSM

People's perception of emptying, disposal and its consequences were assessed. Also, their perception of improved management of FS was measured.

3.6.1 Perception of Preferred Emptying Mechanism

Figure 16 shows perception of the preferred emptying mechanism of containments after it gets filled. Majority of households that have never emptied their containment preferred mechanical emptying mechanism through contacting either municipality or private service providers. Whereas 14% perceived self-emptying and disposed into a pit as shown in figure 16.

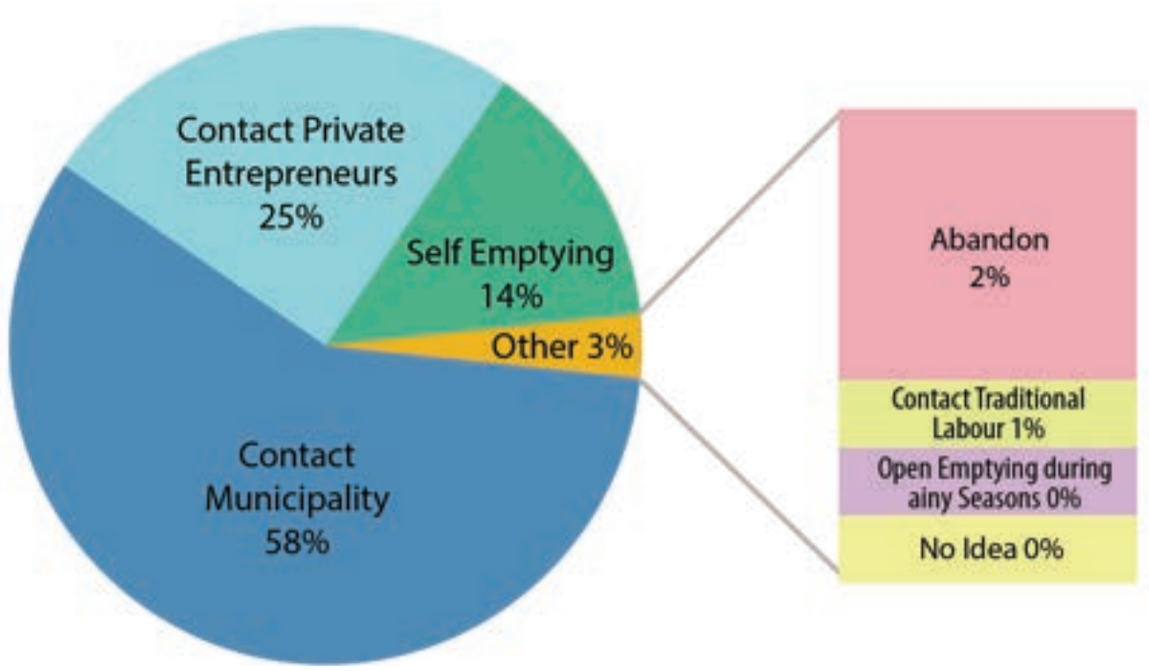

Figure 16 People's perception on preferred emptying mechanism

3.6.2 Perception of Current Practices of FSM

Figure 17 shows the perception of local people on current FSM practices in the municipality. It shows that the majority of the households applies FS into farmland. It also revealed that almost 32% of FS is being disposed into either open land, forest, water bodies or drains. People perceived FS emptied and collected by the municipality is treated in the treatment plant.

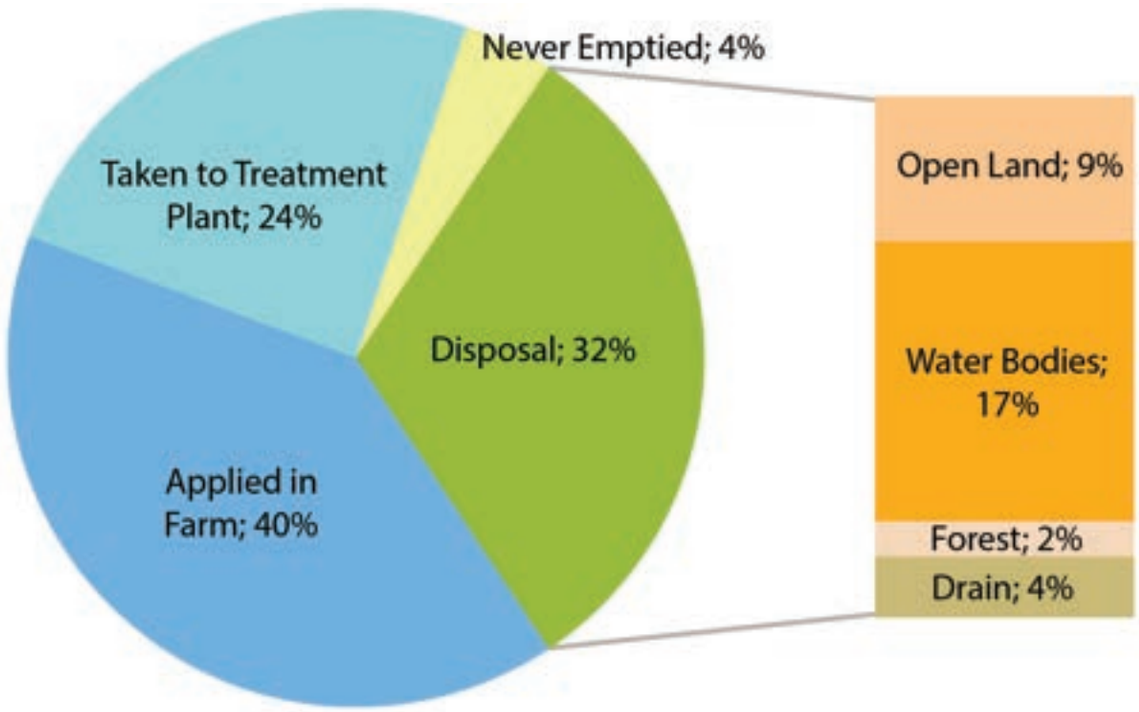

Figure 17 People's perception on current practices of FSM

3.6.3 Perceptions of Improved FSM

Figure 18 shows the perception of improved FSM, which shows that the majority of people preferred the construction of the treatment plant. Also, they insist for strict law and punishment for disobeying the rule. Only 8% of people claimed encouraging reuse option would improve current practices of FSM despite the majority of households using FS in farmland.

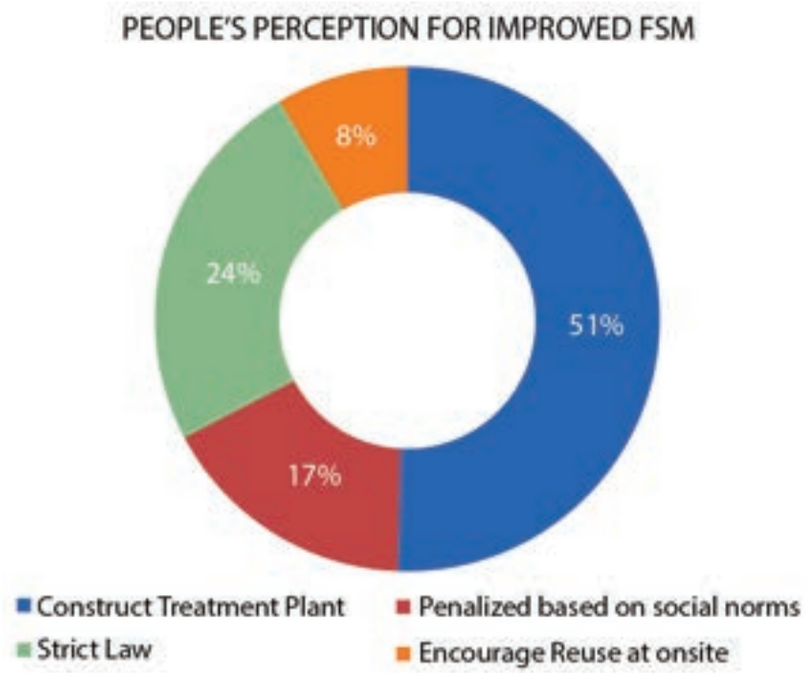

Figure 18 People's perception on Improved FSM

4 Assessment of Feasibility on FSM

4.1 Shit Flow Diagram

The overall status of the flow of faecal sludge is represented by the Shit Flow Diagram (SFD) as shown in figure 19. Only 3% of FS collected in an anaerobic biogas digester has been treated while 31% of FS collected in the fully lined tank is considered safely managed until it is emptied and rest being disposed of haphazardly to the environment. It increased threat on groundwater contamination resulting degradation of human health upon consumption of contaminated water.

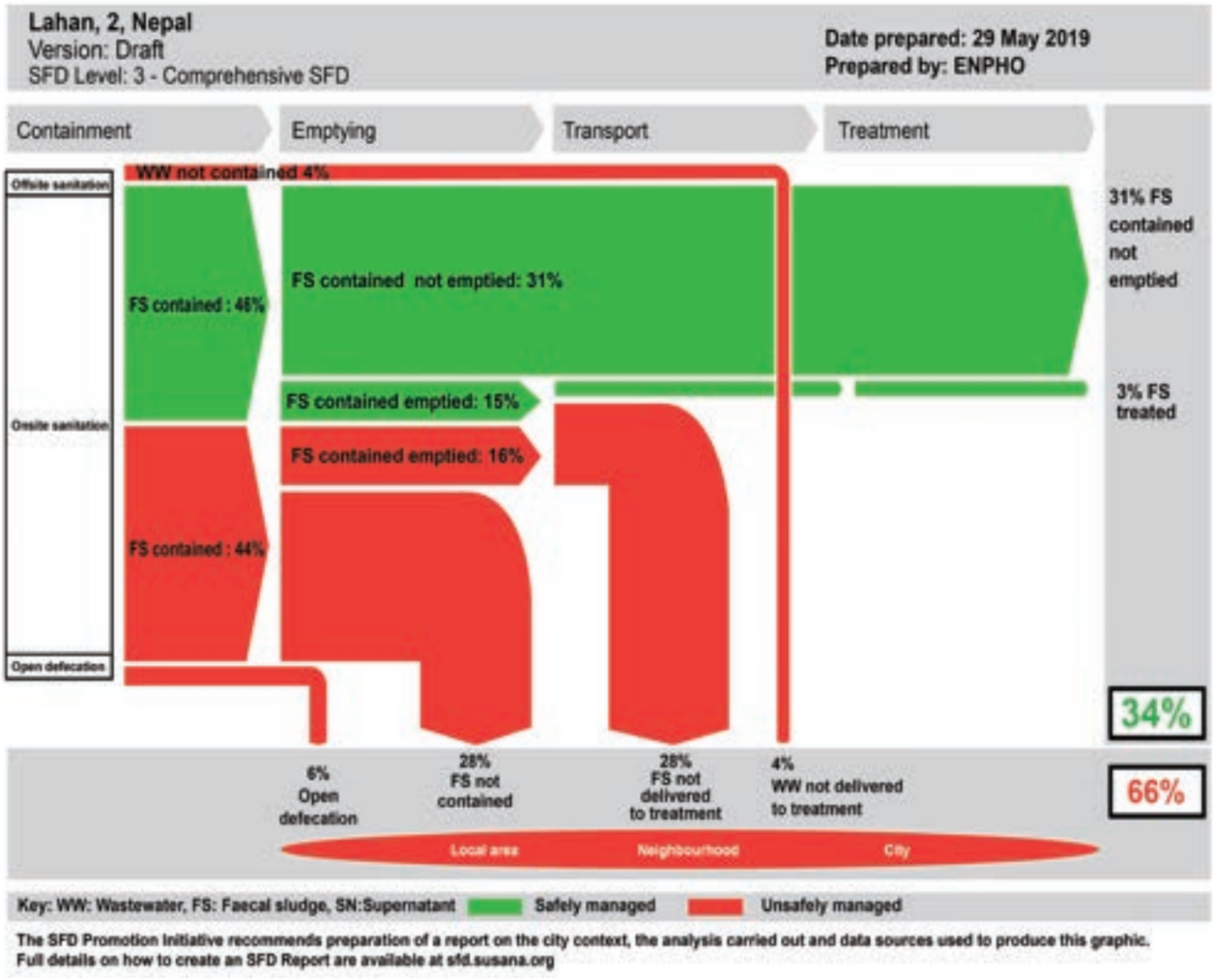

Figure 19 Shit Flow Diagram of Lahan Municipality

4.2 Quantification of Faecal Sludge

Quantification of faecal sludge depends upon many factors like the type of the containment, water content, climate, inflow and infiltration, presence of overflow pipe, user behaviours, sludge age, non-biodegradable fraction and soil characteristics (Borouckaert CJ, 2013). Quantity of FS is estimated based upon the average size of various containment and their emptying frequency obtained from primary data collected during the household survey. The calculation in table 7 shows 50538m^3 of FS produced per year excluding FS from households with an anaerobic biogas digester.

Table 6: Calculation of FS Generation based on Size of Containment in Household

Containment	HHs	Average Volume of containment	Emptying frequency	Total FS in containment
Septic tank	1055	13	0.33	4800
Fully lined tank (sealed)	2110	14	0.30	8862
Lined tank with impermeable walls and open bottom	1468	9	0.50	5872
Twin Pits	3760	3.6	1	13536
Single Pit	5732	1.5	1	8598
Unimproved pit	551	1.6	1	881
FS produced per year				**42550**
FS produced per day				**117**
Total Number of Trips (Vehicle Capacity 4 m^3)				**29**

4.2.1 The volume of Faecal Sludge Emptied from Household

In an average total 13760 m^3 of FS is being emptied in the municipality. The amount is approximately 32.5% of the total volume of FS generated per year based on the size of containment and emptying frequency.

Figure 20 shows the total FS generated calculated based upon the size of the containment and emptied portion. Among this, an average 7490 m^3 and 6162 m^3 of FS per year is being mechanically and manually emptied in the municipality. 53% of FS is being emptied from septic tank, fully lined tank and lined tank with impermeable walls and open bottom. While remaining from twin and single pits is being emptied mechanically. Calculation of volume of FS emptied is given in Annex 1, 2, 3, 4, 5.

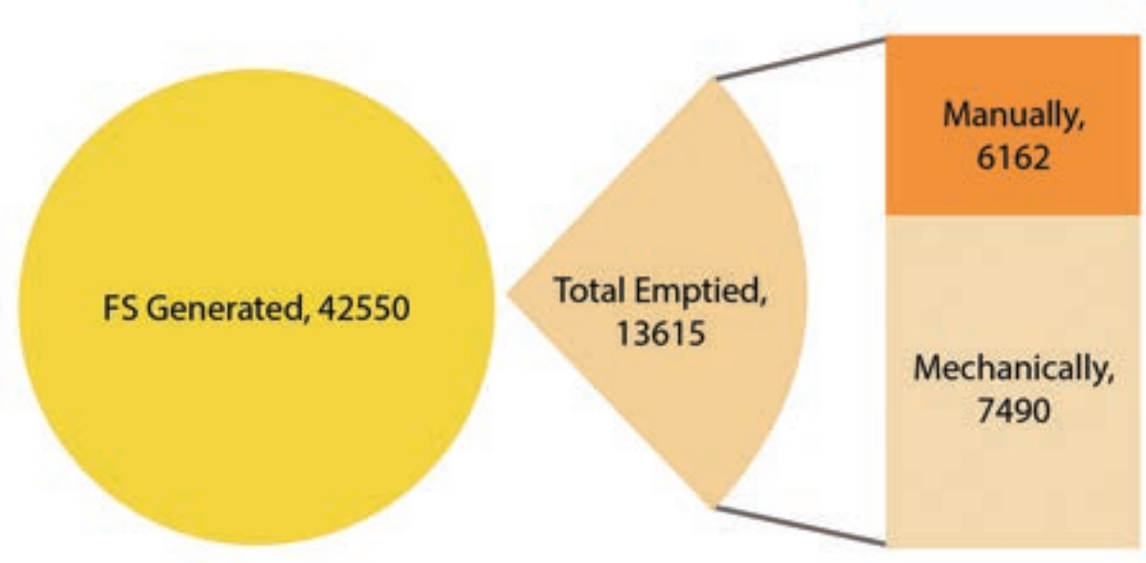

Figure 20 Volume of Faecal sludge emptied per year in Lahan Municipality

4.2.2 The volume of Faecal Sludge Emptied from Institutional Containment

The volume of FS generated from institutional containments is calculated based upon the size of the containment and its emptying frequency. The calculation is shown in table 6 and in an average 2276 m^3 of FS per year is generated from institutions which is equivalent to 6.2 m^3 per day.

Table 6: Calculation on FS Generated from Institutional Containment

Types of Institutional Containment	No. of Institutions	Average Volume (m^3)	Emptying Frequency Factor	Total Volume of FS per year (m^3)
Septic tank	47	21	0.76	750
Fully lined tank (sealed)	68	23	0.6	938
Lined tank with impermeable walls and open bottom	60	20	0.4	480
Twin Pits	13	8	0.5	52
Single Pit	28	2	1	56
			Total	**2276**
			Total FS generated per day	**6.2**
			Total number of Trip (5m^3 capacity of tanker)	**1.25**

However, only approximately 648 m^3 of FS per year is being emptied from institutional containment which is 28% of the total FS generated. Table 7 shows the volume of FS being emptied manually and mechanically from various types of institutional containment.

Table 7: Calculation of FS Emptied from Institutional Containment

Containment	Mechanical Emptying (m^3 /year)
Septic Tank	142
Fully Lined Tank	304
Lined Tank and Open Bottom	180
Twin pit	12
Single Pit	10
Total FS generated per year	648
Total FS generated per day	1.78

4.3 Options for Faecal Sludge Treatment Processes

Faecal Sludge Treatment comprises of solid-liquid separation, stabilization, dewatering/drying, pathogen reduction and production from end-products. These processes are determined by the characteristics of faecal sludge. Since characteristics of FS was not conducted during the study, thus characteristics can be assumed based upon the following information.

4.3.1 Source of Sludge (Types of containment)

Currently, 59% of FS are mechanically emptied from the septic tank, lined tank with impermeable walls and open bottom and fully lined tank respectively. The emptying frequency for these containments is between once every two years and once every three and a half year. Thus it could be estimated that FS would have a higher amount of liquid portion and higher emptying frequency suggest inflow of water into the containment. So, it demands a liquid-solid separation unit in the treatment technology.

4.3.2 Age of accumulated sludge

The emptying frequency of the various containments shows that age of accumulated sludge ranges from 2 years to more than 8 years old. Thus the nature of FS being emptied does not have the same characteristics. FS from pit toilets are emptied frequently that means, comparatively, a fresh sludge (accumulated for only 2 years or less). Thus, such FS would require additional stabilization whereas 8 years old sludge would be digested. Hence, it requires stabilization process in treatment technologies to effectively treat FS.

4.3.3 People's perception towards acceptable of end-products

People's perception of current management of FS revealed that farm application of faecal sludge is practised by many households. The fact is supported by the disposal of collected FS by a private service provider into farmland upon request of farmers. Also, people insisting on encouragement of reuse options as improved FSM indicates social acceptance of end products. Thus, the treatment technologies should incorporate the end product to the safety level. Hence, it requires pathogen reduction mechanism after dewatering/drying for safe use of treated faecal sludge as a soil conditioner or organic fertilizer.

5 Conclusion and Recommendation

The overall sanitation status of the municipality indicates the urgent need for FSM interventions. Installation of anaerobic biogas digester at the household level is remarkable and has a tendency to promote whereas other existing containments are not appropriate owing to groundwater pollution except for fully lined tanks. The higher portion the containment never emptied indicates leakages or unauthorized open emptying practices into an environment with a potential threat to human health. The FS being emptied and disposed of without any treatment by the municipality is a serious issue. The private sector initiating treatment should be encouraged to upgrade the system. In the absence of regulating agency and lack of treatment plants the problem could lead to an outbreak of an epidemic. Hence, the municipality should immediately act on to improve FSM for better environment and human health.

The specific recommendation on each of sanitation value chain for improved FSM are:

Formulate Standards of Containment and Upgrade Existing Containment

Formulation of standards of technically appropriate containment is the foremost step towards managing faecal sludge. The standard should prescribe detail design of the containment together with construction manual. It can be immediately implemented in newly constructed buildings and periodically implemented through the upgrading of the existing containment.

Data Management and Effective Monitoring

The municipality has to develop a data management system such that all details on types of containment, number of users, size and last emptied of all the households are recorded in digital form. This would assist in developing the proper size of the treatment plants, formulating desludging schedule and monitoring to prevent unauthentic discharge of FS into the environment at the household level.

Formulation of Regulations for Emptying Services

Formulation of regulations is essential to discourage unhealthy manual emptying practices and regulate the private sector in the emptying services. The regulation should focus on recognition of private emptying service providers, ways for effective, accessible and affordable services along with occupational health safety of the labours.

Classification of Service Delivery Area and Appropriate Treatment Facilities

Considering the types of containments and distance from purposed site for construction of faecal sludge treatment plant, it would be effective to classify the service delivery areas. The area within distance of 5 km (marked green area in map) from purposed site mostly

covers core urban area of the municipality. The service to this area can be effective with respect to access to containment for desludging and haulage time. Similarly, the area within the radial distance of 10 km (marked as yellow) which covers peri-urban areas and have access to containment through tractors could be served by purposed FSTP as shown in figure 21. While the areas within and farther than radial distance of 15 Km could be best served through construction of decentralized treatment plants.

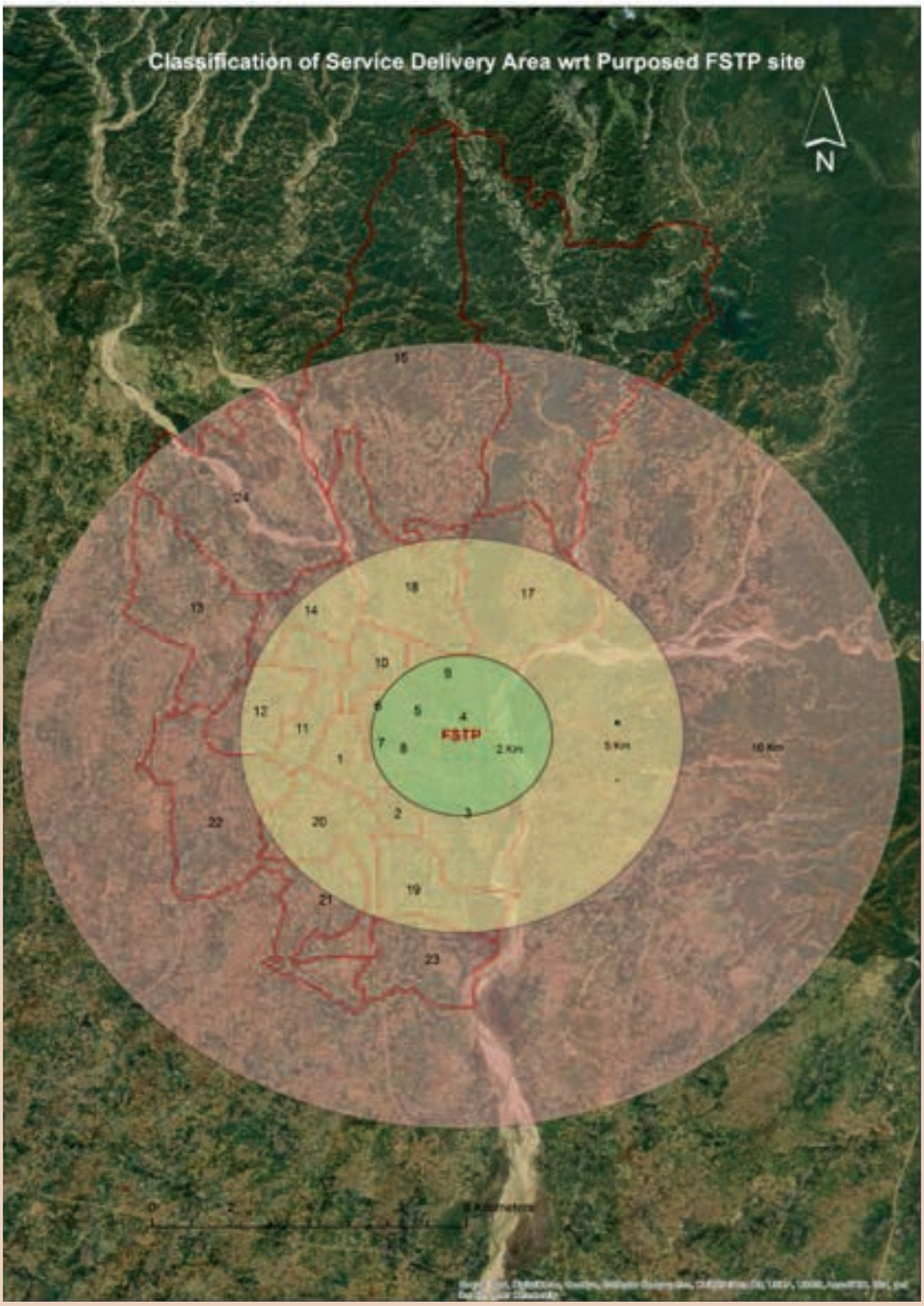

Figure 21: Classification of Service Delivery Areas with respect to Purposed Site for FSTP

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Annexure

Annex 1 Descriptions on containment emptied manually and mechanically

Containment	Percent	HHs	Emptied		Emptied Mechanically		Emptied Mechanically	
			Percent	HHs	Percent	HHs	Percent	HHs
Septic tank	6.1%	1055	56.5%	597	0.0%	0	100.0%	597
Fully lined tank (sealed)	12.2%	2110	28.3%	597	0.0%	0	100.0%	597
Lined tank with impermeable walls and open bottom	8.5%	1468	12.5%	184	0.0%	0	100.0%	184
Twin Pits	21.8%	3760	35.4%	1330	51.7%	688	48.3%	643
Single Pit	33.2%	5732	30.4%	1743	44.7%	780	55.3%	964
Unimproved pit	3.2%	551	41.7%	230	60.0%	138	40.0%	92

Annex 2 Calculation of FS emptied manually and mechanically from Septic tank

Septic tank												
Manual							Mechanical					
Emptying Frequency	Percent	HHs	Volume	FS emptied Manually	Total FS emptied per year	Average Volume	Percent	HHs	Volume	Emptying frequency factor	FS emptied per year	Total FS Emptied per year
Three Times a year	0	0	0	0	0	13	0.0%	0	0	3	0	2601.3
Twice a year	0	0	0	0			0.0%	0	0	2	0	
Every Year	0	0	0	0			0.0%	0	0	1	0	
Every 2 Years	0	0	0	0			38.5%	230	2990	0.5	1495	
Once every 3_5 years	0	0	0	0			53.8%	322	4186	0.25	1046.5	
Once every 6_10 Years	0	0	0	0			0.0%	0	0	0.125	0	
more than 10 years	0	0	0	0			7.7%	46	598	0.1	59.8	
Don't Know	0	0	0	0			0.0%	0	0	0.1	0	

Annex 3 Calculation of FS emptied from fully lined tanks

Fully Lined Tank												
	Manual						Mechanical					
Emptying Frequency	Percent	HHs	Volume	FS emptied per year	Total FS emptied per year	Average Volume	Percent	HHs	Volume	Emptying frequency factor	FS emptied per year	Total FS Emptied per year
Three Times a year	0	0	0	0	0	18	0.0%	0	0	3	0	3291.3
Twice a year	0	0	0	0			0.0%	0	0	2	0	
Every Year	0	0	0	0			0.0%	0	0	1	0	
Every 2 Years	0	0	0	0			30.8%	184	3312	0.5	1656	
Once every 3_5 years	0	0	0	0			53.8%	322	5796	0.25	1449	
Once every 6_10 Years	0	0	0	0			7.7%	46	828	0.125	103.5	
more than 10 years	0	0	0	0			7.7%	46	828	0.1	82.8	
Don't Know	0	0	0	0			0.0%	0	0	0.1	0	

Annex 4 Calculation of FS emptied from lined tank and open bottom

Lined tank and open Bottom												
	Manual						Mechanical					
Emptying Frequency	Percent	HHs	Volume	FS emptied per year	Total FS emptied per year	Average Volume	Percent	HHs	Volume	Emptying frequency factor	FS emptied per year	Total FS Emptied per year
Three Times a year	0	0	0	0	0	9	0.0%	0	0	3	0	828
Twice a year	0	0	0	0			0.0%	0	0	2	0	
Every Year	0	0	0	0			25.0%	46	414	1	414	
Every 2 Years	0	0	0	0			25.0%	46	414	0.5	207	
Once every 3_5 years	0	0	0	0			50.0%	92	828	0.25	207	
Once every 6_10 Years	0	0	0	0			0.0%	0	0	0.125	0	
more than 10 years	0	0	0	0			0.0%	0	0	0.1	0	
Don’t Know	0	0	0	0			0.0%	0	0	0.1	0	

Annex 5 Calculation of FS emptied from twin pits

Twin Pits												
Manual							Mechanical					
Emptying Frequency	Percent	HHs	Volume	FS emptied per year	Total FS emptied per year	Average Volume	Percent	HHs	Volume	Emptying frequency factor	FS emptied per year	Total FS Emptied per year
Three Times a year	13%	92	331.2	993.6	3080.16	3.6	7.1%	46	165.6	3	496.8	2318.4
Twice a year	20%	138	496.8	993.6			21.4%	138	496.8	2	993.6	
Every Year	33%	230	828	828			7.1%	46	165.6	1	165.6	
Every 2 Years	13%	92	331.2	165.6			50.0%	322	1159.2	0.5	579.6	
Once every 3_5 years	13%	92	331.2	82.8			14.3%	92	331.2	0.25	82.8	
Once every 6_10 Years	0%	0	0	0			0.0%	0	0	0.125	0	
more than 10 years	7%	46	165.6	16.56			0.0%	0	0	0.1	0	
Don't Know	0%	0	0	0			0.0%	0	0	0.1	0	

Annex 6 Calculation of FS emptied from single pit

Single pit												
Manual							Mechanical					
Emptying Frequency	Percent	HHs	Volume	FS emptied per year	Total FS emptied per year	Average Volume	Percent	HHs	Volume	Emptying frequency factor	FS emptied per year	Total FS Emptied per year
Three Times a year	41%	322	644	1932	2668	2	4.8%	46	92	3	276	1897.5
Twice a year	6%	46	92	184			14.3%	138	276	2	552	
Every Year	29%	230	460	460			42.9%	414	828	1	828	
Every 2 Years	0%	0	0	0			14.3%	138	276	0.5	138	
Once every 3_5 years	24%	184	368	92			19.0%	184	368	0.25	92	
Once every 6_10 Years	0%	0	0	0			4.8%	46	92	0.125	11.5	
more than 10 years	0%	0	0	0			0.0%	0	0	0.1	0	
Don't Know	0%	0	0	0			0.0%	0	0	0.1	0	

Annex 7 Calculation of FS emptied from unimproved pit

Unimproved Pit												
Manual							Mechanical					
Emptying Frequency	Per-cent	HHs	Volume	FS emptied per year	Total FS emptied per year	Average Volume	Percent	HHs	Volume	Emptying frequen-cy factor	FS emptied per year	Total FS Emptied per year
Three Times a year	33%	46	92	276	414	2	50.0%	46	92	3	276	460
Twice a year	0%	0	0	0			50.0%	46	92	2	184	
Every Year	33%	46	92	92			0.0%	0	0	1	0	
Every 2 Years	33%	46	92	46			0.0%	0	0	0.5	0	
Once every 3_5 years	0%	0	0	0			0.0%	0	0	0.25	0	
Once every 6_10 Years	0%	0	0	0			0.0%	0	0	0.125	0	
more than 10 years	0%	0	0	0			0.0%	0	0	0.1	0	
Don't Know	0%	0	0	0			0.0%	0	0	0.1	0	

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