SFD Report

Rajbiraj Municipality
Nepal

Final Report

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

Date of production: 09/06/2023

Last update: 27/07/2023

SFD Report Rajbiraj Municipality, Nepal, 2023

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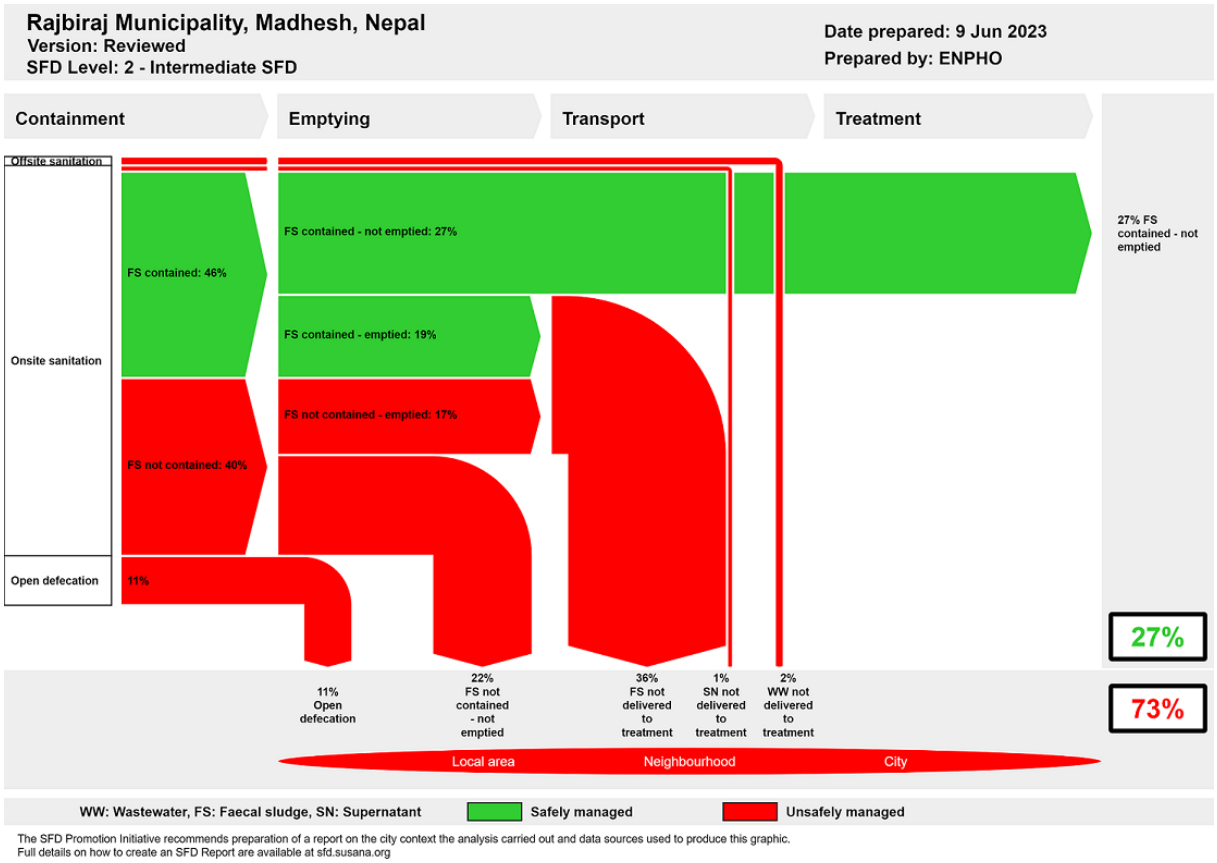
1. The SFD Graphic



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:

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

Status:

Final SFD report.

Date of production: 09/06/2023

3. General city information

Rajbiraj Municipality lies in Saptari District of Madhesh Province, Nepal. It is divided into sixteen wards and covers an area of 55.64 sq. km. It is restructured by merging with Village Development Committees (VDCs) namely (Maleth, Dighwa, Farseth, Bishharia, Deuri Bharuwa) and some wards of VDCs (Haripur-6, Madhyepura 4-7, Boriya 3-7). It lies at 26.5419° N latitude, 86.7567 °E longitude and the altitude of 76 m above sea level.

A population of 71,946 is residing in the municipality with national annual average growth rate of 0.92%. The municipality has temperate climate with dry winter and hot summer. It has an average high temperature of 28.7 °C and average low temperature of 16.5°C and receives 1,700 mm rain per year (Climate-Data, 2021).

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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 study (ENPHO, 2023). Saptari District was declared open defecation free (ODF) on April 4, 2018. Still, 11% of households do not have toilets whereas 89% households have improved sanitation facilities. The households without improved sanitation facility opt for open defecation.

Containment:

The households with access to sanitation facility rely on onsite and offsite sanitation systems. The population from about 2% of households rely on offsite sanitation systems and 87% of households rely on onsite sanitation systems. Households with onsite sanitation systems have different sanitation technologies. The population from 2% of households use septic tanks, 24% use fully lined tanks, 13% use lined tanks with impermeable walls and open bottom, 34% of the households use either single pits or twin pit and 14% use an unlined pit.

Similarly, all the institutional buildings have toilets where 5% have septic tanks, 69% have fully lined tanks, 10% have lined tanks with impermeable walls and open bottom, 11% have single pits and 6% have twin pits.

The municipality has three public toilets at local marketplaces (Haitya and Macha Hatiya) and near municipal office. All three toilets are constructed by the municipality.

Emptying:

Almost 53% of households with onsite containment have emptied their containment. The emptying practice was found in all types of containment in the municipality. Rajbiraj Municipality has its one suction truck that provides emptying services. Also, private desludgers and traditional labours are providing desludging services to households and institutions. In addition, households also practice open emptying that is discharged directly to an open drain.

Transport, Treatment and Disposal/Reuse:

Mechanically emptied Faecal Sludge (FS) is disposed of untreated in a solid waste disposal site in riverbank at Khado whereas manually emptied FS is disposed of untreated into water bodies, fields or dug and dumped.

The SFD graphic shows that excreta generated from 27% of the population are safely managed while FS generated by 73% of the population are unsafely managed. The safely managed excreta generated from 27% of population is temporary as the proportion is only contained and have not been emptied. With the current practice of faecal sludge management (FSM), the proportion of safely managed FS will become unsafely managed once the containments start filling up.

Groundwater is the main source of drinking water in Rajbiraj Municipality. Almost 88% of the households extract groundwater for drinking purpose. However, Nepal Water Supply Cooperation (NWSC) provides piped drinking water supply with 2,700 private taps at households and 79 public taps within the municipality.

Water contamination at source is possible for aquifers. The vulnerability of aquifer depends on lateral spacing between sanitation systems and the groundwater sources. The significant risk to groundwater pollution of Rajbiraj municipality is assumed based on the soil structure, lateral spacing and sanitation systems. Almost 82% of the population using lined tanks with impermeable walls and open bottom and 86% of the population using lined pits with semi-permeable walls and open bottom, and unlined pits possesses the significant risk to groundwater pollution.

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	Rajbiraj 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 Rajbiraj 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/rajbiraj-969239/ [Accessed 3 June 2023].
- MoWS, 2017. *Institutional and Regulatory Framework for Faecal Sludge Management in Urban Areas of Nepal.* Kathmandu,Nepal: Ministry of Water Supply.
- National Statistics Office, 2023. *National Population and Housing Census 2021 National Report,* Kathmandu: National Statistics Office.
- NWSC, 2023. *34th Annual Report,* Kathmandu: Nepal Water Supply Cooperation.

SFD Rajbiraj 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
JMP	Joint Monitoring Programme
KII	Key Informant Interview
KM	Kilometre
MDG	Millennium Development Goal
MLD	Million Liters per Day
MoFAGA	Ministry of Federal Affairs and General Assembly
MoPIT	Ministry of Physical Infrastructure and Transport
MoUD	Ministry of Urban Development
MoWS	Ministry of Water Supply
MuAN	Municipal Association of Nepal
M-WASH-CC	Municipality Water, Sanitation and Hygiene Coordination Committee
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
Pop	Population
PPP	Public Private Partnership
RWSSNP	Rural Water Supply and Sanitation National Policy
SDG	Sustainable Development Goal
SDP	Sector Development Plan
SEIU	Sector Efficiency Improvement Unit
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
UNGA	United Nations General Assembly
UNICEF	United Nations Children's Education Fund
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

Rajbiraj Municipality lies in Saptari District of Madhesh Province, Nepal. It is restructured by merging with Village Development Committees (VDCs) namely (Maleth, Dighwa, Farseth, Bishharia, Deuri Bharuwa) and some wards of VDCs (Haripur-6, Madhyepura 4-7, Boriya 3-7). It is divided into sixteen wards (Rajbiraj Municipality, 2023).The municipality shares its boundary with rural municipalities of Mahadeva and Tilathi Koiladi on the east, Tilathi Koiladi and Chhinnamasta on the south, Bishnupur on the west and, Rupani and Agnisair Krishna Savaran on the North (MoFAGA, 2023). Figure 1 shows the ward boundary map of Rajbiraj Municipality.

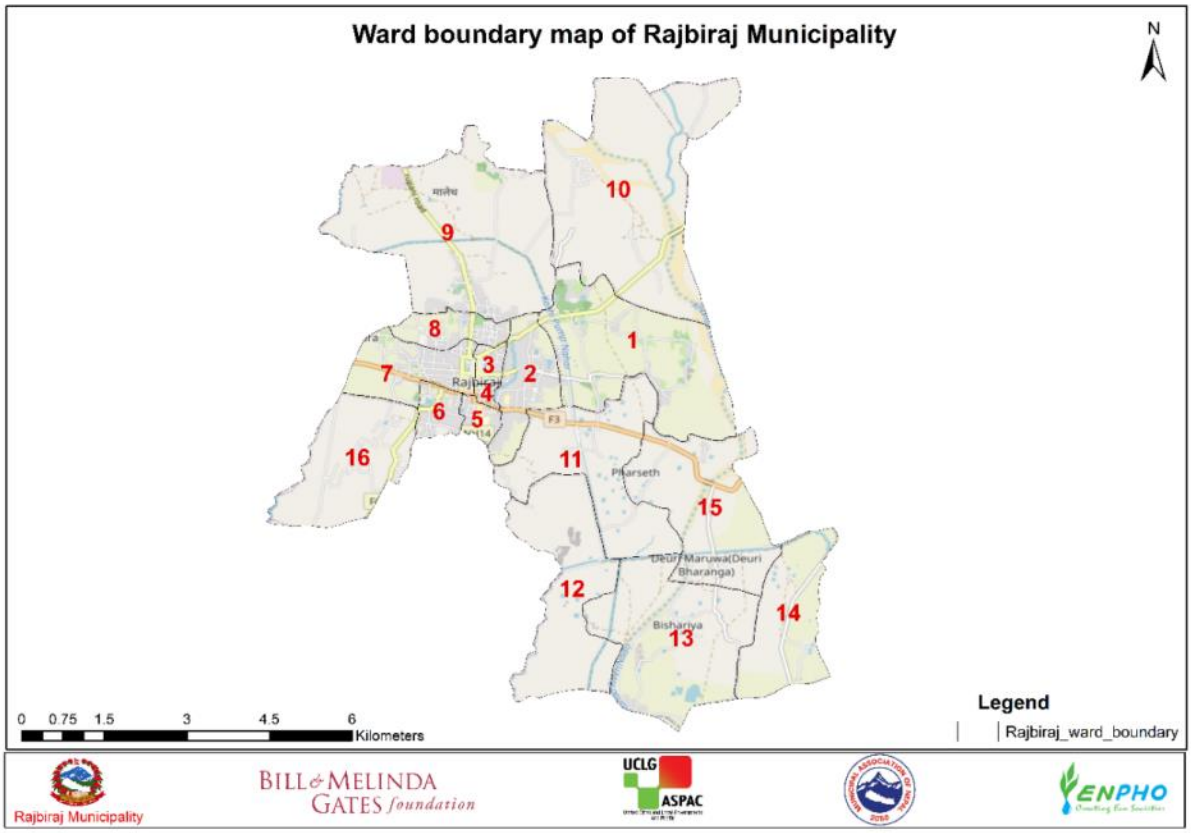

Figure 1: Ward boundary map of Rajbiraj Municipality.

1.1 Population

As per National population and housing census conducted in 2021, Rajbiraj Municipality has a total population of 71,946 with 36,942 male and 35,004 female population, residing on 13,062 households. Among the 16 wards in the municipality, ward no. 4 has the largest population of 4,282, residing on 1,172 households whereas ward no. 7 has the least population of 1,354, residing on 254 households. The annual average population growth rate of Nepal in 2021 is 0.92% (National Statistics Office, 2023).

1.2 Topography and Geography

Rajbiraj Municipality lies at 26.5419° N latitude, 86.7567 °E longitude and the altitude of 76 m above sea level (masl). It is spread over the total area of 55.64 sq. km. (Rajbiraj Municipality,

2023). The soil composiiton 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 system for climatic categorization. This classification is widely used method for portraying climates worldwide based on monthly air temperature and precipitation. The climatic condition of Rajbiraj Municipality falls on temperate climate based on Köppen–Geiger classification. This climatic condition have dry winter and hot summer (Karki, et al., 2015). In Rajbiraj Municipality, the warmest month of the year is May with average temperature of 28.7°C whereas coldest month is January with average of 16.5°C and the annual average temperature is 24.5°C. Additionally, it receives 1,700 mm rainfall annually with the most rainfall in July and the least in December (Climate-Data, 2021).

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 13,062 households distributed in sixteen 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

Saptari District was declared Open Defecation Free (ODF) on April 4, 2018 (MoWS, 2020). The status of ODF indicates accessibility to basic sanitation on each household (HH). In Rajbiraj Municipality, still 11% of the households do not have toilets and practice open defecation. The households practising open defecation go to nearby water bodies or open ground. Figure 2 shows the pictures of open defecation in an open ground.

Figure 2: Open defecation in an open ground in Rajbiraj Municipality.

The remaining 89% of households have improved sanitation facility either with offsite or onsite sanitation system. 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, 2% of households having sanitation facilities have offsite

sanitation system whereas 87% have onsite sanitation system. Figure 3 presents the location map of households with status of access to improved sanitation respectively.

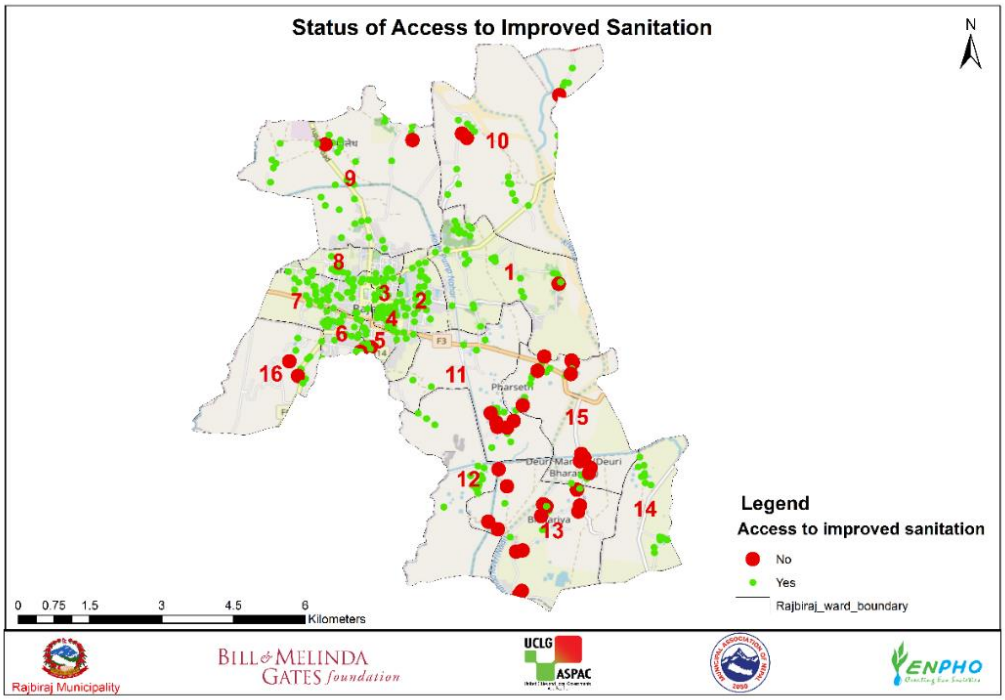

Figure 3: Location map of households with status of access to improved sanitation.

Types of Offsite Sanitation Systems

Rajbiraj Municipality does not have sewerage network still, 2% of households have offsite sanitation system. Here, households with offsite sanitation systems have their toilet connected to open drain that is considered as offsite sanitation system and referred to as toilet with no onsite container. The Faecal Sludge (FS) and wastewater transported is disposed of directly to an open environment or water bodies. The disposal of excreta directly to an open environment or water body without any treatment is one of the causes of disease transmission. Figure 4 shows the outlet of a toilet discharging to an open drain.

Figure 4: Toilet discharges directly to open drain.

Types of Onsite Sanitation Systems

87% of households with sanitation facilities in the municipality have onsite sanitation systems. All the sanitation facilities having containments are considered as onsite sanitation systems. The municipality have the following types of containment:

Septic tank is a watertight rectangular chamber which is parted into two or three parts 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 correctly designed, properly constructed and well maintained 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 (consequently the faecal sludge and effluent is potentially more toxic than the faecal sludge and effluent in a septic tank) (SuSanA, 2018). 24% 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). 13% of households have these types of containments in the municipality.

Single Pit is a circular onsite technology made from concrete rings. This technology has semi-permeable walls and a permeable base (SuSanA, 2018). 19% of households have single pits in the municipality.

Twin Pit is a circular onsite sanitation technology that consists of two sets of concrete rings. This technology also has semi-permeable walls and a permeable base (SuSanA, 2018). Each pit is used alternatively after filled. FS is left to decompose after the pit is filled. Twin pits 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.15% of households have twin pits. Figure 5 shows the inappropriate design of twin pits in the municipality.

Figure 5: Inappropriate design of twin pits, the distance between two pits is less than 1.2m.

Unlined Pit is a dug pit in the ground which have permeable walls and base. These containments are not sealed and thus water infiltrates into the ground (SuSanA, 2018). 14% of households have unlined pits. Figure 6 shows the types of unlined pits found in the municipality.

Figure 6: Types of unlined pits in the municipality.

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

Table 1: Types of onsite sanitation system at households of Rajbiraj Municipality (ENHPO, 2023).

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	24%
Lined tank with impermeable walls and open bottom	Concrete walls OR Cemented brick/stone walls	Soiling or nothing	one two More than two	NA	Soak pit Sewer Open drain/open ground No outlet/overflow	13%
Single pit	Concrete rings piled one after other	Soiling or nothing	NA	One	NA	19%
Twin pit	Concrete rings piled one after other	Soiling or nothing	NA	Two	NA	15%
Unlined pit	Mud mortar brick wall/Mud mortar cement wall/No lining/Dry stone wall	nothing	NA	NA	NA	14%

Figure 7 shows location map of households with different types of containment at Rajbiraj municipality.

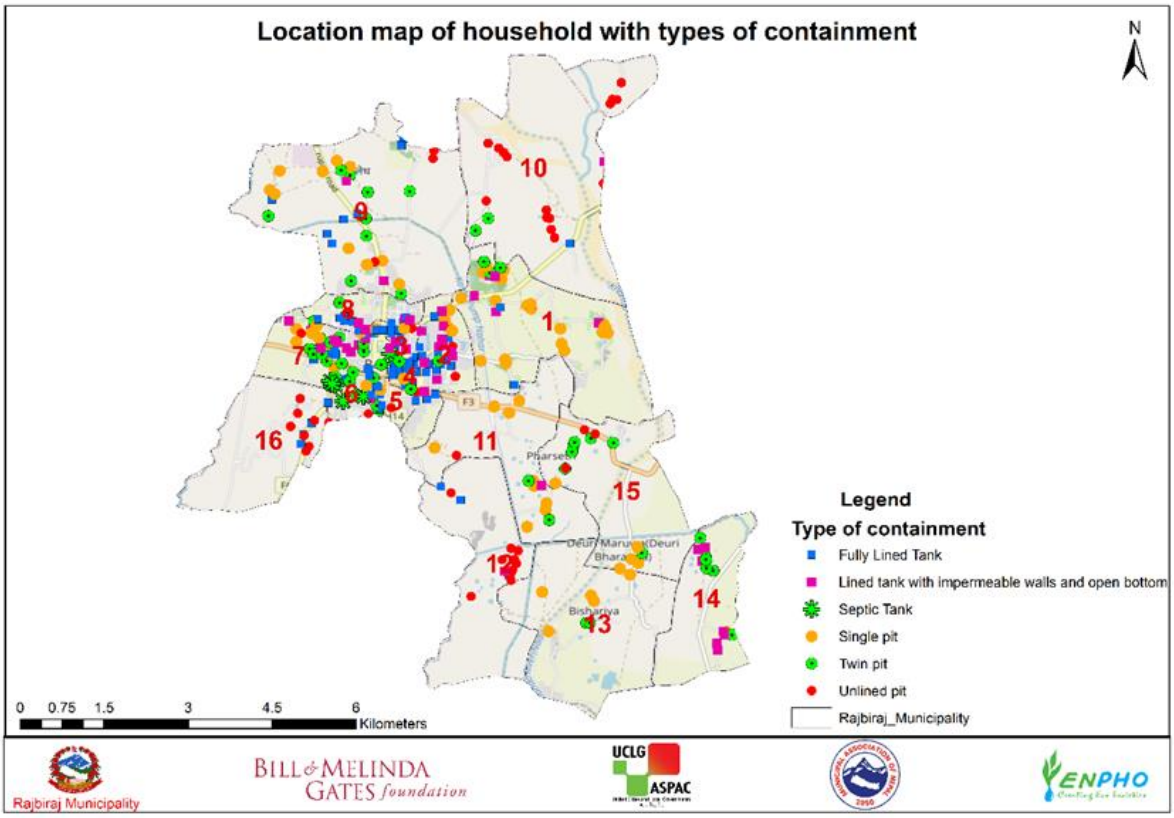

Figure 7: Location map of household with different types of containment.

2.1.2 Sanitation System in Institutional Buildings

The sanitation data of institutions were obtained from educational institutions, government/non-government organizations, commercial buildings, health care centres and hotel/home stay. Altogether 83 institutional buildings were surveyed. Table 2 shows the types and number of surveyed institutions.

Table 2: Type and number of surveyed institutions (ENPHO, 2023).

Type of Institution	Number of Surveyed Institutions
Commercial Buildings	1
Educational Institution	45
Government /Non-government Office	21
Health care centre	11
Hotel/ Home Stay	5
Grand Total	**83**

All the institutional buildings in the municipality have toilets. Among which 69% of buildings have fully lined tanks. These tanks are safe for FS collection and do not have outlet or overflow. However, they can get filled quickly as compared to household buildings since these buildings

have comparatively greater number of users per day. Thus, it will require exceptionally bigger size of tanks or require frequent emptying and emptying cost for it. Moreover, only 5% of institutional buildings have septic tanks in the municipality, 10% have lined tanks with impermeable walls and open bottom, 11% have single pits and 6% have twin pits. Figure 8 shows the location map of institutional buildings with different types of containments in Rajbiraj Municipality.

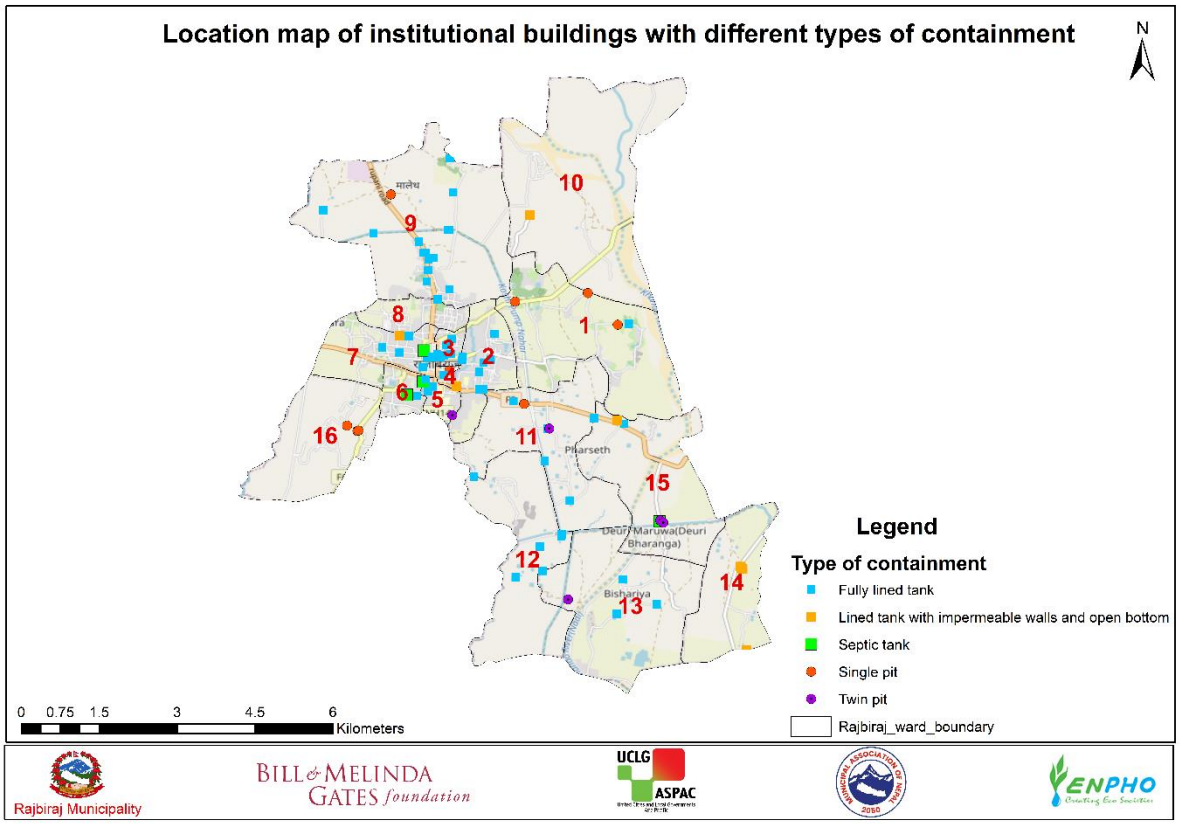

Figure 8: Location map of institutional buildings with different types of containment in Rajbiraj Municipality.

2.1.3 Public Toilets

Rajbiraj Municipality have three public toilets; two located at local marketplaces at *Hatiya* and *Macha Hatiya*, and one near municipal office.

Public toilet at *Hatiya*

The public toilet at *Hatiya* is built by the municipality and managed by a caretaker. With 4 urinals and 4 pans in male compartment and 3 urinals and 2 pans in female compartment, the public toilet at Hatiya serves 13 people at once. The customers of local marketplace are the service recipient of this toilet. It serves 100-200 users per day and charges Rs. 5 (USD 0.04) for urination and Rs. 10 (USD 0.09) for defecating.

The wastewater (WW) from the toilet is connected to the stormwater drainage. The groundwater kept in the 1,000 litre overhead tank is fed on the taps in the toilet compartments for toilet cleaning and other use. A handwashing facility is also provided directly outside the toilet compartments. Toilets are often cleaned using toilet cleaning solutions; nonetheless, the

problem with this public toilet is foul odor and the placement of solid wastes such as packets of *gutka* and sanitary pads within toilet compartments. Figure 9 and 10 shows the condition of the public toilet at Hatiya.

Figure 9: Female Urinals in Public Toilet at Hatiya, Rajbiraj Municipality.

Figure 10: Handwashing station of Public Toilet at Hatiya, Rajbiraj Municipality.

Only limited information could be gathered for two public toilets; one at Macha Hatiya and the other near municipal office. The information was obtained from municipal representatives. The obtained information thus is fed in this report.

Public toilet at *Macha Hatiya*

The public toilet at *Macha Hatiya* is also built by the municipality. For this toilet as well, the customers of local marketplace are the service recipient.

Public toilet near Municipal Office Building

The public toilet near municipal office is also built by the municipality. Unlike other public toilets in the municipality, this toilet does not have specific service receiver.

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 system, almost 53% of households have emptied their containment and 47% have not emptied their containment. The emptying practice have been found for all types of containment. The emptying practice proportion in institutional buildings was more than in households. About 69% of institutional buildings have emptied their containments in the municipality.

In the municipality, mechanical emptying is prevalent. 92% of the households that have emptied containment practised mechanical emptying and 7% practised manual emptying. The practice of open emptying was also found in the municipality. In the open emptying method, the outlet of containment is placed to open drain to discharge effluent during rainy season. Similarly, 85% of institutional buildings that have emptied containments, emptied their containments mechanically and 15% have emptied them manually.

Rajbiraj Municipality owns one suction truck to empty the containments. In addition, private desludgers and traditional labours also provide desludging service to households and institutions. The households also practice self-emptying of containment. Those practising self-emptying uses open emptying method for emptying of containment. The municipality have a 4,000 litre truck for desludging service and charges Rs. 4,000 (USD 36.86) per trip (KII-1, 2022). Moreover, private desludging service providers have various size of desludging truck. The size of desludging truck is up to 6,000 litres and charges up to Rs. 3,500 (USD 32.25) per trip. The private desludgers usually have 4 trips per day (KII-2, 2022). Figure 11 shows picture of desludging suction truck of Rajbiraj Municipality.

Figure 11: Desludging suction truck of Rajbiraj Municipalty.

2.1.5 Treatment and Disposal/Reuse

Rajbiraj Municipality does not have a Faecal Sludge Treatment Plant (FSTP) but it has a designated soild waste and FS dumping site. The dumping site is located 4 km away from the municipality office. It is situated near farmland and a river in an open environment. Figure 12 shows the picture of solid waste and FS dumping site in Khado.

Figure 12: Solid waste dumping site at Khado, Rajbiraj.

Mechanically emptied FS is transported and disposed in this dumping site (KII-1, 2022) (KII-2, 2022). This disposed FS is only dumped and not treated. Moreover, manually emptied FS is dug up and dumped, disposed into fields, water bodies, and stormwater drains. Therefore, all the emptied FS in Rajbiraj Municipality is unsafely disposed of in an open spaces and water bodies.

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

Groundwater is the primary source of drinking water in the municipality. Almost 88% of households extract groundwater for drinking purposes. The municipality has a water demand of 7 Million Litres per Day (MLD). Nepal Water Supply Cooperation (NWSC) under Ministry of Water Supply (MoWS) also distributes water in the municipality. However, it produces only 2.5 MLD of water. It has installed eight deep tube wells to extract groundwater. Water is supplied through piped water supply system. It has installed 2,700 private taps, 79 public taps and 85 government connections. Out of the eight deep tube wells, water supplied from only two is treated. Water from a single deep tube well is treated at full treatment system whereas just chlorinated from the next tube well. However, water from the other six deep tube wells remains untreated (NWSC, 2023).

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 geological structure of Rajbiraj 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 Rajbiraj 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 13 shows the depth of handpumps and horizontal distance of it from source of pollutant by lined tanks with impermeable walls and open bottoms. Almost 82% of the households (i.e. T2A4C10: 82% x 9.12% = 7.5% ≈ 8% of the overall population, where 9.12% 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) are at high risk of groundwater contamination as the water pumped through handpump in these households.

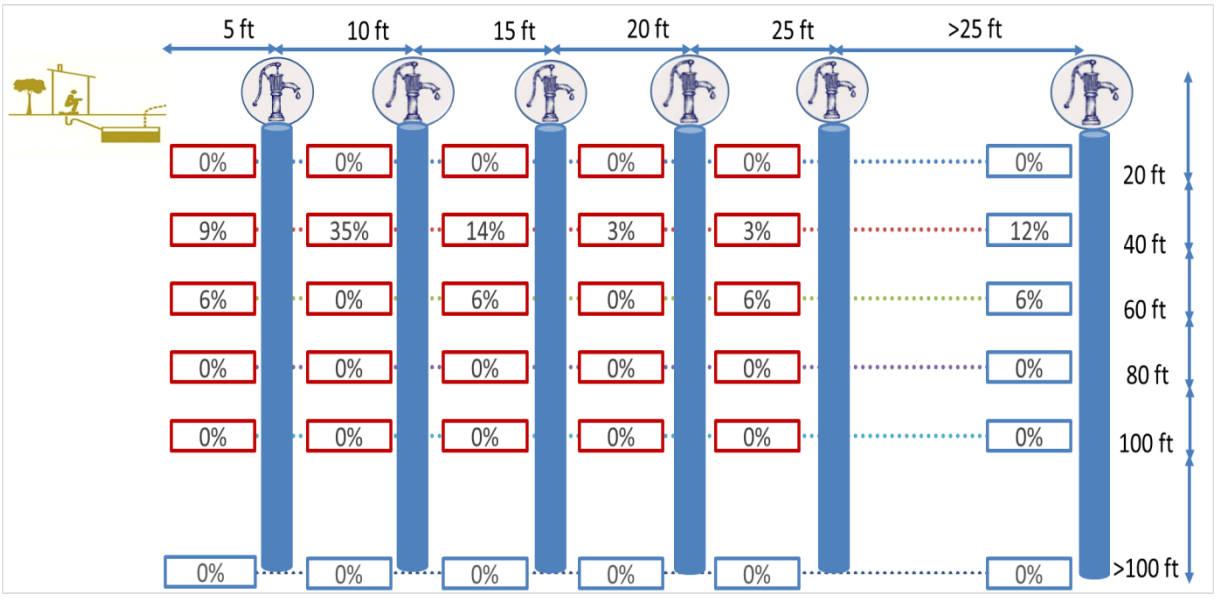

Figure 13: Depth of hand pumps and lateral spacing of it with containment type lined tank with impermeable walls and open bottom.

Figure 14 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 86% of the households (i.e. T2A5C10: 86% x 24.7% = 21.2% ≈ 21% and T2A6C10: 86% x 4% = 3.4% ≈ 4%; where 24.7% is the percentage of population using lined pits with semi-permeable walls and open bottom and 4% is the percentage of population using unlined pits

both with no outlet or overflow and using groundwater as drinking water source) are at high risk of groundwater contamination as the water pumped through handpump in these households.

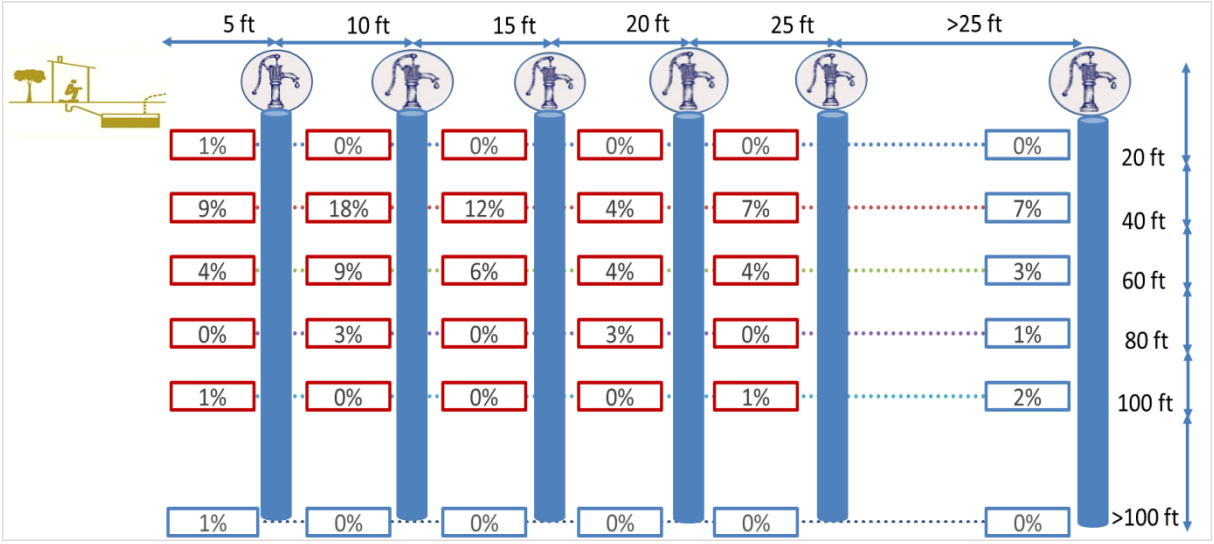

Figure 14: Depth of hand pumps and lateral spacing of it with containment type lined pit with semi-permeable walls and open bottom.

2.2 SFD Selection Grid

Figure 15 shows the types of sanitation technologies present in the Rajbiraj 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.

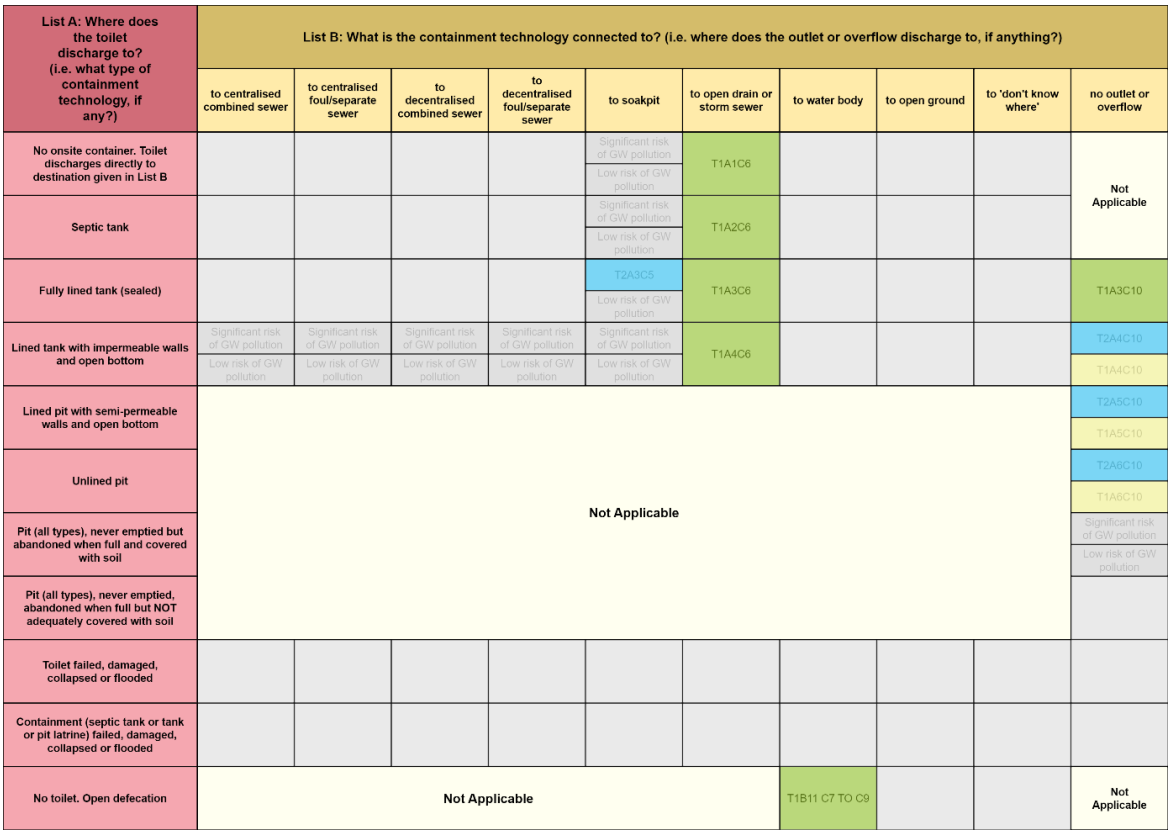

Figure 15: SFD selection grid for Rajbiraj Municipality.

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

Table 3: Explanation of terms used to indicate different frame selected in the SFD selection grid in Figure 15.

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.
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.
T2A3C5	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 (consequently the excreta is potentially more toxic than the excreta in a septic tank). The tank is fitted with a supernatant/effluent overflow connected to a correctly designed, properly constructed and fully functioning soak pit but since the supernatant/effluent flowing from the tank is untreated and since there is a 'significant risk' of groundwater pollution 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 (consequently the excreta is potentially more toxic than the excreta in a septic tank). 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.
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 (consequently the excreta is potentially more toxic than the excreta in a septic tank). 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.
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 50%, as all the septic tanks are connected to stormwater drain or open drain in the municipality. This implies that almost 50% of FS from such types of containment is discharged into open or stormwater in the form of supernatant.

ii. The proportion of FS in fully lined tanks is 91%.

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 16 shows the SFD matrix of Rajbiraj Municipality.

Rajbiraj Municipality, Madhesh, Nepal, 9 Jun 2023. SFD Level: 2 - Intermediate SFD
Population: 71986
Proportion of tanks: septic tanks: 50%, fully lined tanks: 91%, 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	2.0	0.0	0.0					
T1A2C6 Septic tank connected to open drain or storm sewer	2.0			46.0	0.0	0.0	0.0	0.0
T1A3C10 Fully lined tank (sealed), no outlet or overflow	19.0			54.0	0.0	0.0		
T1A3C6 Fully lined tank (sealed) connected to an open drain or storm sewer	4.0			57.0	0.0	0.0	0.0	0.0
T1A4C10 Lined tank with impermeable walls and open bottom, no outlet or overflow	4.0			5.0	0.0	0.0		
T1A4C6 Lined tank with impermeable walls and open bottom, connected to an open drain or storm sewer	1.0			40.0	0.0	0.0	0.0	0.0
T1A5C10 Lined pit with semi-permeable walls and open bottom, no outlet or overflow	13.0			49.0	0.0	0.0		
T1A6C10 Unlined pit, no outlet or overflow	10.0			18.0	0.0	0.0		
T1B11 C7 TO C9 Open defecation	11.0							
T2A3C5 Fully lined tank (sealed) connected to a soak pit, where there is a 'significant risk' of groundwater pollution	1.0			0.0	0.0	0.0		
T2A4C10 Lined tank with impermeable walls and open bottom, no outlet or overflow, where there is a 'significant risk' of groundwater pollution	8.0			11.0	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	21.0			52.0	0.0	0.0		
T2A6C10 Unlined pit, no outlet or overflow, where there is a 'significant risk' of groundwater pollution	4.0			64.0	0.0	0.0		

Figure 16: SFD Matrix of Rajbiraj Municipality.

2.3.2 Proportion of Faecal Sludge Emptied (F3)

The proportion of faecal sludge emptied (F3) is calculated based on percentage containment emptied (ENPHHO, 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, 2022[(1)]; KII-2, 2023[(2)]).

S.N.	Sanitation Technologies	SFD Reference Variable	Percentage of Emptied Containment [(1)]	Emptied Proportion of FS [(2)]	Actual Proportion of Emptied FS (F3)
1	Toilet discharges directly to open drain or storm sewer	T1A1C6	0%	0%	0%
2	Septic tank connected to open drain or storm sewer	T1A2C6	57%	80%	46%
3	Fully lined tank (sealed) connected to an open drain or storm sewer	T1A3C6	71%	80%	57%
4	Fully lined tank (sealed), no outlet or overflow	T1A3C10	68%	80%	54%
5	Lined tank with impermeable walls and open bottom, connected to an open drain or storm sewer	T1A4C6	50%	80%	40%
6	Lined tank with impermeable walls and open bottom, no outlet or overflow	T1A4C10	6%	80%	5%
7	Lined pit with semi-permeable walls and open bottom, no outlet or overflow	T1A5C10	61%	80%	49%
8	Unlined pit, no outlet or overflow	T1A6C10	23%	80%	18%
9	Open defecation	T1B11 C7 TO C9	0%	0%	0%
10	Fully lined tank (sealed) connected to a soak pit, where there is a 'significant risk' of groundwater pollution	T2A3C5	0%	0%	0%
11	Lined tank with impermeable walls and open bottom, no outlet or overflow, where there is a 'significant risk' of groundwater pollution	T2A4C10	14%	80%	11%
12	Lined pit with semi-permeable walls and open bottom, no outlet or overflow, where there is a 'significant risk' of groundwater pollution	T2A5C10	65%	80%	52%
13	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)

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 both set to zero.

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

Variable F3 is the proportion of FS from each type of onsite container which is emptied. The value for this column is obtained from systems that have emptied FS. 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 zero.

2.3.5 Proportion of Supernatant in Open Drain or storm sewer delivered to treatment (S4e and S5e)

Variable S4e is the proportion of supernatant disposed 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 zero as there is no treatment facility.

2.4 SFD Graphic

Figure 17 shows the excreta flow diagram of Rajbiraj 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 27% of population are safely managed and excreta from 73% of the population are unsafely managed. It also represents the sanitation value chain going from left to right.

Offsite Sanitation

Rajbiraj Municipality does not have sewer network, however, 2% of households have offsite sanitation system and wastewater generated from these households is disposed of untreated to an open environment. Therefore, wastewater from 2% population is not treated and is unsafely managed.

Onsite Sanitation

In the municipality, 87% of households relies on onsite sanitation systems. Of the total households having onsite sanitation systems, 46% of the population uses containments where FS is contained, 40% of the population uses containment where FS is not contained.

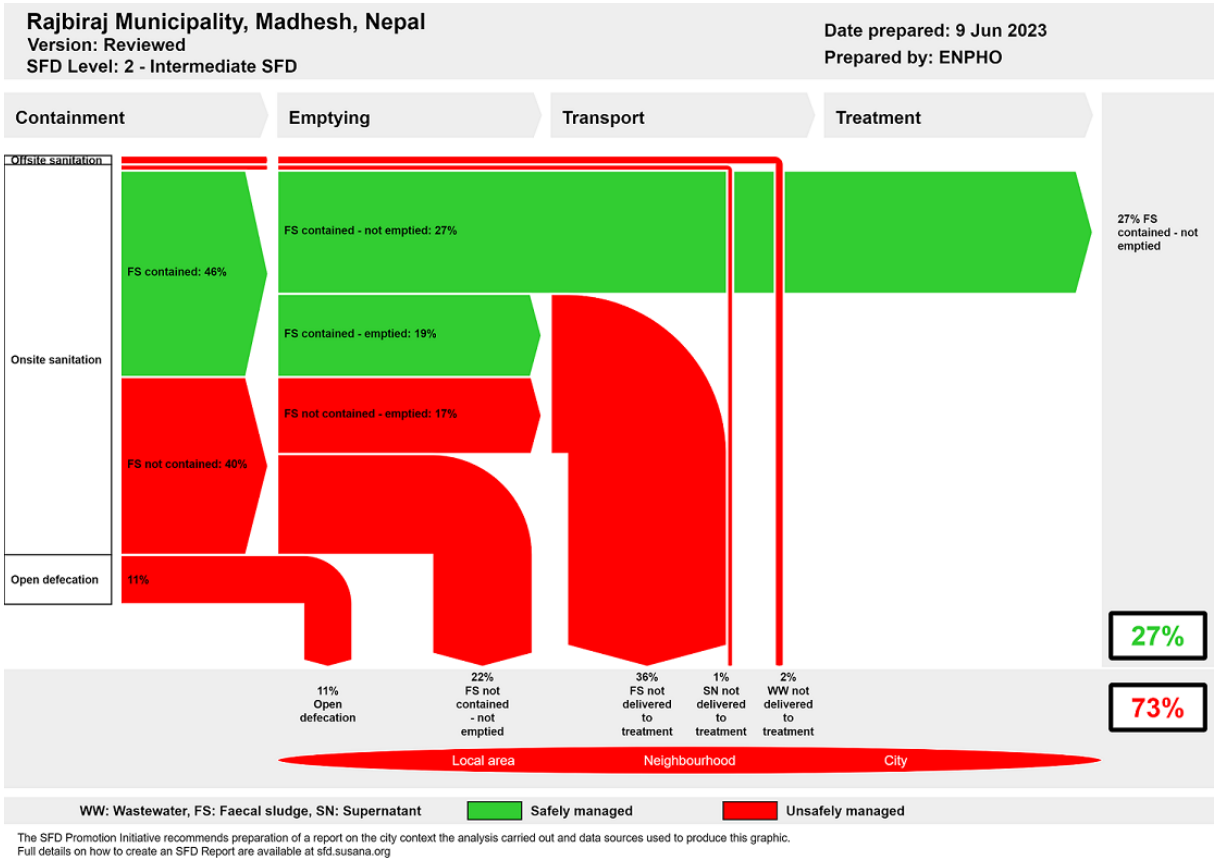

Figure 17: SFD Graphic of Rajbiraj Municipality.

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. 46% 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. Moreover, FS from 27% of the population that is contained, has not been emptied. This FS eventually needs to be emptied as the containment gets filled. Hence, the current practice of FS emptying could lead to unsafe disposal of FS.

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. 40% is obtained from the summation of population using septic tanks connected to open drain or storm sewer (T1A2C6), fully lined tanks connected to an open drain or storm water (T1A3C6), lined tanks with impermeable walls and open bottom connected to an open drain or storm sewer (T1A4C6), fully lined tanks connected to a soak pit with 'significant risk' to groundwater (T2A3C5), 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 27% is obtained from the proportion of the population using sanitation systems where the FS is contained and have not emptied their containment.

FS contained - Emptied

The value of 19% is obtained from the proportion of the population using sanitation systems where the FS is contained and have emptied their containment.

FS not contained - Emptied

The value of 17% 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 22% 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. 36%, is the summation of FS contained emptied and FS not contained emptied. Since Rajbiraj Municipality does not have a FS treatment plant, emptied FS is disposed of untreated to farmlands, dig and dumped, water bodies, stormwater drain/sewer and forests. 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 proper 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 of Open Defecation Free (ODF) status, people residing in 11% 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.

Public Sector Sanitation and Waste Management Procedure, 2079

Rajbiraj Municipality has developed Public Sector Sanitation and Waste Management Procedure in 2079. The purpose of this procedure is to manage and keep public places, important heritage and open spaces clean to identify a city as clean, healthy, beautiful and civilized. Section 3 (14) of the procedure states that every buildings in the municipality must have septic tank. The waste must be stratified and managed accordingly.

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 mainly 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 18.

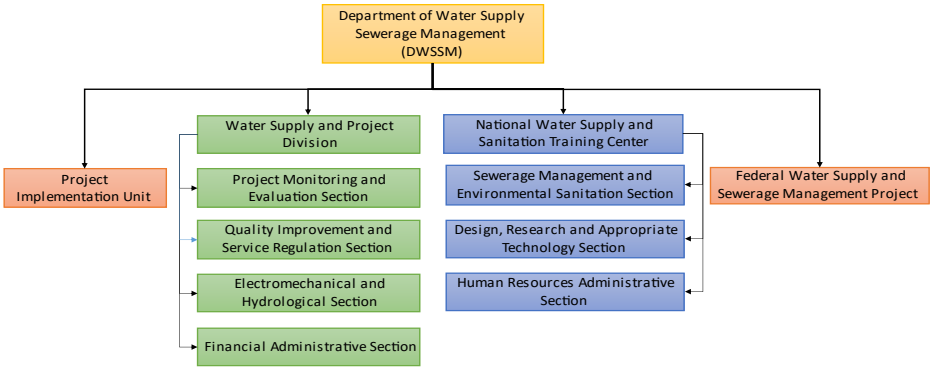

Figure 18: Organizational Structure Department of Water Supply and Sewerage Management (DWSSM).

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.

At Local Government

Municipal council: The activities related to sanitation and environment are managed by Municipality Water, Sanitation and Hygiene Coordination Committee (M-WASH-CC) in the municipality. The municipality does not have a specific section or unit to implement activities of WASH. Moreover, Accelerating Sanitation and Water for All program is implemented under the national plan of UNICEF.

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 socioeconomic 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 either 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 of the containments is carried out 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)

Key Informant Interviews (KIIs) and objective sharing of the study were conducted with major stakeholders of the sanitation sector in the municipality (Table 6). Engineer and Sub-Engineer at the municipality were interviewed on current sanitation services with respect to technical, institutional, and financial aspects. Also, the KII was performed with the owner of private desludging service provider to understand the emptying practice, disposal and treatment of FS as well as finance requirement. Also, an interview was performed with the caretaker of public toilet to understand sanitation status and to understand public toilet management practice.

Table 6: List of Key Informant Interviewed personnel (ENPHO, 2023).

S.N.	Name	Designation	Organization /Company	Purpose of KII	Date
1.	Ashok Kumar Das (KII-1)	Engineer	Rajbiraj Municipality	Sanitation status, municipality representatives	15 September, 2022
2.	Ragu Nath Das (KII-1)	Sub-Engineer	Rajbiraj Municipality	Sanitation status, municipality representatives	15 September, 2022
3.	Kursid Alam (KII-2)	Owner	Super Power Septic Tanky	Emptying practices, finances, requirement, disposal and treatment	17 September, 2022
4.	(KII-3)	Care Taker	Public Toilet-Hatiya	Quantitative and management data on public toilet and public toilet operation	9 June, 2022

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.

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.

Thus, a total of 373 households were sampled from 71,946 households distributed in 16 wards with proportionate stratification random sampling. The total number of households here was calculated by dividing population acquired from municipality website by household size acquired from census 2021.The household samples surveyed in the municipality is shown in Figure 19.

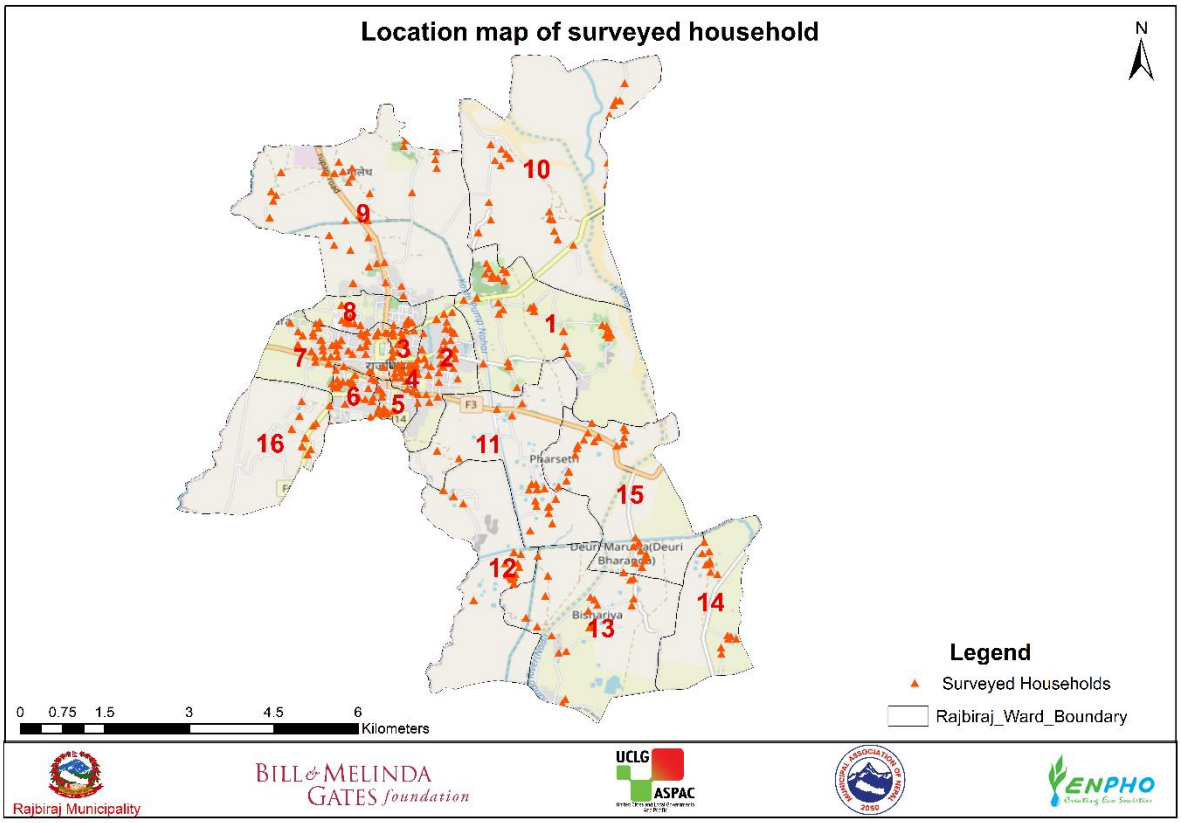

Figure 19: Location map of surveyed households.

4.3 Direct Observation

The solid waste and faecal sludge dumping site was observed during the first visit of Rajbiriaj Municipality. Also, status of public toilet was observed to understand the status of public toilet in the municipality. Figure 20 shows the picture of observation of dumping site at Khado.

Figure 20: Solid waste and FS dumping site of Rajbiraj Municipality.

4.4 Sharing and Validation of Data

The Shit Flow Diagram Sharing and Validation Workshop was conducted on 6 December, 2022 at Rajbiraj Municipality hall to share the findings on sanitation situation survey and receive the suggestions from the municipal stakeholders. Altogether, 23 participants including ward chairpersons, municipal council members, sectoral staffs and other relevant stakeholders actively participated on the workshop and provided valuable suggestion. The participants mentioned to charge penalty for unsafe disposal of FS and to include sanitation in the plannings of municipality. Figure 21 shows the picture of SFD findings sharing during workshop. The list of participants with their designation is attached in Appendix 4.

Figure 21: 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 Ms. Ishrat Pariwan Deputy Mayor of the municipality and Mr. Dharmananda Joshi, Chief Administrative Officer for providing appreciable support, Ashok Kumar Das, Engineer and Raghunath Das, Sub-Engineer for providing valuable information and Mr. Suresh Kumar Yadav, Information Technology Officer for support in program coordination.

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.

We are grateful to Ms. Bhawana Sharma, Executive Director and Mr. Rajendra Shrestha, Program Director of Environment and Public Health Organization (ENPHO) for tremendous support and guidance during the whole process of the study. Together, we would like to thank entire team of ENPHO for their gracious support and MuNASS-II team without whom the study would not have been possible.

We are grateful towards the enumerators, Radha Kumari Chaudhary, Sushank Das, Jitendra Lal Karn, Mohamad Anbar, Kamal Dev Yadav, Sagar Kumar Sah, Sonam Yadav, Rameshwor Yadav, Pankaj Yadav, Rupesh Kumar Yadav, Ramesh Sutihar, Kamlesh Kumar Mandal and Anil Kumar Yadav for their support during the survey.

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7 Appendix

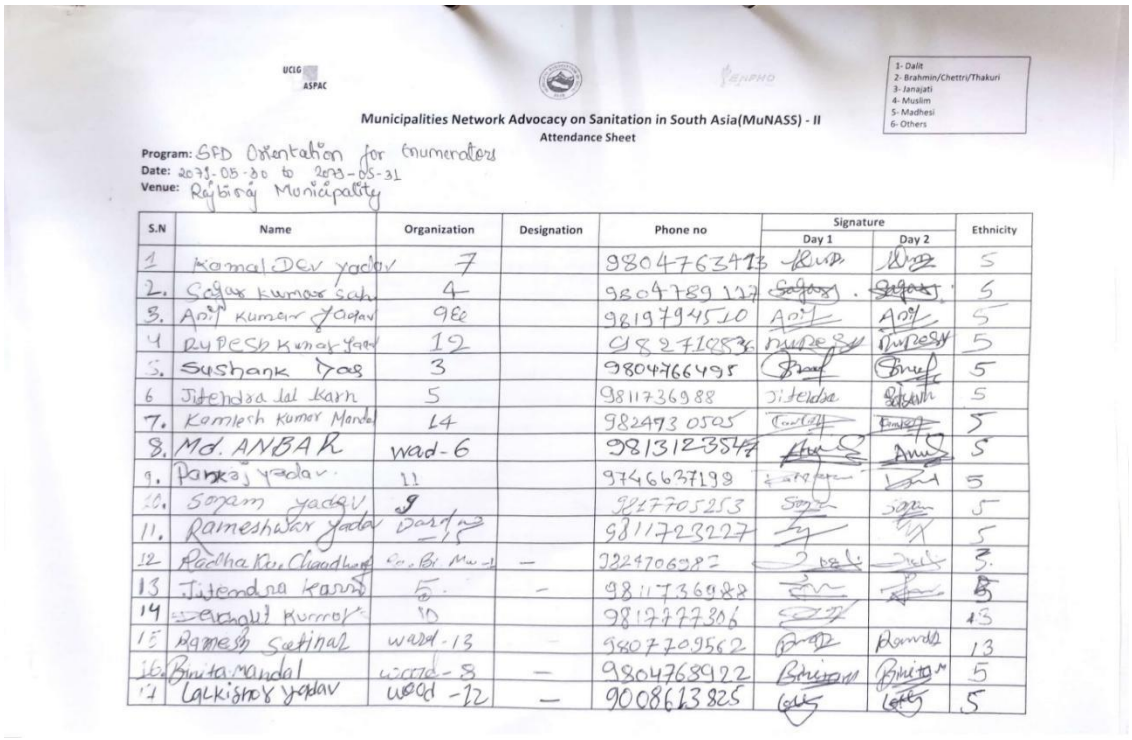
7.1 Appendix 1: Roles and Responsibility of Various Tiers of Governments Delineated in Drafted SDP 2016 – 2030

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.	Total Population	Total Households	Number of Surveyed Households
1	6,140	1,115	32
2	5,328	967	28
3	3,168	575	16
4	3,139	570	16
5	3,306	600	17
6	6,793	1,233	35
7	5,775	1,049	30
8	5,264	956	27
9	6,905	1,254	36
10	4,961	901	26
11	3,624	658	19
12	3,443	625	18
13	3,907	709	20
14	2,726	495	14
15	4,886	887	25
16	2,620	476	14
Total	**71,986**	**13,069**	**373**

7.3 Appendix 3: List of Participants on SFD Survey Orientation



UCIG ASPAC

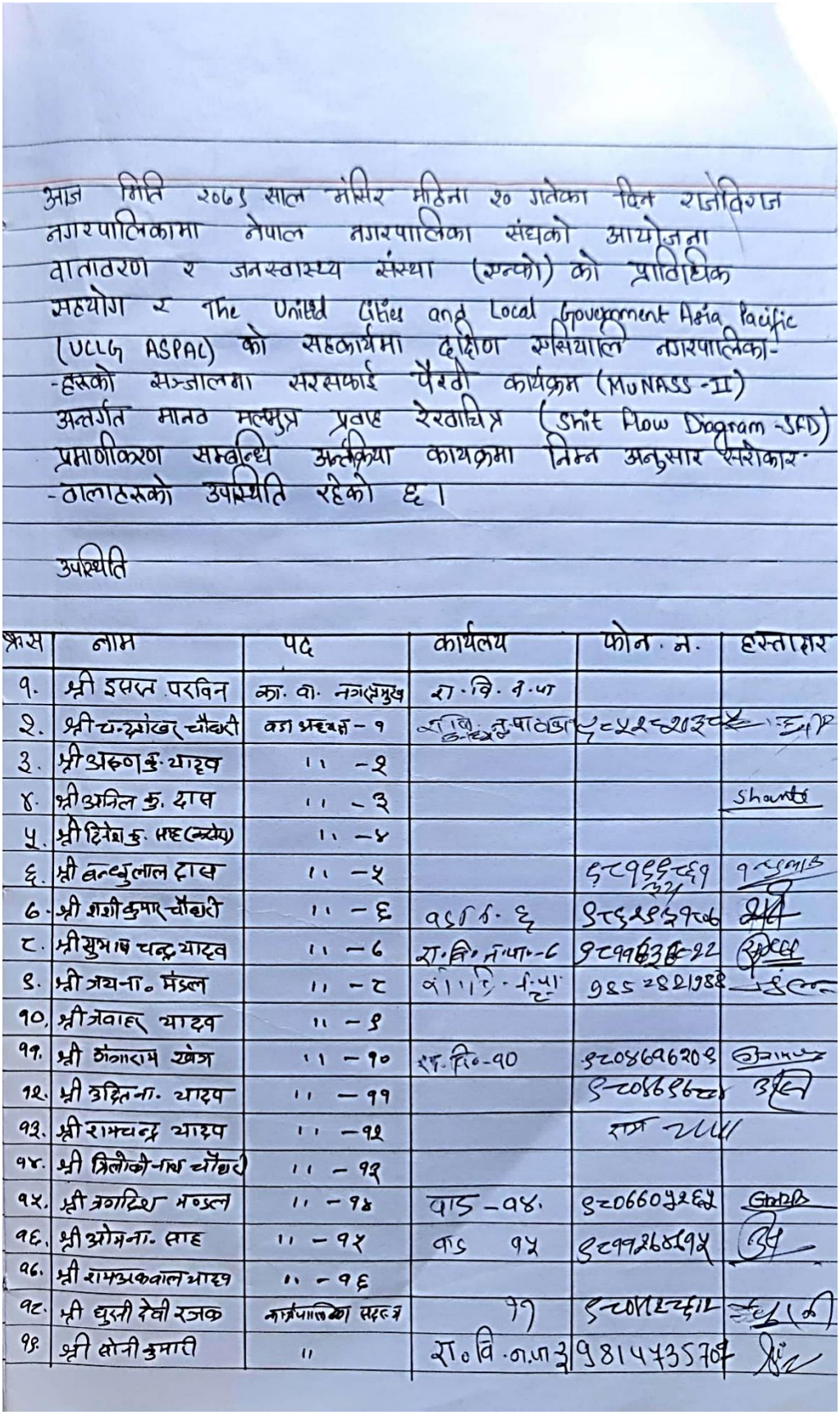
1- Dalit
2- Brahmin/Chettri/Thakuri
3- Janajati
4- Muslim
5- Madhesi
6- Others

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

Program: SFD Orientation for Enumerators
Date: 2079-05-30 to 2079-05-31
Venue: Rajbiraj Municipality

S.N	Name	Organization	Designation	Phone no	Signature		Ethnicity
					Day 1	Day 2	
1	Kamal Dev yadav	7		9804763413			5
2.	Sajan kumar sah	4		9804789127			5
3.	Arif kumar yadav	9Ec		9819794510			5
4	Rupesh kumar yadav	12		9827128536			5
5.	Sushank Das	3		9804766495			5
6	Jitendra lal karn	5		9811736988			5
7.	Kamlesh Kumar Mandal	L4		9824930505			5
8.	Md. ANBAR	wad-6		9813123547			5
9.	Pankaj yadav	11		9746637199			5
10.	Sojan yadav	9		9827705253			5
11.	Rameshwar yadav	Ward no 15		9811723227			5
12	Radha Kr. Chaudhary	Sr. Bi Mu	—	9829706987			5
13	Jitendra karn	5	—	9811736988			5
14	Sarghu Kumar	10		9817777306			15
15	Ramesh Sahani	ward-13		9807709562			13
16	Binita Mandal	ward-8	—	9804768922			5
17	Lalkishor yadav	ward-12	—	9008613825			5

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



आज मिति २०७९ साल मंसिर महिना २० गतेका दिन राजविराज नगरपालिकामा नेपाल नगरपालिका संघको आयोजना वातावरण र जनस्वास्थ्य संस्था (एन्को) को प्राविधिक सहयोग र The United Cities and Local Government Asia Pacific (UCLG ASPAC) को सहकार्यमा दक्षिण एसियाली नगरपालिका-हरुको सञ्जालमा सरसफाई पैरवी कार्यक्रम (MuNASS-II) अन्तर्गत मानव मलमूत्र प्रवाह रेखाचित्र (Shit Flow Diagram-SFD) प्रमाणीकरण सम्बन्धि अन्तर्क्रिया कार्यक्रम निम्न अनुसार सम्पन्न-गरिएको हुँदा उक्त कार्यक्रममा सहभागी हुनुहुने महानुभावहरुको उपस्थिति रहेको छ।

उपस्थिति

क्र.स	नाम	पद	कार्यालय	फोन नं.	हस्ताक्षर
१.	श्री इसरत परविन	का. वो. नगरप्रमुख	रा.वि.नं.पा		
२.	श्री चन्द्रशेखर चौधरी	वडा अध्यक्ष - १	[illegible]	[illegible]	[illegible]
३.	श्री अरुण कु. यादव	,, -२			
४.	श्री अनिल कु. दास	,, -३			Shanta
५.	श्री दिनेश कु. मण्डल (मेयर)	,, -४			
६.	श्री बन्धुलाल दास	,, -५		९८१९९९८९१	[illegible]
७.	श्री शशीकुमार चौधरी	,, -६	वडा नं. ६	९८९२९२९८७	[illegible]
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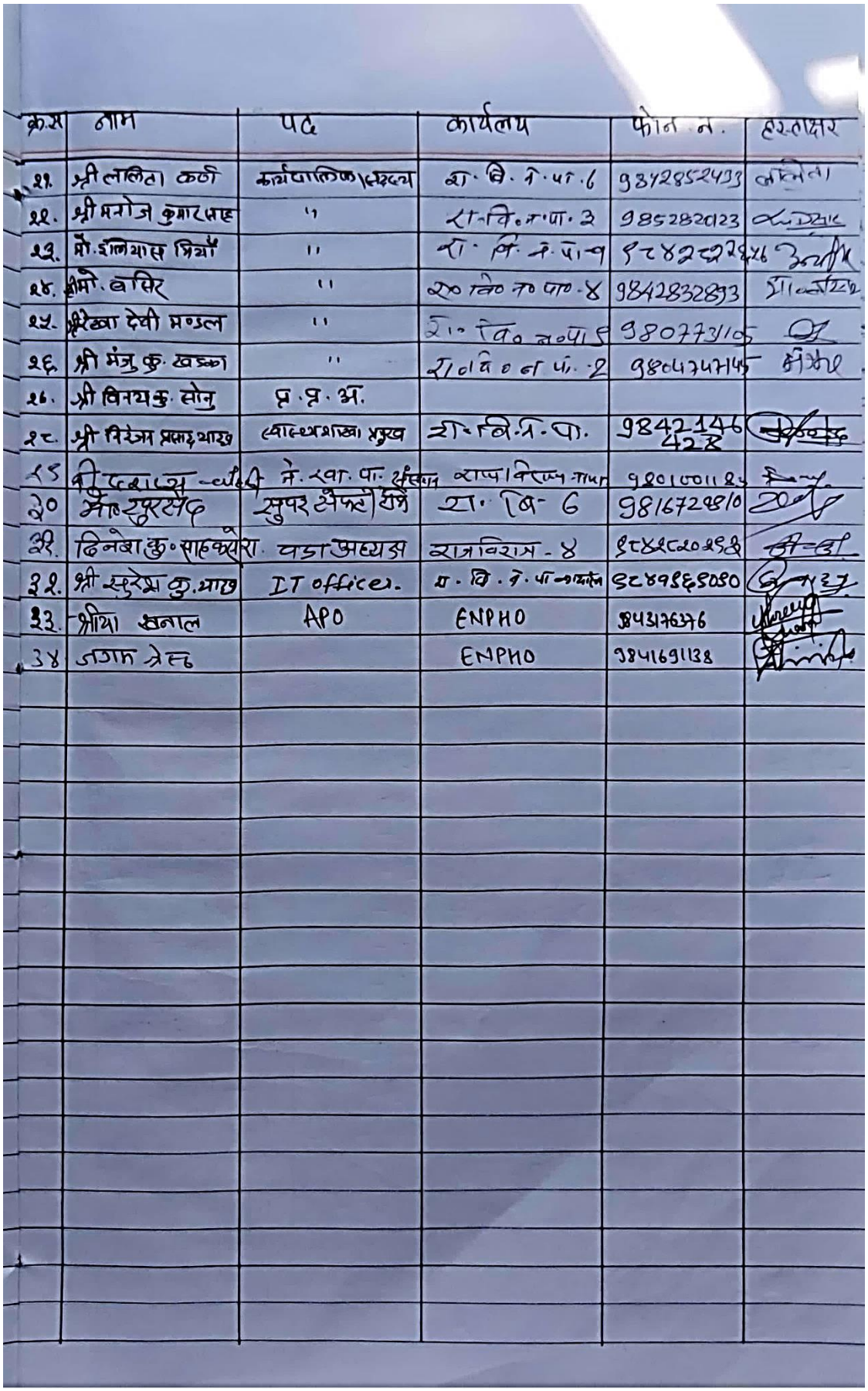
११.	श्री गंगाराम खेत्र	,, -१०	रा.वि.-१०	९८०४६९६२०९	[illegible]
१२.	श्री उदित ना. यादव	,, -११		९८०४[illegible]	[illegible]
१३.	श्री रामचन्द्र यादव	,, -१२		[illegible]	
१४.	श्री त्रिलोकी नाथ चौधरी	,, -१३			
१५.	श्री जगदिश मण्डल	,, -१४	वडा -१४	९८०६६७२६५	[illegible]
१६.	श्री ओमना. साह	,, -१५	वडा १५	९८९९२६८१९५	[illegible]
१७.	श्री रामअकबाल यादव	,, -१६			
१८.	श्री धुरी देवी रजक	नगरपालिका सदस्य	१७	९८०४८२८१८	[illegible]
१९.	श्री सोनी कुमारी	,,	रा.वि.नं.पा.३	९८१४७३५७९	[illegible]



क्र.स	नाम	पद	कार्यालय	फोन न.	हस्ताक्षर
२१.	श्री ललिता कर्ण	कार्यपालिका सहयोग	रा. वि. ने. प. 6	9342852433	ललिता
२२.	श्री मनोज कुमार सह	"	रा-वि-ना-प. 2	9852820123	
२३.	मो. इलियास मियाँ	"	रा. वि. ने. प. 4	9842832846	
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