SFD Report

Mirchaiya Municipality
Nepal

Final Report

This SFD Report - SFD level 2 - was prepared by
Environment and Public Health Organization (ENPHO)

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SFD Report Mirchaiya Municipality, Nepal, 2023

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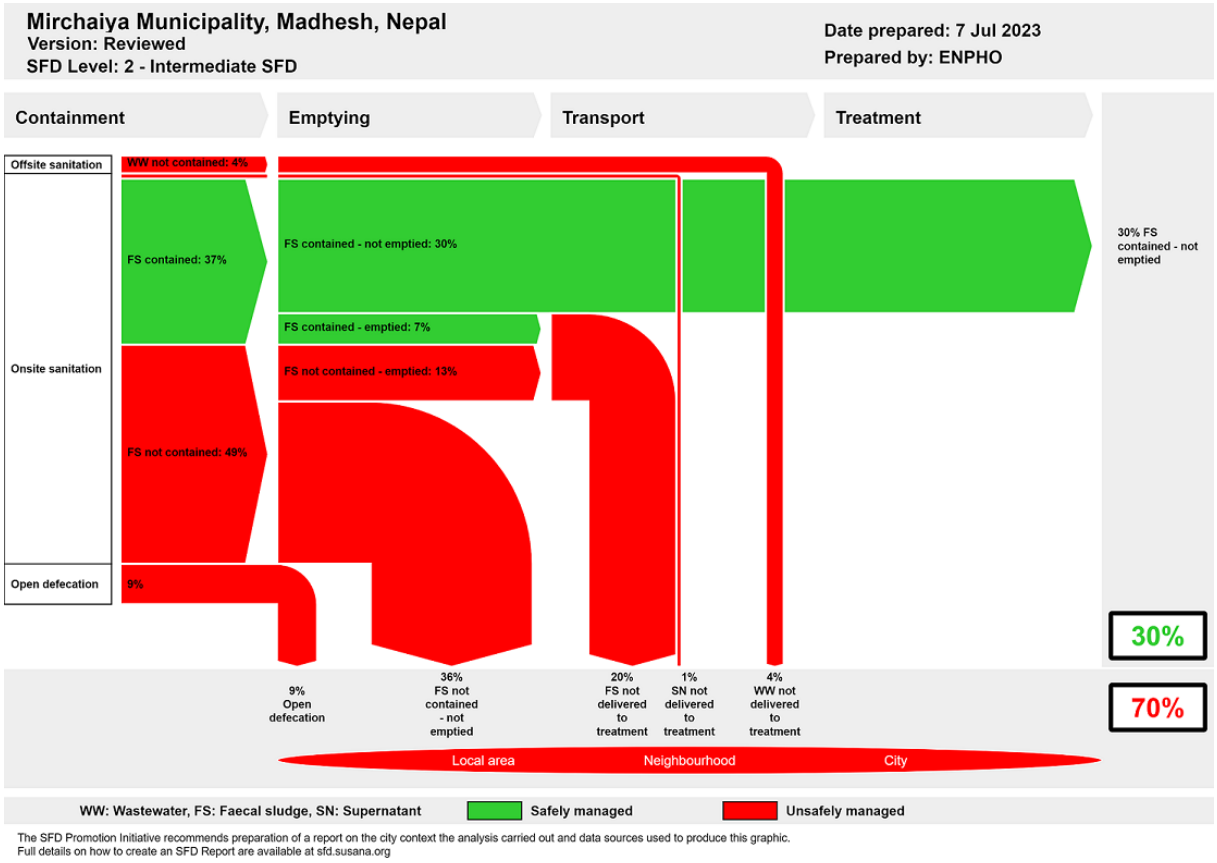
1. The SFD Graphic



The SFD Promotion Initiative recommends preparation of a report on the city context the analysis carried out and data sources used to produce this graphic.
Full details on how to create an SFD Report are available at sfd.susana.org

2. Diagram information

SFD Level:

This SFD is level 2– Intermediate report.

Produced by:

Environment and Public Health Organization (ENPHO).

Collaborating partners:

Mirchaiya Municipality, Municipal Association of Nepal (MuAN), United Cities and Local Government- Asia Pacific (UCLG- ASPAC).

Status:

Final SFD report.

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3. General city information

Mirchaiya Municipality is situated in Siraha District of Madhesh Province in the southern region of Nepal. It is divided into twelve wards and covers an area of 91.97 sq. km. It was established on May 18, 2014 by merging the already-existing Village Development Committees (VDCs), Rampur Birta, Malhaniyakhori, Radhopur, Ramnagar, Mirchaiya, Phulbariya, Sitapur Pra. Da., and Madheshpur Gamharia. It lies at 26.4955° N latitude, 86.1516 °E longitude and at an altitude of 129 m above sea level (masl).

The municipality has a total population of 59,425 and is residing in 12,250 households. The municipality has a temperate climate with dry winters and hot summers. It has an average high temperature of 29.1 °C and average low temperature of 16.4°C. It receives 1,658 mm rainfall per year (Climate-Data, 2021).

4. Service outcomes

The overview of different sanitation technologies across the sanitation value chain in the municipality is briefly explained in this section. All data in this section is from the household and institutional surveys conducted for this survey (ENPHO, 2023). Siraha District was declared Open Defecation Free (ODF) on March 23, 2018. Still, 9% of households do not have toilets whereas 91% households have the coverage of improved sanitation facility. The households without improved sanitation facility opt for open defecation.

Containment:

About 4% of households with improved sanitation facilities rely on offsite sanitation systems and 87% rely on onsite sanitation systems. Households with onsite sanitation systems have different sanitation technologies. About 2% of households have septic tanks, 47% have fully lined tanks, 22% have lined tanks with impermeable walls and open bottom, 14% lined pits with semi-permeable walls and open bottom, and 2% have an unlined pit.

Similarly, 3% of the institutional buildings with toilets have offsite sanitation system whereas 97% have onsite sanitation system. Where 41% have septic tanks, 31% have fully lined tanks, 6% have lined tanks with impermeable walls and open bottom, 13% have single pits, 3% have twin pits and 3% have unlined pits.

The municipality has six public toilets. The toilets are located at local marketplaces of Mirchaiya bazar, Katari chowk, Golbazar, Bakhra bazar, Malteshwor bazar and Malaniya. Among six toilets, three toilets located at Mirchaiya bazar, Katari chowk and Golbazar, are constructed by the municipality. And of those three toilets, toilet located at Mirchaiya bazar is only functional. The information for the other three toilets is unavailable.

Emptying and Transport:

Among the buildings with onsite sanitation systems, 29% of households and 39% of institutional buildings have emptied their containment. Mechanical emptying is prevalent in the municipality. The municipality has its own desludging vehicle for the emptying service. Private desludgers are also providing the service in the municipality.

About 4% of households with offsite sanitation systems have their toilets connected to stormwater drain/open drain or an open ground. In the municipality, open drain was constructed for the transport of stromwater from the roads and the buildings. The outlet of the drain is in the nearby river. Here, 3% of households also discharge FS and wastewater into the drain.

Treatment and Disposal/Reuse:

The Faecal Sludge (FS) emptied by municipal desludging vehicle is disposed of in a FS dumping site, inside a community forest. Whereas FS emptied by commercial desludgers is disposed of in a farmland or along a riverbank.

Groundwater is the primary source of drinking water in the municipality. The households receive piped drinking water supply from Mirchaiya Sana Sahari Water Supply and Users Committee (WSUC). The water supply system extracts water from six deep bores. It has distributed 4812 taps in five wards (ward no. 4, 5, 6, 7 and 8). Moreover, 82% of households still rely on handpumps for drinking water supply.

Water contamination at source is possible for aquifers. The vulnerability of an aquifer depends on lateral spacing between sanitation systems and the groundwater sources. Almost 78% of the population using lined tanks with impermeable walls and open bottom and 63% of population using lined pit with semi-permeable walls and open bottom, and unlined pit possesses the significant risk to groundwater pollution.

The SFD graphic shows that excreta generated from 30% of the population are safely managed while excreta generated by 70% of the population are unsafely managed. The proportion of safely managed FS generated from 30% of population is temporary, since the FS has not been emptied. Once the containment starts to fill, the proportion of not emptied FS will be unsafely managed under the current practice of Faecal Sludge Management (FSM).

5. Service delivery context

Access to drinking water and sanitation has been defined as fundamental rights to every citizen by the constitution of Nepal. To respect, protect and implement the rights of citizen embedded in the constitution the Government of Nepal (GoN) has enforced the Water Supply and Sanitation Law 2022 which emphasized on a right to quality sanitation services and prohibited direct discharge of wastewater and sewage into water bodies or public places.

Several policies have been in place to accomplish the sanitation needs of people. Particularly, NSHMP 2011 has proved to be an important strategic document for all stakeholders to develop uniform programs and implementation mechanisms at all levels. It

strengthened institutional set up with the formation of Water and Sanitation Coordination Committee (WASH-CC) to actively engage in sanitation campaigns. The sanitation campaign was implemented throughout the country mainly focusing on achieving universal access to improved sanitation.

Ministry of Water Supply through its Department of Water Supply and Sewerage Management (DWSSM) articulated and endorsed Institutional and Regulatory Framework (IRF) for Faecal Sludge Management in Urban Areas of Nepal in 2017. The main objective of the IRF is to define the specific roles and responsibilities of key institutions for the effective management and regulation of Faecal Sludge Management (FSM).

6. Overview of stakeholders

Based on the regulatory framework for Faecal Sludge Management (FSM), the major stakeholders for effective and sustaining service delivery as presented in Table 1.

Table 1: Overview of Stakeholders.

Key Stakeholders	Institutions / Organizations
Public Institutions at Federal Government	Ministry of Water Supply
Public Institutions at Provincial Government	Ministry of Water Supply and Energy Development
Public Institutions at Local Government	Mirchaiya Municipality Nepal Water Supply Cooperation
Non-governmental Organizations	Environment and Public Health Organization (ENPHO)
Private Sector	Private FS Emptying and Desludging facility providers, P
Development Partners, Donors	MuAN, BMGF, UCLG ASPAC

7. Process of SFD development

Data on sanitation situation were collected through household and institutional surveys (ENPHO, 2023). Enumerators from the municipality have been mobilized after providing orientation on sanitation technologies, objectives of the survey and proper use of mobile application, KOBOCOLLECT for collection of data for survey. Along with this, Key Informant Interviews (KIIs) were conducted with officers and engineers of municipality, Water Supply and Sanitation Users Committee. Types of sanitation technologies used in various locations have been mapped using ARCGIS. For the Shit Flow Diagram (SFD) graphic production, initially, a relationship between sanitation technology used in questionnaire survey and Shit Flow Diagram Promotive Initiatives (SFD PI) methodology was made. Then, data were fed into SFD graphic generator to produce the SFD graphic.

8. Credibility of data

The major data were collected from random household sampling. Altogether, 373 households and 83 institutions were surveyed from sixteen wards of Mirchaiya Municipality. Primary data on emptying, transportation and current sanitation practices in the municipality were validated from KII with public toilet management, sanitation and environmental section and water service providers The overall data and findings were shared with the stakeholders of the municipality and validated through a sharing program.

9. List of data sources

The list of data sources to produce this executive summary is as follows:

- Climate-Data, 2021. Climate-Data. [Online] Available at: https://en.climate-data.org/asia/nepal/eastern-development-region/ramnagar-969200/ [Accessed 8 July 2023].
- KII-1, 2022. Sanitation Status of Mirchaiya Municipaity. Mirchaiya: s.n.
- KII-3, 2022. Water Supply and quality of water in Mirchaiya municipality. Mirchaiya: s.n.
- Mirchaiya Municipality, 2023. Mirchaiya Municipality. [Online] Available at: https://mirchaiyamun.gov.np/en/brief-Introduction [Accessed 7 July 2023].
- MoWS, 2020. Open Defecation Free Nepal:Narration of the Journey, Kathmandu: Secretariat of National Sanitation and Hygiene Coordination Committee, Nepal.
- National Statistics Office, 2023. National Population and Housing Census 2021 National Report, Kathmandu: National Statistics Office.

SFD Mirchaiya Municipality, Nepal, 2023

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Abbreviations

DWSSM	Department of Water Supply and Sewerage Management
DUDBC	Department of Urban Development and Building Construction
ENPHO	Environment and Public Health Organization
EPA	Environment Protection Act
FS	Faecal Sludge
FSM	Faecal Sludge Management
FSTP	Faecal Sludge Treatment Plant
GoN	Government of Nepal
HH	Household
IRF	Institutional and Regulatory Framework
KII	Key Informant Interview
KM	Kilometre
masl	meter above sea level
MDG	Millennium Development Goal
mm	Millimetre
MoFAGA	Ministry of Federal Affairs and General Assembly
MoPIT	Ministry of Physical Infrastructure and Transport
MoWS	Ministry of Water Supply
MuAN	Municipal Association of Nepal
NPC	National Planning Commission
NSHMP	National Sanitation and Hygiene Master Plan
NWSC	Nepal Water Supply Cooperation
NWSSP	National Water Supply and Sanitation Policy
NUWSSSP	National Urban Water Supply and Sanitation Sector Policy
ODF	Open Defecation Free
PPP	Public Private Partnership
RWSSNP	Rural Water Supply and Sanitation National Policy
SDG	Sustainable Development Goal
SDP	Sector Development Plan
SFD	Shit Flow Diagram
SFD PI	Shit Flow Diagram Promotion Initiative
SN	Supernatant
SuSanA	Sustainable Sanitation Alliance
UCLG ASPAC	United Cities and Local Governments Asia Pacific
VDC	Village Development Committee
WASH	Water, Sanitation and Hygiene
WHO	World Health Organization
WSSDO	Water supply and Sanitation Divisional Office
WSUC	Water Supply and User's Committee
WW	Wastewater
WWTP	Wastewater Treatment Plant

1 City context

Mirchaiya Municipality is situated in Siraha District of Madhesh Province in the southern region of Nepal. It was established on May 18, 2014 by merging the already-existing Village Development Committees (VDCs), Rampur Birta, Malhaniyakhori, Radhopur, Ramnagar, Mirchaiya, Phulbariya, Sitapur Pra. Da., and Madheshpur Gamharia. It is divided into twelve wards. It shares its boundary with municipalities Golbazar on the east, Karjanha on the west, Udayapur District on the north and Naraha rural Municipality and Kalyanpur Municipality on the south (Mirchaiya Municipality, 2023). Figure 1 shows the ward boundary map of Mirchaiya Municipality.

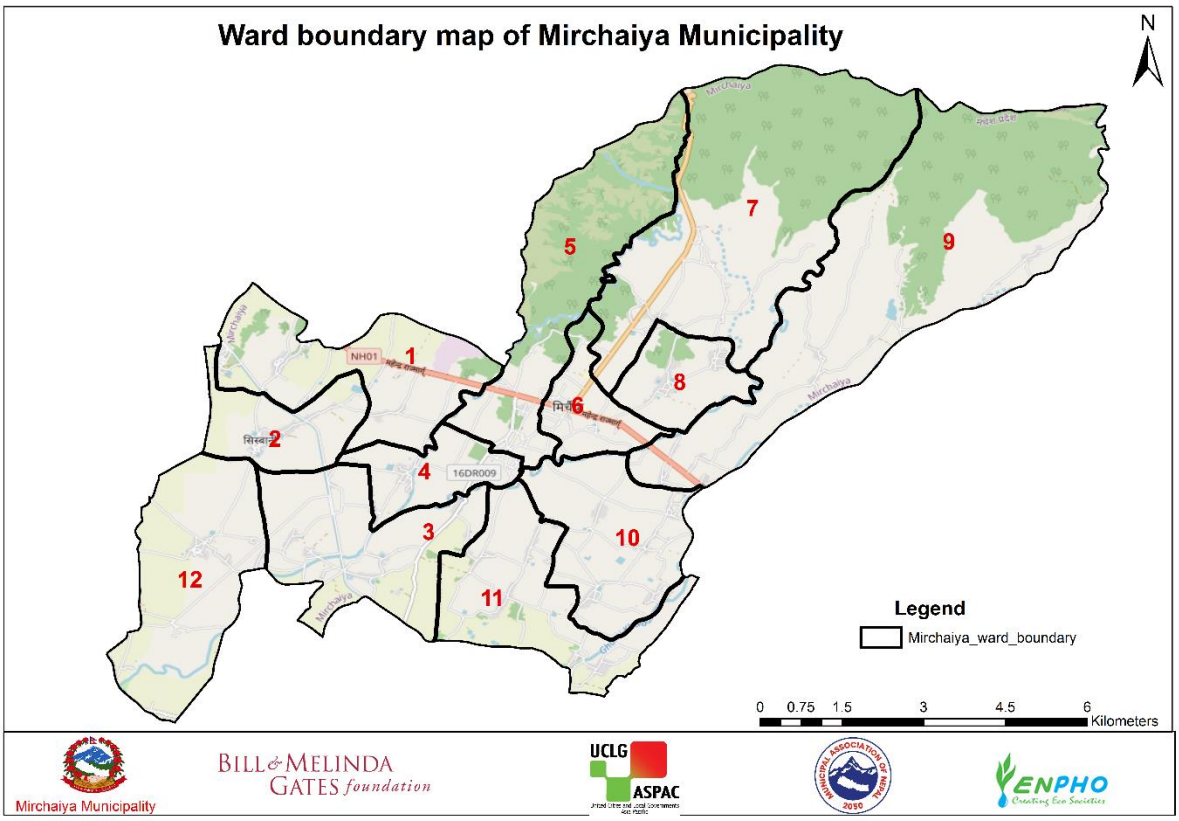

Figure 1: Ward boundary map of Mirchaiya Municipality.

1.1 Population

As per the national population and housing census conducted in 2021, Mirchaiya Municipality has a total population of 59,425 with 29,571 male and 29,854 female population. It has altogether 10,733 households. The annual population growth rate of Mirchaiya Municipality is 1.8% (National Statistics Office, 2023).

1.2 Topography and Geography

Mirchaiya Municipality lies at 26.4955° N latitude, 86.1516°E longitude and at the altitude of 129 m above sea level (masl). It is spread over the total area of 91.97 sq. km. (MoFAGA, 2023). It lies in the Terai region of Nepal. The soil composition of the municipality consists of alluvial sediments i.e. sand, silt and clay along-with coarse gravels (Upreti, 1999).

1.3 Climate

Köppen–Geiger classification is one of the most used systems for climatic categorization. This classification is a widely used method for portraying climates worldwide, based on monthly air temperature and precipitation. The climatic condition of Mirchaiya Municipality falls on temperate climate based on Köppen–Geiger classification. This climatic condition has dry winters and hot summers (Karki, et al., 2015). In Mirchaiya Municipality, the warmest month of the year is May with average temperature of 29.1°C and coldest month is January with average temperature of 16.4°C. The annual average temperature of the municipality is 24.6°C. It receives 1,658 mm rainfall annually. The most rainfall occurs in July and the least in November (Climate-Data, 2021). Figure 2 shows the graph of the monthly average for precipitation and temperature of Mirchaiya Municipality.

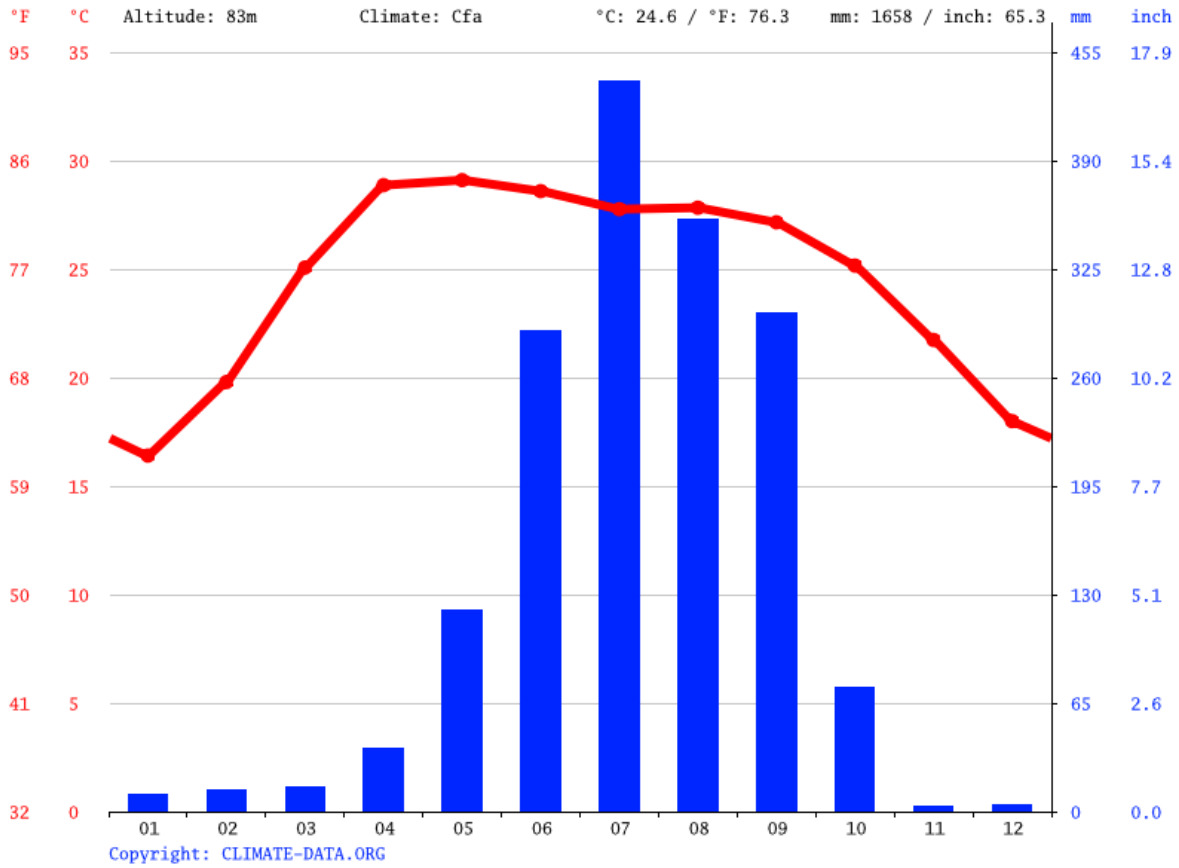

Figure 2: A graph showing the monthly average for precipitation and temperature of Mirchaiya Municipality.

2 Service Outcomes

2.1 Overview

Data on sanitation situation were collected through household and institutional surveys (ENPHO, 2023). A total of 373 households were sampled from 10,733 households distributed in twelve wards (further details are presented in section 4). The results obtained after the triangulation and validation of the data with all the data sources including secondary data, Key Informant Interviews (KIIs) and a validation workshop is presented in this section.

Sanitation is defined as infrastructures, facilities or services provided for safe management of human excreta emanating from toilet while handling, storage, and treatment onsite or offsite conveying it safely to the end use or disposal to protect human health and environment (Affam & Ezechi, 2021).

2.1.1 Sanitation System in Household Buildings

Siraha District was declared Open Defecation Free (ODF) on March 23, 2018 (MoWS, 2020). The status of ODF indicates accessibility to basic sanitation on each household (HH). In Mirchaiya Municipality, still 9% of the households do not have toilets and practice open defecation. The households practising open defecation goes to nearby water bodies or open ground. Figure 3 shows the pictures of open defecation in an open ground.

Figure 3: Open defecation in an open ground in Mirchaiya Municipality.

The remaining 91% of the households have improved sanitation facility either with offsite or onsite sanitation systems. Offsite sanitation refers to a sanitation system in which excreta (referred to as wastewater) is collected and transported away from the plot where they are generated. An offsite sanitation system relies on sewer technology for transport. Onsite sanitation refers to a sanitation technology or sanitation system in which excreta (referred to as faecal sludge) is collected and stored and emptied from or treated on the plot where they are generated (SuSanA, 2018). In the municipality, 4% of the households having sanitation facilities have offsite sanitation systems whereas 87% have onsite sanitation systems. Figure 4 presents the location map of households with status of access to improved sanitation.

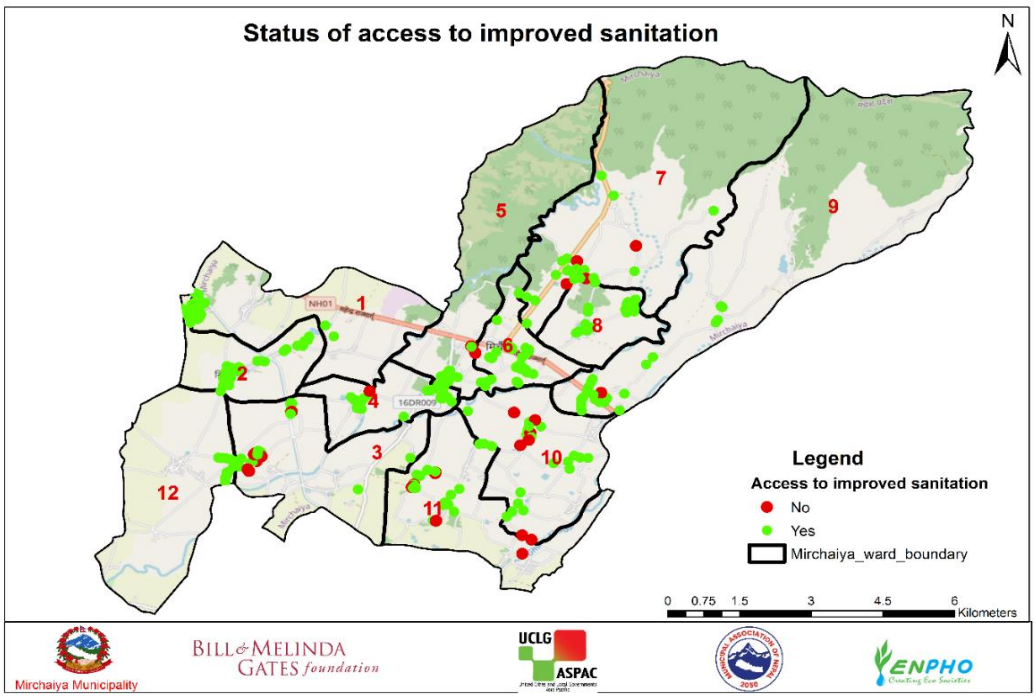

Figure 4: Location map of households with status of access to improved sanitation.

Types of Offsite Sanitation Systems

Mirchaiya Municipality does not have sewerage network, still 4% of the households have offsite sanitation systems. Here, households that have their toilet connected to an open drain/stormwater drain (3%) and an open ground (1%) is considered as offsite sanitation system. It is taken as toilet with no onsite container for the SFD graphic. The drain is constructed for the transport of stromwater from roads and the buildings. The outlet of the drain is in nearby river (KII-1, 2022). However, 4% of the households also discharge Faecal Sludge (FS) and wastewater into the drain. Therefore, FS and wastewater transported through open drain is disposed of directly to an open environment or water bodies. Figure 5 shows the outlet of a toilet discharging to an open environment and to an open drain.

Figure 5: Toilet discharges directly to open environment (left) and open drain (right).

Types of Onsite Sanitation Systems

In the municipality, 87% of the households have onsite sanitation systems. The municipality has the following types of containment:

Septic tank is a watertight rectangular chamber with two or more than two compartments for better storage and stabilization of faecal sludge. The technology is properly sealed, and the effluent is discharged into soak pit (SuSanA, 2018). 2% of households in the municipality have septic tanks.

Fully lined tank is a rectangular tank with impermeable walls and base to safely store FS. It does not have outlet for the discharge of effluent (Strande, et al., 2014). 47% of households have fully lined tanks.

Lined tank with impermeable walls and open bottom is a rectangular onsite technology where the walls of the tank are lined and sealed, and a permeable base. The facility allows infiltration of effluents which could contaminate groundwater (Peal, et al., 2020). 22% of households have these types of containments in the municipality.

Single Pit is a circular onsite technology made from concrete rings. There is no lining between rings, and it allows infiltration of effluents from walls and as well as bottom of the pit. No outlet or overflow for effluent is observed in this type of containment (SuSanA, 2018). 12% of households have single pits in the municipality. Figure 6 shows pictures of a single pit found in the municipality.

Figure 6: Single pits found in the Mirchaiya Municipality.

Twin Pit is also a circular onsite sanitation technology with two sets of concrete rings. It has semi-permeable walls and a permeable base (SuSanA, 2018). Each pit is used alternatively after filled. This technology is ideally designed to safely store and treat FS. It effectively treat FS if there is no exfiltration of water (Saxena & Den, 2022). The facility consists of two sets of pits with the minimum horizontal distance of 1.2m. Both the pits are connected from diversion box. However, most twin pits installed by the households are not as per the design. 2% of households have twin pits. Figure 7 shows the inappropriate design of twin pits in the municipality.

Figure 7: Inappropriate design of twin pits, the distance between two pits is less than 1.2m.

Unlined Pit is a dug pit in the ground. It has no lining in walls and a permeable base. It allows infiltration of effluents from walls and as well as bottom of the pit (SuSanA, 2018). 2% of households have unlined pits.

Table 1 shows the types of onsite sanitation technologies and percentage of households using it at Mirchaiya Municipality.

Table 1: Types of onsite sanitation system at households of Mirchaiya Municipality.

Containment	Wall construction materials	Bottom of containment	Chamber	Number	Connected to	%
Septic Tank	Concrete walls OR Cemented brick/stone walls	PCC or plastered	Two or more than two	NA	Soak pit Sewer Open drain/open ground	2%
Fully Lined Tank	Concrete walls OR Cemented brick/stone walls	PCC or plastered	One or Two	NA	Soak pit Sewer Open drain/open ground No outlet/overflow	47%
Lined tank with impermeable walls and open bottom	Concrete walls OR Cemented brick/stone walls	Soiling or Nothing	One, two or More than two	NA	Soak pit Sewer Open drain/open ground No outlet/overflow	22%
Single pit	Concrete rings piled one after other	Soiling or Nothing	NA	One	NA	12%
Twin pit	Concrete rings piled one after other	Soiling or Nothing	NA	Two	NA	2%
Unlined pit	Mud mortar brick wall/Mud mortar cement wall/No lining/Dry stone wall	Nothing	NA	NA	NA	2%

Here, single pits and twin pits are recategorized under lined pits with semi-permeable walls and open bottom. Thus, 14% of the households in the municipality have lined pits with semi-permeable walls and open bottom.

Figure 8 shows location map of households with different types of containment at Mirchaiya municipality.

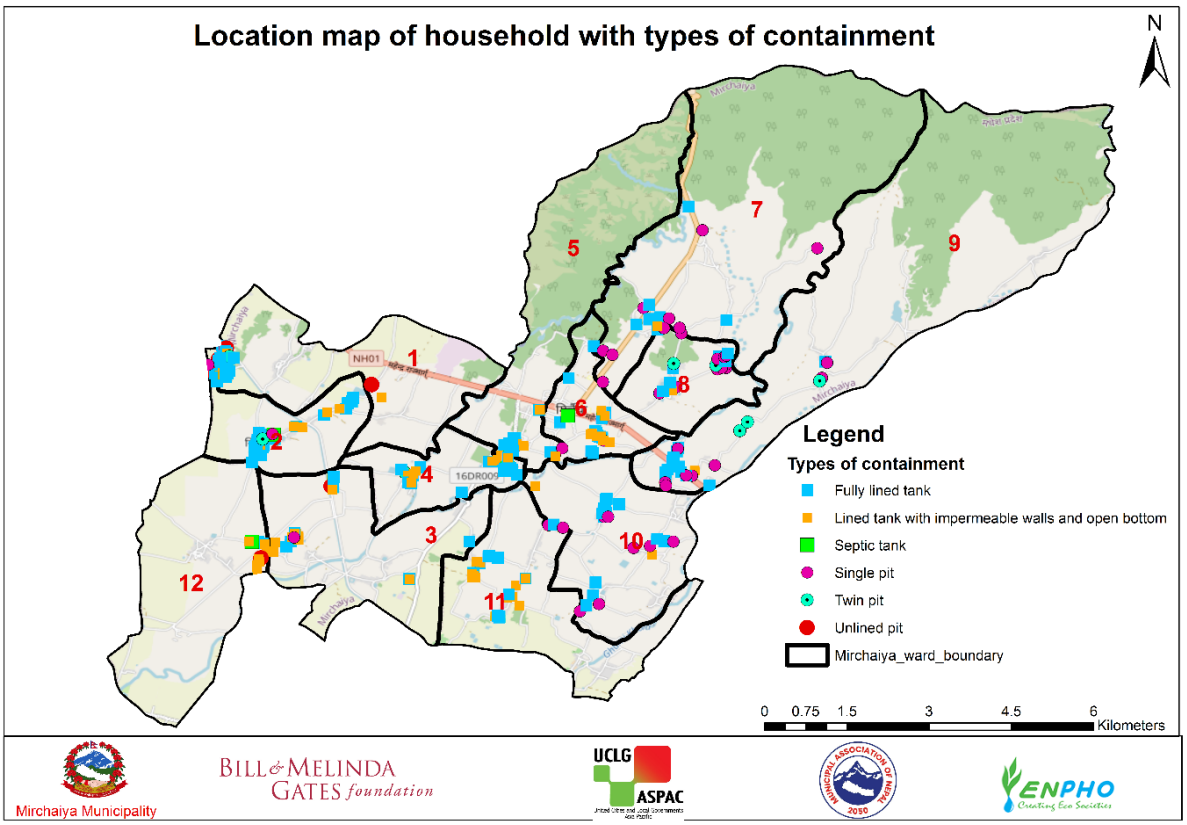

Figure 8: Location map of household with different types of containment.

2.1.2 Sanitation System in Institutional Buildings

Altogether, 32 institutional buildings were surveyed. The sanitation data of institutional buildings were obtained from different types of institutions. Table 2 shows the types and number of surveyed institutions.

Table 2: Type and number of surveyed institutions.

Type of Institution	Number of Surveyed Institutions
Educational Institution	13
Government /Non-government Office	11
Health care centre	8
Grand Total	**32**

All the institutional buildings in the municipality have toilets. About 3% of the institutional buildings have offsite sanitation systems whereas 97% of the buildings have their toilets connected to the containments. Among the buildings with containment, 41% have septic tanks, 31% have fully lined tanks, 6% have lined tanks with impermeable walls and open bottom, 16% have lined pits with semi-permeable walls and open bottom and 3% have unlined pit. Based on the data it is found that, most institutional buildings have properly built containments as compared to households. Figure 9 shows the location map of institutional buildings with different types of containments in Mirchaiya Municipality.

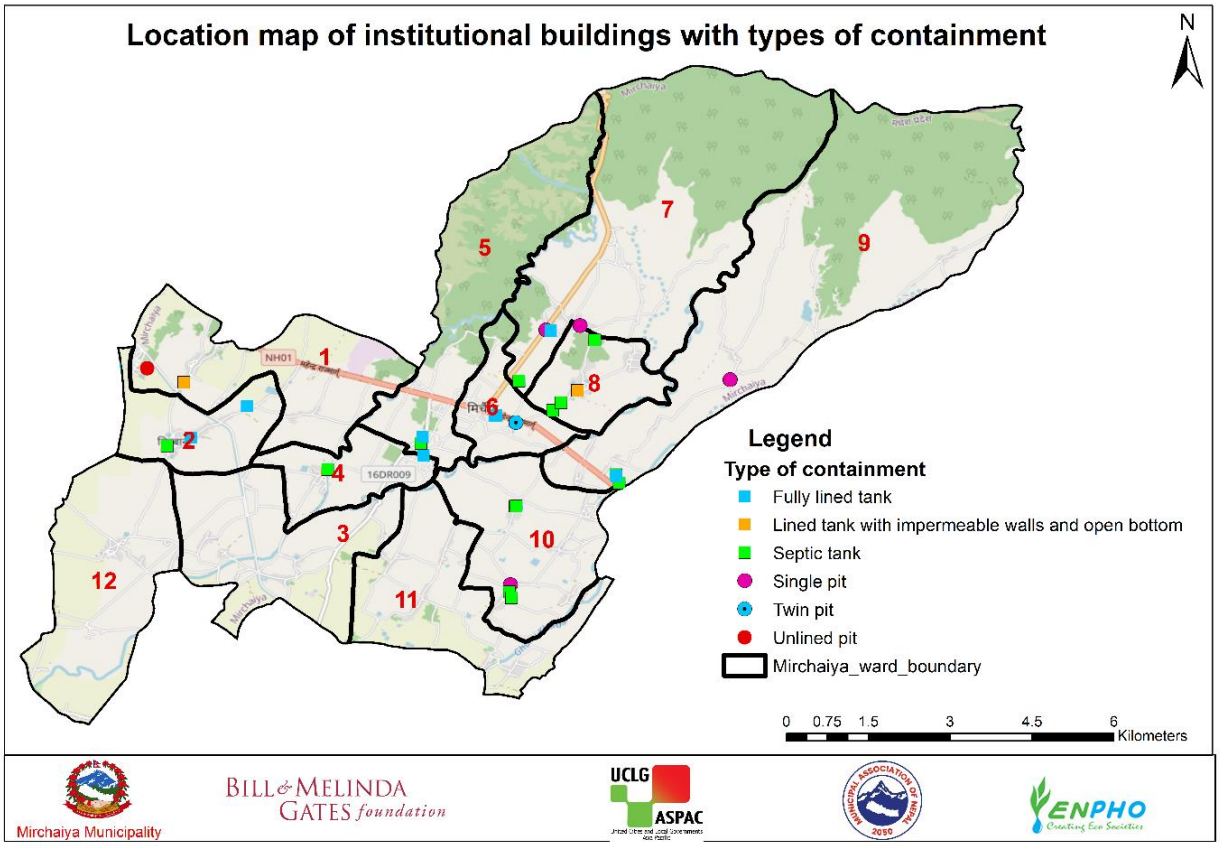

Figure 9: Location map of institutional buildings with different types of containment in Mirchaiya Municipality.

2.1.3 Public Toilets

Mirchaiya Municipality has six public toilets. The toilets are located at local marketplaces of Mirchaiya bazar, Katari chowk, Golbazar, Bakhra bazar, Malteshwor bazar and Malaniya. Three toilets located in Mirchaiya bazar, Katari chowk, and Golbazar, among the six of them, are constructed by the municipality. Only limited information could be gathered for three of those public toilets. Whereas no information could be gathered for the remaining. The obtained information is therefore fed in this report.

Public toilet at Mirchaiya Bazar

The toilet is being managed by the municipality. It serves 5 people at a time, with 2 pan in male compartment and, 2 urinals and 1 pan in female compartment. The outlet of toilet is connected

to the containment installed just outside of the toilet. The public passing by the local marketplace is the service recipient of this toilet.

Water is supplied to the taps of toilet compartments. It is supplied from the two 1,000-litre tanks placed over the roof of the toilet. The toilet compartments do not have proper ventilation and lacks cleanliness. Also, the toilet does not have a handwashing facility. Figure 10 and 11 present the structure and status of the public toilet at Mirchaiya bazar.

Figure 10: Structure of the public toilet at Mirchaiya bazar.

Figure 11: Status of pan (left) and urinals (right) of the public toilet at Mirchaiya bazar.

Public toilet at Katari Chowk

The toilet has two compartments, however it is not functional. Figure 12 is the picture of the non-functional public toilet at Katari chowk.

Figure 12: Non-functional public toilet at Katari chowk.

Public toilet at Golbazar

The toilet has a total of 6 compartments. There are set of 3 separate male and female compartments. This toilet is also not functional (KII-1, 2022).

2.1.4 Emptying and Transport

Emptying is one of the key elements of sanitation service chain. It basically assures the proper operation of containment. Regular emptying of the containment prevents sludge overflow and blockages (Strande, et al., 2014). Moreover, emptying of containment is determined by the number of users, duration of years and types and size of containment.

Among the households with onsite sanitation systems, about 29% of the households have emptied their containment whereas 71% have not emptied them. Similarly, about 39% of the institutional buildings with containment have emptied their containments. The emptying practice proportion was found more in the institutional buildings as compared to the households.

All the households and institutional buildings that have emptied their containments, have used mechanical emptying method only. Both municipal and commercial desludging services are available in the municipality. The municipality has a desludging vehicle with tank capacity of 6,000-litres. It charges NRs. 3,000 (USD 22.9) for a trip, to empty sludge from rectangular tanks, and NRs. 500 (USD 3.8) per ring from concrete ring containments. One driver and one

support staff are employed by the municipality to provide this service (KII-1, 2022). Figure 13 shows a picture of desludging vehicle of the Mirchaiya Municipality.

Figure 13: Desludging vehicle of the Mirchaiya Municipality.

Four desludging services are registered in the municipality to serve commercially (KII-1, 2022). Moreover, unregistered private desludging service providers within and from outside the municipality provide this service in the municipality.

Okhaldhunga Septic Tanki Sarsafai Sewa has been providing desludging services for the past 5 years. However, it is not registered in any government agencies. It is one among the other service providers that serve in the Mirchaiya Municipality. The service provider is equipped with a desludging vehicle with a tank capacity of 6,000-litres. For the service, it charges NRs. 1,200 to NRs.1, 600 (USD 9.1 to 12.2) per trip on average. Generally, it makes 14 trips on average per week. One driver and one helper works at a time for desludging of the containments. The sanitation workers work without any safety equipment. However, they receive NRs. 9,000 (USD 68.6) as accidental insurance along with a salary of NRs. 25,000 (USD 190.8) per month (KII-2, 2022). Figure 14 shows the sanitation workers, from private desludging service providers, emptying a containment of a school at Mirchiaya Municipality.

Figure 14: Private desludger emptying containment of a school at Mirchiaya Municipality.

2.1.5 Treatment and Disposal/Reuse

Mirchaiya Municipality does not have a Faecal Sludge Treatment Plant (FSTP) but it does have a designated place for dumping FS. The dumping site is in the middle of a community forest. Only the municipal desludging vehicle is permitted to dump the FS at the site (KII-1, 2022). While FS emptied by commercial desludging vehicles is dumped in a farmland or along a riverbank (KII-2, 2022). Therefore, the emptied FS is unsafely disposed of in open spaces and water bodies in Mirchaiya Municipality.

2.1.6 Risk Assessment of Groundwater Pollution

The risk of groundwater pollution was assessed based on source of drinking water, secondary data on water quality and the vulnerability of aquifer with regards to lateral spacing between sanitation system and groundwater sources.

a. Sources of drinking water and water production

The Department of Water Supply and Sewerage Management (DWSSM) constructed the water supply system in Mirchaiya in 1995. The system was updated in 2015. The system has three reservoir tanks. The tanks are located at Chagariya with capacity of 3.5 lakh[1] litres, at Mirchaiya with 2.5 lakh litres and at Matirwa with 4.5 lakh litres. Water for each tank is uplifted from two bores with a depth of 450 ft (m) . Mirchaiya Sana Sahari Water Supply and Users Committee (WSUC) under DWSSM has been providing piped drinking water through the system. Till 2022, it has distributed 4,812 taps to households in five wards (ward no. 4, 5 , 6, 7 and 8) of the Mirchaiya Municipality. Iron removal and pressure filter is applied for the treatment of water (KII-3, 2022). Moreover, 82% of households still rely on handpumps for drinking water supply.

[1] One lakh = 10^5

b. The vulnerability of aquifer and lateral spacing between sanitation systems and groundwater sources

The term aquifer pollution vulnerability is intended to represent the varying level of natural protection afforded by the contaminant attenuation capacity of the unsaturated zone or semi-confining beds above an aquifer, because of physicochemical processes (filtration, biodegradation, hydrolysis, adsorption, neutralization, volatilization, and dispersion)—all of which vary with their texture, structure, clay content, organic matter, pH, redox and carbonate equilibria. Groundwater vulnerability is specific to containment type and pollution scenarios (Foster, et al., 2013). Among other anthropogenic activities, improperly designed and constructed and unmanaged sanitation technologies also contribute to the groundwater contamination (EPA, 2015). In addition to it, the key factor to risk of groundwater pollution is the soil type and geological structure. According to WHO, if the travel time of pollutant to groundwater source is less than 25 days, there is significant risk to contamination; low risk, if the travel time is between 25 and 50 days; and very low risk if the travel time is greater than 50 days. The size of pores in the soil determines the infiltration rate (Krishnan, 2011).

The soil composition of Mirchaiya Municipality consists of alluvial sediments i.e. sand, silt and clay along-with coarse gravels (Upreti, 1999) also known as sandy loam soil. In the sandy loam soil, the permeability is approximately 2.5 cm per hour (INREM, 2011). Thus, between 25 and 50 days the pollutant could travel to the depth of approximately 30 metres (98.67 feet) in the soil type of Mirchaiya Municipality and possesses risk of groundwater pollution. Hence, the people using open bottom tanks and consuming water from the handpumps with the depth up to 100 feet (30.48 m) and horizontal distance of the pump within 25 feet (7.62 m) from the source of pollutants are assumed at significant risk to groundwater pollution.

Figure 15 shows the depth of handpumps and horizontal distance of it from source of pollutant by lined tanks with impermeable walls and open bottoms. Almost 78% of the households (i.e. T2A4C10: 78% x 4.9% = 3.8% ≈ 4% of the overall population, where 4.9% is the percentage of population using lined tanks with impermeable walls and open bottom with no outlet or overflow and groundwater as drinking water source) using this type of containment possess significant risk to groundwater contamination.

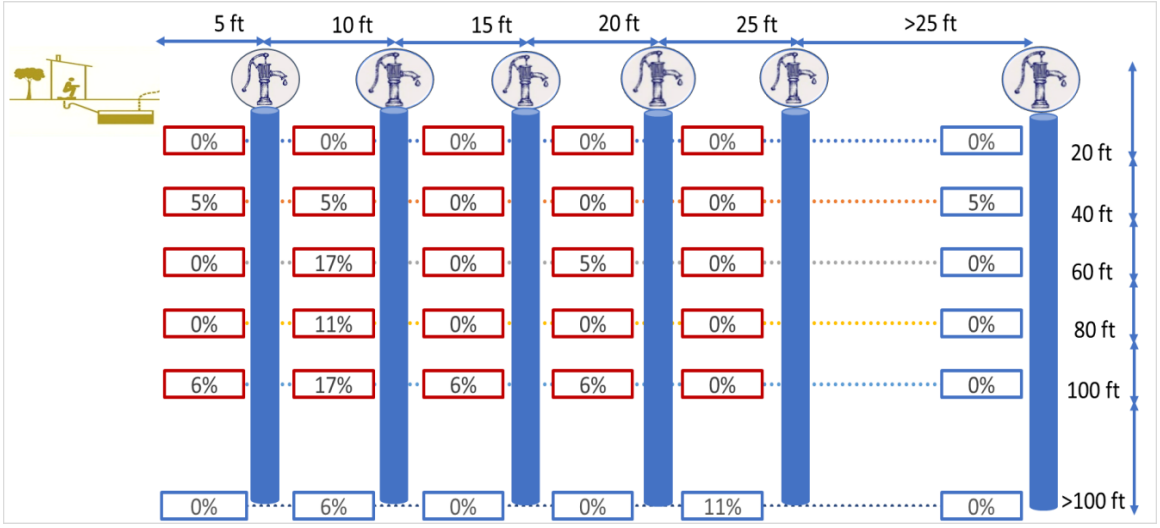

Figure 15: Depth of hand pumps and lateral spacing of it with containment type lined tank with impermeable walls and open bottom.

Figure 16 shows the depth of hand pumps and horizontal distance of it with the containment type lined pit with semi-permeable walls and open bottom and unlined pit. It shows that almost 63% of the households (i.e. T2A5C10: 63% x 9.12% = 5.7% ≈ 6% and T2A6C10: 63% x 1.88% = 1.1% ≈ 1% where 9.12% is the percentage of population using lined pits with semi-permeable walls and open bottom and 1.88% is the percentage of population using unlined pits both with no outlet or overflow and using groundwater as drinking water source) using these type of containments possess significant risk to groundwater contamination.

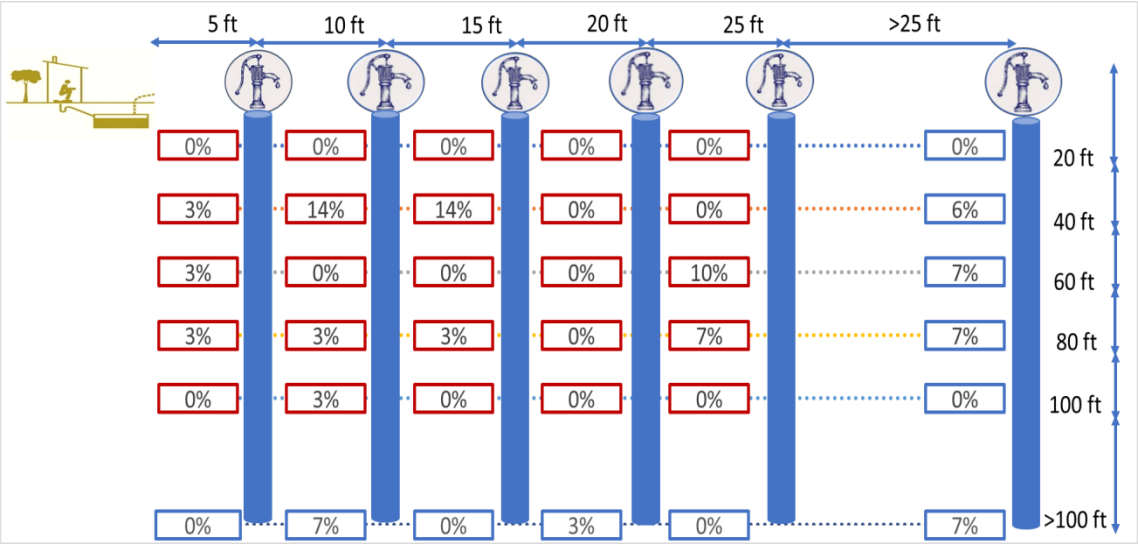

Figure 16: Depth of hand pumps and lateral spacing of it with containment type lined pit with semi-permeable walls and open bottom.

2.2 SFD Selection Grid

Figure 17 shows the types of sanitation technologies present in the Mirchaiya Municipality selected in the Shit Flow Diagram (SFD) selection grid. The vertical column on the left side of grid represents sanitation technologies to which toilet is connected to, and horizontal row at top is connection of the technologies. The households with single pit and twin pits are selected as lined pit with semipermeable walls and open bottom in this selection grid.

List A: Where does the toilet discharge to? (i.e. what type of containment technology, if any?)	List B: What is the containment technology connected to? (i.e. where does the outlet or overflow discharge to, if anything?)									
	to centralised combined sewer	to centralised foul/separate sewer	to decentralised combined sewer	to decentralised foul/separate sewer	to soakpit	to open drain or storm sewer	to water body	to open ground	to 'don't know where'	no outlet or overflow
No onsite container. Toilet discharges directly to destination given in List B					Significant risk of GW pollution Low risk of GW pollution	T1A1C6		T1A1C8		Not Applicable
Septic tank					Significant risk of GW pollution Low risk of GW pollution	T1A2C6		T1A2C8		
Fully lined tank (sealed)					Significant risk of GW pollution Low risk of GW pollution	T1A3C6		T1A3C8		T1A3C10
Lined tank with impermeable walls and open bottom	Significant risk of GW pollution Low risk of GW pollution	Significant risk of GW pollution Low risk of GW pollution	Significant risk of GW pollution Low risk of GW pollution	Significant risk of GW pollution Low risk of GW pollution	Significant risk of GW pollution Low risk of GW pollution	T1A4C6		T1A4C8		T2A4C10 T1A4C10
Lined pit with semi-permeable walls and open bottom	Not Applicable									T2A5C10 T1A5C10
Unlined pit										T2A6C10 T1A6C10
Pit (all types), never emptied but abandoned when full and covered with soil										Significant risk of GW pollution Low risk of GW pollution
Pit (all types), never emptied, abandoned when full but NOT adequately covered with soil										
Toilet failed, damaged, collapsed or flooded										
Containment (septic tank or tank or pit latrine) failed, damaged, collapsed or flooded										
No toilet. Open defecation	Not Applicable						T1B11 C7 TO C9			Not Applicable

Figure 17: SFD selection grid for Mirchaiya Municipality.

The detail description of selected terms in the selection grid is provided in the Table 3:

Table 3: Explanation of terms used to indicate different frame selected in the SFD selection grid in Figure 17.

T1A1C6	A fully functioning toilet discharging directly to an open drain or storm sewer. The excreta is raw, untreated and hazardous and since it discharges directly to an open drain or storm sewer, all the excreta in this system is considered NOT contained.
T1A1C8	A fully functioning toilet discharging directly to open ground. The excreta is raw, untreated and hazardous and since it discharges directly to open ground, all the excreta in this system is considered NOT contained.
T1A2C6	A correctly designed, properly constructed, fully functioning septic tank with an outlet connected to an open drain or storm sewer. The supernatant/effluent flowing from the tank is only partially treated and is still hazardous, therefore all the excreta in this system is considered NOT contained.
T1A2C8	A correctly designed, properly constructed, fully functioning septic tank with an outlet connected to open ground. The supernatant/effluent flowing from the tank is only partially treated and is still hazardous, therefore all the excreta in this system is considered NOT contained.
T1A3C6	A correctly designed, properly constructed and well maintained fully lined tank with impermeable walls and base. It includes poorly designed and/or constructed and/or maintained septic tanks that, because of these faults or deficiencies, are NOT performing as septic tanks, instead they are acting as sealed vaults. Since the tank is fitted with a supernatant/effluent overflow connected to an open drain or storm sewer the excreta in this system is considered NOT contained.
T1A3C8	A correctly designed, properly constructed and well maintained fully lined tank with impermeable walls and base. It includes poorly designed and/or constructed and/or maintained septic tanks that, because of these faults or deficiencies, are NOT performing as septic tanks, instead they are acting as sealed vaults. Since the tank is fitted with a supernatant/effluent overflow connected to open ground the excreta in this system is considered NOT contained.

T1A3C10	A correctly designed, properly constructed and well maintained fully lined tank with impermeable walls and base. It includes poorly designed and/or constructed and/or maintained septic tanks that, because of these faults or deficiencies, are NOT performing as septic tanks, instead they are acting as sealed vaults. However, since the tank is NOT fitted with a supernatant/effluent overflow this system is considered contained.
T1A4C6	A correctly designed, properly constructed and well maintained lined tank with sealed, impermeable walls and an open, permeable base, through which infiltration can occur. It includes wall-lined but open bottomed tanks and containers which are sometimes mistakenly referred to as septic tanks. Since the tank is fitted with a supernatant/effluent overflow connected to an open drain or storm sewer, the excreta in this system is considered NOT contained.
T1A4C8	A correctly designed, properly constructed and well maintained lined tank with sealed, impermeable walls and an open, permeable base, through which infiltration can occur. It includes wall-lined but open bottomed tanks and containers which are sometimes mistakenly referred to as septic tanks. Since the tank is fitted with a supernatant/effluent overflow connected to open ground, the excreta in this system is considered NOT contained.
T2A4C10	A correctly designed, properly constructed and well maintained lined tank with sealed, impermeable walls and an open, permeable base, through which infiltration can occur - the excreta is therefore likely to be partially treated. It includes all lined but open bottomed tanks and containers which are sometimes mistakenly referred to as septic tanks (e.g. cubluks in Indonesia). The tank is NOT fitted with a supernatant/effluent overflow but since there is a 'significant risk' of groundwater pollution this system is considered NOT contained.
T1A4C10	A correctly designed, properly constructed and well maintained lined tank with sealed, impermeable walls and an open, permeable base, through which infiltration can occur. It includes all lined but open bottomed tanks and containers which are sometimes mistakenly referred to as septic tanks (e.g. cubluks in Indonesia). However, since the tank is NOT fitted with a supernatant/effluent overflow this system is considered contained.
T2A5C10	A correctly designed, properly constructed and well maintained pit with semi-permeable, honeycombed lined walls and an open, permeable base, through which infiltration can occur. The tank is NOT fitted with a supernatant/effluent overflow but since there is a 'significant risk' of groundwater pollution this system is considered NOT contained.
T1A5C10	A correctly designed, properly constructed and well maintained pit with semi-permeable, honeycombed lined walls and an open, permeable base, through which infiltration can occur. The tank is NOT fitted with a supernatant/effluent overflow so this system is considered contained.
T2A6C10	A correctly designed, properly constructed and well maintained unlined pit with permeable walls and base, through which infiltration can occur. The tank is NOT fitted with a supernatant/effluent overflow but since there is a 'significant risk' of groundwater pollution this system is considered NOT contained.
T1A6C10	A correctly designed, properly constructed and well maintained unlined pit with permeable walls and base, through which infiltration can occur. The tank is NOT fitted with a supernatant/effluent overflow so this system is considered contained.
T1B11C7 to C9	With no toilet, users defecate in water bodies, on open ground and to don't know where; consequently the excreta is NOT contained.

2.3 SFD Matrix

2.3.1 Proportion of Faecal Sludge from types of sanitation technologies

The second step in the process of developing the SFD graphic is the calculation of the proportion of contents of each type of onsite container which is faecal sludge. SFD matrix calculates the proportion of people using each type of system and the proportion of each system, from which FS and supernatant is emptied, transported and treated. A detailed instruction on how to calculate SFD proportion in SFD PI was used as guide to calculate SFD proportion. As stated on SFD PI, the default "100%" value is used for onsite containers which are connected to soak pits, water bodies or to open ground. This will model the contents as 100% faecal sludge and a proportion of this may be emptied periodically. The remaining not emptied fraction is made up of one or more of the following: faecal sludge which remains in the container, supernatant (when discharging to water bodies or to open ground), and infiltrate. The value for onsite containers that are connected to a sewer network or to open drains is used as "50%" which means half of the contents are modelled FS and a proportion of this may be emptied periodically. The remaining not emptied fraction will comprise faecal sludge which remains in the container and, in the case of open-bottomed tanks, infiltrate. The other half of the contents is modelled as supernatant discharging into the sewer network or to open drains. The formula obtained from SFD PI used for FS proportion calculation is shown below:

$$\frac{(Onsite\ container\ connected\ to\ soak\ pit, no\ outlet, water\ bodies\ or\ open\ ground) * 100 + (Onsite\ container\ connected\ to\ sewer\ network\ or\ open\ drain) * 50}{Onsite\ Container}$$

The calculated FS proportion in each type of sanitation technologies are:

i. The proportion of FS in septic tank is 75%.
ii. The proportion of FS in fully lined tank is 90%.
iii. The proportion of FS from lined tanks with open bottom and all types of pit is 99%.

Upon calculation of proportion of FS in each type of sanitation technologies, the population using the system selected in the SFD selection grid are fed in. The column Population (Pop) gives the proportion of population using type of sanitation system.

Figure 18 shows the SFD matrix of Mirchaiya Municipality.

Mirchaiya Municipality, Madhesh, Nepal, 7 Jul 2023. SFD Level: 2 - Intermediate SFD
Population: 59425
Proportion of tanks: septic tanks: 75%, fully lined tanks: 90%, lined, open bottom tanks: 99%

Containment								
System type	Population	WW transport	WW treatment	FS emptying	FS transport	FS treatment	SN transport	SN treatment
	Pop	W4c	W5c	F3	F4	F5	S4e	S5e
System label and description	Proportion of population using this type of system (p)	Proportion of wastewater in open sewer or storm drain system, which is delivered to treatment plants	Proportion of wastewater delivered to treatment plants, which is treated	Proportion of this type of system from which faecal sludge is emptied	Proportion of faecal sludge emptied, which is delivered to treatment plants	Proportion of faecal sludge delivered to treatment plants, which is treated	Proportion of supernatant in open drain or storm sewer system, which is delivered to treatment plants	Proportion of supernatant in open drain or storm sewer system that is delivered to treatment plants, which is treated
T1A1C6 Toilet discharges directly to open drain or storm sewer	3.0	0.0	0.0					
T1A1C8 Toilet discharges directly to open ground	1.0							
T1A2C6 Septic tank connected to open drain or storm sewer	1.0			20.0	0.0	0.0	0.0	0.0
T1A2C8 Septic tank connected to open ground	1.0			80.0	0.0	0.0		
T1A3C10 Fully lined tank (sealed), no outlet or overflow	27.0			16.0	0.0	0.0		
T1A3C6 Fully lined tank (sealed) connected to an open drain or storm sewer	9.0			19.0	0.0	0.0	0.0	0.0
T1A3C8 Fully lined tank (sealed) connected to open ground	11.0			20.0	0.0	0.0		
T1A4C10 Lined tank with impermeable walls and open bottom, no outlet or overflow	1.0			32.0	0.0	0.0		
T1A4C6 Lined tank with impermeable walls and open bottom, connected to an open drain or storm sewer	1.0			10.0	0.0	0.0	0.0	0.0
T1A4C8 Lined tank with impermeable walls and open bottom, connected to open ground	16.0			30.0	0.0	0.0		
T1A5C10 Lined pit with semi-permeable walls and open bottom, no outlet or overflow	8.0			30.0	0.0	0.0		
T1A6C10 Unlined pit, no outlet or overflow	1.0			0.0	0.0	0.0		
T1B11 C7 TO C9 Open defecation	9.0							
T2A4C10 Lined tank with impermeable walls and open bottom, no outlet or overflow, where there is a 'significant risk' of groundwater pollution	4.0			34.0	0.0	0.0		
T2A5C10 Lined pit with semi-permeable walls and open bottom, no outlet or overflow, where there is a 'significant risk' of groundwater pollution	6.0			26.0	0.0	0.0		
T2A6C10 Unlined pit, no outlet or overflow, where there is a 'significant risk' of groundwater pollution	1.0			64.0	0.0	0.0		

Figure 18: SFD Matrix of Mirchaiya Municipality.

2.3.2 *Proportion of Faecal Sludge Emptied (F3)*

The proportion of faecal sludge emptied (F3) is calculated based on percentage of containment emptied (ENPHO, 2023) and amount of FS emptied during the process (KII-2, 2022). The information on FS emptied from containment is obtained from KII with desludging service providers. In an average 20% of the FS in the containment which is very thick and does not dissolve in water is not removed during emptying (KII-2, 2022). Hence, actual proportion of FS emptied from each containment is calculated as:

$$Actual\ Proportion\ of\ FS\ emptied\ (F3) = percentage\ of\ containment\ emptied \times proportion\ of\ FS\ removed\ during\ emptying$$

Table 4 shows the actual proportion of FS emptied from each containment.

Table 4: Sanitation technologies and proportion of emptied faecal sludge (ENPHO, 2023[1]; KII-2, 2022[2]).

Sanitation Technologies	SFD Reference Variable	Emptied Proportion of FS [1]	FS Emptied from Containment [2]	Actual Proportion of Emptied FS (F3)
Toilet discharges directly to open drain or storm sewer	T1A1C6	0%	0%	0%
Toilet discharges directly to open ground	T1A1C8	0%	0%	0%
Septic tank connected to open drain or storm sewer	T1A2C6	25%	80%	20%
Septic tank connected to open ground	T1A2C8	100%	80%	80%
Fully lined tank (sealed) connected to an open drain or storm sewer	T1A3C6	24%	80%	19%
Fully lined tank (sealed) connected to open ground	T1A3C8	25%	80%	20%
Fully lined tank (sealed), no outlet or overflow	T1A3C10	20%	80%	16%
Lined tank with impermeable walls and open bottom, connected to an open drain or storm sewer	T1A4C6	13%	80%	10%
Lined tank with impermeable walls and open bottom, connected to open ground	T1A4C8	38%	80%	30%
Lined tank with impermeable walls and open bottom, no outlet or overflow	T1A4C10	40%	80%	32%
Lined pit with semi-permeable walls and open bottom, no outlet or overflow	T1A5C10	37%	80%	30%
Unlined pit, no outlet or overflow	T1A6C10	0%	0%	0%
Open defecation	T1B11 C7 TO C9	0%	0%	0%
Lined tank with impermeable walls and open bottom, no outlet or overflow, where there is a 'significant risk' of groundwater pollution	T2A4C10	43%	80%	34%
Lined pit with semi-permeable walls and open bottom, no outlet or overflow, where there is a 'significant risk' of groundwater pollution	T2A5C10	32%	80%	26%
Unlined pit, no outlet or overflow, where there is a 'significant risk' of groundwater pollution	T2A6C10	80%	80%	64%

2.3.3 Proportion of WW transported which is delivered to Treatment Plant (W4c and W5c)

The variable W4c is the proportion of wastewater in open sewer or stormwater drain that is delivered to treatment plant and variable W5c is the proportion of wastewater delivered to treatment plant and treated. The municipality does not have a Wastewater Treatment Plant (WWTP). Hence, discharged wastewater is not treated and thus, the value for variables W4c and W5c is set to 0%.

2.3.4 Proportion of FS emptied which is delivered to Treatment Plant and treated (F4 and F5)

The municipality does not have a treatment plant to treat faecal sludge. Also, the people using twin pits reclassified as lined pits with semi-permeable walls and open bottoms are not using properly. Hence, the portion of FS delivered to treatment plant (F4) and treated (F5) is 0%.

2.3.5 Proportion of Supernatant in open drain or storm sewer delivered to treatment and treated (S4e and S5e)

The variable S4e is the proportion of supernatant disposed of in open drain or storm sewer that is delivered to treatment plant and S5e is the proportion of supernatant that is delivered to treatment plant that is treated. The actual proportion of supernatant from the containment to open drain and storm water drain is not able to observe. Thus, the proportion is estimated at 50% of the faecal sludge in the containment connected to open drain and storm sewer. While the proportion delivered to treatment plant (S4e) and treated (S5e) is 0% as there is no treatment facility.

2.4 SFD Graphic

Figure 19 shows the excreta flow diagram of Mirchaiya Municipality. The graphic shows that excreta generated from the proportion of population that are safely managed is shown in green coloured whereas unsafely managed excreta are shown in red coloured arrowhead. It shows that excreta from 30% of the population are safely managed and excreta from 70% of the population are unsafely managed. It also represents the sanitation value chain going from left to right.

Offsite Sanitation

Mirchaiya Municipality does not have sewer network, however, 4% of households have offsite sanitation systems. The wastewater generated from these households is disposed of untreated to an open environment. Therefore, wastewater from 4% of the population is not treated and is unsafely managed.

Onsite Sanitation

In the municipality, 87% of households rely on onsite sanitation systems. Of the total households having onsite sanitation systems, only 37% of the population uses containment where FS is contained.

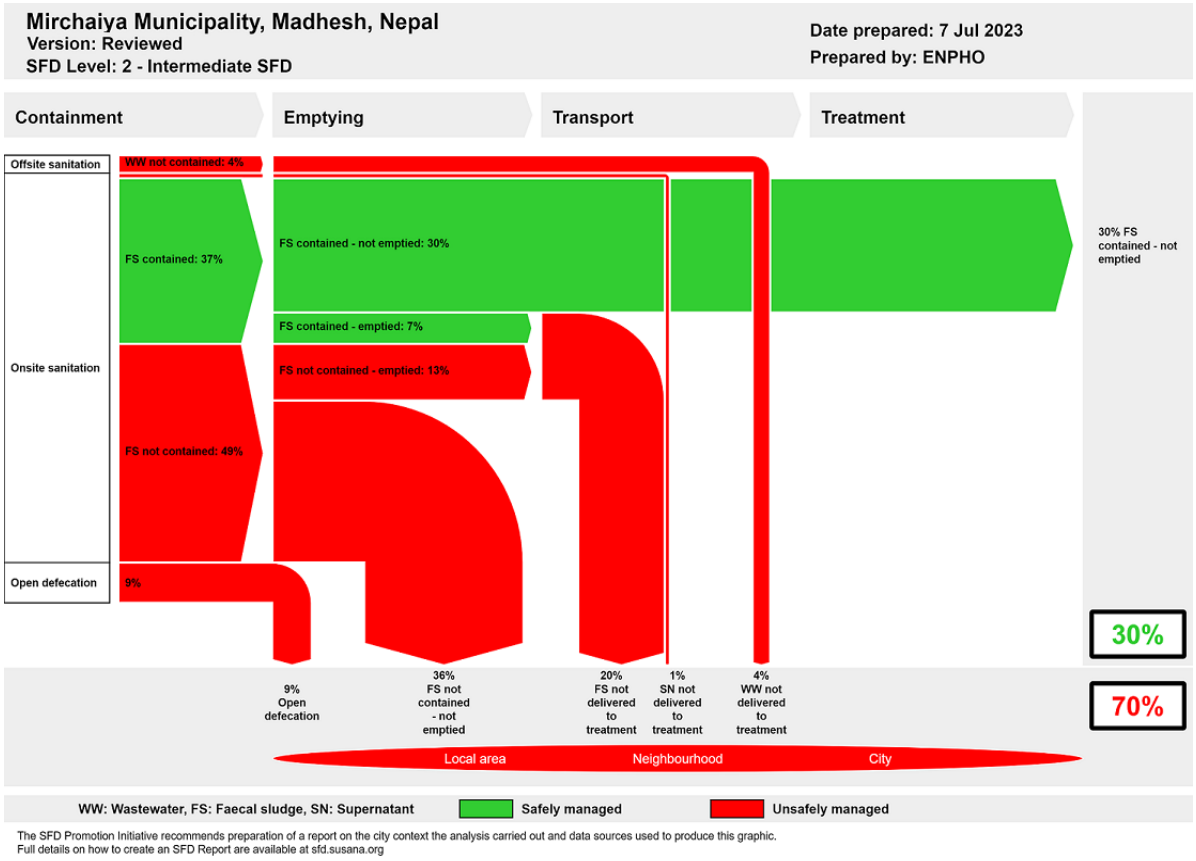

Figure 19: SFD Graphic of Mirchaiya Municipality.

FS contained

The definition of 'FS contained' is faecal sludge contained within an onsite sanitation technology which ensures safe level of protection from excreta i.e. pathogen transmission to the user or general public is limited. These are tanks or pits that are correctly designed, properly constructed, fully functioning, and/or are causing no risk- or only a 'low' risk- of polluting groundwater used for drinking (SuSanA, 2018).

The value of FS contained i.e. 37% is obtained from the summation of population using fully lined tanks with no outlet or overflow (T1A3C10), lined tanks with impermeable walls and open bottom with no outlet or overflow (T1A4C10), lined pits with semi-permeable walls and open bottom with no outlet or overflow (T1A5C10) and unlined pits with no outlet or overflow (T1A6C10) without posing a significant risk to groundwater.

FS not Contained

The definition of 'FS not contained' is faecal sludge contained within an onsite sanitation technology which does not ensure safe level of protection from excreta i.e. pathogen transmission to the user or general public is likely. These are tanks or pits that are incorrectly designed, or poorly constructed, or poorly functioning, and/or are causing a 'significant' risk of polluting groundwater used for drinking (SuSanA, 2018).

The value of FS not contained i.e. 49% is obtained from the summation of population using septic tanks connected to open drain or storm sewer and to open ground (T1A2C6 and T1A2C8), fully lined tanks connected to an open drain or storm water and to open ground

(T1A3C6 and T1A3C8), lined tanks with impermeable walls and open bottom connected to an open drain or storm sewer and to open ground (T1A4C6 and T1A4C8), lined tanks with impermeable walls and open bottom with no outlet or overflow with 'significant risk' to groundwater (T2A4C10), lined pits with semi-permeable walls and open bottom with no outlet or overflow with 'significant risk' to groundwater (T2A5C10) and unlined pits with no outlet or overflow with 'significant risk' to groundwater (T2A6C10).

FS contained - not Emptied

The value of 30% is obtained from the proportion of the population using sanitation systems where the FS is contained and have not emptied their containment. However, this 30% of safely managed FS should be considered as only temporary, as most of the pits and tanks have not yet filled up and the FS generated remains 'not emptied'. Therefore, these systems will require emptying services in the short and medium term as they fill up.

FS contained - Emptied

The value of 7% is obtained from the proportion of population using sanitation systems where the FS is contained and have emptied their containment.

FS not contained - Emptied

The value of 13% is obtained from the proportion of the population using sanitation systems where the FS is not contained and have emptied their containment.

FS not contained - not Emptied

The value of 36% is obtained from the proportion of the population using sanitation systems where the FS is not contained and have not emptied their containment.

FS not delivered to treatment

The proportion of FS not delivered to treatment, i.e. 20%, is the summation of FS contained - emptied and FS not contained - emptied. Since Mirchaiya Municipality does not have a FS treatment plant, emptied FS is disposed of untreated to farmlands, riverbanks, forest or in a FS dumping site. Therefore, this proportion of disposed FS possesses risk to local area and neighbourhood.

Supernatant (SN) not delivered to treatment

The proportion of supernatant is obtained from containments connected to open drain or storm water sewer calculated as 50% of FS contained in each containment. The total proportion of supernatant (SN) is 1% of FS generated by the total population. Since the municipality lacks the sewer network and treatment plant, the supernatant is disposed of directly into water bodies. Hence the proportion of SN not delivered to treatment is 1%.

Open Defecation

Despite Open Defecation Free (ODF) status, people residing in 9% of households still go for open defecation. Mostly, people living in poverty and who do not own land, do not have toilets and despite having toilets, lack in behaviour change have led to open defecation in the municipality.

3 Service delivery context

3.1 Policy, legislation, and regulation

The constitution of Nepal 2015 has established right to access to clean drinking water and citizen as fundamental right. In Article 35 (4) related to right to health recognizes citizen's rights to access to clean drinking water and sanitation. In addition, Right to Clean Environment, Article 30 (1) recognizes that every person shall have the right to live in a healthy and clean environment (GoN 2015). To respect and promote the right of citizens to wards accessing clean drinking water and sanitation services, the government has promulgated and amended necessary laws. The most relevant legislation for promotion of safe sanitation services is discussed here.

Local Government Operation Act, 2017

Local Governance Operation Act 2017 has promulgated to implement the rights of local government and promote co-operation, co-existence, and co-ordination among federal, provincial, and local government. The act defined roles and responsibility of municipalities along with provision and procedure for approving laws and regulations at local level. Regarding the management of sanitation, the act entitles local government to conduct awareness campaigns, design and implement sanitation programs at the local level.

Environment Protection Act, 2019

Environment protection act 2019 is promulgated to prevent and control pollution from different development activities. It defines "Pollution" as the activities that significantly degrade, damage the environment, or harm the beneficial or useful purpose of the environment, by changing the environment directly or indirectly because of wastes, chemical, heat, noise, electrical, electro-magnetic wave, or radioactive ray. It provides the mechanism for appointing environmental inspector to control pollution by federal, provincial, and local government.

Water Supply and Sanitation Act, 2022

The act was promulgated to ensure the fundamental right of citizen to easy access on clean and quality drinking water, sanitation services and management of sewerage and wastewater. It defines sewerage and wastewater management as construction of sewer networks and treatment plants to preserve sources of water. It has entitled federal, provincial, and local level for the operation and management of water and sanitation services. The act also explicitly defines the responsibility of every citizen to preserve, conserve and maintain the sources of water and use responsibly.

Environment Friendly Local Governance Framework 2013

The environment-friendly local governance framework 2013 has been issued to add value to environment-friendly local development concept encouraging environmental protection through local bodies. The framework has set basic and advanced indicators for households, settlement, ward, village, municipality, and district levels for declaration of environment friendly. The use of water sealed toilets in households as basic indicators for sanitation and health. Provision of toilet with safety tank and use as advanced indicators for sanitation. Provision of gender, children and disabled friendly public toilets in parks, petrol pumps and main market as basic indicator for municipal level. Advance indicators such as drainage discharged only after being processed through biological or engineering technique. While it

has failed to identify the necessity of faecal sludge treatment plants as it has assumed safety tank in the households is sufficient for treating faecal sludge.

Institutional and Regulatory Framework for Faecal Sludge Management, 2017

Ministry of Water Supply through its Department of Water Supply and Sewerage Management (DWSSM) articulated and endorsed Institutional and Regulatory Framework (IRF) for Faecal Sludge Management in Urban Areas of Nepal in 2017. The main objective of the IRF is to define the specific roles and responsibilities of key institutions for the effective management and regulation of FSM. The framework primarily envisioned featuring FSM in the national policy and issuing policy directives into local government to incorporate FSM in their urban planning along with strengthening and enhancing the capacity of the local government to deliver effective services. A local government has been endowed with overall responsibility to plan, implement, and regulate the FSM services within its jurisdiction. The provision of the ability to engage the private sector and other relevant stakeholders such as the Water and Sanitation Users Committee (WSUC) in the framework reflects a participatory approach that would help in sustaining the interventions.

Total Sanitation Guideline, 2017

Total Sanitation Guideline was promulgated by the Ministry of Water Supply in April 2017 after the successful implementation of National Sanitation and Hygiene master Plan (NSHMP) 2011. It provides guidelines for sustaining ODF outcomes and initiating post-ODF activities through an integrated water, sanitation and hygiene plan at municipalities and districts. The guideline redefined sanitation as management of services and facilities to safely dispose of/reuse faecal sludge, collection and treatment of solid waste and wastewater to establish a hygienic environment and promote public health. Indicators are set to guide total sanitation movement with an arrangement for resource management, monitoring and evaluation, capacity building.

3.2 Policies

Historically, the National Sanitation Policy (1994) was the guideline for the planning and implementation of sanitation programs. The policy had promoted sanitation issues together with issues on water supply in rural communities. Also, Rural Water Supply and Sanitation National Policy (RWSSNP) 2004, has set a new target to provide safe, reliable, and affordable water supply with basic sanitation facilities. The policy focused on delivering quality services on water and sanitation to the marginalized and vulnerable groups. However, it was unable to address the complex operational issue of urban water supply and sanitation service delivery. Thus, the National Urban Water Supply and Sanitation Sector Policy (NUWSSSP) was formulated and enforced in 2009. It focused on achieving coherent, consistent, and uniform approaches of development in urban areas with the involvement of different agencies and institutions. Both these policies were limited to addressing emerging issues and challenges in the rural and urban areas. Thus, the National Water Supply and Sanitation Policy (NWSSP) was formulated in 2014 by GON to address the emerging challenges and issues with the adoption of new approaches and resolve the inconsistency in RWSSNP and NUWSSSP.

The goal of the NWSSP was to reduce urban and rural poverty by ensuring equitable socio - economic development, improving health and the quality of life of the people and protection of environment through the provision of sustainable water supply and sanitation services. It

adopted innovative technologies and knowledge emerged in the sector. Remarkably, it was the first official document that recognized discharge of untreated wastewater and dumping of septic sludge heavily polluted the surface water sources in urban areas.

Nepal is a signatory of the historical resolution of 2010 United Nations General Assembly on the Human Right to Water and Sanitation. Nepal committed to Millennium Development Goals (MDGs) for 2000- 2015. The goal was accomplished through declaration of the country as free from open defecation on 30th September 2019. After the MDGs, United Nations General Assembly set 17 global goals as Sustainable Development Goals (SDGs). Sanitation is prioritized on SDG 6. The target 6.2 of SDG 6 majorly focuses on sanitation. It mentioned to achieve access to adequate and equitable sanitation and hygiene for all and end open defecation, paying special attention to the needs of women and girls and those in vulnerable situations by 2030. In line with SDG 6.2, Nepal has targeted to provide improved sanitation to 95% households that are not shared and urban households with toilets connected to sewer system or proper FSM to 90% by 2030 (NPC, 2017). National Sanitation and Hygiene Master Plan, 2011 was developed for coordinated planning and implementation of National Sanitation Campaign. The campaign strengthened institutional setup tier of government in a participatory approach. In an alignment total sanitation campaign was initiated formally to sustain ODF. The guideline set various indicators to assess the sustainability of sanitation services. Remarkably, it extended sanitation definition as management of services and facilities to safely dispose of/reuse faecal sludge, collection and treatment of solid waste and wastewater to establish the hygienic environment and promote public health (NPC, 2017).

Similarly, Nepal Water Supply, Sanitation and Hygiene Sector Development Plan (SDP 2016-2030) was formulated in 2016 for sector convergence, institutional and legal reforms, capacity development and establishing coordination and harmonization in the sector. The SDP classified service system and delineated roles and responsibilities for effective and sustainable service delivery. The SDP highlighted that majority of households rely on onsite sanitation system (70%) that requires effective treatment of faecal sludge. However, there is lack of concrete policies, guidelines, and indicators on Faecal Sludge Management in the sector for effective planning, implementation, and service delivery. Nepal was declared ODF nation on September 23, 2019 (MoWS, 2020) however, the target of 90% households with toilets connected to sewer system or proper FSM is yet to be achieved.

3.3 Institutional roles

Federal, provincial, and local government are entitled for implementation of water and sanitation programs to ensure the rights on access to safe water and sanitation.

At Federal Government

National Planning Commission: At the federal government, the National Planning Commission is the specialized and apex advisory body for formulating a national vision, developing policy, periodic plans, and sectoral policies. The NPC assesses resource needs, identifies sources of funding, and allocates budget. It serves as a central agency for monitoring and evaluating development policy, plans and programs. It supports, facilitates, and coordinates with federal, provincial, and local government for developing policy plans and implementation.

Ministry of Water Supply: Ministry of Water Supply is the lead ministry responsible for planning, implementation, regulation, and monitoring and evaluation of sanitation programs in the country (GoN, 2015). Under the MoWS, Department of Water Supply and Sewerage Management (DWSSM) plan and implement water and sanitation projects funded by foreign donors or inter provincial projects or serves at least 15,000, 5,000 and 1,000 people in terai, hilly and mountain region respectively (GoN, 2015). The organizational structure of DWSSM is shown in Figure 20.

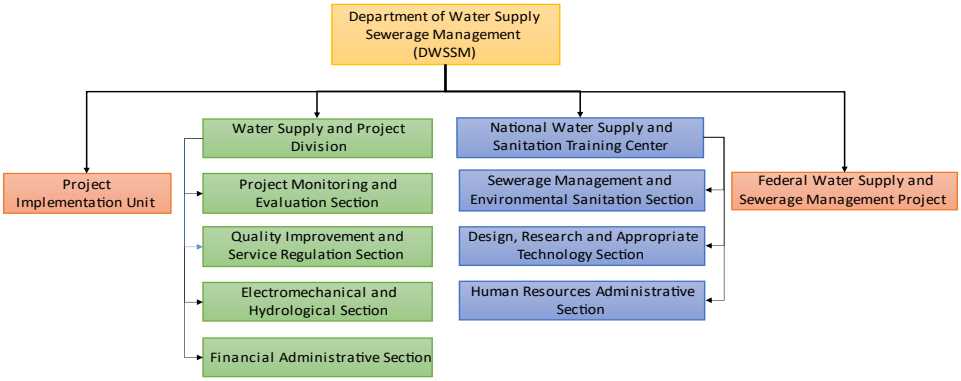

Figure 20: Organizational Structure Department of Water Supply and Sewerage Management (DWSSM).

Ministry of Urban Development: The Ministry of Urban Development (MoUD) works on integrated urban planning and development in municipalities, including faecal sludge management. Department of Urban Development and Building Construction (DUDBC) under MoUD is implementing body and sets the standards for safe, affordable building construction and implementation for managed residential environment.

At Provincial Level

Ministry of Water Supply and Energy Development: Ministry of Water Supply and Energy Development of provincial government in Madhesh is major executing body in the province for planning, developing, and implementing water supply and sanitation programs. Planning and implementation of water supply and sanitation infrastructure in the province is executed through Water supply and Sanitation Divisional Office (WSSDO). WSSDO implements the water and sanitation programs meeting the following criteria:

i. Inter local government projects.

ii. Beneficiaries between 5,000 to 15,000 in terai region, 3,000 to 5,000 in hilly region and 500 to 1,000 in Himalayan region.

3.4 Service provision

Urban Water Supply and Sanitation Policy 2009 has emphasized the Public-Private Partnership (PPP) in water supply and sanitation to improve service delivery (MoPIT, 2009). Also, Public-Private Partnership Policy, 2015 encourages private sector investment in the development and operation of public infrastructure services for comprehensive socio-economic development. The policy has aimed to remedy challenges such as structuring of projects, land acquisition, coordination and approval, payments to private sectors and approval for environment impact (MoF, 2015).

The municipality does not have a sewer network. Toilet system is directly connected to open drain, water bodies or open ground. The toilets that are connected to containments are emptied mechanically by desludging suction truck from municipality or private service providers whereas manually emptied by traditional desludgers.

3.5 Service standards

The sanitation service standards have been set by Nepal Water Supply, Sanitation and Hygiene Sector Development Plan (2016-2030). It classifies sanitation services as high, medium, and basic based on sanitation facilities in place. The sanitation service levels with indicators are shown in Table 5. However, FSM specific standards have yet to be developed and implemented.

Table 5: Sanitation Service Level and its Components.

S.N.	Service Components	Service Level		
		High	Medium	Basic
1	Health and Hygiene Education	✓	✓	✓
2	Household Latrine	✓	✓	✓
3	Public and School Toilets	✓	✓	✓
4	Septic tank sludge collection, transport, treatment, and disposal	✓	✓	✓
5	Surface drains for collection, transmission, and disposal of greywater	✓	✓	✓
6	Small-bore sewer collection for toilet and septic tank effluent, low-cost treatment and disposal		✓	
7	Sanitary sewers for wastewater collection, transmission, non-conventional treatment, and disposal	✓		
8	Sanitary sewers for wastewater collection, the transmission of conventional treatment and disposal	✓		
9	Limited solid waste collection and safe disposal	✓	✓	✓

4 Stakeholder Engagement

4.1 Key Informant Interviews (KIIs)

The Key Informant Interviews (KIIs) and objective sharing of the study were conducted with major stakeholders of the sanitation sector in the municipality. WASH focal person at the municipality was interviewed on current sanitation services with respect to technical, institutional, and financial aspects. Also, a KII was performed with the sanitation worker of private desludging service provider to understand the emptying practice, disposal and treatment of FS as well as finance requirement. Also, an observation was performed to find sanitation status and management practice of public toilet (Table 6 and Figure 21).

Table 6: List of Key Informant Interviewed personnel.

S.N.	Name	Designation	Organization/Company	Purpose of KII	Date
1.	Dhananjay Mahato (KII-1)	WASH Focal Person	Mirchaiya Municipality	Sanitation status, municipality representatives	18 September, 2022
2.	(KII-2)	Sanitation Worker	Okhaldhunga Septic Tanki Sarasafai Sewa	Emptying practices, finances, requirement, disposal and treatment	19 September, 2022
3.	Jay Prakash Shah (KII-3)	Administrative Officer	Mirchaiya Sana Sahari WSUC	Water Supply and quality of water in Mirchaiya municipality	19 September, 2022

Figure 21: KII with WASH Focal Person in the municipality.

4.2 Household Survey

A random household survey was conducted in all wards of the municipality. The municipality selected local enumerators who were oriented prior to the survey and were mobilized for data

collection. A mobile application “KOBOCOLLECT” was used for the household survey. In the orientation, enumerators were clarified on survey objectives, technical terms concerning sanitation, use of the mobile application and procedure of random sampling survey based on the provided map (Figure 22).

Figure 22: SFD orientation to local enumerators of Mirchaiya Municipality.

4.2.1 Determining Sample Size

The number of households to be sampled in the municipality was determined by using Cochran (1963:75) sample size formula $no = \frac{z2pq}{e2}$ and its finite population correction for the proportion $n = n_o/(1+ (n_o-1)/N)$.

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 as the percentage of the population practising some form of sanitation is not known at the intervention sites).
q	1-p	
e	+/-5%	Level of precision or sampling error.
N		A 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

$n_h = (N_h/N)*n$, where N_h is a total population in each stratum.

The detail report of census was published only on 2023. Therefore, the households and population data of 2022 was estimated using census data of 2011 for sampling. Thus, a total

of 373 households were sampled from 10,733 households distributed in twelve wards with proportionate stratification random sampling. The household samples surveyed in the municipality is shown in Figure 23.

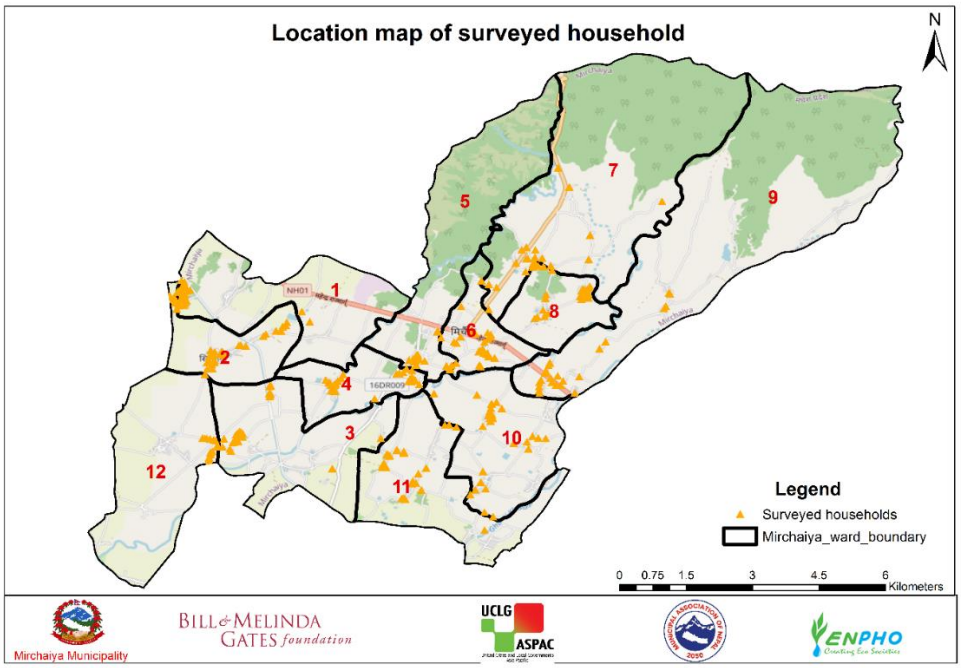

Figure 23: Location map of surveyed households.

4.3 Direct Observation

Various sanitation technologies in the households in all the wards were observed and visual references were kept. Also, observation of the toilet, water source, containments and transportation of faecal sludge were carried out. Figure 24 shows the picture of observation and monitoring of household survey at Mirchaiya Municipality.

Figure 24: Field observation and monitoring of household survey at Mirchaiya Municipality.

4.4 Sharing and Validation of Data

The Shit Flow Diagram Sharing and Validation Workshop was conducted on 1 January, 2023 at Mirchaiya Municipality hall to share the findings on sanitation situation survey and receive the suggestions from the municipal stakeholders. Altogether, 30 participants including deputy mayor, ward chairpersons, municipal council members, sectoral staffs and other relevant stakeholders actively participated on the workshop and provided valuable suggestion. The participants expressed their interest on FSM at policy level and infrastructure development. Figure 25 shows the picture of SFD findings sharing to the participants. The list of participants with their designation is attached in Appendix 4.

Figure 25: Sharing of findings during validation workshop.

5 Acknowledgements

We would like to acknowledge the executing agency, United Cities Local Government – Asia Pacific (UCLG ASPAC) and implementing agency Municipal Association of Nepal (MuAN) of the Municipalities Advocacy on Sanitation in South Asia – II (MuNASS-II) for coordination with the sub-metropolitan city.

We offer sincere acknowledgement to Mr. Shrawan Kumar Yadav, Mayor, Ms. Jivchhi Devi Sah, Deputy Mayor and Mr. Dhananjay Mahato, WASH Focal Person of the municipality for providing valuable time and information during study. Similarly, we would like to thank all the respective staffs of the municipality and key stakeholders involved during the study, without whose help this study would not have been completed.

We would like appreciate Dr. Roshan Raj Shrestha, Deputy Director of Bill and Melinda Gates Foundation (BMGF), Dr. Bernadia Irawati Tjandradewi, Secretary General and Mr. Satish Jung Shah, Knowledge Management Officer, UCLG ASPAC. Similarly, we are very much obliged to Mr. Ashok Kumar Byanju Shrestha, Former President. Mr. Bhim Prasad Dhungana, President,

Mr. Kalanidhi Devkota, Executive Director and Mr. Muskan Shrestha, Sanitation Advocacy Specialist from MuAN for their gracious support during the study.

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7 Appendix

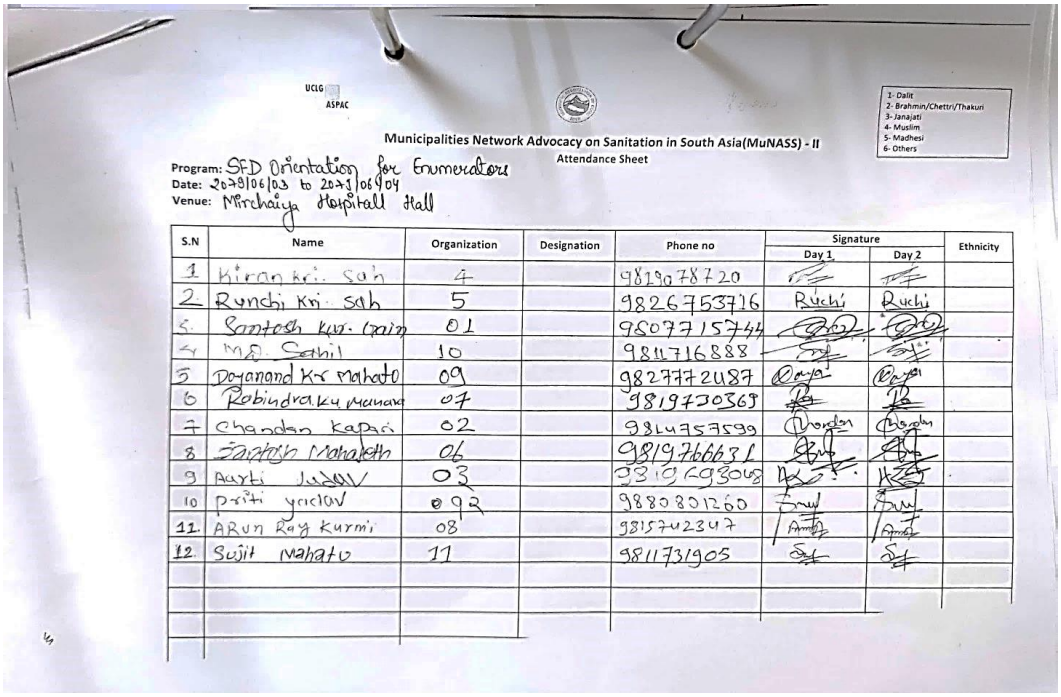
7.1 Appendix 1: Roles and Responsibility of Various Tiers of Governments Delineated in Drafted SDP 2016 – 2030

System Classification		Minimum Key HR Required	Regulation & Surveillance	Financing & Construction	Ownership of System	Service Delivery	
Size	Sanitation					Provision	Production
Small	Onsite sanitation	Water Supply and Sanitation Technician (WSST)	Federal and or Provincial Government	User+/ community+/ other			
Medium	Septage Management	Sub-engineer	Federal and or Provincial Government	Provincial+/ Local Govt+/ Community+/ Private Sector		Local Govt	Users committee/ Utility manager
Large	Septage or FSM Management	WASH Engineer + finance & admin staff	Federal and or Provincial Government	Provincial+/ Local Govt+/ Community+/ Private Sector		Local Govt	Utility Manager
Mega	Septage/ FSM Management	WASH Engineer + finance & admin staff	Federal and or Provincial Government	Provincial+/ Local Govt+/ Community+/ Private Sector		Local Govt	Utility Manager

7.2 Appendix 2: Total number of population and household in each ward and number of surveyed households

Ward No.	Population	Households	Number of surveyed households
1	6,153	1,075	37
2	4,801	839	29
3	4,845	846	29
4	3,783	661	23
5	6,711	1,172	41
6	6,041	1,055	37
7	4,320	755	26
8	3,437	600	21
9	4,721	825	29
10	5,427	948	33
11	7,284	1,272	44
12	3,920	685	24
	61,442	**10,733**	**373**

7.3 Appendix 3: List of Participants on SFD Survey Orientation



UCLG ASPAC

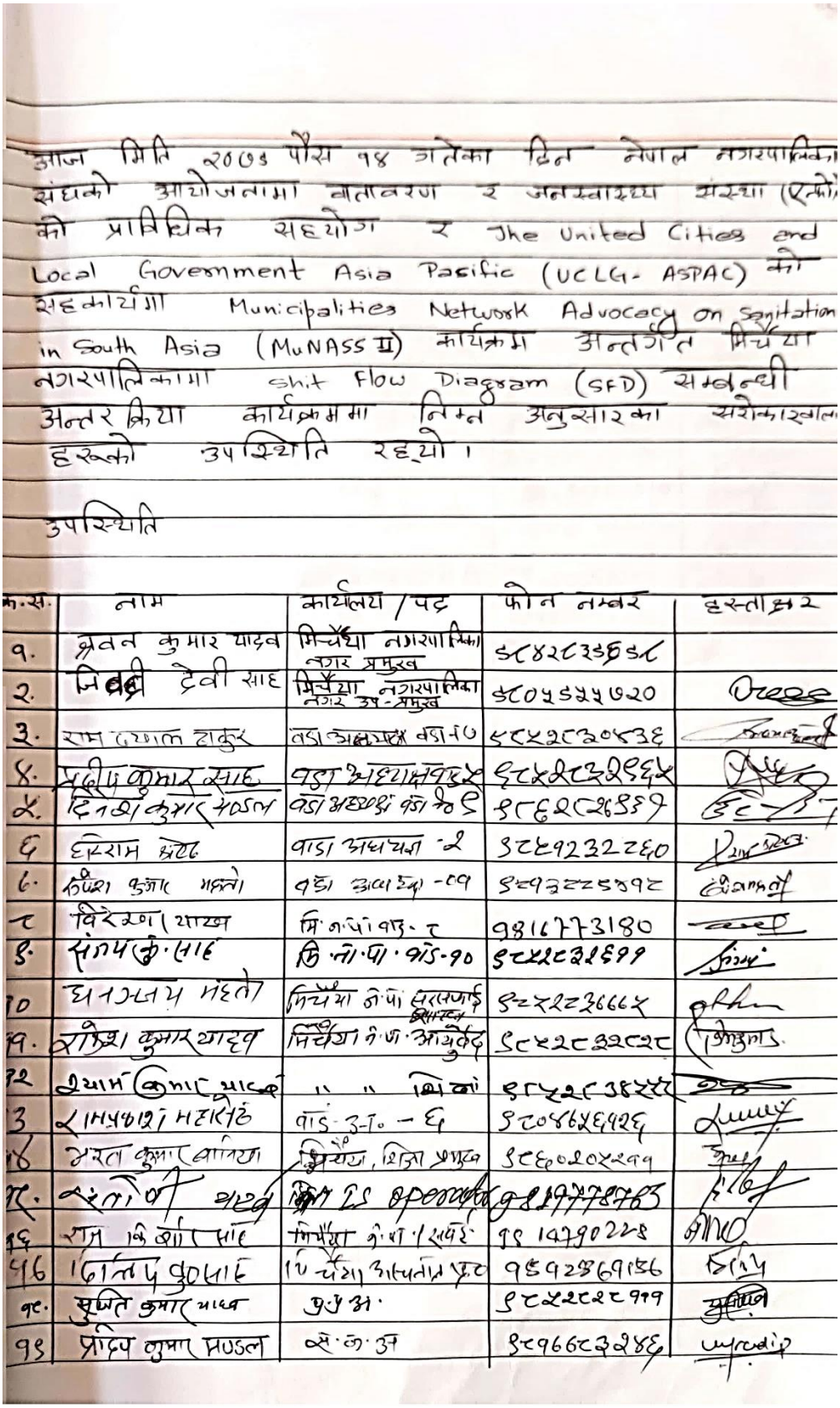
1- Dalit
2- Brahmin/Chettri/Thakuri
3- Janajati
4- Muslim
5- Madhesi
6- Others

Municipalities Network Advocacy on Sanitation in South Asia(MuNASS) - II
Attendance Sheet

Program: SFD Orientation for Enumerators
Date: 2078/06/03 to 2079/06/04
Venue: Mirchaiya Hospitall Hall

S.N	Name	Organization	Designation	Phone no	Signature		Ethnicity
					Day 1	Day 2	
1	Kiran kr. Sah	4		9819078720			
2	Ruchi Kr. Sah	5		9826753716	Ruchi	Ruchi	
3	Santosh Kur. Yadav	01		9807715744			
4	MD. Sahil	10		9811716888			
5	Dayanand Kr Mahato	09		9827772487			
6	Rabindra Ku Manav	07		9819730369			
7	Chandan Kapar	02		9814757599			
8	Santosh Mahakth	06		9819766631			
9	Aarti Yadav	03		9819693068			
10	Priti Yadav	02		9809801260			
11	ARun Ray Kurmi	08		9815723417			
12	Sujit Mahato	11		9811731905			

7.4 Appendix 4: List of Participants in Sharing and Validation Workshop



आज मिति २०७३ पौस १४ गतेका दिन नेपाल नगरपालिका संघको आयोजनामा वातावरण र जनस्वास्थ्य संस्था (एन्को) को प्राविधिक सहयोग र The United Cities and Local Government Asia Pacific (UCLG-ASPAC) को सहकार्यमा Municipalities Network Advocacy on Sanitation in South Asia (MuNASS II) कार्यक्रम अन्तर्गत मिर्चैया नगरपालिकामा Shit Flow Diagram (SFD) सम्बन्धी अन्तर क्रिया कार्यक्रममा निम्न अनुसारका सरोकारवाला हरुको उपस्थिति रहयो।

उपस्थिति

क्र.स.	नाम	कार्यालय / पद	फोन नम्बर	हस्ताक्षर
१.	अतन कुमार यादव	मिर्चैया नगरपालिका वडा प्रमुख	९८४२८३६७८	
२.	निवदी देवी साह	मिर्चैया नगरपालिका नगर उप-प्रमुख	९८०५३५५७२०	
३.	राम दयाल ठाकुर	वडा अध्यक्ष वडा नं७	९८५२८३०५३६	
४.	प्रदीप कुमार साह	वडा अध्यक्ष वडा नं ६	९८५२८२९६५	
५.	दिनेश कुमार मण्डल	वडा अध्यक्ष वडा नं ६	९८६२८२६३९७	
६	हरिराम ठाकुर	वडा अध्यक्ष -२	९८५९२३२८६०	
७.	कविता कुमारी मल्लो	वडा अध्यक्ष -०९	९८५३८८३९७८	
८	विरेन्द्र	मि.न.पा.वडा.८	9816773180	
९.	संजय कु.साह	मि.न.पा.वडा-१०	९८५२८३१६९९	
१०	घनश्याम महतो	मिर्चैया न.पा. सरसफाई	९८५२८३६६८५	
११.	राकेश कुमार यादव	मिर्चैया न.ज.आयुर्वेद	९८५२८३२८२८	
१२	श्याम कुमार यादव	" " शिक्षा	९८५२८३८२२८	
१३	रामबाबु महतो	वडा-३-उ - ६	९८०४८५६५२६	
१४	भरत कुमार बर्मा	शिक्षा, शिक्षा प्रमुख	९८६०२०५२५५१	
१५.	[illegible]	[illegible]	९८१९७४८७	
१६	राम विलास साह	मिर्चैया न.पा./सर्भेयर	९८ १९७९०२२८	
१६	दिनेश कुमार	मि.न.पा. सर्भेयर	९८५२८६९१५६	
१८.	सुमित कुमार यादव	उ.अ.	९८५२८२८७१९	
१९	प्रदिप कुमार मण्डल	से.क. उ	९८९६८३२४६	

क्र.सं.	नाम	कार्यालय / पद	फोन नम्बर	हस्ताक्षर
२०	दिलिप कुमार सिंह	मि.चौ.अस्पताल/ [illegible]	९८४४०२४४६०	
२१.	गणेश गुप्ता	रोजगार संयोजक / मिर्चैया न.पा	९८४४२४३६५६	
२२.	हेम नारायण शाह	रोजगार सहायक	९८०३२०३२२१	
२३	मन यादव	मि.न.पा.-१२ वडा सदस्य		
२४	जित कुमार साह	मिर्चैया न.पा. प्रशासन शाखा प्रमुख	९८१९८६१२८२४	
२५	श्रवण कुमार महतो	मिर्चैया न.पा. / जिन्सी शाखा	९८०२९४१३२१	
२६	विद्यानन्द सरदार	लहान-6, [illegible]	९८०२६९५२६४१	
26	ई. तपेश्वर यादव	[illegible], इन्जिनियर	9823345020	
२८.	सरोज कुमार साह सई		9814785914	
२९.	रंजु कु. यादव	(क. ना. (न.))	9842845790	
30	सोनिला कुमारी महतो	मिर्चैया न.पा. (म.वि.नि.)	9862025697	
३१	अनिता थुजु	एन्फो	9849358197	
32.	बुद्ध वज्राचार्य	एन्फो	9851322020	

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