# SFD Promotion Initiative

# Lamahi
# Nepal

## Final Report

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SFD Report Lamahi, Nepal, 2019

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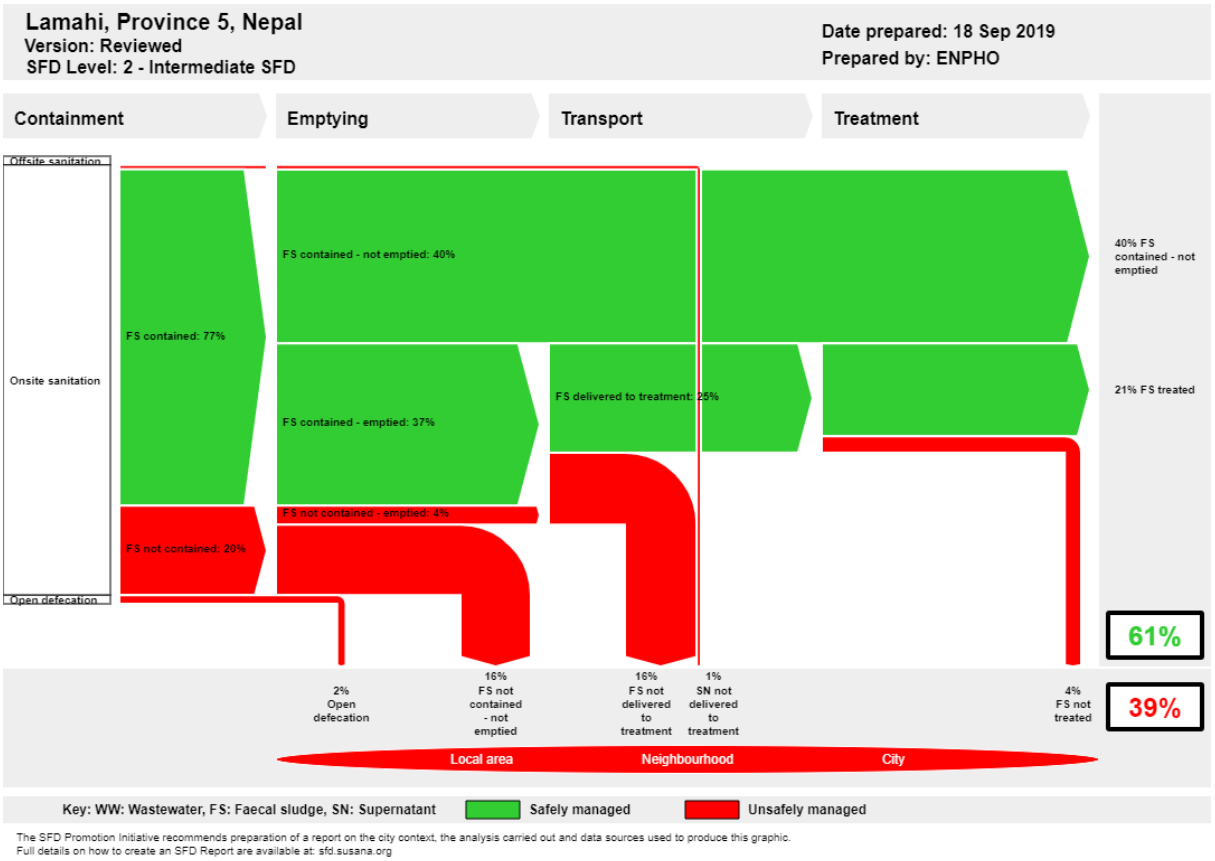
## 1. The Diagram




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

### Desk or field based:

Intermediate. Level 2 report.

### Produced by:

Environment and Public Health Organization (ENPHO).

### Collaborating partners:

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

### Status:

Final SFD report.

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## 3. General city information

Lamahi municipality is located in Dang district of province number 5, Nepal. The municipality covers an area of 327 square kilometres along the stretch of East-West highway in the country. The municipality is home to 47,655 people as per census 2011. The municipality is divided into 9 wards.

The municipality is located at geographical coordinates of 28° 7' 0" N, 82° 18' 0" E in a lower region of Dang Dekuri valley. The valley contains Churia, a sub-Himalaya range in the north, Dundwa range of Siwalik in the south and the inner Terai in mid. The west Rapti River in the south and its tributary Arjun Khola flows through the valley. It has a humid and subtropical climate with average monthly temperatures ranging from 14°C in the winter to 28°C in the summer months. The average annual rainfall in the region is 1,198.26 mm.

## 4. Service delivery context

Access to drinking water and sanitation has been defined as fundamental rights of every citizen by the constitution of Nepal. In order to respect, protect and implement the rights of citizen embedded in the constitution, the Government of Nepal (GON) has billed the Water Supply and Sanitation Law 2018 which has emphasized in 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 placed to accomplish the sanitation need of people. Particularly, NSHMP 2011 has proved as an important strategic document for all stakeholders to develop uniform programs and implementation mechanism at all level. It strengthens institutional set up with the formation of water and sanitation coordination committee at every tier of government to actively engage into sanitation campaign. The document adopted sanitation facilities as improved, basic and limited in line with WHO/UNICEF guideline. The sanitation campaign throughout the country was focused to achieve universal access to improved sanitation.

The draft Sector Development Plan (SDP) has envisioned the delineation of roles and responsibility of federal, provincial and local government in an aim to initiate sustainability of Open Defecation Free (ODF) outcomes from sanitation campaign and way forward to post ODF. It mainly emphasized sector convergence, institutional and legal reforms, and capacity development of the service providers. Together, with a commitment to Sustainable Development Goal (SDG) and promulgation of Total Sanitation Guideline 2017, it assists the service provider with clear indicators and targets to be achieved. The latest outcome, specifically to manage Faecal Sludge Management (FSM) in the country is the Institutional and Regulatory Framework for Faecal Sludge Management. The framework envisaged featuring of FSM on national policies through the federal government and issuing policy directives at the local level along with enhancing the capacity of the service providers. The overall planning, implementation and regulating of FSM service chain have been authorized to local government. In this regard, the local government can develop a partnership with either private sector or water and sanitation user committee for effective service delivery. However, the local government has yet to develop rules and regulations, and standards to effectively deliver services across the sanitation value chain.

## 5. Service outcomes

The overview of different sanitation technologies across the sanitation value chain in the municipality is briefly explained in this section.

*Containment:* The municipality has declared open defecation free zone in 2014. The municipality lacks sewer networks thus it depends on onsite sanitation system. At the household level, the majority of houses have installed anaerobic biogas digester designed for the integrated treatment of animal manure, kitchen/garden waste and faecal sludge. While in core urban areas the technology is not preferred as the shift of occupation from agriculture to service and business. In the core urban areas, either fully lined tank or lined tank with impermeable walls with open bottom are installed by majority of households, while the household which could not afford biogas digester or does not have cattle, has installed lined pits with semi-permeable walls and open bottom in rural areas of the municipality.

The majority of institutions established and operated in the core urban areas consists of fully lined tanks to collect faecal sludge. While institutions in the rented buildings do not have an idea on types of sanitation technology being used in the building. Similarly, three major public toilets built by Town Development Committee in the bus park area are being operated. These public toilets have been connected to septic tanks constructed according to their guidelines.

The urban ward numbers 3, 4, 5 and 6 are supplied with piped drinking water supply system operated by Lamahi Drinking Water Supply and Sanitation User's Committee. While rural drinking water supply systems exist in few areas, the rest of approximately 50% households relies on shallow groundwater extracted with hand pumps and tube wells. The significant risk of groundwater contamination is observed on the basis of soil characteristics, types of containment, depth of groundwater and lateral spacing of the groundwater source and containment.

The churia region consists of fluvial sedimentary rocks that are soft, loose and easily erodible. This property favours high permeability rate and risk of shallow groundwater contamination. The risk is increased with containment type with an open bottom and semi-permeable walls. Further, the

depth of shallow groundwater is observed within the minimum range of 25 feet (7.52 m) and lateral spacing of average 20 feet (6.09 m) from the containment. Thus, approximately 95% and 97% of households depending on shallow groundwater and containment such as lined tank or pit with open bottom are significantly risked to health hazard due to groundwater contamination.

*Emptying and Transportation:* Both traditional manual scavenging and mechanical emptying practices are observed. Unpredictably, while it was revealed that only 19.4% of households have emptied their containments at least once after the installation, others have never been emptied. This indicates towards high rate of seepages in the area. Emptying and transportation services have been provided by both the municipal sanitation section and private entrepreneur.

*Treatment and Disposal/ End Use*: The municipality dump collected FS in its landfill site without any forms of treatment. The private desludging entrepreneur has developed a disposal mechanism in its own land, where liquid is separated out of the FS and pumped out to irrigate land without any treatment. The dried sludge is applied as a soil conditioner.

## 6. Overview of stakeholders

Based on the regulatory framework for FSM, the major stakeholders for effective and sustaining service delivery are as presented in Table 1.

**Table 1 Overview of Stakeholders**

| Key Stakeholders | Institutions / Organizations / |
|---|---|
| **Public Institutions at Federal Government** | National Planning Commission, Ministry of Water Supply and Sanitation, Ministry of Environment and Population, Ministry of Federal Affairs and General Administration, Department of Water Supply and Sewerage, Department of Environment, Local Government (Municipal Council) |
| **Public Institutions at local Government** | Municipality<br>Drinking-Water Supply and Sanitation User's Committee<br>Town Development Committee |
| **Non-governmental Organizations** | Environment and Public Health Organization (ENPHO) |
| **Private Sector** | DN Septic Tank Cleaners |
| **Development Partners, Donors** | MuAN, BMGF,UCLG ASPAC |

## 7. Credibility of data

The major data were collected from random household sampling. Altogether, 375 households and 85 institutions were surveyed from all the wards of the municipality. The primary data on emptying and transportation were validated with KIIs from private entrepreneurs and sanitation section of the municipality. The overall data and findings were shared with the stakeholders of municipality and validated through sharing program.

Major limitation during the collection of data is the types of containments: whether it is lined or unlined is based upon the responses from the respondent.

## 8. Process of SFD development

The data on the sanitation situation is collected through a household survey (ENPHO, 2019). The community mobilizers from the sub-metropolitan were mobilized after providing the orientation on sanitation technologies, objectives of the survey and using mobile application for the survey. Also, KIIs were conducted with officers form the municipality, water supply system, town development committee and private emptying entrepreneurs to understand the situation across the service delivery chain. For the production of the SFD graphic, initially, a relationship between sanitation technology used in a questionnaire survey and SFD PI methodology was made. Then, data were fed in the graphic generator to produce the SFD graphic.

## 9. List of data sources


- ENPHO, 2019. Study on Sanitation Status of Lamahi Municipality, s.l.: s.n
- KII3, 2019. Interview with Mr Bhagwati Prashad Chaudhary and Jang Bahadur Chaudhary, Lamahi Water Supply and Sanitation User's Committee [Interview] 2019.
- KII4, 2019. Interview with Mr Tulsi Ram Aryal, Sub-engineer at Lamahi Town Development Committee [Interview] (April 2019).
- BGS, 2001. Groundwater Quality: Nepal, s.l.: British Geological Survey, Natural

Environment Research Council and WaterAid.

- City Population, 2017. City Population. [Online] Available at: https://www.citypopulation.de/php/nepal-mun-admin.php?adm2id=5606 [Accessed 27 08 2019].

Lamahi, Nepal, 2019

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# Abbreviations

| | |
|---|---|
| BGS | British Geological Survey |
| BMGF | Bill and Melinda Gates Foundation |
| CBS | Central Bureau of Statistics |
| DWSS | Department of Water Supply and Sewerage |
| ENPHO | Environment and Public Health Organization |
| FS | Faecal Sludge |
| FSM | Faecal Sludge Management |
| GON | Government of Nepal |
| IRF | Institutional and Regulatory Framework |
| KII | Key Informant Interview |
| MOF | Ministry of Finance |
| MOFAGA | Ministry of Federal Affairs and General Administration |
| MOPPW | Ministry of Physical Planning and Works |
| MOWSS | Ministry of Water Supply and Sanitation |
| NPC | National Planning Commission |
| NPR | Nepalese Rupees |
| NRWSSSP | National Rural Water Supply and Sanitation Sector Policy |
| NSHMP | National Sanitation and Hygiene Master Plan |
| NUWSSSP | National Urban Water Supply and Sanitation Sector Policy |
| ODF | Open Defecation Free |
| PPE | Personal Protective Equipment |
| PPP | Public Private Partnership |
| SDG | Sustainable Development Goal |
| SDP | Sector Development Plan |
| SFD | Shit Flow Diagram |
| SFD PI | Shit Flow Diagram Promotion Initiative |

| | |
|---|---|
| STWSSP | Small Town Water Supply and Sanitation Project |
| UCLG ASPAC | United Cities of Local Government Asia Pacific |
| UNICEF | United Nations Children's Education Fund |
| USAID | United States |
| VDC | Village Development Committee |
| WASH | Water, Sanitation and Hygiene |
| WEDC | Water Engineering and Development Centre |
| WHO | World Health Organization |
| WSUC | Water and Sanitation Users Committee |

# 1 City context

Lamahi municipality is located in Dang District of Province number 5, Nepal. The municipality was formed on 2nd December 2014 by merging then Sonpur and Chailahi Village Development Committee. The municipality was reformed on 5th March 2017 where Satbariya VDC was merged into it according to the new federal structure of the country. The municipality is divided into 9 wards and covers an area of 327 square kilometres along the stretch of East-West Highway of the country as shown in Figure 1.

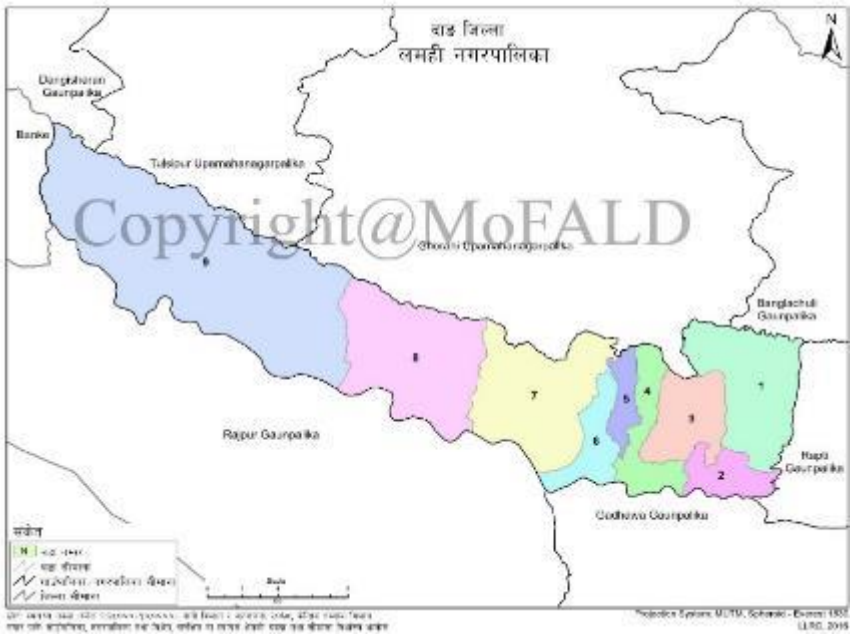



**Figure 1: Location map of Lamahi Municipality.**

## 1.1 Population

As per the national census 2011, the total population of the municipality is 47,655 residing in 9,432 households (MoPE, 2017), while the total population was 38,632 during the national census in 2001. Thus, the city has observed a population growth rate of 2.18% per year (City Population, 2017).

## 1.2 Geography

The municipality is located in Dang Deukhri valley, a lower region in Dang District at the geographical coordinates of 28° 7' 0" N, 82° 18' 0" E. The valley contains Churia, a sub-Himalaya range in the north, Dundwa range of Siwalik in the south and the inner Terai in mid. This zone consists of fluvial sedimentary rocks of Neogene to Quaternary period that is soft, loose and easily erodible and is represented by sandstone, siltstone, mudstone and conglomerate. Furthermore, the lower Siwalik zone comprises of fine-grained red, ash grey, grey and reddish-brown sandstone interbedded with purple, grey and green shales and mudstones (Dhakal S, 2014). The West Rapti River, a boundary of the municipality in the south and its tributary Arjun Khola flows through the valley.

### 1.3 Climate

Lamahi has a humid and subtropical climate. Average monthly temperatures range from 14°C in the winter to 28°C in the summer months and are variable within the region due to changes in topography (USAID, 2019). The average annual rainfall in the region from 2013 to 2017 was recorded to be 1,198.26 mm (CBS, 2019).

# 2 Service delivery context description

## 2.1 Policy, legislation and regulation

### *2.1.1 Policy*

The constitution of Nepal 2015 has envisioned access to drinking water and sanitation as fundamental rights of the citizens that would be delivered and managed by federal, provincial and local governments in mutual coordination (GON, 2015). GON through its Ministry of Water Supply (MoWS) has billed Water Supply and Sanitation Law 2018 in its federal parliament to respect, protect, promote, fulfil and implement the provisions in the constitution. The billed law has entitled every citizen a right to quality sanitation services and prohibited the direct discharge of wastewater and sewage into water bodies or public places directly against the prescribed standard in section 38. Also, it has provision of imprisonment for term ranging from three months to one year or a fine of up to NPR 5, 00,000 (US$ 4,390) or both to the offender (MoWS, 2018).

Beside current developments in laws and policies, earlier National Sanitation Policy (1994) was the first sanitation specific policy that provided guidelines for the planning and implementation of sanitation programs. An unofficial revised version was produced in 2002, however, it was not ratified by GON instead National Rural Water Supply and Sanitation Sector Policy (NRWSSSP) was approved in 2004 (WEDC, 2005). The policy was formulated to provide a basic level of water supply to all people such that development of water supply and sanitation services supports the social and economic development of the nation and improves the health status. It mainly focused on participatory approach and community leadership project development with emphasized given on optimization of local resources and installation of locally appropriate technology (DWSS, 2004). Similarly, the GON approved National Urban Water Supply and Sanitation Policy (NUWSSSP) in 2009. The policy uses Water and Sanitation Hygiene (WASH) services as a tool for poverty reduction. Output-Based Aid Approach was adopted for supporting the construction of household toilets along with cost recovery principles and decentralized waste management in urban areas (DWSS, 2009). A Unified National Water Supply and Sanitation Sector Policy (NWSSSP) was approved in 2014 by the GON to resolve existing inconsistent and incoherent in rural and urban sanitation policies. The NWSSSP aimed to grab many opportunities like new technologies and knowledge, and service delivery approaches emerged in the sector. Remarkably, NWSSSP was the first official document that recognized discharge of untreated wastewater and dumping of septic sludge heavily polluted into surface water sources in urban areas. Further, it pinpointed that densely located onsite sanitation facilities in urban and rural localities have been posing a risk of groundwater pollution. The policy set strategy to develop and enforce wastewater quality standards for discharging all kinds of wastewater into natural water bodies

and agricultural lands. Reuse options with appropriate treatment were highly prioritized and mandatory provisions were set for constructing onsite treatment facilities in hospitals, industries and commercial buildings (DWSS, 2014).

Based upon these policies, National Sanitation and Hygiene Master Plan (NSHMP) 2011 was formulated and implemented by the GON. Coordination among various stakeholders and local leadership was highly emphasized to develop participatory integrated sanitation programs. It basically focused on universal access to sanitation through the construction of household toilets and declaration of Open Defecation Free zones. It has set ODF as a basic indicator to universal access on improved sanitation with due consideration on sustainable changes in hygiene behaviours including proper use of toilet and waste management practices in the urban and rural areas. It provided strategic direction for all the concerned stakeholders to formulate an enabling environment for harmonizing the efforts of stakeholders, maintaining uniformity and standards and developing institutional arrangement at all levels of government (NPC, 2011). It strengthens institutional set up with the formation of water and sanitation coordination committee at every tier of government in a participatory approach. Also, it defined what sanitation facility should be promoted to achieve universal access to improved sanitation.

The national sanitation coverage after the implementation of NHSMP 2011 is 95.5% until March 2018 (MoWS, 2018). Thus upon achieving good progress towards the sanitation coverage, the GON has drafted Nepal Water Supply, Sanitation and Hygiene Sector Development Plan (SDP 2016-2030) in 2016 emphasizing sector convergence, institutional and legal reforms, capacity development of the sector institutions and establishing coordination and harmonization. The draft SDP has classified service system and delineated roles and responsibilities accordingly for effective and sustainable service delivery as shown in Appendix 1.

Together, with a national commitment to pursuing and achieving the Sustainable Development Goals (SDGs) by 2030, National Planning Commission (NPC) formulated targets and indicators for coordinated efforts to achieve the goals in 2017. Similarly, Total Sanitation Guideline 2017 has envisioned sustaining ODF outcomes and initiating post-ODF activities through integrated water, sanitation and hygiene plan at every local level. It has set various indicators and remarkably 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 the hygienic environment and promote public health (NPC, 2017).

All these above-mentioned policies and guideline states Faecal Sludge Management (FSM) as a component of the sanitation system. Lack of concrete policies, guidelines and indicators on FSM was felt in the sector for effective planning, implementation and service delivery. Thus, through in-depth discourses on FSM, Ministry of Water Supply and Sanitation (MOWSS) through its Department of Water Supply and Sewerage (DWSS) articulated and endorsed Institutional and Regulatory Framework for Faecal Sludge Management in Urban Areas of Nepal in 2017.

The main objective of the FSM framework is to define the specific roles and responsibilities of key institutions for the effective management and regulation of FSM. It is framed upon existing laws such as Environmental Protection Act and Rules 1997, Self-Local Governance Act and Rules 1999, Environmental Standards on Effluent Discharge 2000, Nepal National Building Code 2003, and Land Acquisition Act amendment 2010 (MOWS, 2017). 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 Water and Sanitation Users Committee (WSUC) in the framework reflects a participatory approach that would help in sustaining the interventions.

### *2.1.2 Institutional roles*

At the federal government, National Planning Commission (NPC) is responsible for planning the national sanitation programs in coordination with the respective ministry. Department of Water Supply and Sewerage under Ministry of Water Supply and Sanitation (MOWS) is a leading authoritative agency for development and implementation of sanitation policy and programs. Earlier, the sanitation programs were implemented through its regional offices at the local level. The policies formulated had to be channelized through Ministry of Federal Affairs and General Administration (MOFAGA), a ministry at federal government accredited with the role of coordination, cooperation, facilitation and monitoring and evaluation of activities undertaken by local governments; regulation and management of the civil service in the country. The schematic diagram as shown in Figure 2 illustrates roles and responsibilities for effective management of faecal sludge at federal government.

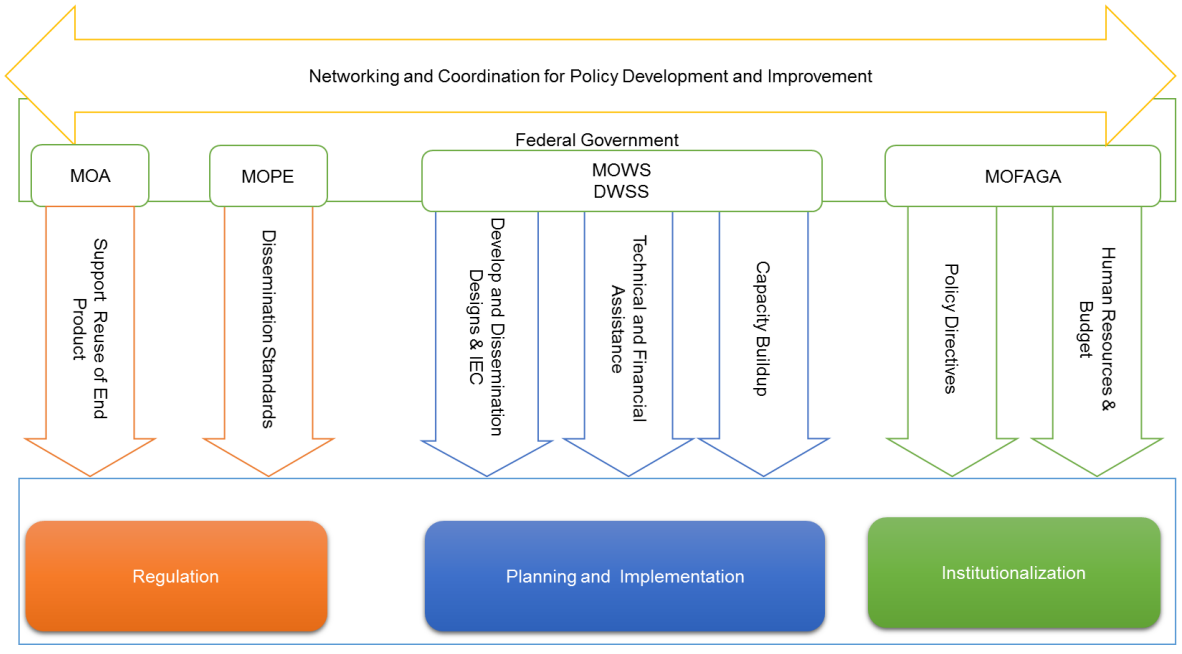


**Figure 2: Institutional arrangements and their responsibility for FSM at the federal government.**

Ministry of Physical Infrastructure and Development is entitled with authority for water supply and sanitation programs at the provincial government. The draft SDP has envisioned the role of the provincial government as roles of regulation and surveillance on small scale sanitation systems implemented by the local government whereas it is responsible to undertake implementation program of medium to mega-scale sanitation interventions in coordination with federal and local government.

The Constitution of Nepal 2015 and Local Government Operation Act 2017 enabled local government to implement sanitation interventions to enhance public health and living standards. Generally, local government in coordination and partnership with Water and Sanitation User Committee (WSUC) and developing agencies have been implementing water supply and sanitation programs. The IRF for FSM has delineated the roles and responsibility of local government across all sanitation values chain as presented in Figure 3.

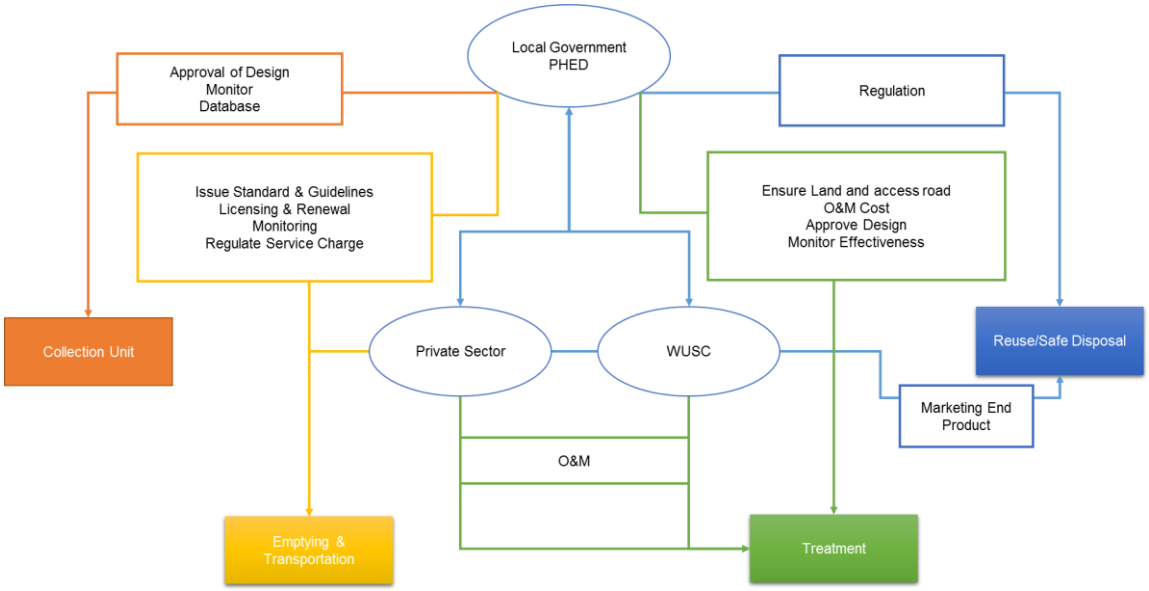


**Figure 3: Roles and responsibility of local government (municipality) for FSM.**

### *2.1.3 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 (MOPPW, 2009). Also, Public-Private Partnership Policy 2015 encourages private sector investment in 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).

Similarly, Drinking Water Rules 1998 has envisioned the formation of water users committee for effective service delivery of water supply and sanitation in the community. In line with this provision, Small Town Water Supply and Sanitation Users Association were formed through the implementation of Small Town Water Supply and Sanitation Project (STWSSP) in the municipality.

Specifically, in sanitation service chain, desludging services have been providing by municipality and private entrepreneur in Lamahi Municipality. The municipality has initiated emptying service since 2018 through its sanitation section. The service is being provided within the municipality and its neighbouring Rapti Rural Municipality. The municipality has imported a suction tank with a capacity to load 3,500 litres of faecal sludge per trip. Altogether, six staffs were engaged in sanitation section while only a driver and a helper are mobilized during the

emptying services. These staffs were provided with general personal protective equipment (PPE) such as gloves, masks and gumboots along with 20% of collected tariffs as an incentive. However, the knowledge on health hygiene and safety procedure are not provided till date.

Similarly, DN Septic Tank Cleaners, a private desludging entrepreneur, has been providing the service since 1994 in the region. Currently, the entrepreneur owns a desludging vehicle with a capacity of 3,500 litres. The desludging vehicle was manufactured and assembled in Butwal Industrial Zone in Nepal. A vacuum pump operated with tractor generator is assembled in the tank. One helper with a driver is mobilized for emptying the containment. General PPE such as gloves and mask were provided to the labour while they lack formal training on the emptying, health and hygiene.

### *2.1.4 Service standards*

The sanitation service standards have been proposed in the draft Nepal Water Supply, Sanitation and Hygiene Sector Development Plan (2016-2030). It has classified sanitation services as high, medium and basic on the basis of knowledge and facilities in place. The sanitation service levels with indicators are shown in Table 1. However, FSM specific standards have yet to be developed and implemented.

**Table 1: 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 | ✓ | ✓ | ✓ |

**Source: MoWSS, 2017**

# 3 Service Outcomes

## 3.1 Overview

### 3.1.1 Household Level Sanitation System

All three VDCs Sonpur, Chailahi and Satbariya merged to form Lamahi Municipality, which has been declared Open Defecation Free (ODF) zone during 2014. Despite ODF status, it was revealed that 97.6% of households have a toilet in their house while 0.8% shared toilet with their neighbours and remaining almost 1.6% still practices open defecation. All the households with access to toilet rely on onsite sanitation system. The municipality has only developed a stormwater drainage system in core urban settlement and newly planned urban areas.

### 3.1.2 Institutional Level Sanitation System

Altogether 85 institutions operated either from its own building or rented whole building were surveyed to understand the sanitation system. The types of institutions and their location surveyed are shown in Figure 4. The list of institutions surveyed is given in Appendix 2.


**Figure 4: Types of institutional buildings surveyed and their location.**

It was observed that most of the institutions have been established and operated in the core urban area of the municipality except educational institutions. Majority of institutions (62.2%) have connected toilet into the fully lined tank while unlined tanks with open bottom and pits were observed at rural areas. Noticeably, 12.2% of institutions functioning from rented buildings in the urban area does not know or have any idea about types of containments.

### 3.1.3 Public Toilets

Lamahi Town Development Committee under the Ministry of Physical Planning and Works has constructed three public toilets in the main bus park area. These toilets serve passengers and local people operating their small business around the bus park. These toilets have been leased by the town development committee in annual tender processes. Public toilet A was designed for 300 users per day while remaining other two were designed for 100 users per day (KII4, 2019). It was revealed that a number of users exceeded the designed capacity. All the three toilets consist of a septic tank connected with soak pit. The descriptions on public toilets and pictures in the bus park are presented in Appendix 3.

Similarly, the public toilet has been constructed and operated in the junction to the Ghorahi sub-metropolitan. The toilet consists of 5 urinals and 2 toilet seat in the male compartment while there are 3 toilet seats in female compartment. The waste from the toilet is collected in twin pits.

Thus, types of sanitation technology selected in the SFD selection grid in the municipality is shown in Figure 5.

| 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<br>Low risk of GW pollution | | | | | Not Applicable |
| Septic tank | | | | | Significant risk of GW pollution<br>Low risk of GW pollution | T1A2C6 | | | | |
| Fully lined tank (sealed) | | | | | Significant risk of GW pollution<br>Low risk of GW pollution | | | | | T1A3C10 |
| Lined tank with impermeable walls and open bottom | Significant risk of GW pollution<br>Low risk of GW pollution | Significant risk of GW pollution<br>Low risk of GW pollution | Significant risk of GW pollution<br>Low risk of GW pollution | Significant risk of GW pollution<br>Low risk of GW pollution | T2A4C5<br>Low risk of GW pollution | T1A4C6 | | T1A4C8 | | T2A4C10<br>T1A4C10 |
| Lined pit with semi-permeable walls and open bottom | Not Applicable | | | | | | | | | T2A5C10<br>T1A5C10 |
| Unlined pit | | | | | | | | | | T2A6C10<br>T1A6C10 |
| Pit (all types), never emptied but abandoned when full and covered with soil | | | | | | | | | | Significant risk of GW pollution<br>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 | | | | | | | | | T1B10 C7 TO C9 | |
| No toilet. Open defecation | Not Applicable | | | | | | | | T1B11 C7 TO C9 | Not Applicable |

**Figure 5: SFD selection grid for Lamahi Municipality.**

## 3.2 SFD Matrix

Figure 6 shows the SFD matrix of Lamahi Municipality.

**Lamahi, Province 5, Nepal, 18 Sep 2019. SFD Level: 2 - Intermediate SFD**
**Population: 47655**
**Proportion of tanks: septic tanks: 50%, fully lined tanks: 100%, lined, open bottom tanks: 99%**

| System label | Pop | F3 | F4 | F5 | S4e | S5e |
|---|---|---|---|---|---|---|
| System description | Proportion of population using this type of system | 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 |
| T1A2C6<br>Septic tank connected to open drain or storm sewer | 1.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| T1A3C10<br>Fully lined tank (sealed), no outlet or overflow | 47.0 | 71.0 | 75.0 | 85.0 | | |
| T1A4C10<br>Lined tank with impermeable walls and open bottom, no outlet or overflow | 5.0 | 14.0 | 0.0 | 0.0 | | |
| T1A4C6<br>Lined tank with impermeable walls and open bottom, connected to an open drain or storm sewer | 1.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| T1A4C8<br>Lined tank with impermeable walls and open bottom, connected to open ground | 3.0 | 22.0 | 0.0 | 0.0 | | |
| T1A5C10<br>Lined pit with semi-permeable walls and open bottom, no outlet or overflow | 24.0 | 13.0 | 0.0 | 0.0 | | |
| T1A6C10<br>Unlined pit, no outlet or overflow | 1.0 | 0.0 | 0.0 | 0.0 | | |
| T1B10 C7 TO C9<br>Containment (septic tanks, fully lined tanks, partially lined tanks and pits, and unlined pits) failed, damaged, collapsed or flooded - connected to water bodies, or open ground or 'don't know where' | 2.0 | 0.0 | 0.0 | 0.0 | | |
| T1B11 C7 TO C9<br>Open defecation | 2.0 | | | | | |
| T2A4C10<br>Lined tank with impermeable walls and open bottom, no outlet or overflow, where there is a 'significant risk' of groundwater pollution | 1.0 | 15.0 | 0.0 | 0.0 | | |
| T2A4C5<br>Lined tank with impermeable walls and open bottom, connected to a soak pit, where there is a 'significant risk' of groundwater pollution | 1.0 | 0.0 | 0.0 | 0.0 | | |
| T2A5C10<br>Lined pit with semi-permeable walls and open bottom, no outlet or overflow, where there is a 'significant risk' of groundwater pollution | 11.0 | 29.0 | 0.0 | 0.0 | | |
| T2A6C10<br>Unlined pit, no outlet or overflow, where there is a 'significant risk' of groundwater pollution | 1.0 | 40.0 | 0.0 | 0.0 | | |

**Figure 6: SFD matrix of Lamahi Municipality.**

### *3.2.1 SFD Matrix Explanation*

The sanitation technologies and the corresponding percentage of the population using those systems in the municipality are shown in Table 2.

**Table 2: Sanitation technologies with SFD reference variable and percentage of the population using each type.**

| S.N. | Sanitation Technologies | SFD Reference Variable | Percentage of Population |
|---|---|---|---|
| 1 | Septic tank connected to open drain or storm sewer | T1A2C6 | 1% |
| 2 | Fully lined tank (sealed) no outlet or overflow | T1A3C10 | 47% |
| 3 | Lined tank with impermeable walls and open bottom, no outlet or overflow | T1A4C10 | 5% |
| 4 | Lined tank with impermeable walls and open bottom connected to an open drain or storm sewer | T1A4C6 | 1% |
| 5 | Lined tank with impermeable walls and open bottom, connected to open ground | T1A4C8 | 3% |
| 6 | Lined pit with semi-permeable walls and open bottom, no outlet or overflow | T1A5C10 | 24% |
| 7 | Unlined pit, no outlet or overflow | T1A6C10 | 1% |
| 8 | Containment (septic tanks, fully lined tanks, partially lined tanks and pits, and unlined pits) failed, damaged, collapsed or flooded – connected to water bodies, or open ground or “don’t know where” | T1B10C7 to C9 | 2% |
| 9 | Open defecation | T1B11C7 To C9 | 2% |
| 10 | Lined tanked with impermeable walls and open bottom, no outlet or overflow, where there is a ‘significant risk’ of groundwater pollution | T2A4C10 | 1% |
| 11 | Lined tank with impermeable walls and open bottom connected to a soak pit, where there is a significant risk of groundwater pollution | T2A4C5 | 1% |
| 12 | Lined pit with semi-permeable walls and open bottom, no outlet or overflow, where there is a significant risk of groundwater pollution | T2A5C10 | 11% |
| 13 | Unlined pit, no outlet or overflow, where there is a ‘significant risk’ of groundwater pollution | T2A6C10 | 1% |

The technically appropriate septic tank has been rarely installed in the municipality. Majority of households in the municipality have connected waste from toilets into an anaerobic biogas digester which receives the excreta and flushing water directly from a toilet through a pipe. Approximately 38% of households have an anaerobic biogas digester installed at their house. The anaerobic biogas digester is designed for the integrated treatment of toilet products,

animal manure and kitchen and garden waste. The system is predominated in the households located at *Narti, Kaudya, Sundabari, Raniyapur, Sonpur, Keruniya, Bankatti, Jakhera, Narayanpur, Bangaun, Falkapur, Majgaun, Chailahi, Ghumna, Semrahwa* and *Badkaghumna* located in ward numbers 1, 2, 3 and 4 as shown in Figure 7.

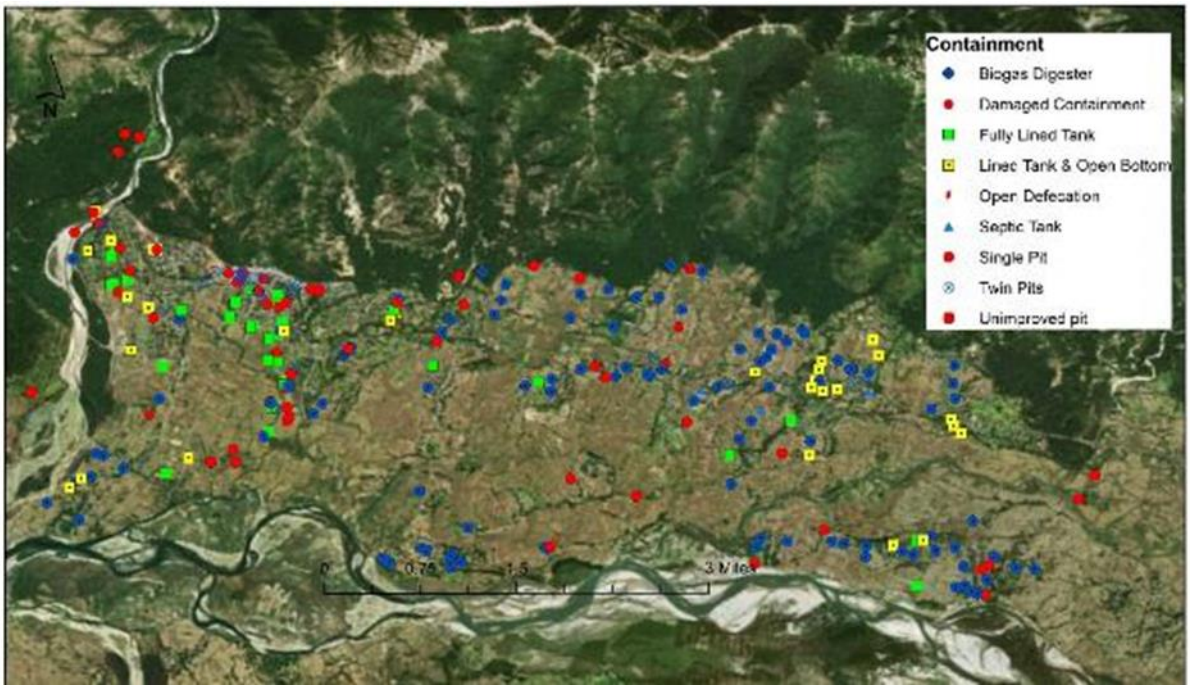


**Figure 7: Distribution of various sanitation technologies in wards 1, 2, 3, 4, 5 and 6 of Lamahi Municipality.**

Similarly, households in a core urban area and market along East-West Highway have installed fully lined tank containment. For the preparation of SFD matrix, the anaerobic biogas digesters are considered as fully lined tank (sealed) with regular emptying mechanism and system capable of treating faecal sludge onsite. Thus, in an aggregate 47% of the population uses fully lined tank (sealed) with no outlet and overflow (T1A3C10). Figure 8 shows a toilet connected to biogas digester and a fully lined tank.

**Figure 8: Toilet connected to biogas digester and a fully lined tank.**

Households located in the small market area mostly in the junctions to the rural areas preferred lined tanks with impermeable walls and open bottoms. These containments are either connected to open drain or open ground. Upon estimation of risk on groundwater contamination, it was observed that the population with a lined tank with impermeable walls and open bottom:

i. No outlet or overflow without significant risk of groundwater pollution (T1A4C10) is 5%,
ii. Connected to an open drain without significant risk to groundwater contamination (T1A4C6) was 1%,
iii. Connected to open ground without significant risk to groundwater (T1A4C8) is 3%, here open grounds refers to farmland.
iv. No outlet or overflow with a significant risk of groundwater pollution (T2A4C10) is 1% and
v. Connected to soak pit with a significant risk of groundwater pollution (T2A4C5) is 1%.

**Figure 9: Toilet connected to lined pits.**

Single pit and twin pits as shown in Figure 9, considered as a lined pit with semi-permeable walls and open bottom were predominately installed in the rural areas of the municipality in wards 4, 6, 7, 8 and 9 as shown in Figure 10.

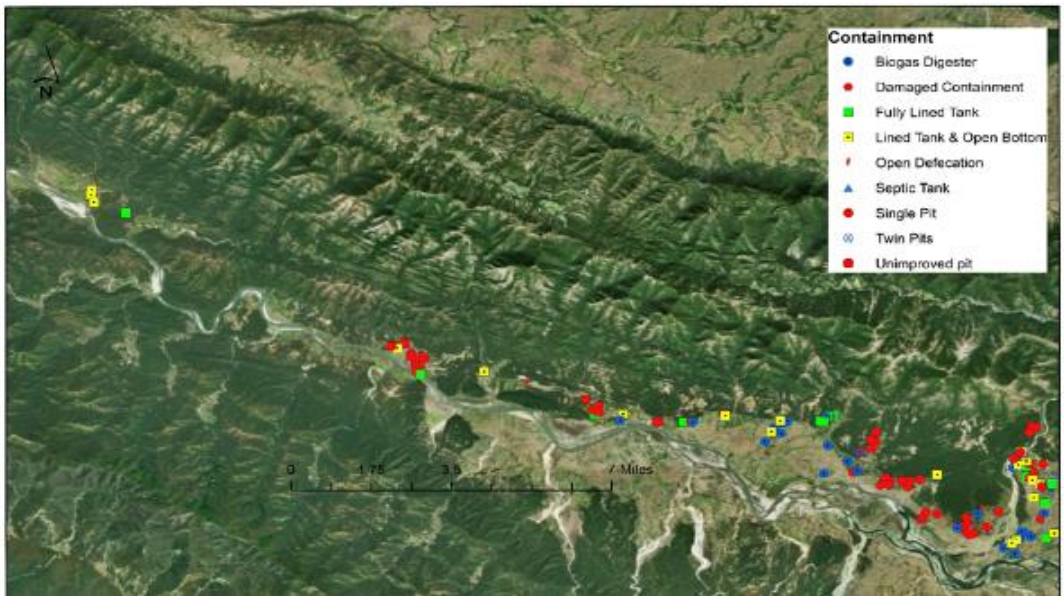


**Figure 10: Distribution of various sanitation technologies Installed at households in ward numbers 6, 7, 8 and 9 of Lamahi Municipality.**

It was revealed that 24% of the population with lined pits with semi-permeable walls and open bottom without outlet or overflow (T1A5C10) has a low risk of groundwater pollution, while 11% of the population with the same technology (T2A5C10) have a significant risk of groundwater pollution. Also, still 2% of population rely on unlined pits (T1A6C10 and T2A6C10 each 1%) and containments of 2% of the population have been damaged (T1B10 C7 TO C9). Open defecation still exists in the municipality, where approximately 2% of the population defecates in nearby forest, rivers or open lands (T1B11 C7 TO C9).

The proportions of FS in septic tanks, fully lined tanks and lined tanks/all types of pits (step two of the graphic generator) were set to 50%, 100% and 99%, according to the relative proportions of the systems in the city, as suggested in the guidance given in the Frequently Asked Questions (FAQs) from the Sustainable Sanitation Alliance (SuSanA) webpage and the SFD PI methodology.

### *3.2.2 Risk of Groundwater Pollution*

The risk of groundwater pollution is assessed according to the following explained criteria.

**1. Sources of Drinking Water and Water Production**

District Office of Drinking Water established Piped drinking water supply to urban areas of Lamahi municipality during 1997. It supplied drinking water in 1,298 households through 150 $m^3$ of an overhead water tank, shown in Figure 11. The system was upgraded in 2012 under second small-town drinking water supply and sanitation program. Currently, the system has connected 3,477 private taps in ward numbers 3, 4, 5 and 6. The major sources of water are groundwater extracted from deep bores in three places at a depth of 120 m (KII3, 2019).

**Figure 11: Lamahi drinking water supply and Sanitation Organization Office building and overhead water tanks.**

The system consists of a slow sand filter to treat water. Regular monitoring of the water quality at the source has been conducted by Lamahi Drinking Water Supply and Sanitation Organization. The water quality report monitored in 2016 as listed in Appendix 7 shows no microbiological contamination.

Similarly, rural drinking water supply systems have been in operation in other wards of the municipality (KII3, 2019). However, still, approximately 50% of households rely on hand pumps and tube wells extracted from shallow groundwater table. Among these, households with a hand pump or tube well as major source of drinking water, 10% have lined tank with impermeable wall and open bottom, while 21% of households have line pits with semi-permeable walls and open bottom.

## 2. The vulnerability of the aquifer and Lateral Spacing between sanitation systems and groundwater source

The municipality is located in the inner Terai region in between Sub-Himalaya range in north and Dundwa range of Siwalik in the south. The region consists of fluvial sedimentary rocks that are soft, loose and easily erodible. They are represented by sandstone, siltstone, mudstone and conglomerate. Further, at lower region towards the south, it comprises of fine-grained red, ash grey, grey and reddish-brown sandstone (Dhakal S, 2014). The fluvial deposits such as sandy sediments increase the higher permeability and thus risk of shallow groundwater contamination (BGS, 2001). Thus, depth of hand pumps installed at households with lined tank with impermeable walls and open bottom and lined pits were assessed.

It was observed that among 10% of households depending on hand pumps for drinking water and having containment type of lined tank with impermeable walls and open bottoms, 25% of hand pumps extract groundwater from the depth of fewer than 20 feet (6.09 m). Similarly, 70% of hand pumps extract groundwater from depth of 40 feet (12.19 m) while remaining pumps out from depth greater than 80 feet (24.38 m). Similarly, among 21% of households depending on hand pumps for drinking water and having lined pits with semi-permeable walls and open bottoms, 38%, 59% and 3% have extracted water from the depth of less or equal to 20 feet (6.09 m), 40 feet (12.19 m)and 60 feet (18.28 m), respectively.

Also, the lateral spacing of hand pumps and containments of both lined tank and lined pits with the open bottom is as shown in Table 3.

**Table 3: Lateral spacing of source of drinking water and containments.**

| S.N. | Types of Containment | 5 – 10 ft. (1.52-3.04m) | 10 – 15 ft. (3.04-4.57m) | 15 – 20 ft. (4.57-6.09m) | 20 – 25 ft. (6.09-7.62m) | More than 25 ft. (7.62m) |
|---|---|---|---|---|---|---|
| 1 | Lined tanks with impermeable walls and open bottom | 10% | 25% | 35% | 25% | 5% |
| 2 | Lined pits with semi-permeable walls and open bottom | 29% | 44% | 18% | 6% | 3% |

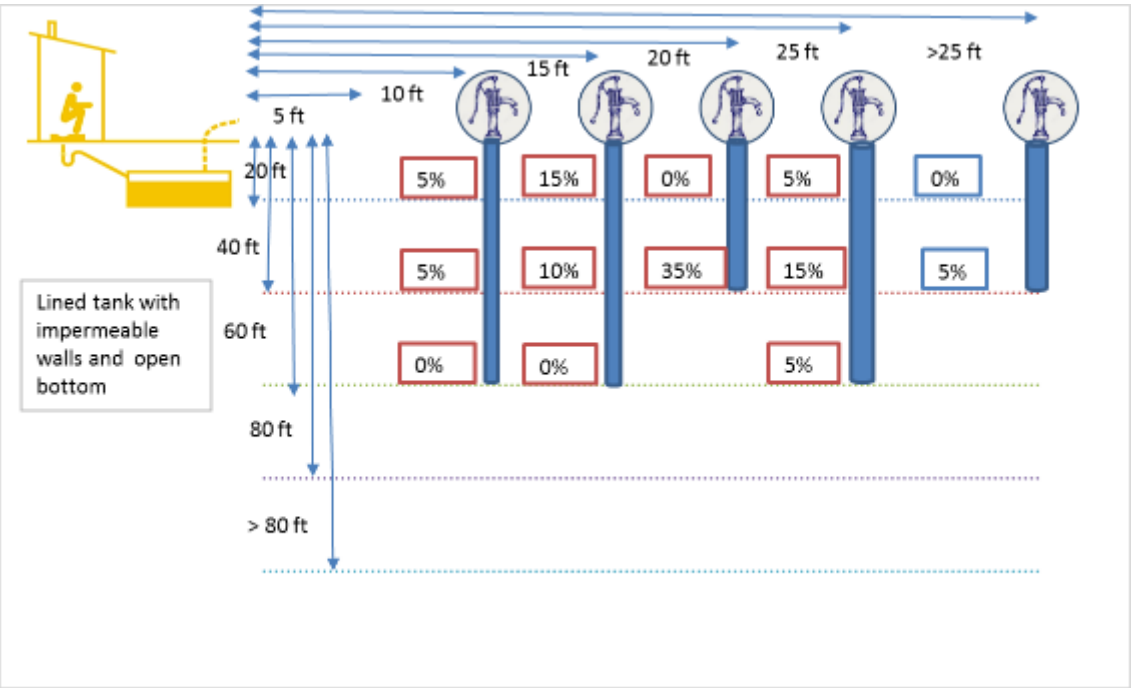


**Figure 12: Depth of hand pumps and lateral spacing of it with containment type lined tank with impermeable wall and open bottom.**

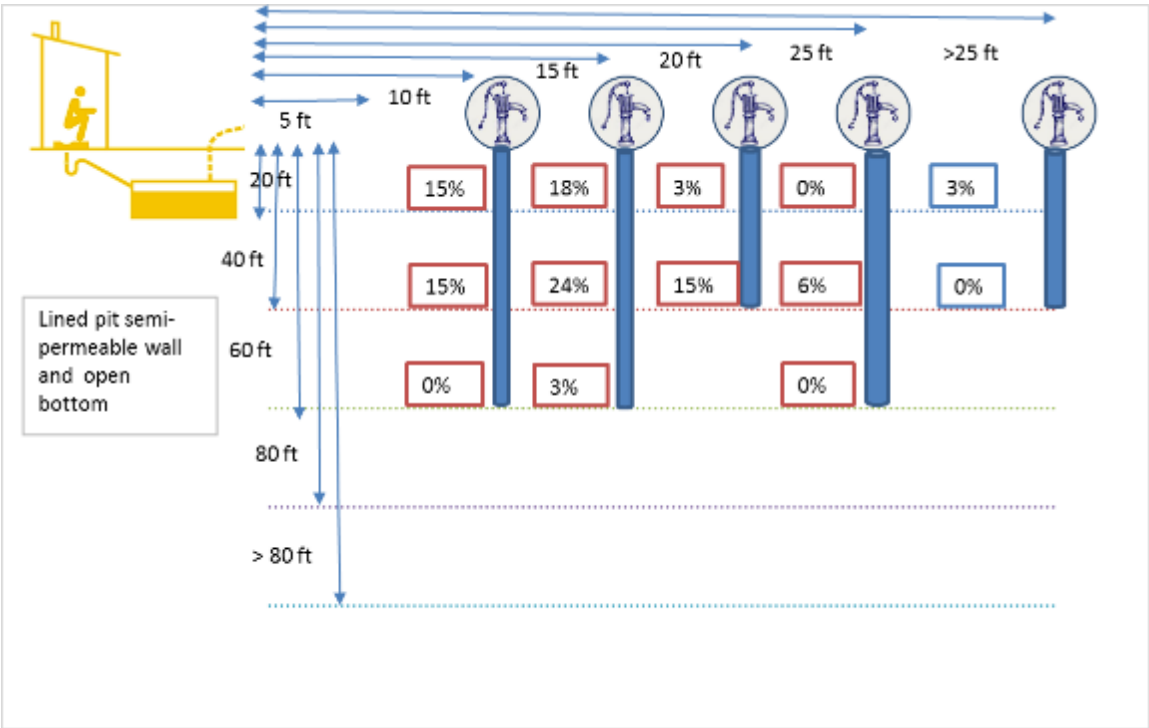


**Figure 13: Depth of hand pumps and lateral spacing of it with containment type lined the pit with semi-permeable wall and open bottom.**

### *3.2.3 Emptying of Faecal Sludge*

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

Both traditional manual scavenging and mechanical emptying of the containments are practised in the municipality. However, only 19.4% of containments have been emptied at least once since the installation. Among these, 34% of were mechanically emptied by desludging service providers. The types of sanitation technologies that have been emptied and the proportion of FS emptied is presented in Table 4.

**Table 4: Sanitation technologies and proportion of emptied faecal sludge.**

| S.N. | Sanitation Technologies | SFD Reference Variable | Percentage of Emptied containment | Emptied Proportion of FS | Actual Proportion of emptied FS (variable F3) |
|---|---|---|---|---|---|
| 1 | Septic tank connected to open drain or storm sewer | T1A2C6 | 0% | | 0% |
| 2 | Fully lined tank (sealed) no outlet or overflow | T1A3C10 | 79% | 90% | 71% |
| 3 | Lined tank with impermeable walls and open bottom, no outlet or overflow | T1A4C10 | 15% | 90% | 14% |
| 4 | Lined tank with impermeable walls and open bottom connected to an open drain or storm sewer | T1A4C6 | 0% | | 0% |
| 5 | Lined tank with impermeable walls and open bottom, connected to open ground | T1A4C8 | 24% | 90% | 22% |
| 6 | Lined pit with semi-permeable walls and open bottom, no outlet or overflow | T1A5C10 | 17% | 80% | 13% |
| 7 | Unlined pit, no outlet or overflow | T1A6C10 | 0% | | 0% |
| 8 | Containment (septic tanks, fully lined tanks, partially lined tanks and pits, and unlined pits) failed, damaged, collapsed or flooded –connected to water bodies, or open ground or “don’t know where” | T1B10C7 to C9 | 0% | | 0% |
| 9 | Open defecation | T1B11C7 To C9 | 2% | | |
| 10 | Lined tanked with impermeable walls and open bottom, no outlet or overflow, where there is a ‘significant risk’ of groundwater pollution | T2A4C10 | 17% | 90% | 15% |

| | | | | | |
|---|---|---|---|---|---|
| 11 | Lined tank with impermeable walls and open bottom connected to a soak pit, where there is a significant risk of groundwater pollution | T2A4C5 | 0% | | 0% |
| 12 | Lined pit with semi-permeable walls and open bottom, no outlet or overflow, where there is a significant risk of groundwater pollution | T2A5C10 | 37% | 80% | 29% |
| 13 | Unlined pit, no outlet or overflow, where there is a 'significant risk' of groundwater pollution | T2A6C10 | 50% | 80% | 40% |

The value for the emptied portion of FS (column 4 in Table 4) was obtained with reference to household survey and KIIs with desludging service providers. It was revealed in manual emptying practises that the tank was emptied completely. In mechanical emptying, the portion of FS emptied is determined by the amount of liquid present in the sludge and height of filter cap installed with suction hose to prevent blockages in it during pumping. Generally, lined tanks have higher volume of liquid (90% of FS), which is pumped out while in pits, due to high viscosity and lengthy-time for adding water and stirring, almost 25% to 30% is left in the containment. Thus, the portion of FS emptied from lined tank and pits were estimated 90% and 80%, respectively according to both mechanical and manual emptying practises.

### *3.2.4 Treatment and Disposal/Reuse*

The municipality does not have any forms of the treatment plant for faecal sludge. However, the percentage of population using anaerobic biogas digester in good condition were considered as the proportion of emptied FS delivered to treatment plant (F4). It was observed that only 75% of the anaerobic biogas digesters were properly maintained. Among these, 85% of the users utilized the treated slurry as soil conditioner or mixed in with compost pit before applying into farmland. Hence, the portion of the FS delivered to treatment which is treated (F5) is assumed at 85%. While the FS emptied and transported by the municipality is disposed in its landfill site which is extended approximately in 2,500 square meters located in the jungle, shown in Figure 14. The FS is dumped into open land and buried with solid waste collected from the municipality, shown in Figure 14.

**Figure 14: Disposal site of faecal sludge emptied and transported by municipality service.**

The private entrepreneur disposes of the FS in his own land as shown in Figure 15. The entrepreneur has developed pits where solids and liquids are separated. The liquid is pumped up and used for irrigation and solid left to dry. The dried sludge has been used as soil conditioner in his own farm. Figure 15 shows disposal pit, liquid and solid separation site and dried sludge cake.

**Figure 15: Disposal site of FS emptied by private service provider in Lamahi Municipality.**

## 3.3 SFD Graphic

Figure 16 shows the SFD graphic for Lamahi. It shows that, currently, 61% of faecal sludge is being safely managed. More accurately, 21% of faecal sludge has been safely managed in the household level anaerobic biogas digester where FS is treated and applied as a soil conditioner. 40% of faecal sludge accumulated in the containment ensures a safe level of protection from faeces that are not emptied and safely stored, i.e. pathogen transmission to the user or the general public is limited. However, a significant proportion of this safely managed sludge (almost half of it) comes from tanks and pits with semi-permeable walls and open bottom without outlet or overflow (T1A4C10 and T1A5C10) which are not emptied. Similarly, the other half comes from FS not emptied from fully lined tanks (T1A3C10). In the medium- to long-term use, as the population and population density increases, this practice would not be sustainable and improve sanitation management services may be required since those tanks eventually will require emptying services. Whereas, 16% of FS is emptied but disposed into environment without treatment. Another 16% of FS is not contained- not emptied and gets infiltrated into groundwater from technically inefficient containment such as unlined pits, damaged containment, lined tank or pit with open bottoms. Also, 2% of FS is being directly released into environment through open defecation.

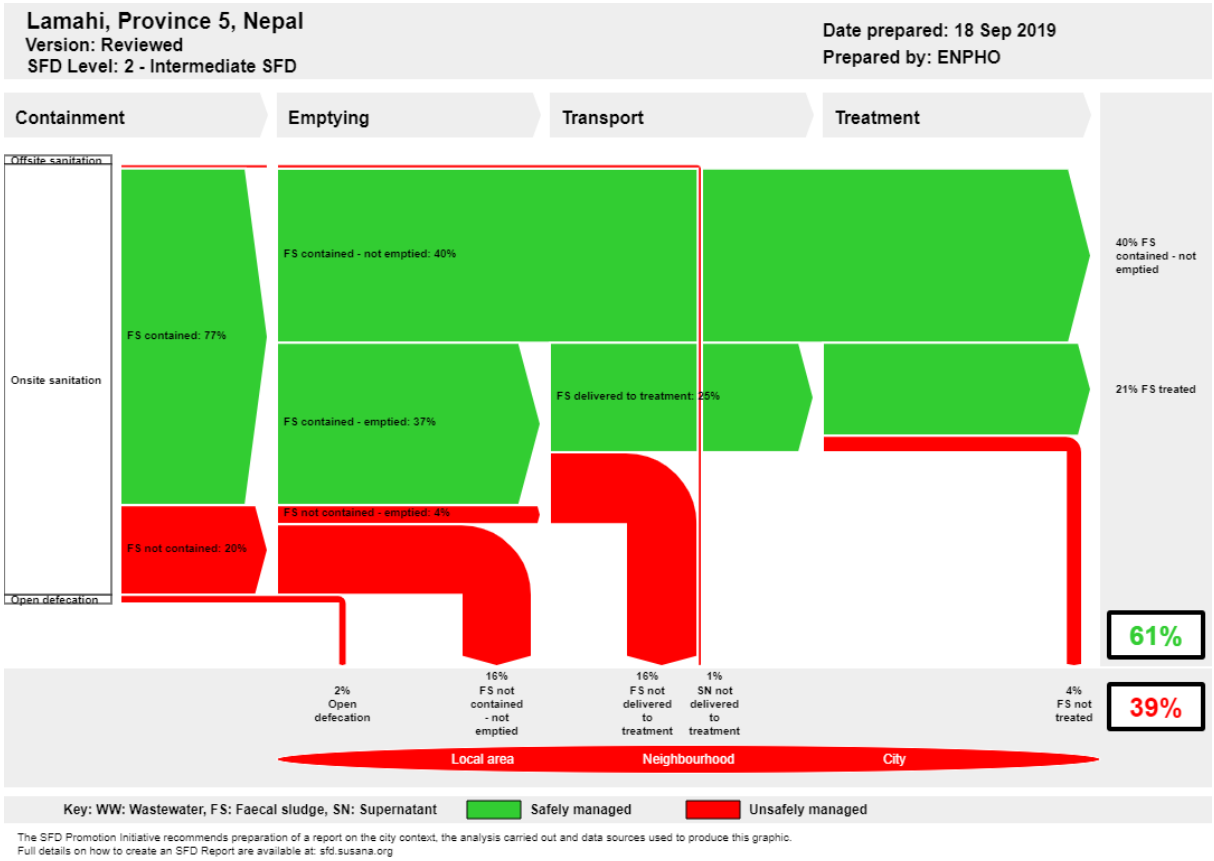


**Figure 16: SFD graphic of Lamahi Municipality.**

### Offsite Sanitation System

Nepal Demographic and Health Survey reported that 6.9% of the urban population in the country have offsite sanitation systems connected to piped sewer networks (MoH, Nepal, New ERA and ICF, 2017). However, no piped sewer networks have been developed in Lamahi Municipality. Thus, all the population have connected their household toilets in onsite sanitation system.

### Onsite Sanitation System

The population relying on onsite sanitation system is 98%. Among them, 77% are using technically effective containment that safely stores faeces and 21% with unsafe containment. The descriptions on flow of FS from the onsite sanitation system as shown in the SFD graphic is explained in Table 5.

**Table 5: Description of the percentages of the SFD graphic.**

| Variables | Description | Percent |
|---|---|---|
| FS contained not emptied | FS that is contained within an onsite sanitation technology and not removed where there is no significant risk to groundwater pollution. These containments are fully lined tanks (T1A3C10), lined tanks with impermeable walls and open bottom without outlet or overflow (T1A4C10), lined pit with semi-permeable walls and open bottom without outlet or overflow (T1A5C10) and unlined pits (T1A6C10) without significant risk to groundwater. | 40% |
| FS contained – emptied | FS that is contained in onsite sanitation technology and emptied either mechanically or manually. | 37% |
| FS delivered to a treatment | FS that is removed from onsite technology and delivered to the treatment plant. In this particular case, there is no FSTP and anaerobic biogas digester at household level is considered as the treatment facility. | 25% |
| FS not treated | FS delivered into treatment plant but not treated and disposed of haphazardly. | 4% |
| FS treated | FS treated in a well functioned anaerobic biogas digester | 20% |
| FS not contained | FS that is not contained within an onsite sanitation technology such as lined tanks, lined pits and unlined pits connected to an open environment where higher risk to groundwater pollution exists. | 20% |
| FS not contained emptied | FS that is removed from an onsite sanitation technology where FS is not contained which is emptied using either motorized or manual emptying equipment. | 4% |
| FS not contained – not emptied | FS that is not contained within an onsite sanitation technology and not removed which may either remain in the containment or infiltrate to ground polluting groundwater. | 16% |
| FS not delivered to the treatment | FS emptied from an onsite sanitation system either FS contained or not but not delivered to the treatment plant. | 16% |
| SN not delivered to the treatment | SN not contained from septic tanks connected to open drain or storm sewer. | 1% |

### Open Defecation

Despite declaring Open Defecation Free zone, approximately 2% of the population practised open defecation in the nearby jungles, rivers and open spaces.

# 4 Stakeholder Engagement

## 4.1 Key Informant Interviews

The KIIs and sharing of the objective of the study were conducted with the major stakeholders in sanitation sector in the municipality as shown in Figure 17. Mayor of the municipality and staffs from sanitation section of the municipality were interviewed on current sanitation services. Also, officers from Lamahi Small Town Water Supply and Sanitation Committee were interviewed focusing on sources of drinking water and their quality.

Also, sub-engineer from Lamahi Town Development Committee was interviewed to understand public toilets constructed in the bus park area. Finally, the proprietor of DN Septic Tank Cleaners was interviewed on emptying services in the municipality. The interview was mainly focused on their current service area, a number of emptying vehicles, its registration, service charges and challenges they faced in the business.

**Figure 17: Interview with municipal staff from sanitation section in Lamahi Municipality.**

## 4.2 Household Survey

A random household survey was conducted in all wards of the municipality through mobilization of volunteers selected by the municipality. The household survey was conducted using mobile application “KOBOCOLLECT” after orientation. Two days orientation training was conducted to make volunteer understand the objective of the survey, technical terms regarding sanitation, use of mobile application and conducting random sample survey as shown in Figure 18.

**Figure 18: Orientation program on household questionnaire survey to local volunteers.**

### *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 $n_o = \frac{Z^2pq}{e^2}$ and its finite population correction for the proportion $n = \frac{n_0}{1+\frac{(n_0-1)}{N}}$.

Where,

| | | |
|---|---|---|
| $Z^2$ | 1.96 | At the confidence level of 95%. |
| p | 0.5 | Assuming that about 50% of the population should have some sanitation characteristics that need to be studied (this was set at 50% since this percentage would yield the maximum sample size since the percentage of the population practising some form of sanitation is not clearly 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

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

Thus, a total of 375 households were sampled from 9,432 households distributed in 9 wards with proportionate stratification random sampling as shown in Appendix 6.

### *4.2.2 Direct Observation*

Various sanitation technologies in the households in all the wards were observed and visual references were kept. Also, observation of the emptying and transportation of the containments was carried out. The disposal site of both the municipality and private entrepreneur was observed during the usage.

### *4.2.3 Sharing and Validation of Data*

The sharing and validation of findings on sanitation status were conducted in the municipality hall participated by the mayor, ward chairpersons, general members of municipal council and other relevant stakeholders, shown in Figure 19. The participants responded that the findings of this study reflected the current sanitation situation of the municipality. The program was also participated by executive director of a Municipal Association Nepal (MuAN) and suggested to develop FSM plan and effectively implement it in order to provide sustainable sanitation services in the municipality. The list of participants with their designation is attached in Appendix 8.

**Figure 19: Sharing and validation of findings of a household survey in Lamahi Municipality.**

# 5 Acknowledgements

We would like to acknowledge United Cities Local Government - Asia Pacific (UCLG ASPAC) for funding the Municipalities Network Advocacy on Sanitation in South Asia (MuNASS) and Municipal Association of Nepal (MuAN) for coordination with the municipality.

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# 7 Appendix

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

**Table 6: Roles and responsibilities 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: Number of Institutions in the survey

**Table 7: Number of the surveyed institution.**

| Ward | Financial Institutions | Hotel/ Home Stay | Commercial Buildings | Educational Institutions | Government /Non-government Office | Community Buildings | Health Care Centre | Total |
|---|---|---|---|---|---|---|---|---|
| **1** | 1 | | | 1 | 1 | | | 3 |
| **2** | | | | 5 | 1 | | 2 | 8 |
| **3** | | | | 9 | 1 | | | 10 |
| **4** | | 1 | | | 3 | | | 4 |
| **5** | 11 | 17 | 5 | 3 | 7 | | 2 | 45 |
| **6** | | | 1 | 2 | | | | 3 |
| **7** | | | | 4 | | 1 | | 5 |
| **8** | | | | 3 | 1 | | | 4 |
| **9** | | | | 3 | | | | 3 |
| **Total** | 12 | 18 | 6 | 30 | 14 | 1 | 4 | 85 |

## 7.3 Appendix 3: Description of Public Toilet in the Bus Park

**Table 8: Description on a public toilet in the bus park.**

| Public Toilet | No. of Urinals | No. of a toilet seat | | The average number of users per day | Containment Size ($m^3$) |
|---|---|---|---|---|---|
| | | Male | Female | | |
| **Public Toilet A** | 6 | 5 | 3 | 600 | 36 |
| **Public Toilet B** | 4 | 3 | 3 | 200 | 12 |
| **Public toilet C** | No | 1 | 1 | 120 | 12 |

**Source: (KII4, 2019)**

## 7.4 Appendix 4: Stakeholder identification

**Table 9: Stakeholder Identification.**

| S.N. | Stakeholder group | In Lamahi Municipality context |
|---|---|---|
| 1 | Municipal Council | Municipal Council, Lamahi Municipality |
| 2 | Ministry in charge of water supply and sanitation | Department of Water Supply and Sewerage Management |
| 3 | Ministry in charge of environmental protection | Department of Environment |
| 4 | Service provider for solid waste management | Sanitation Section of Lamahi Municipality |
| 5 | Service provider for construction of onsite sanitation | Local masons |
| 6 | Service providers for emptying and transportation | Sanitation section of Lamahi Municipality, Private mechanized emptying service entrepreneurs |
| 7 | Service provider for operation and maintenance of treatment infrastructure | N/A |
| 8 | Market participants practising end-use of FS end products | N/A |
| 9 | Service provider for disposal of FS (sanitary landfill) | Sanitation section of Lamahi Municipality, Private mechanized emptying service entrepreneurs |
| 10 | External agencies associated with FSM services | Municipal Association Nepal,<br>Environment and Public Health Organization |

## 7.5 Appendix 5: Tracking of Engagement

**Table 10: Tracking of Stakeholder engagement.**

| S.N. | Name of Organization | Person | Designation | Date of Engagement | Purpose of Engagement |
|---|---|---|---|---|---|
| 1 | Lamahi Municipality | Kul Bahadur K.C. | Mayor | 18 April 2019 | KII (1) |
| 2 | Sanitation Section, Lamahi Municipality | Kuleshwor Chaudary | Officer | 18 April 2019 | KII (2) |
| 3 | Lamahi Water Supply and Sanitation User's Committee | Bhagwati Prashad Chaudhary | Secretary | 23 April 2019 | KII (3) |
| | | Jang Bahadur Chaudhary | Treasurer | | |
| 4 | Lamahi Town Development Committee | Tulsi Ram Aryal | Sub-engineer | 24 April 2019 | KII (4) |
| 5 | DN Septic Tank Cleaners | Dulam Das Chaudhary | Proprietor | 24 April 2019 | KII (5) |
| 6 | Lamahi Municipality | Rup Narayan Chaudhary | Senior AHW Officer | 19 April 2019 | Household survey |
| 7 | Lamahi Municipality | | Local Volunteers | 19 to 24 April 2019 | Household survey |

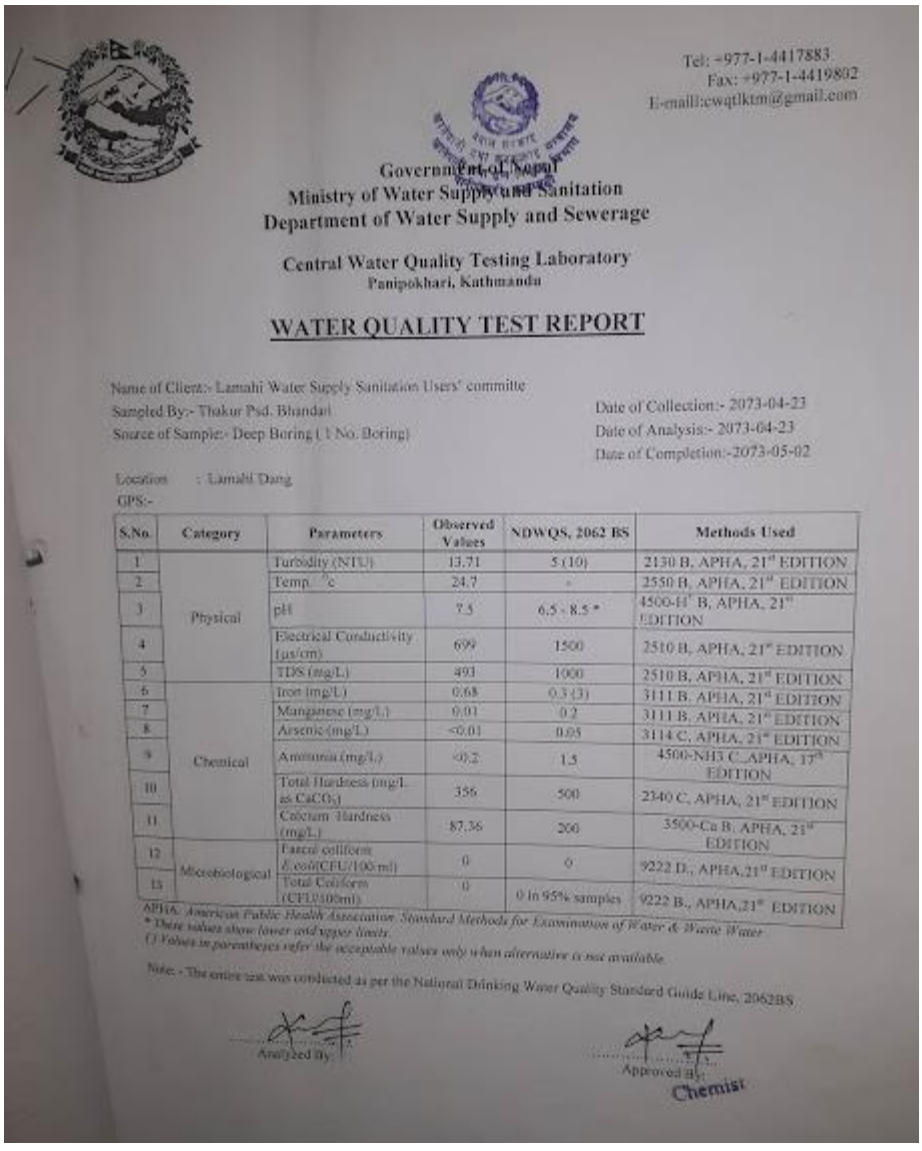
## 7.6 Appendix 6: Number of household in each ward and sampled number of household

**Table 11: Number of total household in each ward and sampled households.**

| Ward | Households | Sample |
|---|---|---|
| 1 | 984 | 39 |
| 2 | 1,032 | 41 |
| 3 | 1,257 | 50 |
| 4 | 991 | 39 |
| 5 | 1,644 | 65 |
| 6 | 1,023 | 41 |
| 7 | 927 | 37 |
| 8 | 882 | 35 |
| 9 | 692 | 28 |
| Total | | 375 |

## 7.7 Appendix 7: Water Quality Report from Lamahi Water Supply and Sanitation User's Committee

**Figure 20: Water quality report of the source (deep well water).**



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Government of Nepal
Ministry of Water Supply and Sanitation
Department of Water Supply and Sewerage

Central Water Quality Testing Laboratory
Panipokhari, Kathmandu

WATER QUALITY TEST REPORT

Name of Client:- Lamahi Water Supply Sanitation Users' committe
Sampled By:- Thakur Psd. Bhandari
Source of Sample:- Deep Boring (1 No. Boring)

Date of Collection:- 2073-04-23
Date of Analysis:- 2073-04-23
Date of Completion:-2073-05-02

Location : Lamahi Dang
GPS:-

| S.No. | Category | Parameters | Observed Values | NDWQS, 2062 BS | Methods Used |
|---|---|---|---|---|---|
| 1 | Physical | Turbidity (NTU) | 13.71 | 5 (10) | 2130 B, APHA, 21st EDITION |
| 2 | | Temp. °c | 24.7 | - | 2550 B, APHA, 21st EDITION |
| 3 | | pH | 7.5 | 6.5 - 8.5 * | 4500-H+ B, APHA, 21st EDITION |
| 4 | | Electrical Conductivity (µs/cm) | 699 | 1500 | 2510 B, APHA, 21st EDITION |
| 5 | | TDS (mg/L) | 493 | 1000 | 2510 B, APHA, 21st EDITION |
| 6 | Chemical | Iron (mg/L) | 0.68 | 0.3 (3) | 3111 B, APHA, 21st EDITION |
| 7 | | Manganese (mg/L) | 0.01 | 0.2 | 3111 B, APHA, 21st EDITION |
| 8 | | Arsenic (mg/L) | <0.01 | 0.05 | 3114 C, APHA, 21st EDITION |
| 9 | | Ammonia (mg/L) | <0.2 | 1.5 | 4500-NH3 C, APHA, 17th EDITION |
| 10 | | Total Hardness (mg/L as $CaCO_3$) | 356 | 500 | 2340 C, APHA, 21st EDITION |
| 11 | | Calcium Hardness (mg/L) | 87.36 | 200 | 3500-Ca B, APHA, 21st EDITION |
| 12 | Microbiological | Faecal coliform /t.coli(CFU/100 ml) | 0 | 0 | 9222 D., APHA,21st EDITION |
| 13 | | Total Coliform (CFU/100ml) | 0 | 0 in 95% samples | 9222 B., APHA,21st EDITION |

APHA: American Public Health Association Standard Methods for Examination of Water & Waste Water
* These values show lower and upper limits.
() Values in parentheses refer the acceptable values only when alternative is not available

Note: - The entire test was conducted as per the National Drinking Water Quality Standard Guide Line, 2062BS

Analyzed By:

Approved By:
Chemist

**Figure 21: Water quality report of the reservoir tank.**

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Department of Water Supply and Sewerage

Central Water Quality Testing Laboratory
Panipokhari, Kathmandu

WATER QUALITY TEST REPORT

Name of Client:- Lamahi Water Supply Sanitation Users' committe
Sampled By:- Thaker Pd. Bhandari
Source of Sample:- RVT

Date of Collection:- 2073-04-23
Date of Analysis:- 2073-04-23
Date of Completion:-2073-05-02

Location : Lamahi Dang
GPS:-

| S.No. | Category | Parameters | Observed Values | NDWQS, 2062 BS | Methods Used |
|---|---|---|---|---|---|
| 1 | Physical | Turbidity (NTU) | 2.56 | 5 (10) | 2130 B, APHA, 21st EDITION |
| 2 | | Temp. °c | 24.9 | - | 2550 B, APHA, 21st EDITION |
| 3 | | pH | 7.5 | 6.5 - 8.5 * | 4500-H+ B, APHA, 21st EDITION |
| 4 | | Electrical Conductivity (µs/cm) | 674 | 1500 | 2510 B, APHA, 21st EDITION |
| 5 | | TDS (mg/L) | 438 | 1000 | 2510 B, APHA, 21st EDITION |
| 6 | Chemical | Iron (mg/L) | 0.36 | 0.3 (3) | 3111 B, APHA, 21st EDITION |
| 7 | | Manganese (mg/L) | 0.02 | 0.2 | 3111 B, APHA, 21st EDITION |
| 8 | | Arsenic (mg/L) | - | 0.05 | 3114 C, APHA, 21st EDITION |
| 9 | | Ammonia (mg/L) | <0.2 | 1.5 | 4500-NH3 C, APHA, 19th EDITION |
| 10 | | Total Hardness (mg/L as $CaCO_3$) | 274 | 500 | 2340 C, APHA, 21st EDITION |
| 11 | | Calcium Hardness (mg/L) | 72.12 | 200 | 3500-Ca B, APHA, 21st EDITION |
| 12 | Microbiological | Faecal coliform E.coli(CFU/100 ml) | 0 | 0 | 9222 D., APHA,21st EDITION |
| 13 | | Total Coliform (CFU/100ml) | 0 | 0 in 95% samples | 9222 B., APHA,21st EDITION |

APHA: American Public Health Association, Standard Methods for Examination of Water & Waste Water
* These values show lower and upper limits
( ) Values in parentheses refer the acceptable values only when alternative is not available

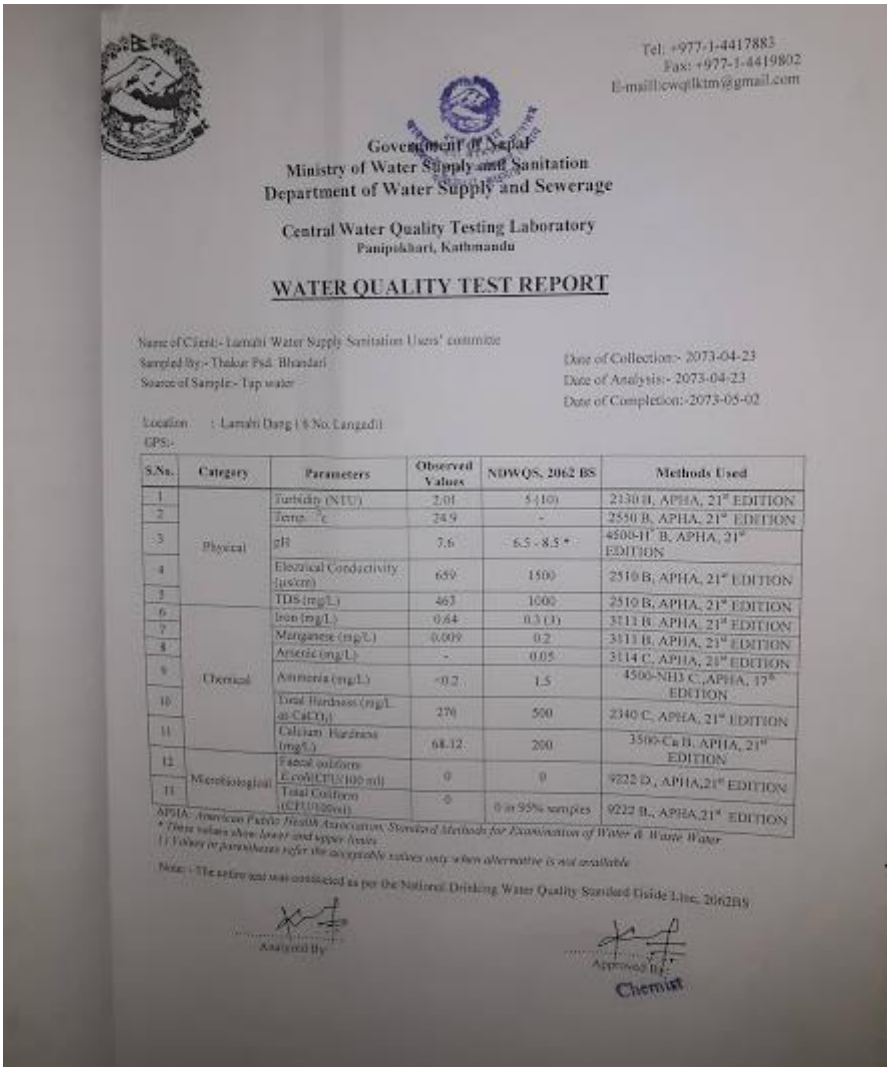
Note: - The testing was conducted as per the National Drinking Water Quality Standard Guide Line, 2062BS

Analysed By:

Approved By:

Chemist

**Figure 22: Water quality report of tap water.**



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Government of Nepal
Ministry of Water Supply and Sanitation
Department of Water Supply and Sewerage

Central Water Quality Testing Laboratory
Panipokhari, Kathmandu

WATER QUALITY TEST REPORT

Name of Client:- Lamahi Water Supply Sanitation Users' committe
Sampled By:- Thakur Pd. Bhandari
Source of Sample:- Tap water

Date of Collection:- 2073-04-23
Date of Analysis:- 2073-04-23
Date of Completion:-2073-05-02

Location : Lamahi Darg ( 8 No. Langadi)
GPS:-

| S.No. | Category | Parameters | Observed Values | NDWQS, 2062 BS | Methods Used |
|---|---|---|---|---|---|
| 1 | Physical | Turbidity (NTU) | 2.01 | 5 (10) | 2130 B, APHA, 21st EDITION |
| 2 | | Temp. °c | 24.9 | - | 2550 B, APHA, 21st EDITION |
| 3 | | pH | 7.6 | 6.5 - 8.5 * | 4500-H+ B, APHA, 21st EDITION |
| 4 | | Electrical Conductivity (µs/cm) | 659 | 1500 | 2510 B, APHA, 21st EDITION |
| 5 | | TDS (mg/L) | 463 | 1000 | 2510 B, APHA, 21st EDITION |
| 6 | Chemical | Iron (mg/L) | 0.64 | 0.3 (3) | 3111 B, APHA, 21st EDITION |
| 7 | | Manganese (mg/L) | 0.009 | 0.2 | 3111 B, APHA, 21st EDITION |
| 8 | | Arsenic (mg/L) | - | 0.05 | 3114 C, APHA, 21st EDITION |
| 9 | | Ammonia (mg/L) | <0.2 | 1.5 | 4500-NH3 C, APHA, 17th EDITION |
| 10 | | Total Hardness (mg/L as $CaCO_3$) | 270 | 500 | 2340 C, APHA, 21st EDITION |
| 11 | | Calcium Hardness (mg/L) | 68.12 | 200 | 3500-Ca B, APHA, 21st EDITION |
| 12 | Microbiological | Faecal coliform E.coli/CFU/100 ml | 0 | 0 | 9222 D, APHA,21st EDITION |
| 13 | | Total Coliform (CFU/100ml) | 0 | 0 in 95% samples | 9222 B, APHA,21st EDITION |

APHA : American Public Health Association, Standard Methods for Examination of Water & Waste Water
* These values show lower and upper limits
( ) Values in parentheses refer the acceptable values only when alternative is not available

Note: - The entire test was conducted as per the National Drinking Water Quality Standard Guide Line, 2062BS

Analyzed By

Approved By
Chemist

## 7.8 Appendix 8: List of Participants in Sharing and Validation of findings

| S.N. | Name | Organization | Designation |
|---|---|---|---|
| 1 | Kul Bahadur KC | Lamahi Municipality | Mayor |
| 2 | Kalanidhi Devkota | MuAN | Executive Director |
| 3 | Gahendra Bahadur Dangi | Lamahi Municipality | Chief Administrative Officer |
| 4 | Bam Bahadur Bisokarma | Lamahi Municipal Council | General Member |
| 5 | Bhagabati Basnet | Lamahi Municipal Council | General Member |
| 6 | Rabindra Kshetri | Lamahi Municipality | Officer Level IX |
| 7 | Shanta Sharma | Lamahi Municipality | Assistant Officer |
| 8 | TIrtha Raj Poudel | Lamahi Muncipal Council | General Member |
| 9 | Num Raj Poudel | Lamahi Municipality | Ward Chairperson |
| 10 | Nepabu Chaudhary | Lamahi Municipality | Ward Chairperson |
| 11 | Ramesh Kumal | Lamahi Muncipal Council | General Member |
| 12 | Thage Nepali | Lamahi Muncipal Council | General Member |
| 13 | Pushpa Raj Adhikari | Lamahi Municipality | |
| 14 | Ganga Kumari Chaudhary | Lamahi Muncipal Council | General Member |
| 15 | Narendra Kumar Gupta | Lamahi Municipality | ITO |
| 16 | Ramesh Chand | Lamahi Municipality | Computer Operator |
| 17 | Amar Kumar Chaudhary | Lamahi Municipality | Officer |
| 18 | Ram Bhajan Chaudhary | Lamahi Municipality | Officer |
| 19 | Krishna B. Khatri | Lamahi Municipal Council | General Member |
| 20 | Anita Chaudary | Lamahi Municipal Council | General Member |
| 21 | Narayan Khadka | Lamahi Municipal Council | General Member |
| 22 | Gayatri Thapa | Lamahi Municipality | AHW |
| 23 | Rup Narayan Chaudahry | Lamahi Municipality | Focal Person , MUNASS project |
| 24 | Jagam Shrestha | ENPHO | SWO |
| 25 | Buddha Bajracharya | ENPHO | PC |

**Figure 23: Attendance sheet of sharing program in Lamahi Municipality.**