Itahari Sub-Metropolitan City Strategy (CWIS)

Green City-Wide Inclusive Sanitation Strategy (CWIS)

2022

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Glossary and Abbreviations

CWIS	Citywide Inclusive Sanitation
FSTP	Faecal Sludge Treatment Plant
GHG	Greenhouse Gases
IMIS	Integrated Municipal Information System
ISMC	Itahari Sub-Metropolitan City
OSS	On-site sanitation systems. Example Septic Tanks, Pit Latrines
SDG	Sustainbale Development Goals
IWA	International Water Association
EDM	Environment and Disaster Management
SWM	Solid Waste Management
FSM	Faecal Sludge Management
CSDA	City Santiation Service Delivery Assessment
FS	Faecal Sludge
W2E	Waste to Energy
FIs	Financial Institutions
IRF	Institutional and Regulatory Framework
MOWS	Ministry of Water Supply
DWSSM	Department of Water Supply and Sewerage Management
WUSC	Water Users and Sanitation Committee
DRR	Disaster Risk Reduction
IEE	Initial Environmental Examination
EIA	Environment Impact Assessment
WHO	World Health Organization
IPPC	Intergovernmental Panel on Climate Change
CDD	Consecutive Dry Days
CWD	Consecutive Wet Days
PT	Public Toilets
ENPHO	Enivronment and Public Health Organization
SFD	Shit Flow Diagram
FGD	Focus Group Discussion
UN	United Nation
UNFCCC	United Nation Framework Convention on Climate Change
CDM	Clean Development Mechanism
TPD	Tons per Day
C&T	Collection & Transport

1. Background

The Citywide Inclusive Sanitation (CWIS) is a new concept in urban sanitation. The approach, framework is evolving following field level validation, learnings and feedback. The CWIS goal envisions that "everyone in a city benefit from equitable, safely managed sanitation services, by an authority mandated, accountable and supported to ensure services are delivered irrespective of the technologies or business models used to reach service targets" (Schrecongost et al., 2020).

CWIS is a public service approach to planning and implementing urban sanitation systems with a focus on achieving inclusive outcomes, as summarized by Sustainable Development Goal (SDG) 6. The CWIS service framework includes the core outcome and functions as shown in the table below.

CORE CWIS OUTCOMES	**EQUITY**	**SAFETY**	**SUSTAINABILITY**
	Services reflect fairness in distribution and prioritization of service quality, prices, deployment of public finance/ subsidies	Services safeguard customers, workers and communities from safety and health risks by reaching *everyone* with safe sanitation	Services are reliably and continually delivered based on effective management of human, financial and natural resources
CORE CWIS FUNCTIONS	**RESPONSIBILITY**	**ACCOUNTABILITY**	**RESOURCE PLANNING AND MANAGEMENT**
	Authority(s) execute a clear public mandate to ensure safe, equitable and sustainable, sanitation services for all	Authority's(ies') performance against its mandate is monitored and managed with data, transparency, and incentives	Resources–human, financial, natural, assets–are effectively managed to support execution of mandate across time/space

Source: Schrecongost (2019), IWA Development Congress

To achieve the national targets for sanitation, SDGs and to support safe, healthy urban living environments, sanitation services must be organized into public service systems. CWIS systems are expected to advance the outcomes of safe, equitable, and sustainable services for all users in a city. To achieve these outcomes at scale, the inherent failures associated with sanitation service markets must be corrected by publicly organized sanitation service systems. For systems to function safely, at scale, over time, and inclusively, they must be organized to support three functions: responsibility, accountability, and resource planning and management.

The CWIS principles states that:

- Everyone benefits from safe services and public investment equitably, with a focus on reaching the poorest
- Gender and social equity are designed into planning, management, monitoring
- Human waste is safely managed along the sanitation chain, starting with containment
- Authorities operate with a clear, inclusive mandate, performance targets, resources, and accountability
- Authorities deploy range of hardware, funding and business models to meet goals
- Comprehensive long-term planning fosters innovation, pro-poor financing; informed by analysis of needs, resources
- Political will and accountability incentivize improvements in capacity, leadership, outcomes

1.1 Objective

The overall objective of this report is to support Itahari sub-metropolitan city (ISMC) to develop a Green CWIS strategy document. The document is viewed as strategic document with to guide municipality to develop detailed sanitation plan and decide on green sanitation sector projects.

1.2 Scope of Work

The scope of work was divided into two parts, the first involved understanding of the existing sanitation situation including analysis of the financial status and municipal capacity gaps to undertake CWIS. The second part involved development of CWIS improvement strategies, through engagements with the municipal team and experts.

This document is high level strategic document. The detailed level planning for the sanitation projects is beyond the scope of this document.

2. ISMC Overview

Itahari Sub-Metropolitan City (ISMC) lies in Sunsari District in Province 1 and is the largest city, 93.78 km2) in the district. The administrative jurisdiction of Itahari Sub-Metropolitan City (ISMC) is 93.78 sq. km. The city is surrounded by the Morang district in the east, Ramdhuni Municipality in the west, Dharan sub-metropolitan city in the north and Duhavi Municipality in the south. The city is divided into 20 wards, housing a total population of 140,517 (Census 2011). As per the preliminary census report, Itahari has an estimated city population of 1,98,098 (CBS, 2021). ISMC is one of the fastest growing cities of Eastern Nepal (Wikipedia).

The city has 20 administrative wards out of which eight wards are identified as core wards and urban in nature, eight are semi-urban and identified as outer while rest are identified as rural wards as seen in Figure 1.

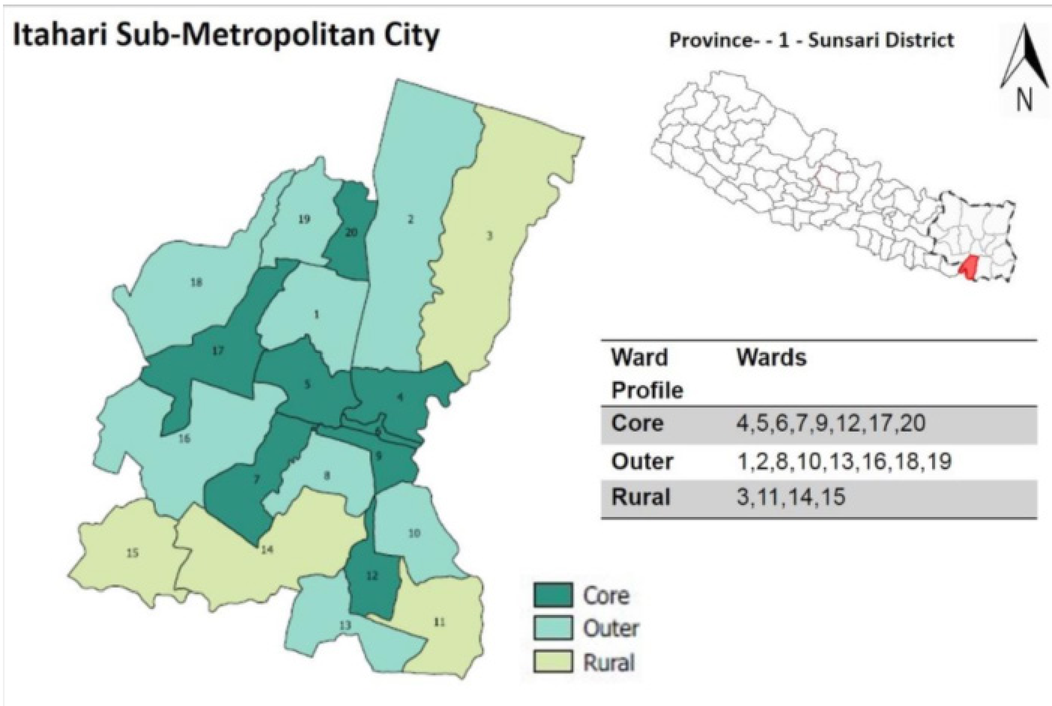


Figure 1 Itahari Sub-Metropolitan City
Source: World Bank (2020)

2.1 Demographic status

As per 2011 census survey the average family size of ISMC is 4.15. A study conducted in 2017 shows the average family size of 4.87. The household's main source of income was found to be business (27%) followed by private services (22%) and agriculture (18%) (ENPHO, 2017).

2.2 Land use pattern

The land use pattern of ISMC shows that most parts of the sub-metropolis is covered by agricultural area (54.9%) followed by residential (22.5%) and forest cover (12.9%). The current land use map is provided in Annex 1. A comparison of the land use map over the past two decades shows a significant increase in the residential areas. While, the forest cover has remained the same, agricultural area has been used up for residential purposes as observed from the recent land use map presented in Annex 2.

3. Institutional arrangement

The city assembly and executive council are headed by the mayor and deputy mayor and are the decision-making body. Various committees are formed under them and work under the city assembly or executive council for solid waste management. The sub-metropolitan has nine functional branches, environment and disaster management unit is further divided into sub-branches as shown in Figure 2.

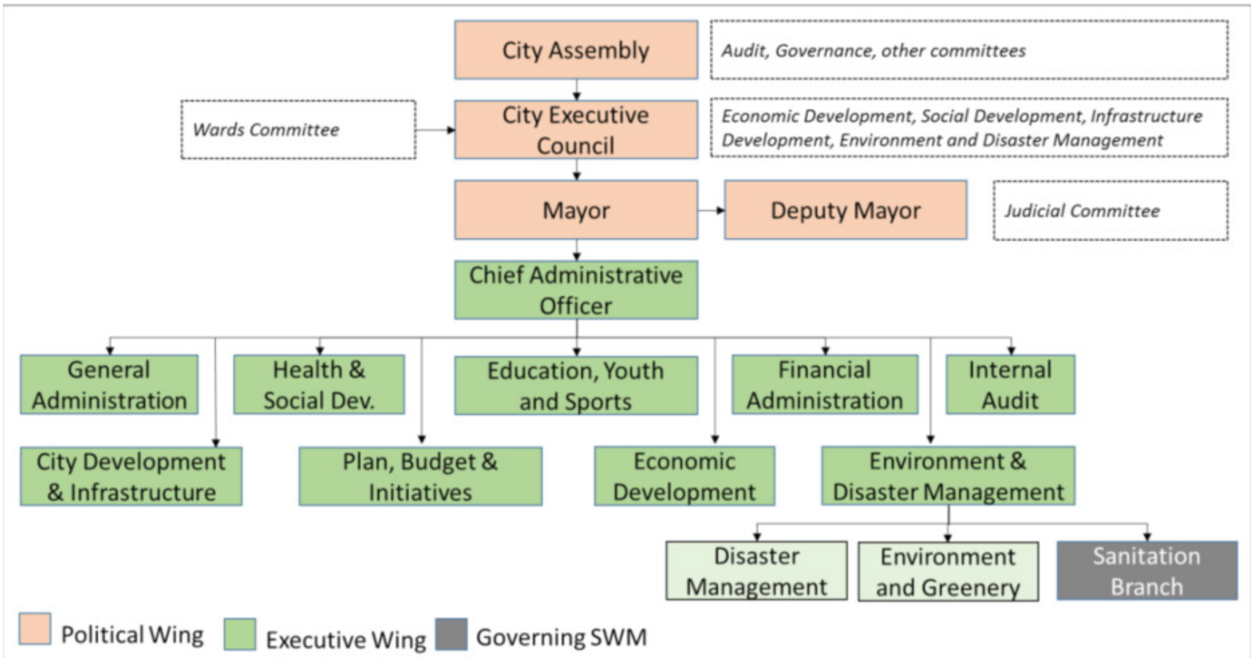


Figure 2 Organizational structure ISMC

The environment and disaster management (EDM) is responsible for sanitation and disaster management. As per the organizational structure, there are 12 staffs allocated for this unit. Within the EDM, there are three sub section mainly the Environment and Greenery Section, Solid waste Management Section and the Disaster Management Section as shown in the Figure 3.

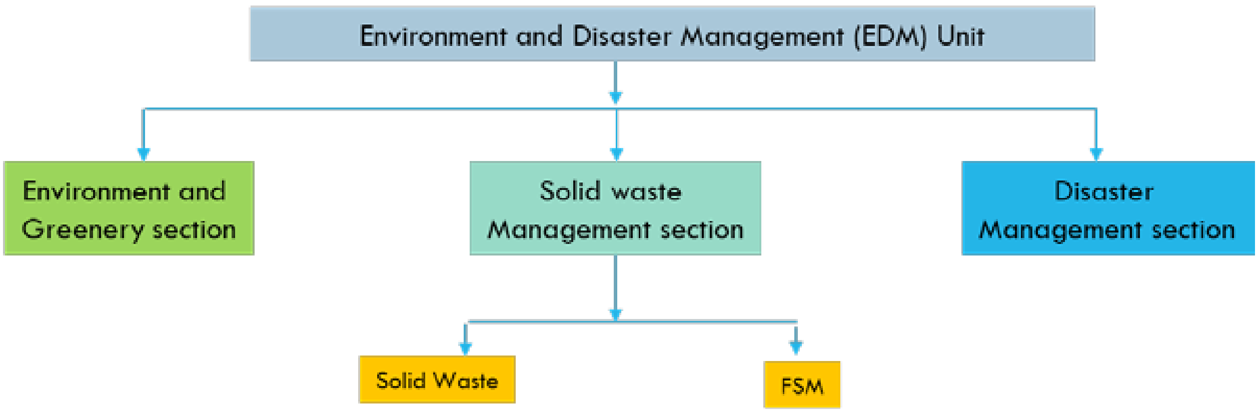


Figure 3: ISMC Institutional Arrangement for Sanitation

The SWM section is responsible for management of both solid waste and faecal sludge management (FSM) in the city. Within EDM, there are currently five staffs assigned while 3 are actually working mainly the unit Head/SWM in charge, an Environmental Engineer and an Environmental Inspector.

3.1 Sanitation service delivery framework

A City Sanitation Service Delivery Assessment (CSDA) carried out for ISMC based on a desk review and consultation with officials of EDM unit. The CSDA looks into three different pillars to assess sanitation service delivery of a given city mainly the Enabling, Delivering and the Sustaining pillars. The Enabling pillar assess the policy, legal and institutional environment. Delivering pillar looks into the resources and mechanisms available to improve sanitation. Finally, the Sustaining pillar, assesses the operating environment, funding and personnel needed to provide ongoing and sustainable sanitation services.

CSDA Full Assessment

City name Itahari ITSMC

Date 01-Jun-2021

Sewered sanitation

	WC, house connection	Sewerage	Sewage treatment & reuse
Enabling			
Policy, legislation	0.0	0.0	0.0
Planning, budgeting	0.3	0.0	0.0
Inclusion	0.0	0.0	
Delivering			
Funding	0.0	0.0	0.0
Capacity, outreach	0.0	0.0	0.0
Inclusion	0.0	0.0	
Sustaining			
Regulation, cost recovery	0.0	0.0	0.0
Institutions, service providers	0.0	0.0	0.0
Inclusion	0.2	0.2	

Non-sewered sanitation

	Toilet, pit or septic tank	Emptying & transport	Sludge treatment & reuse
Enabling			
Policy, legislation	0.3	0.2	0.0
Planning, budgeting	0.0	0.0	0.0
Inclusion	0.0	0.0	
Delivering			
Funding	0.0	0.0	0.0
Capacity, outreach	0.0	0.3	0.0
Inclusion	0.0	0.0	
Sustaining			
Regulation, cost recovery	0.2	0.3	0.0
Institutions, service providers	0.0	0.0	0.0
Inclusion	0.2	0.2	

Each pillar is composed of three building blocks, of which one focuses on inclusion. Each building block, in turn, is composed of between one and four indicators, or specific questions, which are each assigned a score during the assessment process. Separate assessments are made for each of the three steps in the service chain. The tool calculates a mean value for each step of the service chain in each building block and presents it in traffic light form – green for satisfactory, yellow for improving, and red for poor (Blackett and Hawkins, 2020).

The CSDA shows that almost all indicators with reference to the Enabling, Delivering and Sustaining pillars for both sewered and non-sewered sanitation is marked in red. This indicates that most of these conditions are not currently not fulfilled or enabling for citywide inclusive sanitation service delivery. There is a clear need to improve all the pillars for delivering citywide inclusive sanitation services.

3.2 Budget allocations

Analysis of the past fiscal year budget allocations (2077/78) showed that only NPR 1,49,99,450 ($130,430) was allocated for the EDM unit which was less than 1% of the total budget ($15.4 million) allocated. A major percentage of the budget was allocated for physical infrastructure development. Environment and sanitation sectors fell under least priority. In terms of the source of the budget, almost 50% was sourced in from federal grants while only 21% was projected through local income sources (Figure 4).

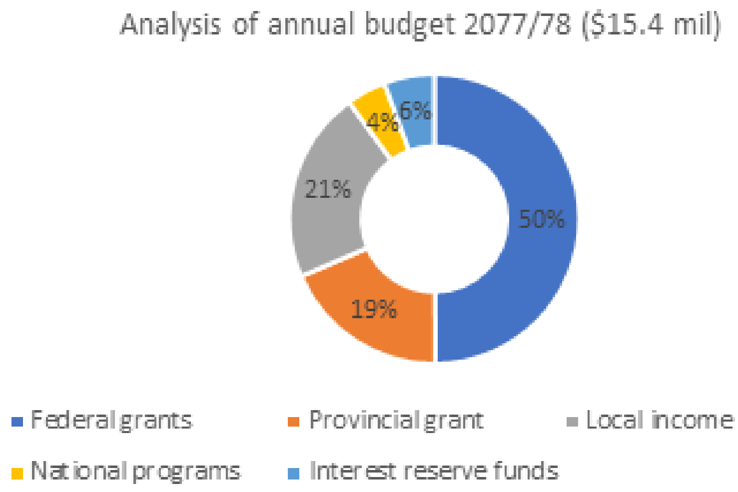


Figure 4: Analysis of annual budget 2077/78 of ISMC

3.3 Local Stakeholders

Table 1 provides a list of key stakeholders with their roles and responsibilities with reference to development of the CWIS strategy for ISMC.

Table 1: Key stakeholders, their roles and responsibilities

Key Stakeholders	Expected roles and responsibilities
Municipality	• Lead the CWIS strategy development process • Provide inputs and relevant information of the municipality • Coordinate with relevant stakeholders as part of developing the strategy • Agree to invest in creating a database system for CWIS implementation • Define appropriate sanitation bylaws at the municipal level • Develop a licensing mechanism to regulate faecal sludge (FS) entrepreneurs • Mobilize local resources as required for sanitation improvement especially for vulnerable areas
Ward level representatives	• Support to organize ward level interactions • Support to identify and prioritize local level sanitation needs • Provide inputs for sanitation improvement options • Support to identify monitoring and compliance mechanism
FS entrepreneurs	• Provide relevant information with reference to existing practices across the sanitation service chain • Strategic inputs on defining FSM service model • Register with the municipality to operate FSM services • Organize between entrepreneurs to deliver FSM services
Enviro Care Concern Pvt. Ltd (SWM company)	• Provide relevant information with respect to existing solid waste management service delivery including waste production, collection and disposal • Provide inputs to define a sustainable FSM service model • Readiness to explore pilot treatment of FS including co-digestion of FS in the W2E plant
Household/ Communities	• Define sanitation priorities in the communities/settlement • Identify options and strategies to improve sanitation status especially containment upgradation • Inputs to define community awareness and mobilization strategy • Support to identify poor and vulnerable areas
Community based groups	• Support to define sanitation awareness and mobilization mechanism • Take up potential roles to engage with communities during CWIS implementation
Local farmers	• Identify possibilities of using treated FS • Willingness to trial out application of treated FS with potentials of scaling up
Financing institutions (FIs)	• Provide information on the type of loans for households • Explore options to mobilize funds for sanitation system improvement at a reduced interest rate targeting the poor and vulnerable households

4. Policies and regulatory framework

This section provides an overview of the relevant policies and the regulatory framework with reference to the sanitation governance of the sub-metropolis.

4.1 Institutional Regulatory Framework for FSM (2017)

The Institutional and Regulatory Framework (IRF) for FSM in Urban areas of Nepal (2017) mandates the Local Bodies such as ISMC as key agency responsible for FSM services within their jurisdiction, including planning, implementation, monitoring and development and application of business model for service delivery (MoWS, 2017). The Local Bodies may seek:

- Technical and management support from the Department of Water Supply and Sewerage Management (DWSSM), Ministry of Water Supply and Sanitation
- Seek local governance support from the Ministry of Local Development and Federal Affairs;
- Engage Water Users and Sanitation Committee (WUSC) for the operation and management of FSM service chain until Local Bodies have institutional and management capacity; and
- Outsource to a licensed private FSM entrepreneur for the collection, transport, treatment and end use based on Article 116 of Local Self-Governance Act

The IRF has clearly outlined the role of the different stakeholders with reference to FSM. ISMC so far does not have a policy and FSM by laws at hand.

4.2 Land Use and Land Management Act, 2077

As per the land Use and Land Management Act 2077 of ISMC, there are nine distinguished categories of land use mainly residential areas, agricultural areas, industrial areas, commercial areas, forests, river and lakes, areas for public use, cultural heritage sites, and land designated by the federal and local governments as per the requirements. The Act mandates development of a land use plan based on assessment of local needs and context. As per Clause 3, Section 2 of the Act, it mandates development of a separate land use plan for both urban and rural areas. Interchanges of land use between the different categories is prohibited by the Act.

4.3 Disaster Risk Reduction (DRR) and Management Act, 2077

The DRR and Management Act, mandates that any development related activities within the municipality should ensure disaster risk reduction measures. Likewise, the Act mandates the need to relocate or transfer people living in the vulnerable areas to safer locations and the need to conduct public awareness programs with reference to potential risks and hazards from disaster induced events.

4.4 Solid waste Management Policy and Act

At the federal level, the Solid Waste Management Act (2068) provides legal and regulatory framework to manage waste generated in their jurisdiction, engage private entities for waste management, institute a mechanism at federal to provide continued policy and regulatory guidance for solid waste management and guide local government to engage local communities. Solid Waste Management Rules (2070) further enforces the Solid Waste Management Act (2068) by governing the service delivery.

The pollution control due to solid waste is enforced through Environment Protection Act (2019) and Environment Protection Rules (1997) and necessitates to carry out Initial Environmental Examination (IEE) or Environment Impact Assessment (EIA) based on annual quantity of waste disposed, population of urban center and size of current waste management facility.

The local SWM Act was being drafted by ISMC during the consultation process of this strategy development. The Act was pending approval from the municipal council. The details of the SWM Act could not be obtained.

4.5 Municipal Building Code

As per the municipal building code, it is mandatory for each new building to construct a Septic Tank. This provision comes into effect when a new building design is being reviewed and approved by the municipality. Hence, most new buildings have sealed containments in their premises. However, the municipality does not provide any reference of standard septic tanks designs.

5. Climatology Analysis

Climate variability and change effecting the timing, intensity and spatial distribution of weather- and climate-related events, increasing temperatures and associated increase the frequency, intensity and duration some severe extreme weather events, increase variable and unpredictable precipitation and increase mean sea-level all place strain on sanitation systems and increase risk of infectious diseases. Therefore, climate variability and change must be considered in the design, operation and management of sanitation systems to minimize public health risks. (World Health Organization (WHO)). Further, Intergovernmental Panel on Climate Change (IPPC) has identified sanitation is an important vehicle for indirect climate change impacts on health (IPCC, 2014a). The health consequences arising from climate impacts on sanitation systems include increased risk of disease/illness from exposure to pathogens and hazardous substances via environmental contamination, and /or increased risk of disease/illness resulting from a lack of adequate sanitation where systems have been destroyed or damaged. Poor and vulnerable groups without access to good quality health care and fundamental public services experience overlapping forms of disadvantage are likely to face the worst effects (WHO & DFID 2009). In this regards, to understand the vulnerability of sanitation system, climate assessment of ISMC was carried out.

This section provides a summary of the analysis of climate change situation in ISMC. The precipitation and temperature datasets were extracted for Province 1 using a boundary line. Finally, these datasets were merged to present the past to recent climatology over the ISMC. Details of the climate change analysis is presented in a separate report.

5.1 Decadal variation of precipitation

- The decadal changes of the annual precipitation on Itahari sub-metropolitan city (Figure 5). shows that the precipitation has significantly increased over the study area from 1951 to 2020. The highest precipitation area is mainly located in the northern part of the metropolitan city, clearly visible after the 1980s. The data used has a coarse resolution (original resolution 25km), and the precipitation changes might be missed at a small domain level, therefore, the larger domain, i.e. Province 1, was taken as the representative basis for further analysis.
- Precipitation changes are mainly visible after the 1980s; therefore, trends and extreme precipitation analyzed over the four decades (1980-2020).

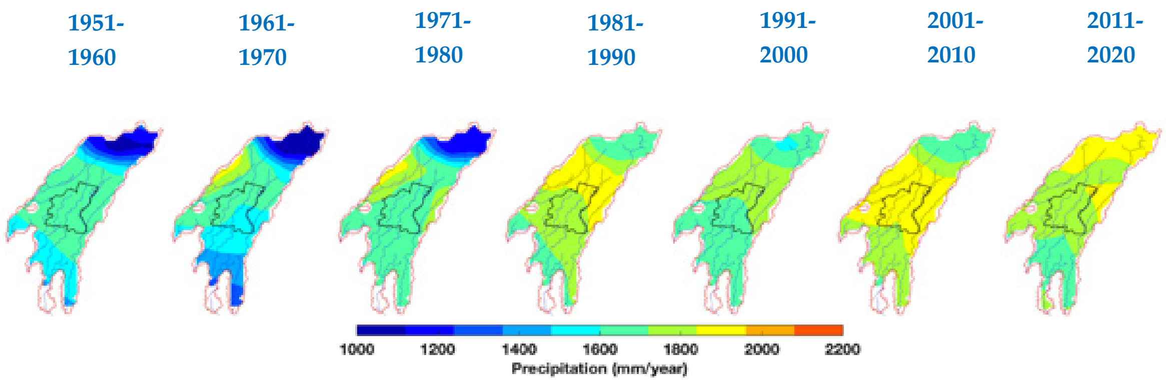


Figure 5: Decadal variation of mean annual precipitation over ISMC

5.2 Long-term variation precipitation and its extremes

- The seasonal cycle of precipitation over Province 1 during 1980–2020 shows the highest proportion of precipitation in the summer monsoon season (72%), followed by pre-monsoon (17%), winter (6%), and post-monsoon (5%) seasons, respectively (Figure 6a). The precipitation increases in June, reaching maximum in July, and gradually decreases from August and September. The result further shows that annual precipitation mainly comprises summer precipitation in Province 1. Attention must be taken during this season as high precipitation could lead to possibility of flash floods, landslides.
- Further, the annual and seasonal precipitation trends over Province 1 for 1980–2020 shows that as the precipitation is becoming more intense (Figure 6), the annual precipitation is increasing at a rate of 5.53 mm/year (p<0.01) over province 1 (Figure 6b).
- Similarly, a significant increasing trend was observed in monsoon and pre-monsoon at a rate of 4.26 mm/year and 1.36 mm/year, respectively. This indicates that the ongoing climate change and global warming have accelerated the distribution of high-precipitation; such acceleration may lead to frequent landslides and flash floods in the downstream areas of province 1.
- Province 1 has experienced a decrease in winter precipitation at a rate of -0.40 mm/year (p=0.15), which may increase the number of dry spells (drought) (Figure 6f). The decrease in precipitation can have adverse effect on sanitation system mainly draughts.

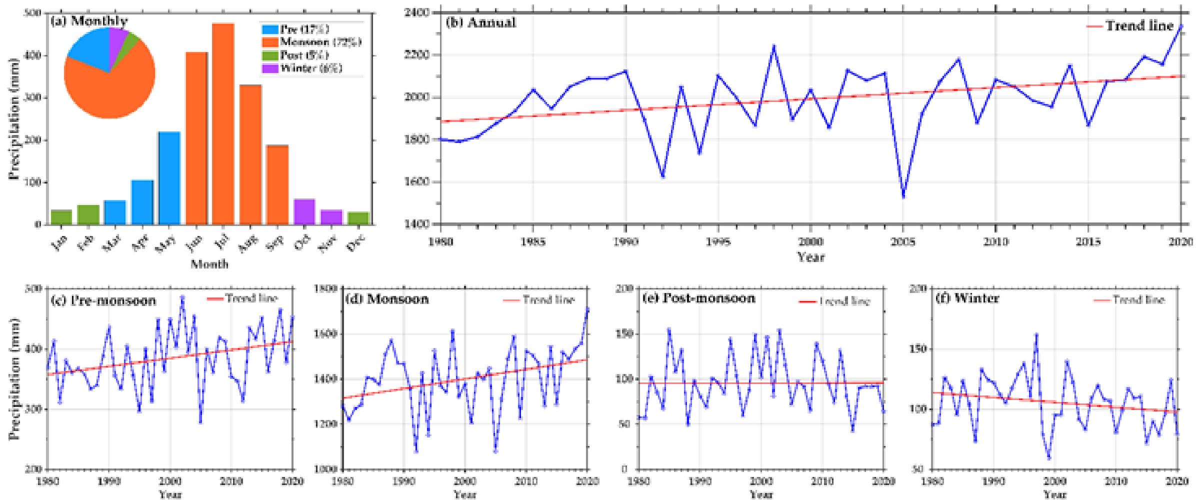


Figure 6. Temporal distribution of seasonal and annual precipitation over Province 1 during 1980-2020.

5.3 Decadal variation of temperature

- The analysis of the average temperature change over Province 1 for the last four decades shows that the average temperature is maximum in the south and minimum in the north over the study area (Figure 7).

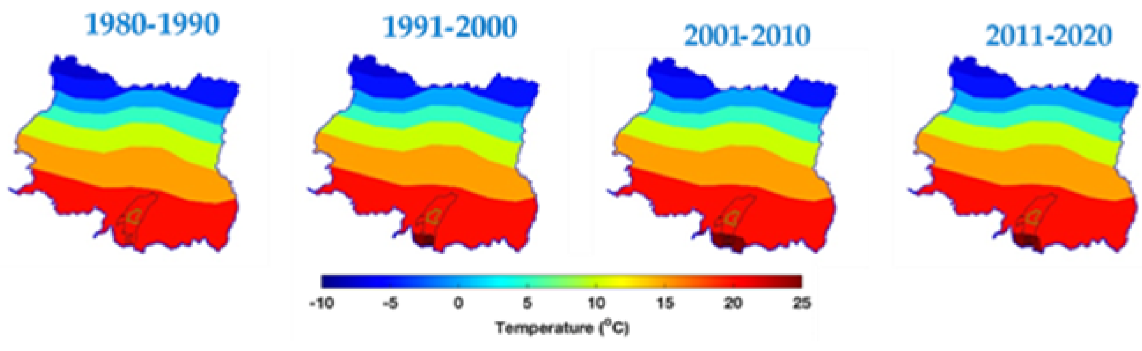


Figure 7. Decadal variation of mean annual temperature between 1980 and 2020 over Province 1.

- The average temperature during the study period was 14.5oC. The distribution of the temperature is attributed to the elevation of Province 1. The annual temperature does not show significant decadal changes over the study area. However, it is interesting to observe that the increased temperature over the southern part of the ISMC, mainly after the 1990s.
- This increase in the temperature may impact the wastewater treatment, septic tank, and latrines, leading to increased pathogen and lower the dissolved oxygen levels. The temperature increase induces the algal bloom and produces bacterial and fungal content in the water.

5.4 Long-term temperature variation

- Monthly mean temperature over province 1 shows noticeable seasonal variation, with a maximum in June (18oC) and a minimum in January (6oC) (Figure 8a). Temperature increases from January to June, whereas it decreases from September to December. The mean annual temperature in Figure 8b further shows the significant increment at a rate of 0.02 oC/year.
- The pre-monsoon has a relatively small increasing trend. However, the increment is insignificant. A significant upward trend of mean temperature was observed in monsoon, post-monsoon, and winter at a rate of 0.02 oC/year ($p<0.01$), 0.03 oC/year ($p<0.01$), and 0.02 oC/year ($p<0.05$), respectively
- The spatial distribution of temperature suggests that ISMC is located in the warmer region. Increased temperature due to ongoing climate change and global warming will potentially impact overall sanitation management. For instance, the warmer temperature disturbs biological wastewater treatment and its efficiency, the proliferation of algal blooms or microbes carried by vectors in water, increased corrosion of sewers, quicker drying of fecal sludge in dry latrines etc.
- Post-monsoon and winter are comparatively dry seasons, and temperature rise can intensify sanitation problem; therefore, safety measures must be taken over the study region.

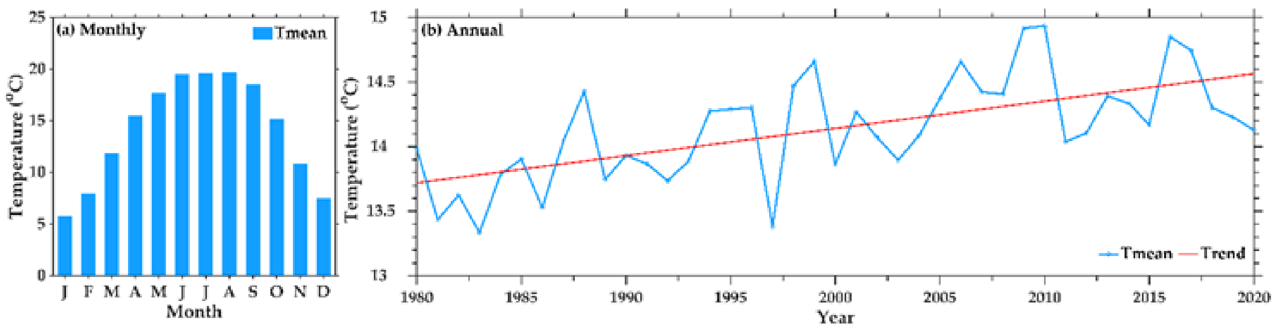


Figure 8. Annual cycle of temperature (a) and inter-annual variation of mean temperature (b) over Province 1.

5.5 Projected precipitation and its extremes

- A similar pattern of the seasonal precipitation cycle was found for the projected similar to the observation in province 1, with higher precipitation in the monsoon followed by pre-monsoon, post-monsoon, and winter (Figure 9a). The temporal distribution of projected changes in annual and seasonal mean precipitation for SSP585 emission scenarios over province 1 is shown in Figure 9b-f.

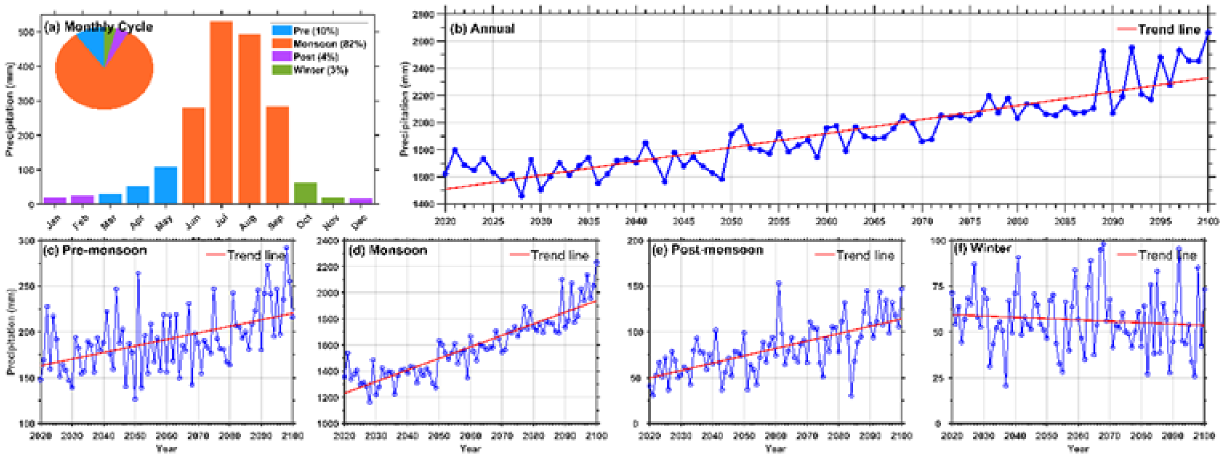


Figure 9. (a) Seasonal cycle and the trend of projected precipitation (b) annual, (c) pre-monsoon, (d) monsoon, (e) post-monsoon, and (f) winter over the Province 1 during 2020-2100.

- Figure 9 shows a significant increase in mean precipitation in the future relative to the observation period at a rate of 10.28 mm/year. Similarly, the precipitation is projected to increase for pre-monsoon, monsoon, and post-monsoon, which is significant at a 99% confidence interval.
- A large increase in precipitation was observed for the monsoon (8.82 mm/year, $p<0.01$), and the changes are significant and robust. The projected climate change can result in flooding over Province 1, affecting sanitation and damaging drainage infrastructure and wastewater treatment facilities. The flooding water can burst sewer lines, overwhelm waste treatment plants, and overflow pit latrines and septic tanks. In Nepal, sanitation facilities in urban and slum areas are highly vulnerable to flooding because they are often poorly designed and constructed.
- The projected winter precipitation reduces at province 1. Winter over the study region will be relatively dry than other seasons due to reduced precipitation.
- Reduced precipitation is likely to create water scarcity affecting safe sanitation practices. Moreover, dry condition mainly reduces availability of groundwater affecting irrigation and other usage.
- Heavy precipitation events in province 1 will increase during 2020-2100; however, there will be a sharp decrease in consecutive dry days (CDD) spells (Figure 10a-b). The extreme precipitation events and consecutive wet days (CWD) spells at province 1 shows an upward trend (Figure 10c-d). This indicates that province 1 will have more intense rainfall than dry events, leading to flooding.

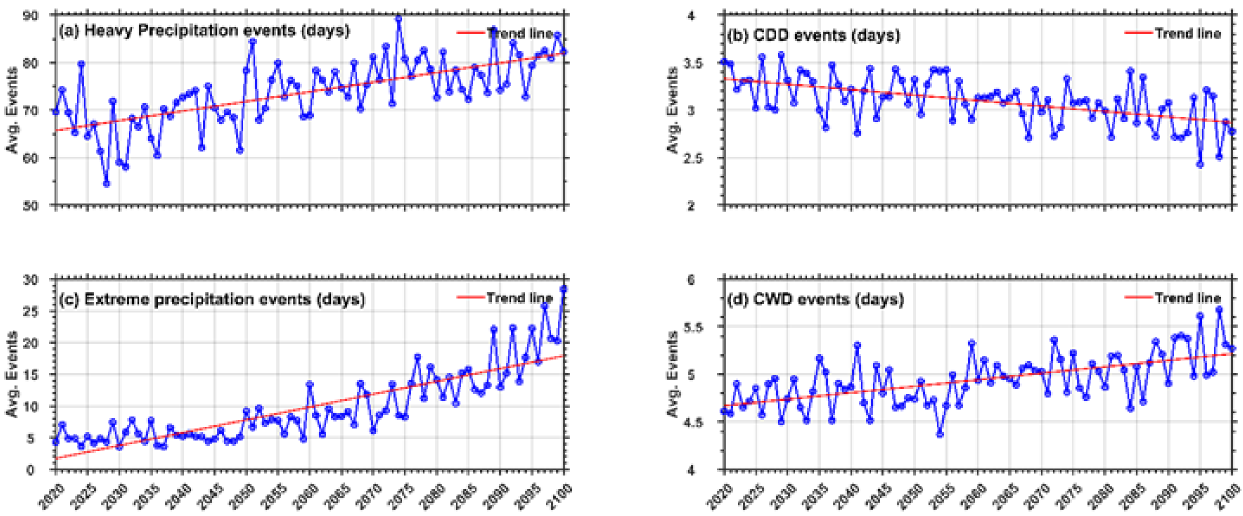


Figure 10. The projected trend of precipitation events (a) heavy, (b) CDD, (c) extreme, and (d) CWD over province 1 during 2020-2100.

5.6 Projected temperature

- The seasonal cycle of the projected temperature over province 1 is shown in Figure 11a, which shows a similar pattern as historical temperature. The mean temperature warming will increase significantly over Nepal seasonally and annually (Figure 11 b-f). A higher increase trend will be observed in monsoon and winter than post-monsoon and pre-monsoon.

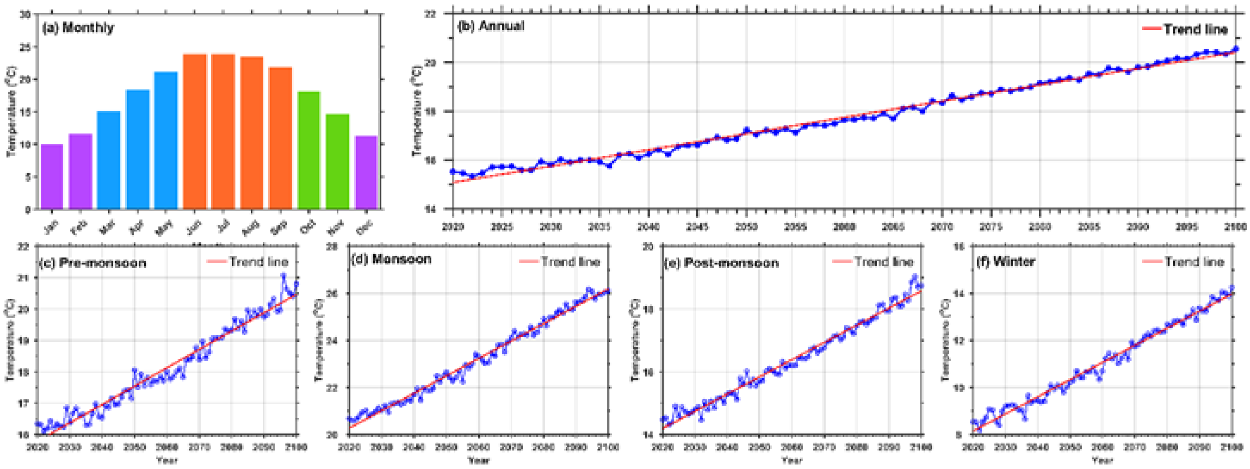


Figure 11. (a) Seasonal cycle and the trend of projected temperature (b) annual, (c) pre-monsoon, (d) monsoon, (e) post-monsoon, and (f) winter over the Province 1 during 2020-2100.

- Furthermore, the annual mean temperature will increase significantly at a rate of 0.07°C per year, which is significant at a 99% confidence interval. These temperature rise may lead to dry conditions or water scarcity over Province 1, thus creating unprecedented competition among water users across political boundaries and impacting sanitation systems.

5.7 Inundation and flood mapping

Floods are the most common (and among the most deadly) natural disasters in Nepal, mainly in the low-elevation area, causing destruction every year. As global warming continues to exacerbate, precipitation and the temperature pattern are changing, and extremes are expected to increase. The country has experienced increasing temperature since the 1980s, and it is projected to increase sharply. Moreover, the country has been experiencing extreme precipitation events in recent years; for instance, the record-breaking rainfall recorded in 2020 caused devastating floods in most parts of Nepal.

Figures 12 show the inundated years for the different years over ISMC during 2015–2021. The result shows a sharp annual increment in the flood and inundation area. The precipitation is becoming more frequent and intense due to climate change, which may be responsible for deadly floods and increased inundation. The highest flood-affected area was observed in the year 2019, covering 30.88% of the city.

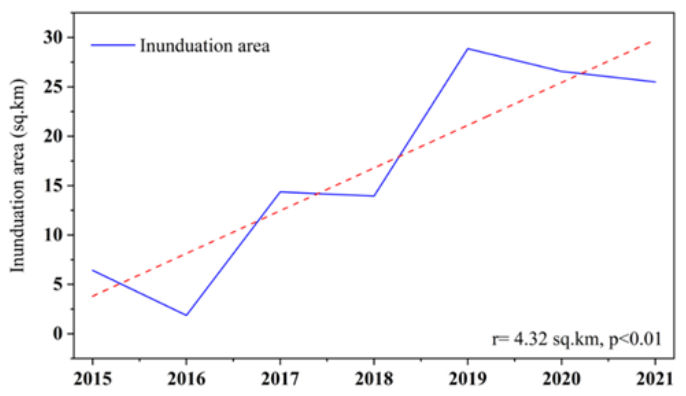


Figure 12. Yearly inundation area in pre-monsoon and monsoon season in ISMC

Table 2. Inundation area in ISMC with respect to the city area

Year	Area (sq. km)	% of City Area
2015	6.42	6.86
2016	1.86	1.98
2017	14.36	15.36
2018	13.94	14.91
2019	28.87	30.88
2020	26.57	28.42
2021	15.5	16.58

Most of the inundated area lies in the southern part of Chatara Main Canal and the northwestern part of East-West Highway (Figure 13 and 14). However, Itahari Bazar and the east-west highway, northeastern part of the city, and southeastern Khanar settlements are unaffected by the inundation from 2015–2021. All of the settlements other than Khanar in the south of the Chatara Canal are inundated every year, indicating high flooding areas.

The inundation in the northwestern part of the east-west highway was mainly found around Serha Khola, Hakraha Khola, affecting the Janagalutol, Bhawanipur, Amaha, Paterwa, and Rahipur (Purbatol and Pashchimtol). Similarly, in the central northern part, the inundation has been found around Kharsala Khola, Panipiya Khola, and Sukumari Khola. As the precipitation extremes are increasing, the northern part of the Chatara Main Canal and the north central part of the east-west highway is also being affected after 2017 (Figures 13 and 14). The inundation in the northern part may be related to the seasonal streams (generated from hills), whereas the inundation in the southern part is related to the canal infrastructure.

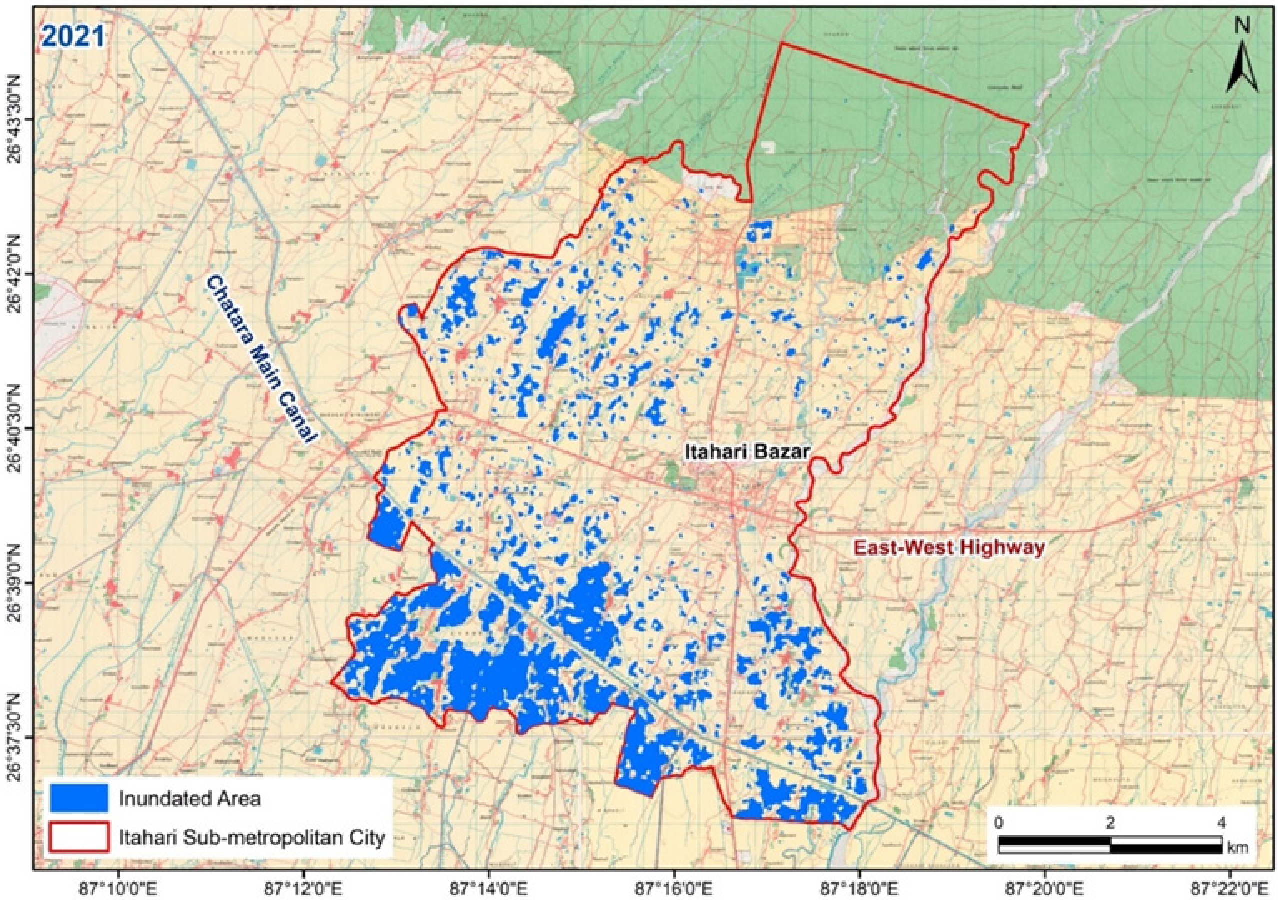


Figure 13. Inundated areas over ISMC during monsoon 2021

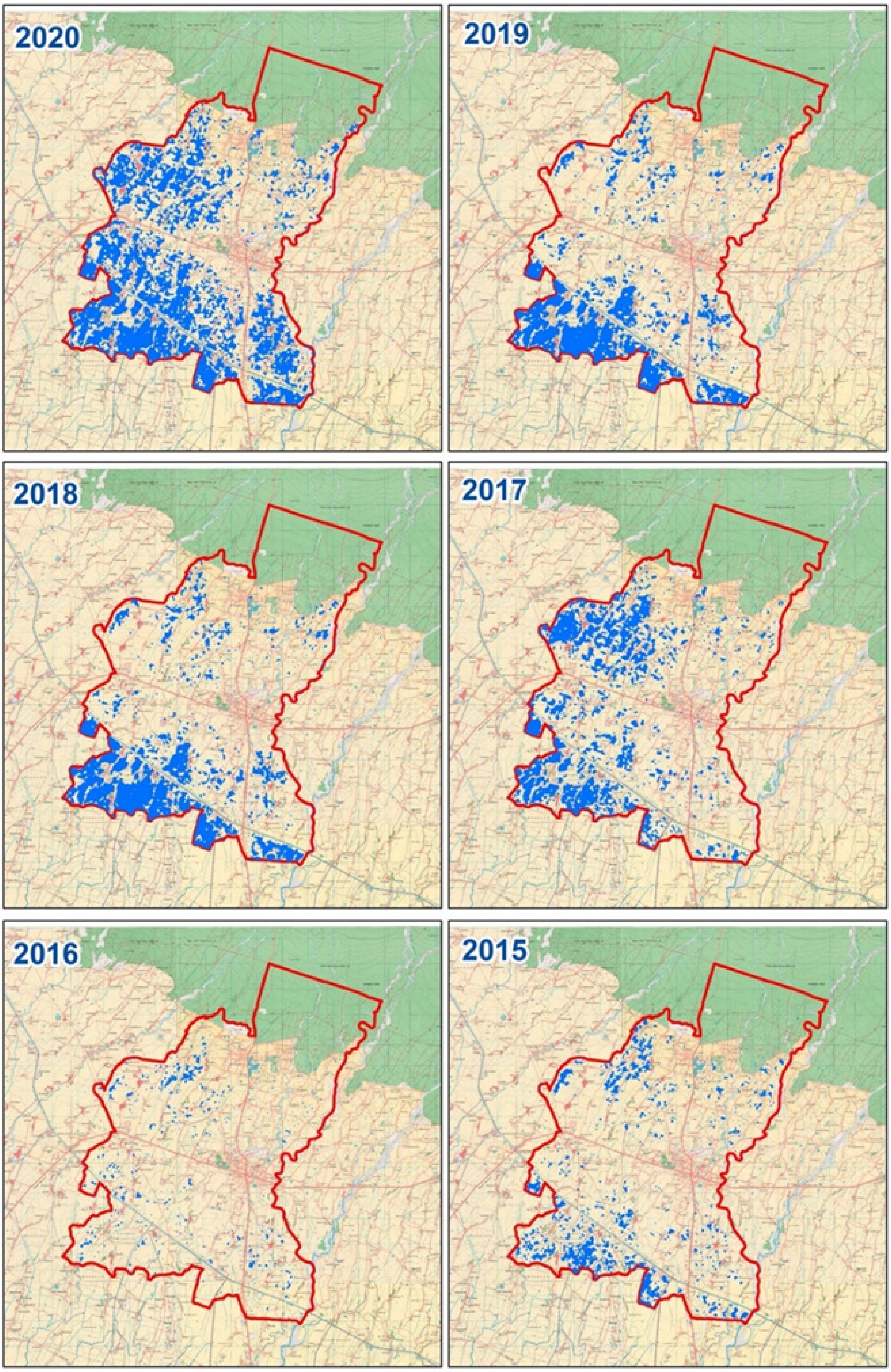


Figure 14: Inundated areas over ISMC during monsoon, between 2015 and 2020.

5.8 Climate change vulnerability

Climate change – a change in the state of the climate that can be identified by changes in the mean and/or the variability of its properties and that persists for decades or longer – exacerbates existing challenges such as rapid population growth, urbanization, migration, land-use change, and other forms of environmental degradation (WHO: Guideline on sanitation and health). Nepal is among the most vulnerable countries to climate change and is at high-risk due to the country's fragile topography, the climate-sensitive livelihoods of the people and their limited adaptative capacity (Nepal's Second Nationally Determined Contribution (NDC), 2020).

The overarching assessment criteria to assess climate vulnerability as per reference from Government of Nepal[1] and USAID[2] are:

- Climate stressors (e.g., rainfall changes, temperature change) that contribute to vulnerability. (Assessed in above section)
- Vulnerable groups or physical assets (e.g., alternative livelihoods, agricultural areas, limited land use)
- Location of potentially vulnerable areas and communities, ecosystems, infrastructure and resources are located (e.g., human settlements in mountainous regions, coastal areas or in a floodplain);
- Occurrence of hazards (e.g., during monsoon or cyclone season);
- Internal and external factors that make specific groups of people (e.g., children, elderly individuals) and resources vulnerable (e.g., poor community cohesion).

Climate vulnerability for Itahari' s sanitation sector is thus assessed based on increased precipitation and increased temperature as the key climate stressor. With the climate change the severity of these climate stressor is foreseen to be further increased in future thus, it is crucial to consider these in the initial planning phase.

The assessment of the sector from climate change perspective is presented in sections 6.6 and 8.3 of this report.

1 https://www.mope.gov.np/download/CLIMATE%20CHANGE%20VULNERABILITY%20MAPPING%20FOR%20NEPAL%20INNER.pdf.9c65a3385899194206e28d0e224f5dec

2 https://www.climatelinks.org/sites/default/files/asset/document/2018_USAID-ATLAS-Project_Designing-Climate-Vulnerability-Assessments.pdf

6. Sanitation System Analysis

The section below provides an overview of the existing sanitation system and services at ISMC across the sanitation service chain.

6.1 User Interface

ISMC is open defecation free zone, almost 100% household have access to toilets at households. There are all together 8 public toilets located in different Wards of the sub-metropolis. Public toilets (PT) in ***hatiya*** (market) Line in ward 9 and ***Tarahara hatyia*** (market) in ward 20 are managed by the sub-metropolitan. Whereas, the public toilet located at the bus park was installed and managed by the Buspark Committee (ISMC, 2021). Likewise, a smart public toilet is currently under construction within the municipality office. Please refer to Annex 3 for locations of the PTs.

6.2 Containment

Pit Latrines and Holding Tanks are the common type of containments at the household level. Only a fraction (0.5%) of the population have Septic Tanks (Figure 15).

Most of the toilets/containments were constructed over the last decade (Figure 16).

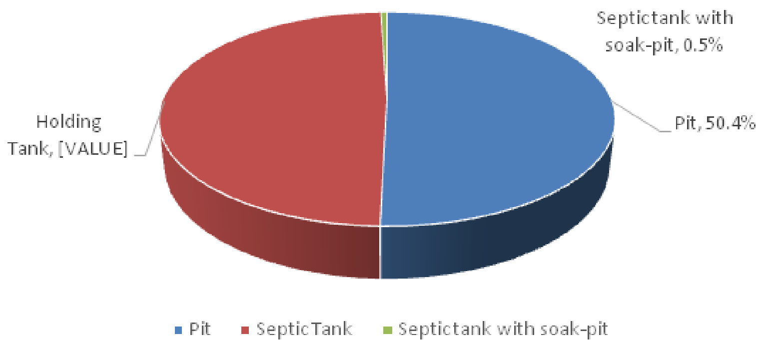


Figure 15 Percentage of types of containment
Source: (ENPHO (2017)

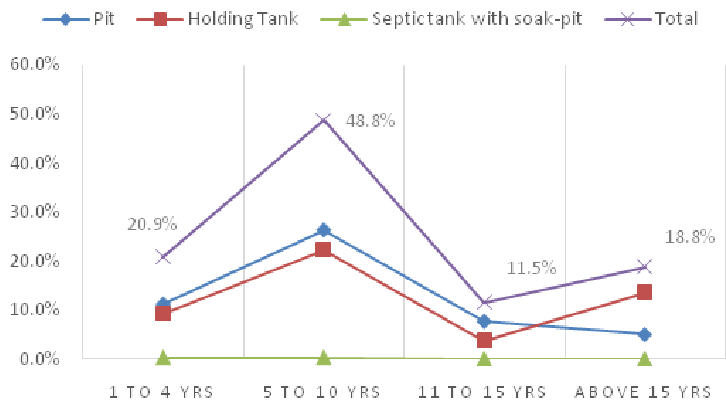


Figure 16: Age of containments
Source: ENPHO (2017)

The average size of holding tank was found to be 17.4 m^3 while that of Pits and Septic Tanks were 1.5 m^3 and 5.6 m^3 respectively (Table 3). As per the shit flow diagram (SFD) report of ENPHO (2017), 37% of the households have holding tanks which are greater than 20 m^3. Likewise, 70% of the houses with pit type of containment have volume between 1 to 2 m^3.

Table 3: Volume of different types of containment

Types of Containment	Maximum Volume (m^3)	Average Volume (m^3)	Minimum Volume (m^3)
Holding Tanks	45.0	17.4	1.3
Pit latrines	5.7	1.5	0.8
Septic tanks	6.3	5.6	4.9

Source: adapted from ENPHO (2017)

The figures above indicate that majority of the households have constructed large holding tanks and septic tanks to accommodate more sludge volume in ISMC. Normally, as per standard design practices, a household with a family size of 5 members, will require an average septic tank volume of 3-5m^3 at a desludging interval of 3.5 years.

6.3 Emptying and conveyance

6.3.1 Service providers

There are currently 11 desludging trucks operating within ISMC. These trucks are owned by multiple entrepreneurs among which one of the entrepreneurial group owns 2 trucks. The average volume of truck is between 5-6 m3. The current tariff charged for emptying per trip is Rs. 2500. This rate is applicable only for ISMC around a 15 kms service radius. The emptying charge per trip increases with distance. The FS service providers are providing emptying services to neighboring municipalities as well such as Dharan, Inaruwa and Dhuhabi Municipalities. As per the FS entrepreneurs, the relatively small size of the trucks is to access the narrow lanes and roads in some parts of the city.

6.3.2 Emptying practices

The main reason for emptying was due to filling and overflow of the sludge in the containments. Only around 10% of the households practice routine desludging while 85% empties once the containment is overflowing (ENPHO, 2017).

Past study shows that around 42% of the households have never emptied their containment among which around 70% are holding tanks and 30% are pit latrines. Among household taking mechanical emptying services, majority (25.1%) empty it annually or every 3 years (17.6%) as shown in Figure 17.

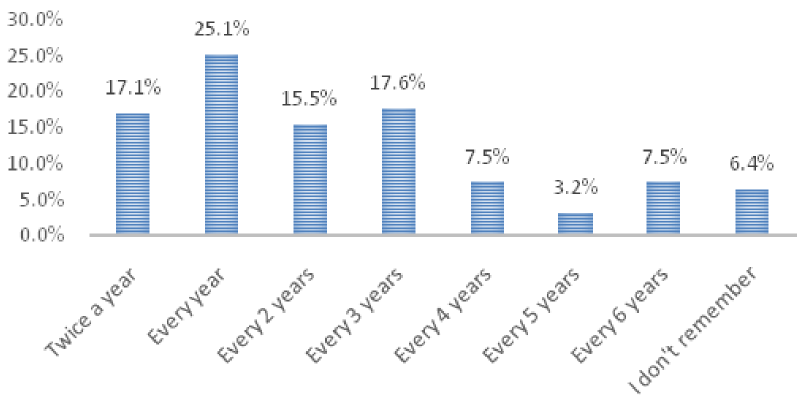


Figure 17: Frequency of FS Emptying at Households
Source: ENPHO (2017)

With respect to emptying services, majority of the household opt for manual emptying (68.4%) either through private manual emptying services (54%) or self emptying (14.4%). Only around 22.5% of the households opted for mechanical emptying services among which 15% used private mechanical emptying and 7.5% used mechanical emptying services of the municipality.

Among the containments emptied, majority of the pit latrines were emptied manually while holding tanks were emptied mechanically (Figure 18).

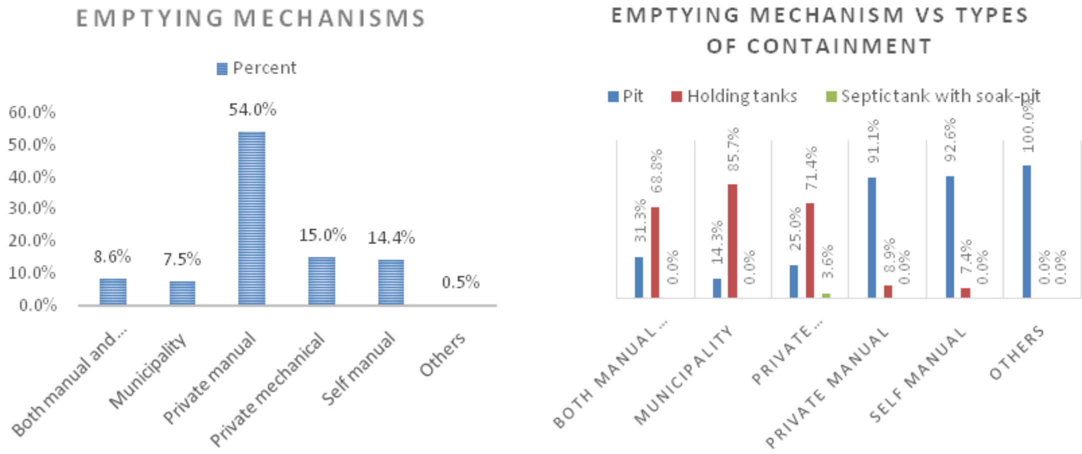


Figure 18: Distribution of Emptying Service, ISMC
Source: ENPHO (2017)

Likewise, the ENPHO study (2017) also shows that containments were not fully emptied when they were serviced. Only 46.4% of the containments were completely emptied for households served by private mechanical emptying services. On an average, around 25% of total faecal sludge contents still remained in the containments following mechanical desludging.

6.3.3 Emptying practices and income levels

Low-income households opted for manual emptying as it was cheaper compared to mechanical emptying. This relation is visible Figure 19 where household with income levels 30,000 per month opt more for manual emptying as compared to mechanical. During 2017 (ENPHO survey), manual emptying costs < NRs 1000 to NRs 2000 per emptying while mechanical emptying costs were between NRs 2000 to NRs 3000 per trip.

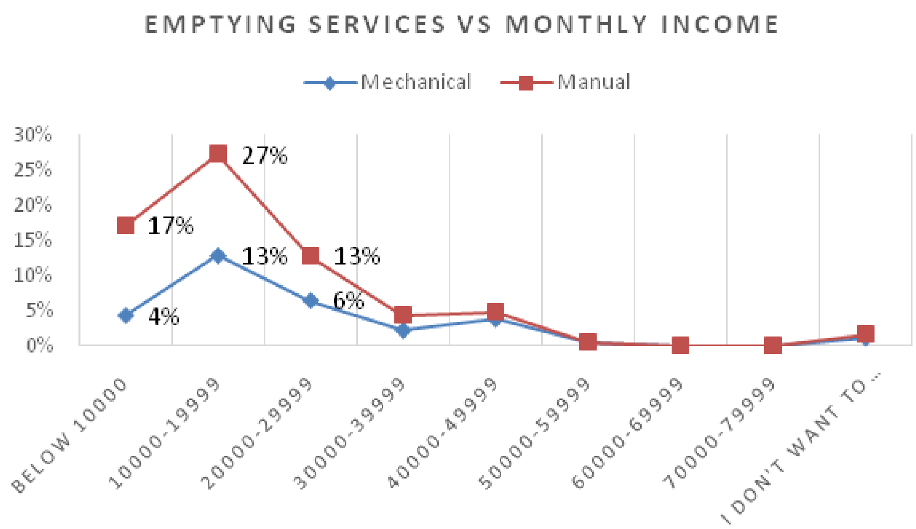


Figure 19: Emptying practices with Household Income Levels
Source: ENPHO (2017)

Focus Group Discussions (FGDs) conducted in the low-income settlements during 2021 concurred with the above facts. Almost all households in the low-income areas have pit latrines as the major form of containments and almost all opt for manual emptying. Over the years, manual emptying charges have increased. On average manual emptier charges around Rs. 2000 per pit emptied. The price increased with additional number of concrete rings/depth of the pit.

It was found that some household in the low-income settlements empty their pits twice a year due to the small containment size. A comparison of the mechanical emptying services opted by households annually in the city (Rs 2500/trip per year) versus manual emptying services taken up by low-income households (Rs 4000/year) shows that under these instances low income households pay more for desludging their pits.

Household in low income who live in vulnerable conditions are prone to flood hazards. Most of the squatter settlements are close to riverbanks and were inundated during successive flooding events in the past. They indicated that they do not receive any form of mechanical emptying services neither public not private services. They were aware about mechanical emptying services but reluctant to take the service as they feel it is expensive. Households in these settlements collectively requested for a subsidized rate for emptying due to their low-income status.

6.4 Treatment and end-use

ISMC lacks proper facility for disposal and treatment of faecal sludge. All mechanically emptied sludge is currently dumped inside the community forest located in between Itahari and Dharan (see Annex). The same location is also currently being used to dispose the municipal solid waste collected from the city core. Each private FS trucks pay Rs 3500 per month to the community forest users group as a disposal fee.

The sludge is currently being disposed directly in sludge pond which overflowed into the forest area (Figure 20). Private entrepreneurs indicated in the past years, there were farmers from the hills, who collected the dried sludge from the sludge pond to use it in agriculture. However, during the consultation stage of the CWIS strategy development, these stakeholders could not be contacted.

Figure 20: Temporary Faecal Sludge Disposal Site of ISMC

The shift flow diagram (SFD) of ISMC developed in 2018 shows a clear need for sludge management at the citywide level. The FSM status has remained the same over the years. As per the SFD, 9% of the excreta was not emptied and safely stored while, 91% of the excreta was found unmanaged and disposed directly into the open (Figure 21).

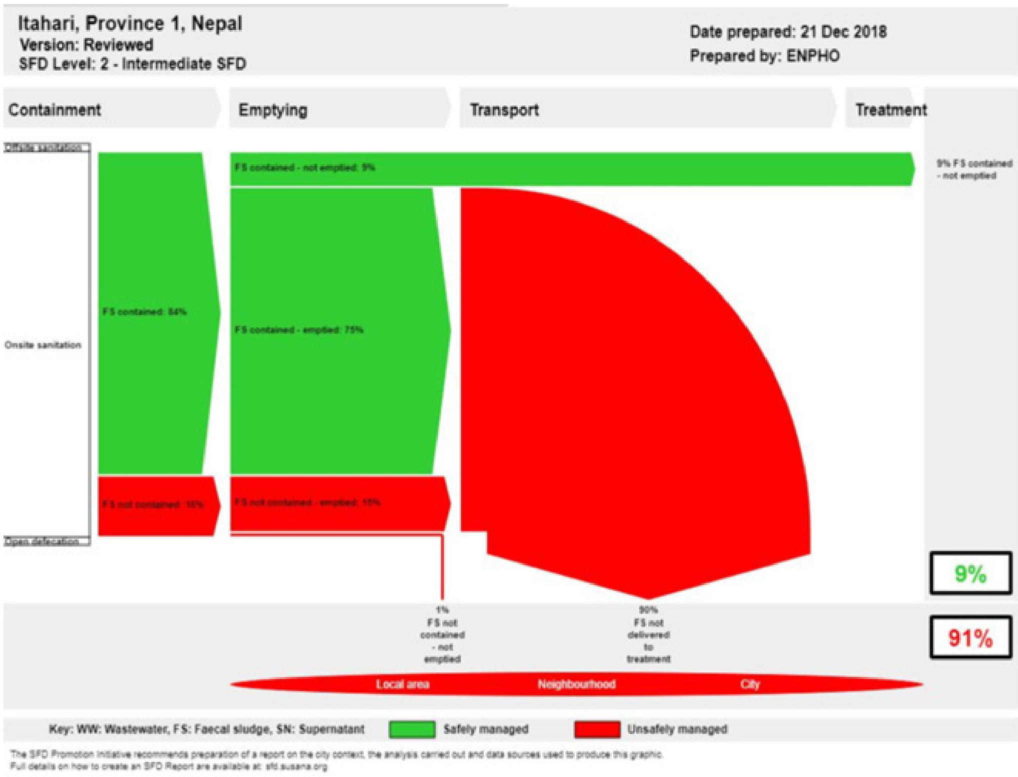


Figure 21 Shit Flow Diagram (SFD) Itahari Sub Metropolitan City
Source: ENPHO (2018)

6.5 Estimation of FS generation

Using sludge collection method, on the basis of average size of containments and emptying frequency, the total sludge collected in the sub metropolis was 9,520 cubic meter (m^3) per year which is around 26 m^3 /day (ENPHO, 2017). The detail calculations using this method is provided in Annex.

Based on data collected from private mechanical waste emptier, the total faecal sludge emptied and transported was 175 m^3 per week. With the estimation that only 40% of the total sludge emptied was from ISMC, faecal sludge generated was estimated at 10 m^3/day (Table 4).

Table 4: Quantification of faecal sludge based on private entrepreneurs

Particular	ESTH	JB
Number of trip per day per truck	2	2
Number of Truck	2	3
Volume of FS per trip (m^3)	5	2.5
Total FS collected per day (m^3)	20	15
Total FS collected per day (m^3)	35	
Total FS collected per week, average 5 working days (m^3)	175	
FS collected from ISMC is around 40% of the total sludge collected (m^3)	70	
Deslugable FS collected mechanically from Itahari in a day (m^3)	10	

Source: ENPHO (2017)

Compared to 2017, the sludge volume collected has gradually increased over the years in ISMC. Based on information collected from the private entrepreneurs, individual FS trucks, on an average makes 2-3 trips per day. Considering a minimum of 2 trips per truck and an average truck volume of 5.5 m^3, the amount of sludge currently brought at the disposal site is around 121 m^3/day. Assuming a similar scenario as in 2017 where, 40% of the sludge collected by private trucks is from ISMC, the sludge volume expected to be treated at the municipality is around 50m^3/day.

6.6 Climate change perspective to Existing Sanitation Practices

Literatures have revealed climate change's potential impact on sanitation system is extensive, from both mitigation aspect as well as adaptation aspect and this demands immediate action for sector to assess from climate change angle (Guy, UN position paper). ITMC, as one of the fastest growing city with provincial growth rate of 6.23% (MOPE, 2017) and receiving 41.6% of inter-district migration in the Terai town (SFD, ENPHO, 2018), the impacts of climate change will be aggravated in days to come. Thus, its crucial for the sector to assess the existing situation from climate change perspective and incorporate the findings into the sectoral plans. Box below, briefly defines climate change adaptation and climate change mitigation, two ways to respond to climate change.

Climate change mitigation: Efforts/actions to limit global warming and its related effects, which involves reduction in anthropogenic emissions of greenhouse gases (GHG) as well as activities that reduce their concentration in the atmosphere. (Wikipedia)

Climate change adaptation: The process of adjusting to current or expected climate change and its effects
Source: Wikipedia

From the mitigation perspective, Nepal is one of the lowest GHG emitters, contributing to only 0.06% of global emissions, and waste sector's (including sanitation) contribution to the overall national GHG emission is 3.28% (TNA, 2021). However, among the waste categories, wastewater treatment and discharge alone emits 70% (i.e. 644.8137 Gg CO_2. Eq. out Waste sector total 923.5860 Gg C02 Eq.). This emission will be in increased with time as country is urbanizing in fast pace of 3% (UNDESA).

From adaptation perspective, Nepal is among the most vulnerable countries to climate change (Second NDC, 2020). Public health concerns of unmanaged handling of the waste and the wastewater including faecal sludge are crucial.

Figure 22 outlines the climate adaptation and mitigation links to sanitation across the value chain.

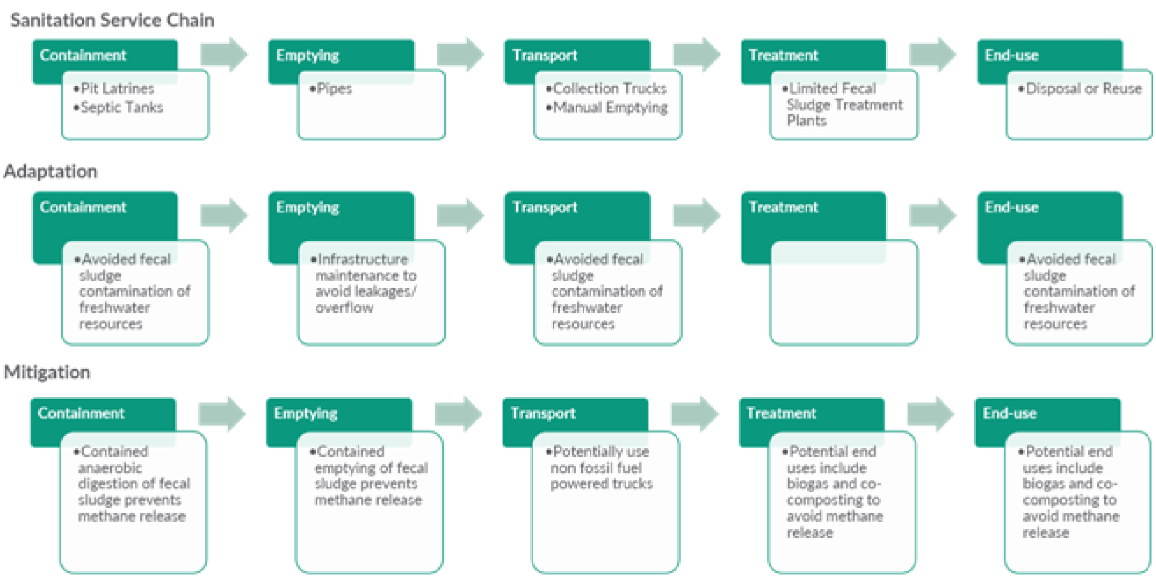


Figure 22 Key elements of climate adaptation and mitigation across the sanitation chain

It is also expected that with identifying the climate risks for the sanitation sector, municipalities like Itahari sub-metropolitan city should be able to access climate finance to develop and strengthen their sanitation infrastructure, while making it resilient to climate change.

6.6.1 Climate change mitigation

As mentioned earlier, human excreta, if not properly managed, is a globally significant source of greenhouse gas (GHG) emissions. The main gases emitted in the sanitation services chain as laid out in the globally verified methodologies and guidelines such as IPCC, UNFCCC and the greenhouse gas (GHG) protocol are methane and nitrogen (TNC, 2021). Pit latrines are estimated to account for approximately 1% of global anthropogenic methane emissions (Reid et al., 2014; https://www.frontiersin.org/articles/10.3389/fenvs.2020.00130/full). Thus, it is crucial to understand the greenhouse gas from the existing practices in ISMC to understand the mitigation aspect. Currently in Itahari, waste-water together with fecal sludge is contained in holding tanks, pit latrines and very few have septic tanks. Where greenhouse gases, mainly methane, builds up and without proper emptying and treatment practices, these gases are let out in the atmosphere. Methane is considered to be one of the most potent green house gases with a global warming potential of about 28 over a 100-year time period (IPCC, Working Group 1, Assessment Report 5, 2013).

Baseline Emission:

Based on methodology developed by the clean development mechanism (CDM) methodology, the baseline emissions from the current sanitation practices is estimated based information below (Table 5).

Table 5: Baseline emissions calculations method for ISMC

Main emissions	Containment	Transport (Excluded in ISMC baseline emission)
Potential emissions and corresponding CDM methodology	Emissions from septic tanks, pit latrines (Methodology usage CDM methodology for emissions from solid waste disposal sites[3])	Transport emissions [4]
Main assumptions	Fecal sludge is contained in conditions similar to a shallow, unmanaged landfill Organic waste is deposited at the landfills and not segregated	Emissions from consumption of fuel to take to treatment facility
Main variables	Quantity of fecal sludge contained	Distance and frequency of emptying

Note: Emission from transport has not be calculated

The formula used to calculate the baseline emission is presented at Annex. Using the formula, the current baseline emission from existing sanitation practices for Itahari is calculated to be 1505 eq CO_2/year (Table 6). This will be higher if the emission from transport is taken into consideration.

Table 6: Estimated baseline emissions from current sanitation practices, ISMC

Emissions – eq Co_2 / year	Baseline emission	Remarks
Emissions – eq tn Co_2 / year	1505	The baseline emission is calculated from the current FS disposal of 50 m^3/day.

GHG mitigation

Estimates for potential emission reduction for Itahari sub-metropolitan city is again based on the clean development mechanism (CDM) methodologies since they are the most appropriate for project contexts with clear boundaries around specific infrastructure and volume. The methodologies and assumptions are laid out in Table 7 below.

3 https://cdm.unfccc.int/methodologies/PAmethodologies/tools/am-tool-04-v6.0.1.pdf
4 https://cdm.unfccc.int/methodologies/DB/F5U41CTG7ENWK9RSSL5BV1LUPDG76W

Table 7 Sanitation Service Chain and corresponding GHG emission calculation methodology for proposed options in CWIS

Main emissions	Containment	Transport	Treatment	Disposal / Reuse
Potential emissions and corresponding CDM methodology	Emissions from solid waste disposal sites[5] Emissions from septic tanks, pit latrines	Transport emissions[6]	Fecal sludge treatment -considered to be negligible if standard open-air treatment and captured Biogas – gas from reactor calculated as per gas avoided from solid waste disposal sites	Compost- Emissions released during composting Emissions saved from savings of fertilizers Biochar – savings from fossil fuel consumption – either coal or LPG
Main assumptions	Fecal sludge is contained in conditions similar to a shallow, unmanaged landfill Organic waste is deposited at the landfills and not segregated	Emissions from consumption of fuel to take to treatment facility	Fecal sludge treatment – none Biogas - assume gas from solid waste disposal sites is captured	Emissions from composting can be assumed minor Savings from fertilizer mainly from reduction in transport as these are imported and equivalent fossil fuel energy to produce
Main variables	Quantity of fecal sludge contained	Distance and frequency of emptying	No fecal sludge treatment Biogas – volume of fecal sludge contained	Average distance for import of fertilizer Approximate fossil fuel energy needed to produce

The estimated emissions saving of GHG gases measured in tons of CO_2 equivalent gas is provided in Table 8. It is to be noted that the emission reduction for ISMC is calculated based on treatment of fecal sludge either through conventional faecal sludge treatment plant (FSTP) or through anaerobic digestion process to produce and capture biogas. The greater savings are with biogas since the methane captured is also a replacement for fossil fuel and so has equivalent savings as a fuel replacement. It should be noted though that the methane production from fecal sludge alone is low, higher emission reductions would be possible with the combination with other waste streams.

Table 8 Emission reduction per option based on Fecal Sludge estimates from section...

Emissions – eq Co_2 / year	**FSPT**	**Biogas**
Emissions – eq tn Co_2 / year	1505	1647 (additional 142 from LPG offsetting)

FSTP construction will reduce the baseline emission completely, while treatment through biogas will reduce the baseline emission to some extent. It will off-set the emission from usage of liquified petroleum gas (LPG gas) with the assumption that biogas will replace LPG.

Other options to mitigate could be:

- promotion of composting toilets (Reid et al, 2014),
- regular emptying of septic tanks (IPCC, 2006) and good wastewater management (Howard et al., 2016) can reduce GHG emissions resulting from the breakdown of excreta. (WHO: Discussion paper: Climate, sanitation and Health).

[5] https://cdm.unfccc.int/methodologies/PAmethodologies/tools/am-tool-04-v6.0.1.pdf
[6] https://cdm.unfccc.int/methodologies/DB/F5U41CTG7ENWK9RSSL5BV1LUPDG76W

6.6.2 Climate Adaptation

From adaptation perspective, climate change-related health consequences from sanitation systems generally fit within two overarching categories: (i) increased risk of disease or illness from exposure to pathogens and hazardous substances through increased environmental contamination, and/or (ii) increased risk of disease or illness resulting from a lack of access to adequate sanitation when systems are destroyed or damaged. (Discussion paper) Further, climate change reduces predictability of water availability, undermining the functionality of water and sanitation systems. Based on the identified potential climate change effects for ITMC, Table 9 summarizes the impact to the sanitation, as identified by literature which is also applicable for ITMC.

Table 9 Summary of the observed climate change, potential hazards, and possible impacts on the sanitation

Climate change effect	Potential hazards	How it will impact the sanitation
More intense or prolonged precipitation (Mainly in the pre-monsoon and monsoon season)	• Increased flooding • Increased erosion, landslides • Contamination of and damage to surface water and groundwater supplies • Changes to groundwater recharge and groundwater levels	• Destruction and damage to sanitation infrastructure • Damage to other infrastructure/systems on which sanitation systems rely (e.g., electricity networks, road networks) • Flooding of on-site systems causing spillage and contamination • Flooding and collapse of pit latrines, including via groundwater • Overflow and/or obstruction of sewerage and septic systems • Floating of septic systems due to groundwater levels • Disruption in the reach to FSM services (like desludging) • Treatment plants receive flows that exceed their design capacities, resulting in flows bypassing the treatment processes
Declining of the rainfall (winter season)	• Longer dry periods • Reduced surface water flows • Reduced groundwater levels/resources	• Declining water supply impeding the function of water-reliant sanitation systems • Obstruction creates reduced capacity in rivers or ponds that receive wastewater • Increased reliance on wastewater for irrigation which, if not adequately managed, can increase health risks • Increased corrosion of piped sewers • Higher pollution concentration in wastewater and reduced capacity of receiving water bodies to dilute wastewater • Ground movement in soils with high clay content leading to broken pipes and joints
Rise in temperature (all seasons)	• Higher ambient air temperatures in homes or facilities • Higher freshwater temperatures • Hot and cold temperature extremes	• Reduced efficiency of biological wastewater treatments • The proliferation of algal blooms or microbes carried by vectors in water • Increased corrosion of sewers • Quicker drying of faecal sludge in waterless latrines

Note: this table is modified from the discussion paper on climate, sanitation and health

The key adaptation measures, as identified in the position paper, United Nation (UN) – climate change and the human rights to water and sanitation :

- Ensuring the resilience of water and sanitation infrastructure to climate change is a major climate change adaptation measure. Whether threatened by flooding or drought, water and sanitation infrastructure need to be made more robust and flexible. This requires new approaches and innovative technologies, sufficient infrastructure investments, capacity development, and technology transfer (Climate change and the human rights to water and sanitation; position paper).

- Accessibility is the big concern during climate induced disasters, needs of marginalized groups, especially women, children, persons with disabilities, and elderly persons, needs to be prioritized and plan together with the community. Being able to readily change the management and operation of sanitation services, continual learning, and good understanding of sanitation system components can help to develop sanitation services that adapt to changing conditions. (Discussion paper).

Vulnerable groups and physical assets:

Considering flooding as the major impact due to climate change, the population groups vulnerable to climate change in Itahari is presented under Table 10:

Table 10: Venerable groups as a result of climate change impacts, ISMC

Populations at risk	Impact	Risk in ITMC
Populations drawing water from wells that are close to poorly constructed fecal sludge containments (septic tanks, latrines and pits)	Fecal contamination of water sources such as groundwater or rivers causing diarrheal diseases	51% of the people using tubewell (City profile, Household survey, 2075)
Marginalized population living in flood area	Fecal contamination of water sources causing public health emergency	Southern area of the city prone to inundation (as presented in the inundation maps in section5.7)

Drawing on the WHO guidelines on sanitation and health[7] the sanitation physical assets at risk during flooding periods and until flood waters subside are listed in Table 11.

Table 11: Physical assets at risk as a result of climate change impacts, ISMC

Physical Assets	Impact	Risk in Itahari using data collected by ENPHO
Poorly constructed septic tanks (0.5%), pits (50.4%) and holding tanks (49.1%)	Damage causing fecal sludge leakage that can propagate into water sources and wells	The majority of containment installations (50.4% pit, 49.1% holding tanks) are not the proper quality containment systems

Based on above discussion, to avoid contamination, some of the key adaptation measures for ITMC have been identified Table 12.

Table 12: Sanitation chain and potential adaptation measures for Itahari sub-metropolitan city

	Current Situation	Potential measure	Impact of measure (High/ Medium/Low)
Containment – Pit latrine	Most do not have sealed base	Provide incentives for retrofitting of tanks	High
Containment – holding tanks	Not a proper containment structure	Provide incentive for upgradation	
Containment – septic tanks	Negligible population with access to septic tanks	New houses to have septic tanks and incentives for retrofitting of tanks	High
Transport – Sewers	None	Sewerage in core urban area with treatment facility for sewage line	High
Treatment – FSTP	-	Introduce FSTP	High

[7] WHO. 2018. Guidelines on Sanitation and Health. https://apps.who.int/iris/bitstream/handle/10665/274939/9789241514705-eng.pdf6

6.7 Sludge Quality

Toxicity tests carried out for FS from ISMC showed that, Ammonia content was found to be in the rage from 224.39 to 1253 mg/L (Figure 23). Ammonia content was highest in the household. The optimum levels of ammonia inside the digesters has a very important role in the stability of the anaerobic digestion process to ensure adequate buffer capacity of the methanogenic medium. However, high concentrations could disrupt the process. Past studies report that, concentration greater than 3000mg/L showed an inhibitory effect by 40% on biogas generation process (GGGI, 2021).

Nitrate concentrations for sludge samples collected from ISMC ranged from 2.25 to 29.98 mg/L. Reference results from studies carried out for digestion of organic waste showed that Nitrate concentration below 0.75mg/L did not show inhibitions on biogas production. Ammonia concentrations at higher levels could be an inhibiting factor for biogas production.

Sludge samples showed absence of Arsenic, Selenium, Hexavalent Chromium and Mercury. Few sample from households showed presence of high Total Alkalinity. Precautionary measures have been recommended while using faecal sludge from such establishment for the production of biogas (Eco-Concern, 2021).

Parameters	Industry	Public Toilet	Household	Hospital	School
	Itahari				
Ammonia	1317.93	224.39	1514.92	749.41	1353.99
Nitrate	2.39	2.25	29.98	6.36	31.56
Total Alkalinity	4100	1200	5040	1880	4420
Cadmium	ND(<0.003)	ND(<0.003)	ND(<0.003)	ND(<0.003)	ND(<0.003)
Copper	ND(<0.02)	0.74	0.13	0.03	ND(<0.02)
Lead	0.02	0.09	0.01	0.02	ND(<0.01)
Manganese	ND(<0.05)	1.69	1.51	0.16	0.09
Nickel	0.02	0.06	0.03	0.02	0.01
Zinc	0.11	6.24	0.84	0.25	0.06
Arsenic	ND(<0.005)	ND(<0.005)	ND(<0.005)	ND(<0.005)	ND(<0.005)
Selenium	ND(<0.005)	ND(<0.005)	ND(<0.005)	ND(<0.005)	ND(<0.005)
Hexavalent chromium	ND(<0.02)	ND(<0.02)	ND(<0.02)	ND(<0.02)	ND(<0.02)
Mercury	ND(<0.005)	ND(<0.005)	ND(<0.005)	ND(<0.005)	ND(<0.005)

Figure 23: Quality of FS samples, ISMC

7. Storm water and wastewater management

Storm water management is a concern in ISMC. During continuous rainfall events, the sub-metropolis often faces inundation in different parts of the city. During 2021 (during Dashain), the city was inundated which also caused fatalities.

The main storm water lines runs parallel to the highway and main roads in the city. Likewise, there are side drains running along the inner parts of the city but does not cover the entire city area. An overview of the current storm water drainage network is provided in Annex 4.

One of the key problems with the current storm water drainage network is an ad-hoc based construction without adequate planning at the citywide level. A city map showing areas that are frequently inundated is provided in Annex 5. All storm water drains ends of in the major rivers flowing through the city.

There is currently no wastewater management plan at the city level nor immediate plans to develop in near future. Wastewater generated at the households are discharged directly into existing storm water drains. In the core part of the city, household are connected to the existing storm water drains where both grey and black water is also discharged.

8. Solid waste management

This section provides a brief overview on the SWM status of ISMC. The World Bank study report (2020) has been taken as the key basis to understand the SWM context.

The solid waste in the city is managed based on public-private partnership with a private operator who is responsible for collection, transportation and disposal of waste at the designated site by the sub-metropolitan city The private operator is also responsible for ensuring that not more than 25% of the waste received is disposed in the landfill site via anaerobic digestion and material recovery. The waste is collected daily in four wards (5,6,9 and 10) daily which covers 21% of Itahari's population while rest, except 14, are collected weekly. Ward 14 being completely rural in nature has no method of waste collection.

As per Environment Protection Act, industries located in the city manage their own waste via their own waste treatment system where as health care establishments segregate bio-medical waste and store them which however is substantially mixed with the municipal solid waste.

The waste is disposed in Charkose Jhadi without any treatment and falls along a stream emerging from the Setvi River (Annex 6). The biogas plant is supported by Alternative Energy Promotion Center (AEPC) and acts as a join decision making authority alongside the city.

8.1 Quantification and characterization of solid waste

Assessment done by the World Bank (2020) shows that the sub-metropolitan generated nearly 58 MT daily of which 48% is from domestic waste generators, 19% by commercial and rest by bulk generators such as markets and institutions. Among this, 26 MT of waste is taken to the waste disposal facility daily as shown in Table 13.

Table 13 Waste quantification

S.N	Particular	Quantity (MT/day)
A	**Primary waste quantification**	
1	Estimated waste from households	28
2	Estimated waste from bulk generators	11
3	Estimated waste from commercial establishments	19
4	Estimated waste from institutions/ offices	01
B	**Total waste generation**	**58**
C	**Estimated current population**	**157457**
D	**Estimated per capita waste generation per day (gram)**	**369**
E	**Average waste quantity received at dump site**	**26**

Source: World Bank (2020)

The waste flow in different parts of the waste management chain shows that only 39 tons per day (TPD) of waste is available for collection out of which only 26 TPD (66%) of the waste produced reaches the dumping site indicating either low service coverage or inefficiency in collection and transport services. The uncollected fraction i.e. 12 TPD (33%) is probably dumped into the open environment.

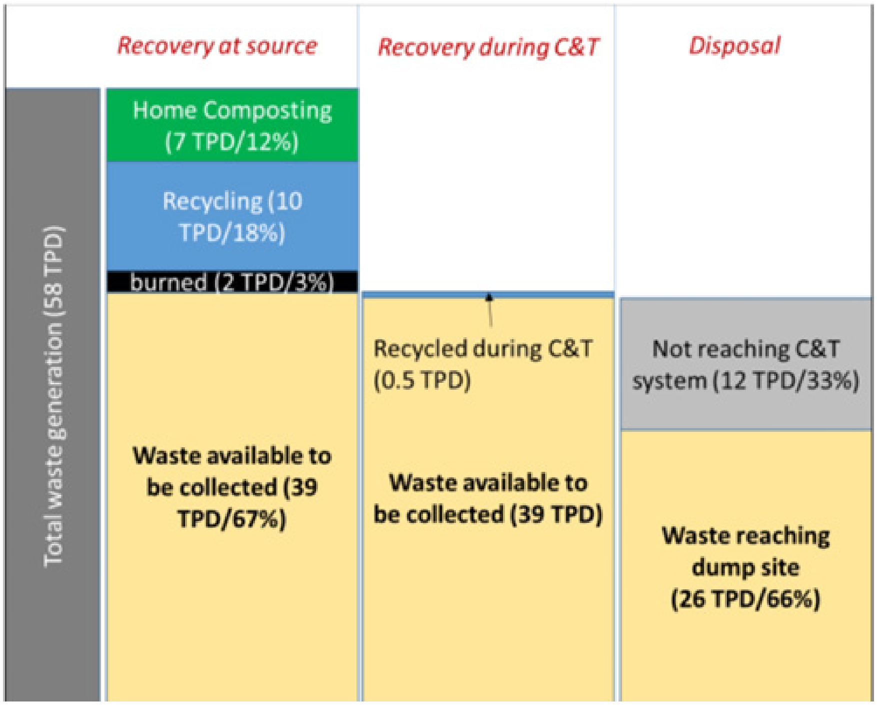


Figure 24: Municipal Solid Waste flow, ISMC

Source: World Bank (2020)

The waste characterization of ISMC is provide in Annex 8. As per the waste composition, 65% of the waste is organic in nature, followed by glass and plastics. The moisture content of waste is also quite high (58%) making it suitable for anaerobic digestion.

8.2 SWM disposal and treatment

The private service provider is currently disposing waste directly in the temporary dumping site inside the community forest along the Itahari-Dharan Corridor. There is a currently a Waste to Energy (W2E) Plant under construction to process the organic fraction of the municipal waste. The plant will use a mixed feed to generate bio-gas which the company plans to bottle and sell it to the industries.

It was observed that only the organic fraction of the solid waste will be processed in the W2E plant. However, the processing and management of the inorganic fraction still remains a subject of concern for city. This has not been adequately thought upon. In the absence of a designated landfill site for ISMC, management of solid waste is a serious challenge.

8.3 Climate change perspective to solid waste

It is to be noted that the assessment in this section have been done taking into consideration organic fraction of the solid waste. The assessment considering other fractions of solid waste is beyond the scope of this document. Similar to the sanitation value chain, each step of solid waste management value chain directly or indirectly contributes to GHG emission or impacted from climate change issues. Figure 25 below shows an assessment of the solid waste service chain from a climate change mitigation and adaptation perspective.

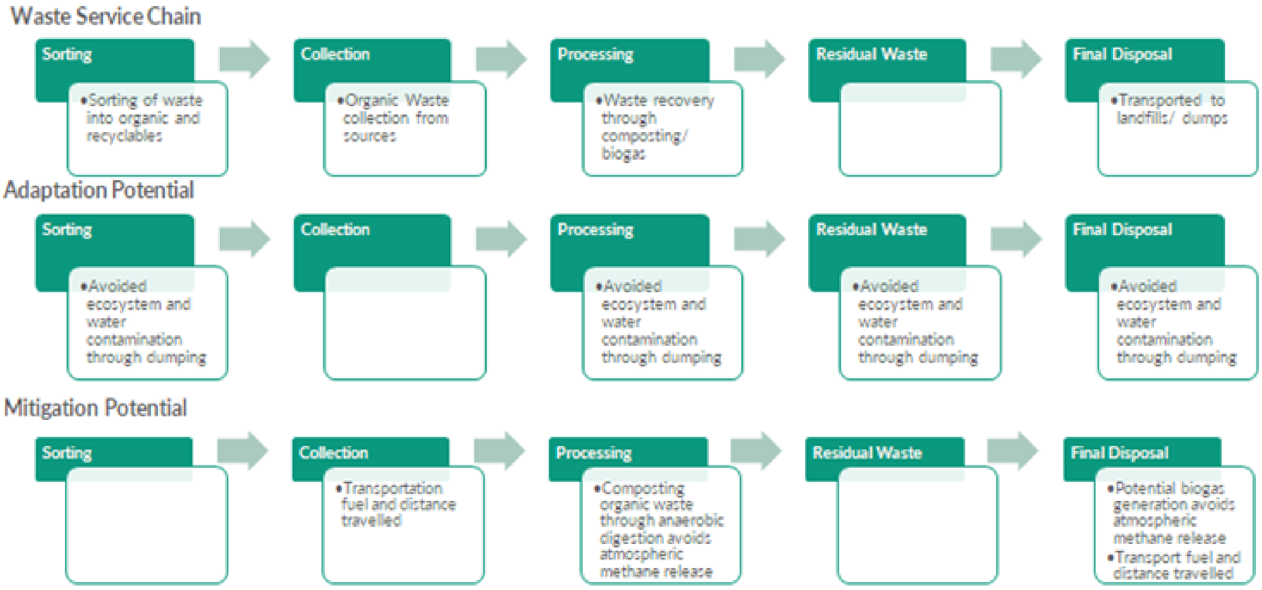


Figure 25: Potential climate adaptation and mitigation measures across SWM service chain

Climate Mitigation: Organic waste and GHG reduction options

Anaerobic decomposition of organic fraction of solid waste in landfill produce methane (CH_4) as greenhouse gas. The table below outlines the potential emissions from organic portion of solid waste using the CDM methodology and presents options for disposal or reuse of waste. The greenhouse mitigation estimates are presented below:

Table 14: Potential GHG mitigation estimates for organic fraction of solidwaste

Main emissions	Containment	Transport	Treatment	Disposal / Reuse
Potential emissions and corresponding CDM methodology	Emissions from solid waste disposal sites[8]	Transport emissions[9]	Biogas – gas from reactor calculated as per gas avoided from solid waste disposal sites	Compost- Emissions released during composting (depending on method for composting) Emissions saved from savings of fertilizers Biochar – savings from conventional fuel consumption – either coal or LPG

The baseline emission from the MSW in ISMC is 3201 eq. tn CO_2 per year, based on current solid waste disposal of 50 tons/day with 44% organic content (World Bank, 2020). The calculation uses the CDM methodology (same as calculated for FS in sanitation section 6.6.1). With the operation of large biogas plant by Enviro Care Concern Pvt. Ltd there will be a substantial emission reduction from the organic solid waste in near future.

Climate Adaptation: Organic waste and climate resiliency options

A high-level analysis assessing the climate vulnerabilities in Itahari and the current and potential organic waste management practices is provided in Table 15 below.

8 https://cdm.unfccc.int/methodologies/PAmethodologies/tools/am-tool-04-v6.0.1.pdf
9 https://cdm.unfccc.int/methodologies/DB/F5U41CTG7ENWK9RSSL5BV1LUPDG76W

Table 15: Climate resiliency options for organic waste management (as potential option for ISMC)

Current and potential waste management practices	Adaptation & future vulnerability to climate change	Options and Co-Benefits	Impact
Uncontrolled disposal (open dumping & burning)	Highly vulnerable Warmer temperatures in the future could promote pathogen growth and disease vectors from uncontrolled organic waste	Consider alternative lower-cost medium technology solutions (e.g., landfill with controlled waste placement, compaction, and daily cover materials)	High
Controlled landfilling with landfill gas recovery and utilization	Indirect low vulnerability or positive effects Higher temperatures in the future could increase rates of microbial methane oxidation rates in cover materials	Primary control on landfill CH_4 emissions with >1200 commercial projects Potential local source of renewable energy to replace fossil fuels Landfill gas projects comprise 12% of annual registered CERs under CDMa Oxidation of CH_4 and NMVOCs in cover soils is a smaller secondary control on emissions	Low
Controlled landfilling without landfill gas recovery	Indirect low vulnerability or positive effects Higher temperatures in the future could increase rates of microbial methane oxidation rates in cover materials	Use of cover soils and oxidation in cover soils reduce rate of CH4 and NMVOC emissions with gas monitoring and control	Low
Thermal processes including incineration, industrial co-combustion, and more advanced processes for waste-to-energy (e.g., fluidized bed technology with advanced flue gas cleaning)	Low vulnerability	Reduces GHG emissions relative to landfilling Costly, but can provide significant mitigation potential for the waste sector, especially in the short term Replaces fossil fuels (Already at the final stage of construction at ISMC)	Low
Aerobic biological treatment (composting), a component of mechanical biological treatment (MBT)	Indirect low vulnerability or positive effects Higher temperatures increase rates of biological processes (Q10)	Reduces GHG emissions Can produce useful secondary materials (compost) provided there is quality control on material inputs and operations Can emit N_2O and CH_4 under reduced aeration or anaerobic conditions	

9. Circular Economy

The concept of circular economy is described by the Ellen McArthur Foundation as looking beyond the take-make-waste model to build a circular economy approach that aims to redefine growth, focusing on positive society wide benefits. It entails decoupling economic activity from the consumption of finite resources and shift away from waste generation in the system. The circular model aims to keep the products and materials in a loop rather than generate waste, which ultimately regenerates natural systems.

Globally and nationally, the products/by-products from waste and sanitation have been in re-use since time immemorial specially in agriculture and in more recent times in energy. Figure 26 presents the potential opportunities of harnessing resource from waste. Circular economy in waste/sanitation is identifying the resource potential of different waste streams for recovering water, energy and soil nutrients.

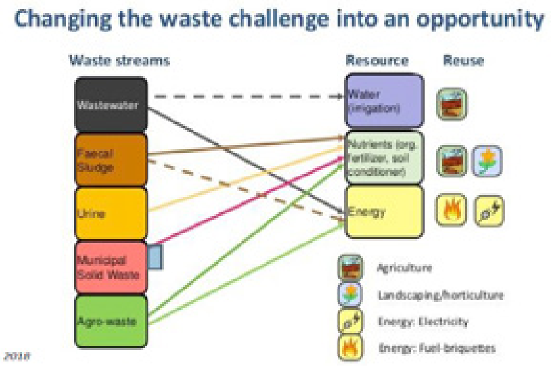


Figure 26 *Changing the waste challenge into an opportunity. (Source: Otoo and Dreschsel, 2018)*

There are few potential re-use by-product from national and global practices like- biogas, fuel pellets, briquettes, distilled water, fly ash in construction, compost/fertilizer etc. At present context in Nepal including Itahari, most treatment options that are being used to manage the waste and sanitation have potential to produce one or either of the products that could be :

- Generation of biogas that supports the diversification of energy mix in the country
- Production of waste/sanitation-based fertilizer; as every wastewater/fecal sludge and waste treatment plant operation

Market assessment to understand the demand of sanitation fertilizer and biogas in ISMC

The preliminary market assessment to understand the market of both fertilizer and biogas was done. To comprehend the market for biogas the existing market of the liquified petroleum was assessed. To understand the market for organic fertilizer, following information were used for the estimation:

- Total land area of ISMC: 11,299 hectors
- Percentage of land area for agriculture: 54.93% (Source Land-use mapping report)
- Percentage decrease in agriculture land: 2.93%

Table 17 shows the potential market for organic fertilizer for the five years' time.

Table 16: Estimation of quantity of organic fertilizer for ISMC (5 years period)

Years	Estimated demand forecast for organic fertilizer (in tons)	
	Scenario A: Requirement of chemical and organic fertilizer if the farm uses combination of both (75:25; standard agriculture practice, interview with agri-economist)	Scenario B: Requirement of organic fertilizer if the farm uses only organic fertilizer
2021	2989	18,619
2022	3269	17636
2023	3705	16653
2024	4185	15670
2025	4707	14687

From the energy perspective, presently 76% of households are using liquified petroleum gas (LPG) gas as cooking fuel. Biogas is renewal energy source that can replace the use of LPG for cooking. Biogas sector is in continuous research and development, and in the future, biogas has full potential to replace LPG. Table 18 below estimates total figure from the five years data that shows the savings on cost if ISMC could switch from LPG to biogas at the household level, as cooking fuel.

Table 17: Estimation of cost saved by using biogas in ISMC, based on its potential to replace LPG

Years	Population (Census 2021)	LPG consumption (KG)	Cost of LPG (NPR)	Equivalent KG of biogas as replacement (KG)	Cost of biogas (NPR)	Cost saved (Cost of LPG – cost of biogas (NPR)
2021	198,098	5.2 million	512 million	4 million	417 million	95 million
2022	210,440	5.5 million	544 million	4.9 million	443 million	101 million
2023	223,550	5.9 million	578 million	5.2 million	471 million	107 million
2024	237,477	6.2 million	614 million	5.6 million	500 million	114 million
2025	252,272	6.6 million	653 million	6 million	531 million	121 million

Note: This is based on household consumption estimates

The main challenge to mainstream circular economy at present is, there is no quality market presence of the products from sanitation, as sanitation sector has not been assessed from the business angle. However, to go ahead in that direction, following are the key challenges:

1. Social acceptance of the sanitation-based products needs to be ensured
2. Present policy environment should be reformed to uplift the product from sanitation.
3. Standardized the quality of sanitation products.
4. Robust coordination with the concerned sectors to achieve proper market development. The concerned sector here means specially agriculture and energy (at least) in the present context.
5. Conscious choice of treatment technologies should be based on the intended re-use of the byproducts.
6. Market promotional awareness programs dedicated to creating the demand at the national and local level jointly with the concerned other sectors.
7. Lastly, to ensure the safety and quality of the re-use product, strategically limit or negate the use of hazardous cleaning agents by strategically promoting greener cleaning practices of sanitation system.

10. Key gaps and needs across sanitation systems

The major gaps and challenges identified from existing policy, institutional and overall sanitation system analysis have been summarized below across different domains.

Institutional set up and policy

- The institutional set up and management of ISMC shows although there are adequate staffs allocated but the responsible staffs perform different roles. There is a need to provide clear roles and responsibilities within the team.
-
- With reference to the existing policy and regulatory instruments, there are no local level policies or bylaws governing the management and operation of sanitation services particularly FSM in ISMC. The need for a FSM bylaw was realized during discussions with the Deputy Mayor, staffs of the EDM unit and local stakeholders.

Climatology and vulnerability

- Long-term historical seasonal and annual precipitation distribution shows the increasing trend, highest (lowest) increment in monsoon season (post-monsoon) season at a rate of 4.26 mm/year (0.004 mm/year). Increment in precipitation in the monsoon season leads to frequent extreme precipitation and flood events; on the other hand, the decreasing trend of winter precipitation leads to drought over Province 1.
- Similarly, the annual temperature is also found to be increasing at a rate of 0.02oC/year. Analysis of extreme precipitation events shows that heavy (≥10 and <25 mm) and extreme (>25 mm) precipitation events along with consecutive wet days are increasing from 1980 to 2020. Further, projected precipitation and temperature for the next 80 years is also expected to increase, leading to frequent flood and warm days over the Province 1.
- Inundation and flood map also shows that southwestern and northwestern part of the ISMC are more vulnerable to floods. These flood-prone areas are located along with the cannel and foothills areas
- The projected winter precipitation reduces at province 1. Winter over the study region will be relatively dry than other seasons due to reduced precipitation.
- Reduced precipitation is likely to create water scarcity affecting safe sanitation practices. Moreover, dry condition mainly reduces availability of groundwater affecting irrigation and other usage.

Sanitation systems

- Due to absence of FSM regulations, none of the private FS service providers were compelled to register their services with the sub-metropolis. Likewise, there was no uniformity in the FS tariffs charged by the service providers. The FSM services across the service chain remained unregulated.
- Status of the containment characteristics shows lack of uniformity in the types and size containments indicating absence in adherence of a standard design practices at the city level.
- Sludge emptying practices at the household level varied. Low income and vulnerable settlements use unsafe containments mainly pit latrines and majority opt for manual emptying services. Both the manual pit emptier and the households using pit latrines face potential health risk due to unsafe handling and disposal practices.

- Low income, squatter settlements within ISMC are mostly located along the river banks and in flood prone zones. These households have witnessed flooding events in the past from climate induced disaster events. During flooding, the sanitation systems remain dysfunctional and poses serious challenge to practice safe sanitation.
- Manual emptying is prevalent especially when it comes to emptying of pits. One of the reasons identified is also due to the inefficient emptying devices used for emptying thick quality sludge.
- Proper disposal and treatment of sludge is a serious concern for both faecal sludge and solid waste streams. In the absence of designated treatment and disposal facilities, the waste generated from ISMC is being disposed haphazardly and is posing serious public health risks.
- The processing and management of the inorganic fraction of the municipal solid waste will remains a subject of concern for the city. There are yet no concrete plans for its management. One of the key concern is finding a potential site to establish a landfill site.
- The W2E plant is expected to cater to the organic fraction of the municipal solid waste provided that household level segregation takes place efficiently. This issue has not yet been adequately thought and discussed at the city level.
- There is a strong demand from the private FS service providers to establish a faecal sludge treatment plant at the earliest.

11. CWIS Strategy

This section outlines the Citywide Inclusive Sanitation Strategy for ISMC. Key gaps identified across the sanitation service chain have been aligning with the CWIS core outcomes and functions and strategies recommended accordingly. Most indicators suggested across core outcomes and functions under the CWIS framework is either absent or not addressed.

CWIS Core Outcomes		Strategies		
Equity	**Status & Gaps**	**Short (within 1 year)**	**Medium (2-3 years)**	**Long term (4-5 years)**
Services reflect fairness in distribution and prioritization of service quality, prices, deployment of public finances/subsidies	• No uniformity in the FS tariffs charged by the FS service providers.	• Regulate FS tariff such that the marginalized group have access to affordable emptying services • Municipality establishes a regular system of monitoring overall performance of services including set tariffs	• Regular monitoring of services, performance and tariff	• Regular monitoring of service performance
	• Mechanical FS service provides hardly reach low income/squatter settlements with their services	• Municipality regulates services and supports to create awareness to serve low income settlements	• Develop policy to support low income/ squatter areas with improved sanitation facilities and desludging services	

Table 18: Strategy across CWIS Core Outcomes

Safety				
Services safeguard customers, workers and communities from health risks by reaching everyone with safe sanitation	• No uniformity in the types, size and design of containments indicating lack of adherence of a standard design • Almost 50% containments are holding tanks and remaining are pit latrines • Low income and vulnerable settlements use unsafe containments mainly pit latrines and majority opt for manual emptying services.	• Develop standard design guidelines for Septic Tanks and safe containments • Institutionalize design guidelines within the municipal systems while approving building designs	• Develop climate resilient containment upgradation designs options including financing mechanisms • Develop a containment upgradation strategy for ISMC • Demonstrate strategic design options of containment upgradation	• Implement containment upgradation program
	• No safety protocols followed by both manual and mechanical sludge emptier • Both the manual pit emptier and the households using pit latrines face potential health risk due to unsafe handling and disposal practices. • Manual emptying prevalent for pit emptying. One of the reasons is due to inefficient emptying devices used for emptying thick sludge	• Develop health and safety guidelines and protocols for personals associated with handling and managing faecal sludge • Together with technical partners, improve manual emptying practices (ensuring livelihood and dignity)	• Provide design options to upgrade existing mechanical emptying devices • Link FS entrepreneurs with technology and financing options	• Gradually discourage manual emptying practices • Shift to only mechanical emptying practices
	• Proper disposal and treatment of sludge is a serious concern for both faecal sludge and solid waste streams. In absence of designated treatment and disposal facilities, FS generated from ISMC is disposed haphazardly posing serious public health risks.	• Prepare for FSTP design including business plans	• Initiate construction of FSTPs • Initiate commissioning of the FSTP	
Sustainability				
Services are reliable and continually delivered based on effective management of human, financial and natural resources	• During flooding, the sanitation systems remain dysfunctional and poses serious challenge to practice safe sanitation. • • Low income, squatter settlements within ISMC are mostly located along the river banks and in flood prone zones. Households have witnessed flooding. This has often disrupted sanitation systems	• Develop a plan of action to service households during flooding events • Align climate resilient sanitation interventions with the disaster preparedness, response and reduction (DRR) strategy • Using climate vulnerability status forecast (flood maps) as the basis, map out highly vulnerable population and households to improve sanitation conditions	• Implement climate resilient sanitation design options in highly vulnerable areas • Establish embankments in flood prone areas (dykes) • Initiate dialogue for relocation of vulnerable settlements • Develop a sustainable FSM service model exploring options of a public private partnership modality	• Relocate highly vulnerable settlements to safer grounds

Table 19: Strategy across CWIS Core Functions

Functions		Strategies		
Responsibility	Status & Gaps	Short (within 1 year)	Medium (2-3 years)	Long term (4-5 years)
Authority (s) execute a clear public mandate to ensure safe, equitable, sanitation services for all	• No local level policies or bylaws governing the management and operation of sanitation services particularly FSM in ISMC. • • FSM services across the service chain remains unregulated	• Develop Sanitation Policy and FSM bylaws which regulates services across the sanitation chain. • Adopt standard septic tank design guidelines implemented in other municipalities of Nepal • Develop FSM occupational health and safety (OHS) guidelines/protocols • Train service providers and sanitation workers on OHS practices	• Operationalize FSM by-laws • Establish a compliance and monitoring mechanisms involving local Ward Offices to check adoption of standard containments • Improve database and monitoring mechanism using tools such as IMIS for smooth FSM service delivery • Monitor OHS practices	• Periodically monitor
	• Due to absence of FSM regulations, none of the private FS service providers are compelled to register services with the sub-metropolis	• Enacting the FSM bylaws, register all private FS entrepreneurs within the municipality domain	• Issues service license to FS service providers • Regulate FSM service across the sanitation service chain	
Accountability				
Authority (s) performance against its mandate is monitored and managed with data, transparency and incentives	• Lack of information at the authority level on number/types/size of containment, demand for emptying, local practices, number of service provides, transport and disposal practices, tariff, grievances redressal mechanism, etc. • No clear targets available for improving sanitation conditions	• Initiate ground work to develop an Integrated Municipal Information Management System (IMIS) including mapping of poor and vulnerable areas • Collect disaggregated data either using secondary information (if available) or through primary investigation to fulfil several CWIS • indicators	• Develop a CWIS plan for ISMC • Initiate operationalization of CWIS plan together with implementation of priority issues	

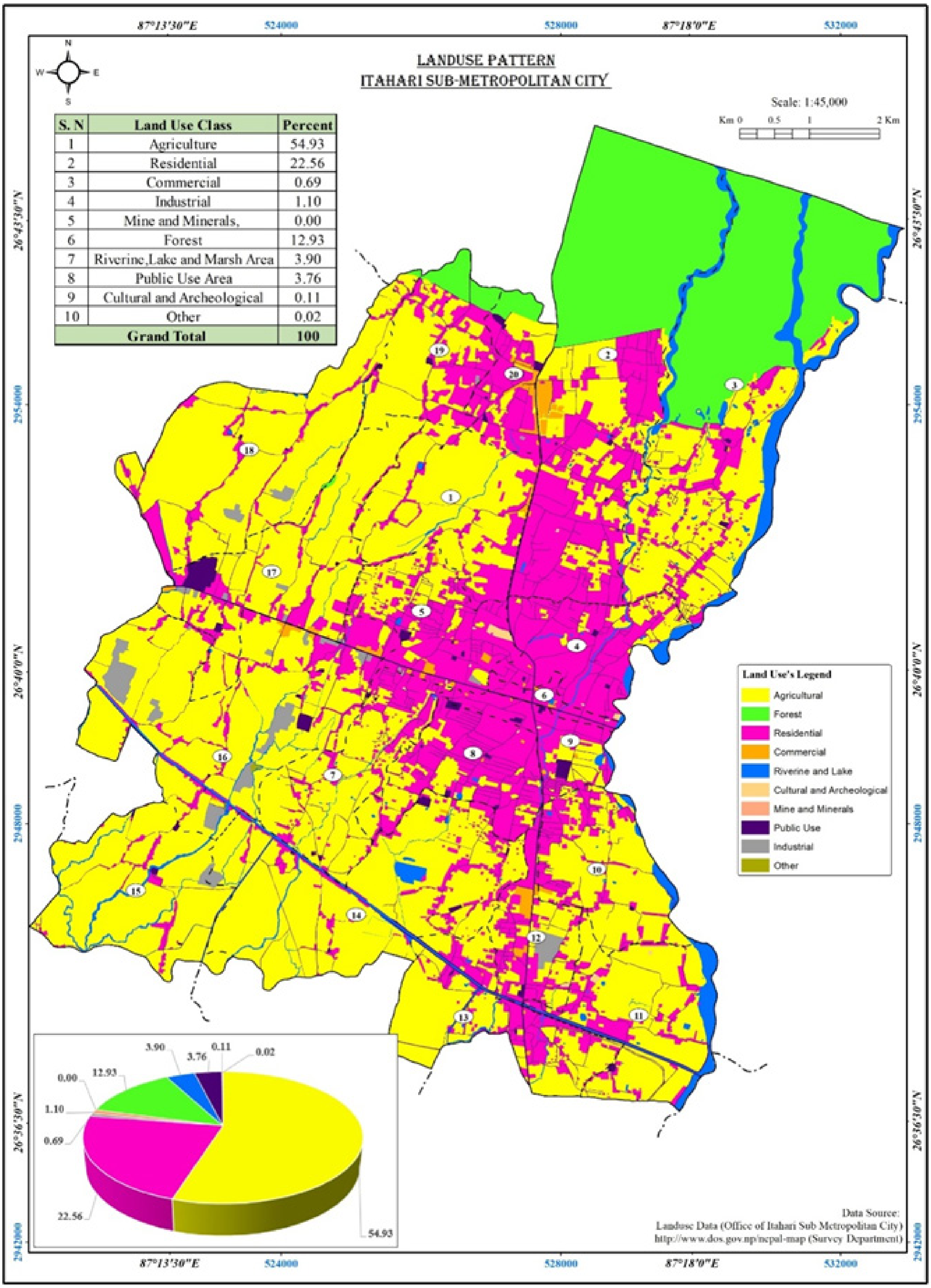
Resource planning and Management				
Resource -human, financial, natural assets are effectively managed to support execution of mandate across time/ space	• Very low budget allocation for EDM unit • • Strong demand from the private FS service providers to establish a faecal sludge treatment plant at the earliest but no planning and resource allocation.	• Develop CWIS plan for ISMC • Initiate discussions with local stakeholders to identify suitable land for development of FSTP for ISMC including options of building a FSTP site within the current W2E premises • Identify local team leader/ player from potential FSTP site and engage with the community through support from local CBOs • Conduct exposure visit to • neighboring Charali FSTP for local community stakeholders • Develop consensus on the treatment site and initiate development of detail project report (DPR) for FSTP including options for co-digestion of FS in the W2E plant	• Together with private FS service providers and the municipality, develop a business plan for FSTP and its operation • Resource mapping for FSTP construction • Initiate construction of FSTP with technical assistance from line agencies • Develop standard operating procedures (SOP) for FSTP	
	• Adequate staffs available in the EDM unit but responsible staffs perform different roles. • Need for demarcation of clear roles and responsibilities within the team	• Review JDs of the team and assign specific roles and responsibilities including for FSM		

12. References

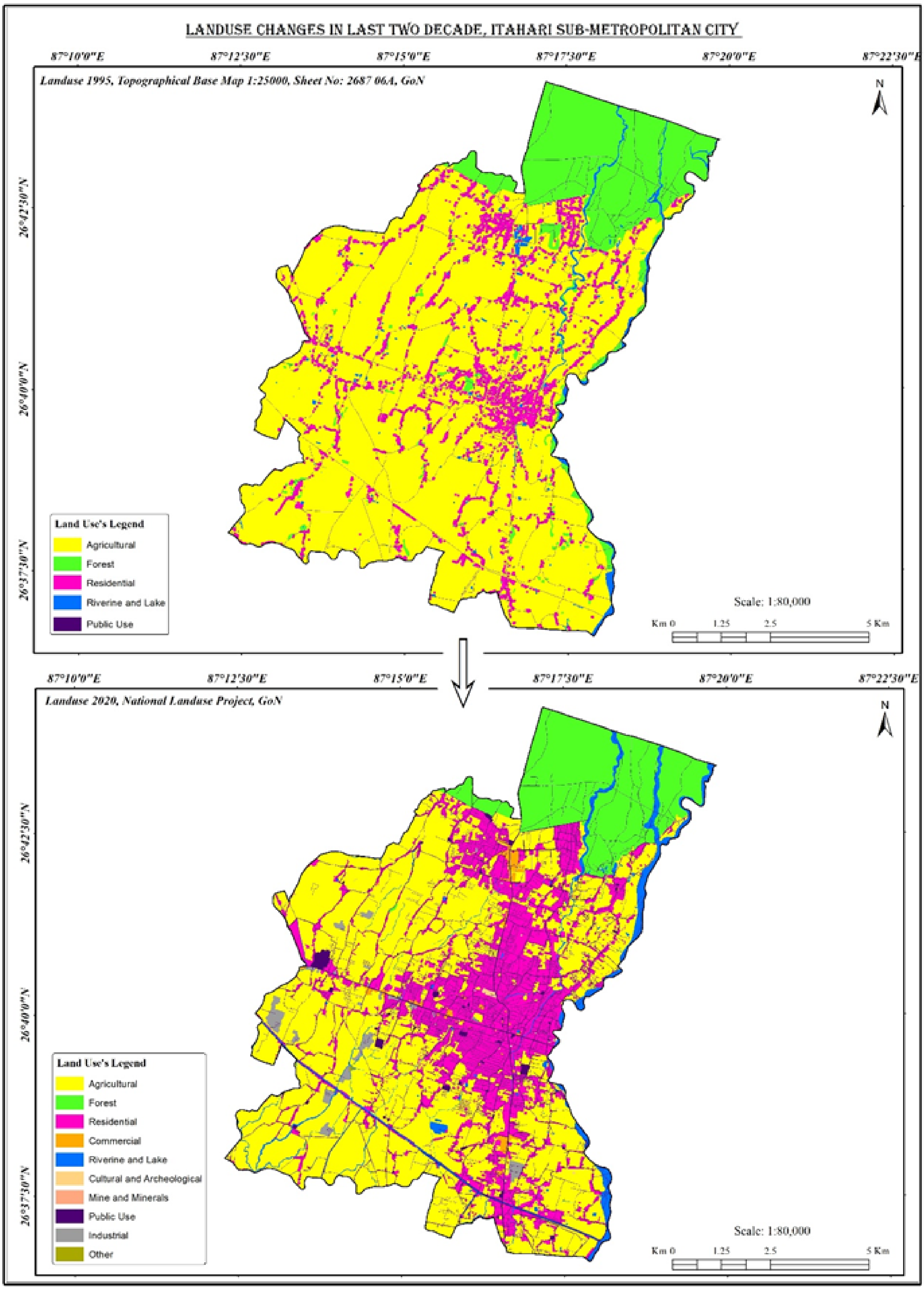
ENPHO (2017), Feasibility Study on Fecal sludge Management, Itahari.
ENPHO (2018). SFD Report, Itahari.
GGGI-Eco Concern (2021) Faecal Sludge Assessment for Large Scale Biogas Plants in Nepal
World Bank (2020). Strategic Assessment of Solid Waste Management Services and Systems in Nepal of Itahari Sub-Metropolitan City.

13. Annex

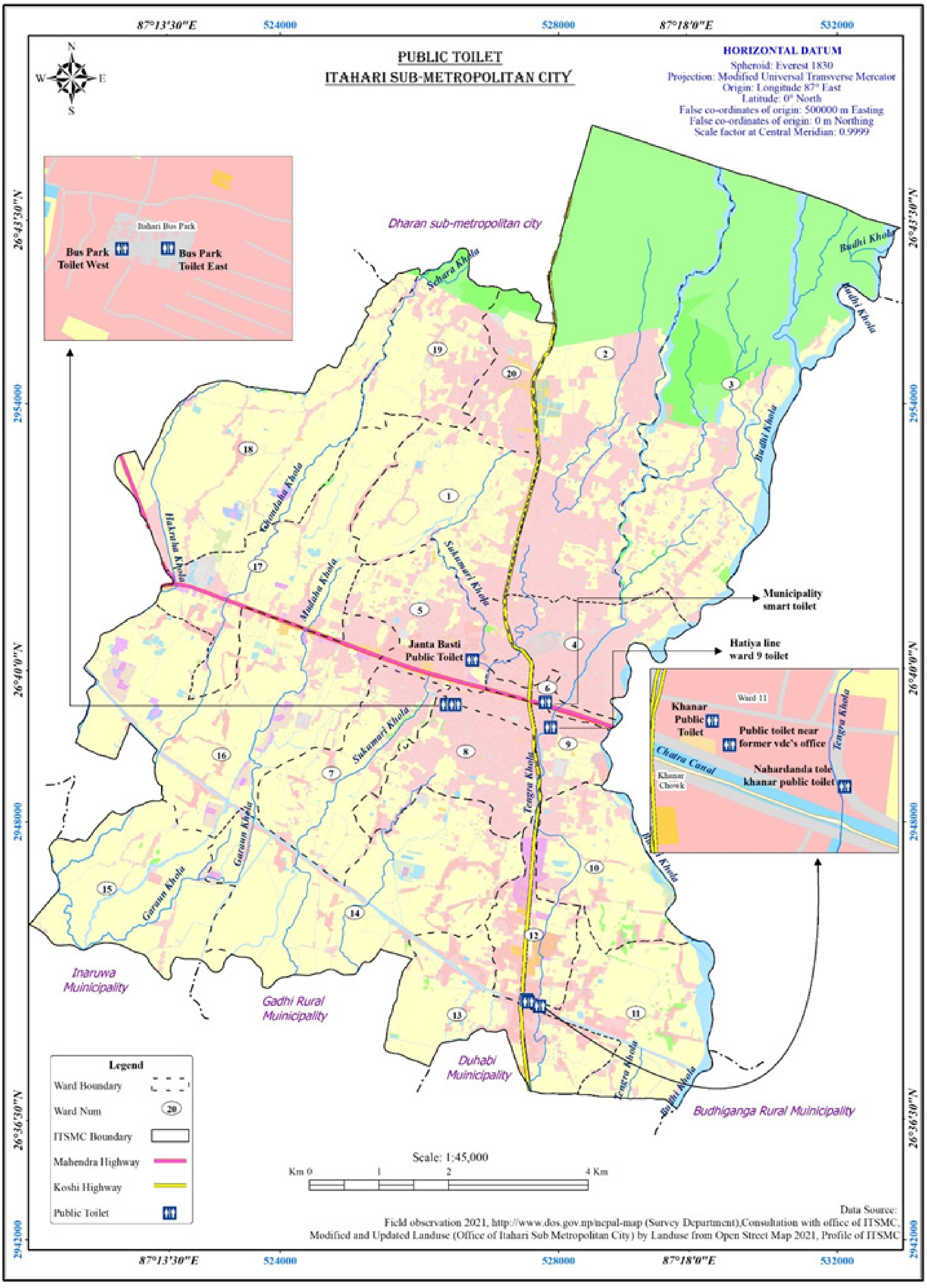
Annex 1: Land Use Map, ISMC



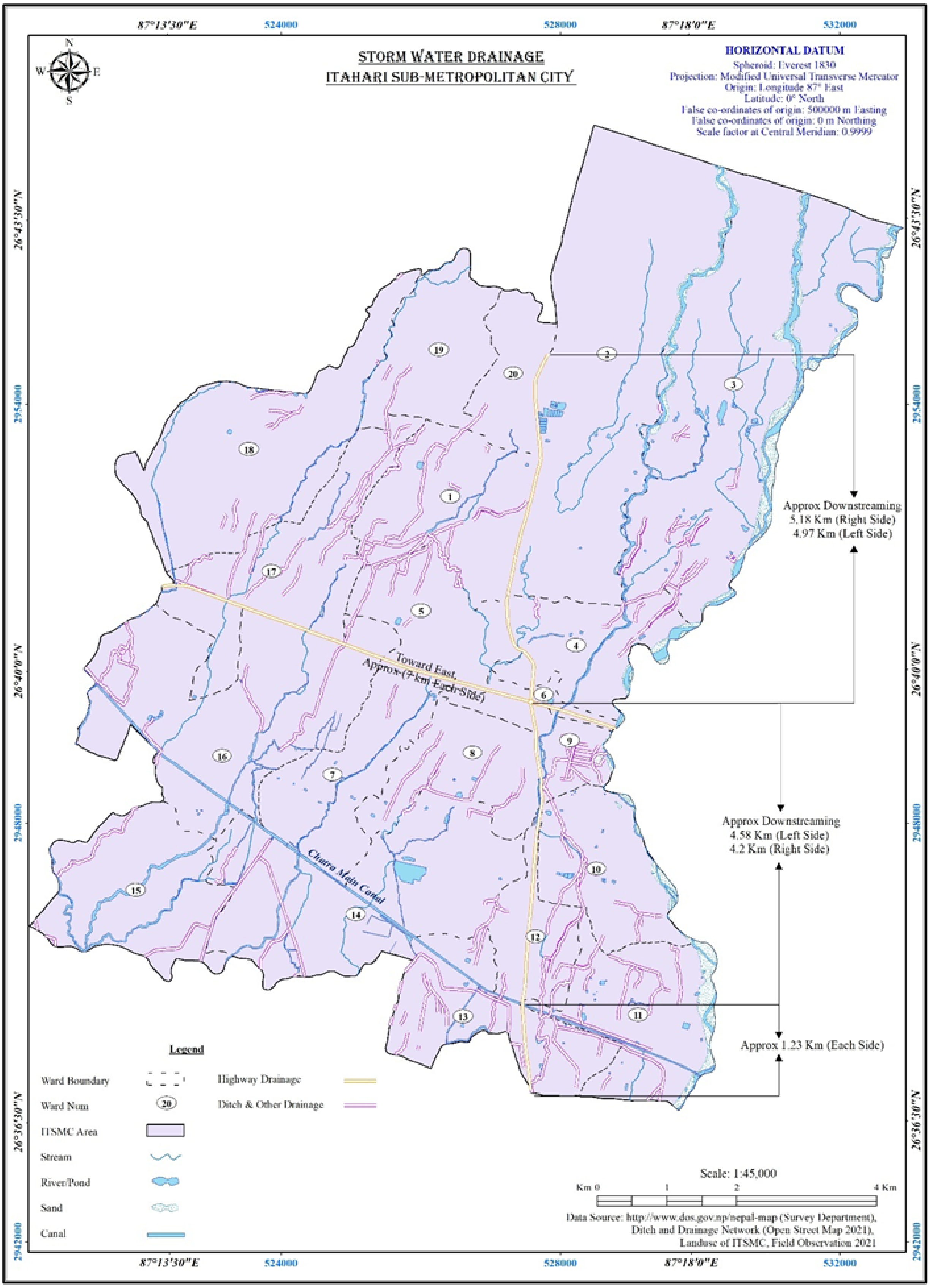
Annex 2: Land Use Change over last 20 years, ISMC



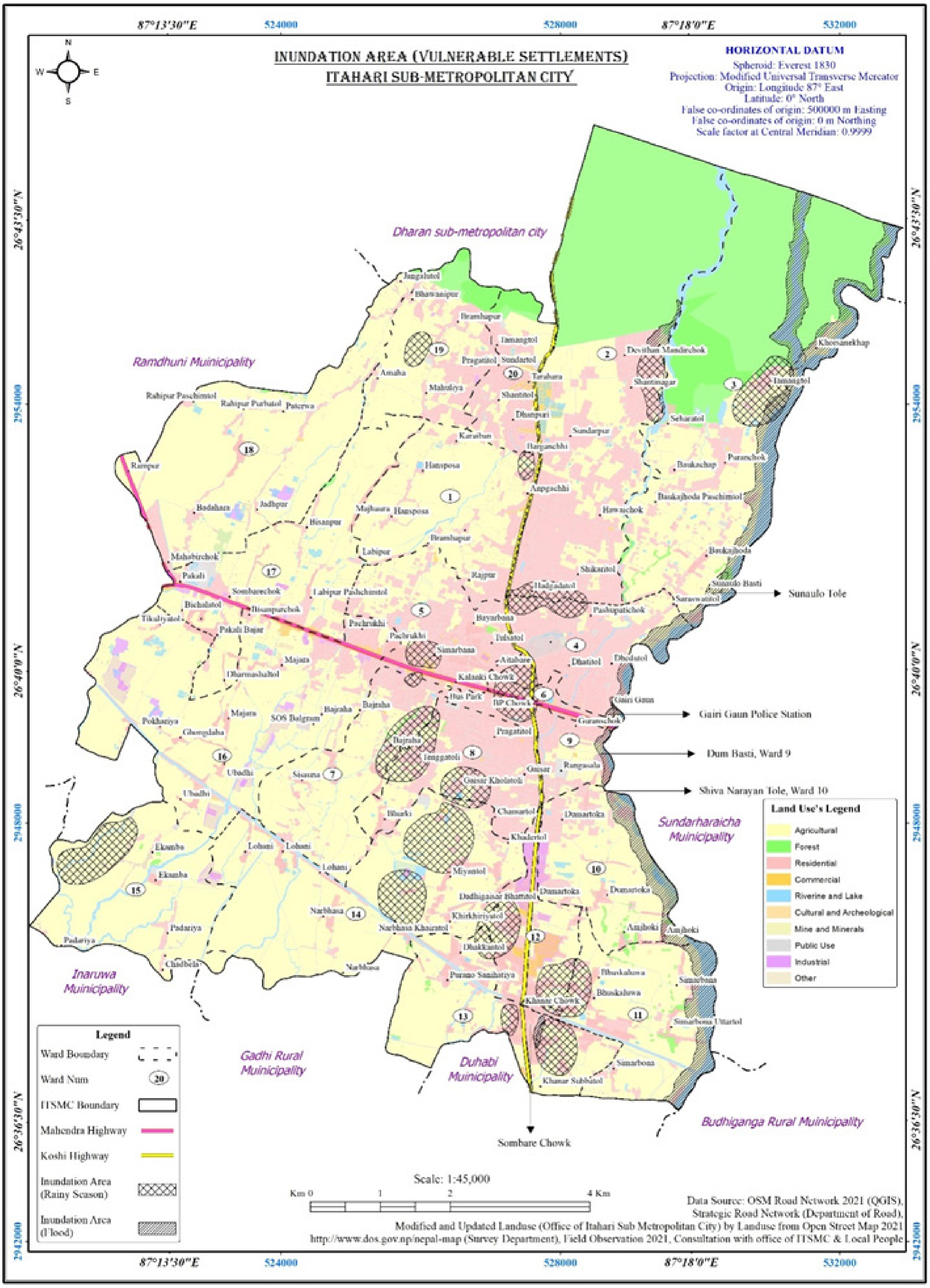
Annex 3: Public Toilet locations, ISMC



Annex 4: Storm water drainage network, ISMC



Annex 5: Inundation area due flooding, ISMC



Annex 6: Current faecal sludge and solid waste disposal site, ISMC

Annex 7: Quantification of faecal sludge at ISMC

Total Households	33794					
Containment	Pit	Holding tank	Septic tank			
Average Volume (liter)	1.5	17.5	5.6			
Percent	50.4%	49.1%	0.5%			
Households	17032	16593	169			
Total volume of FS (liter) considering the containment is full	25548	290375	946			
Percent Emptied within a year	15%	4.60%	0			
Emptied volume of Sludge within a year	3832	13357	0			
Percent Emptied within 4 years	19%	9%	0.5%			
Emptied volume of Sludge within 4 years	4854	25553	5	Volume Cu. Meter	Sludge collected per year	Sludge collected per day
Total Sludge Collected since 5 years	8686	38910	5	47601	9520	26

Source: ENPHO (2017)

Annex 8: Solid Waste Characterization of ISMC

S.N	Parameter	Unit	Point of waste generation	Downstream sample
A	Physical composition			
1	Organic	%	44.37	65.15
2	Plastic	%	4.82	8.07
3	Paper	%	5.79	5.65
4	Glass	%	36.05	16.07
5	Rubber	%	0.09	0.65
6	Textile	%	1.71	2.32
7	Metal	%	4.21	2.09
8	Others	%	2.95	0.00
B	Chemical Composition			
1	Moisture	%	64.06	58.37
2	Bulk density	Kg/m3	187.18	271.27
3	Organic content	%	44.36	61.15
4	Calorific value	Kcal/mg	1893	2.16
5	Carbon/ Nitrogen ratio		64.17	52.10
6	Total solid	%	35.94	41.63
7	Volatile solid		79.26	67.11

Source: World Bank (2020)

Annex 9: Sample of FSM bylaw, Mahalaxmi Municipality

खण्ड २, संख्या : १३

महालक्ष्मी राजपत्र

खण्ड : २ संख्या: १३, मिति २०७८/१२/२

भाग-१

महालक्ष्मी नगरपालिका

महालक्ष्मी नगरकार्यपालिकाद्वारा प्रकाशित

मानव मलमूत्रीय फोहोर व्यवस्थापन विनियम, २०७८

Annex: GHG emission calculation methodology

The emissions are calculated as follows:

$$\left.\begin{matrix} BE_{CH4,SWDS,y} \\ PE_{CH4,SWDS,y} \\ LE_{CH4,SWDS,y} \end{matrix}\right\} = \varphi_y \times (1 - f_y) \times GWP_{CH4} \times (1 - OX) \times \frac{16}{12} \times F \times DOC_{f,y} \times MCF_y \times \sum_{x=1}^{y} \sum_{j} \left(W_{j,x} \times DOC_j \times e^{-k_j \times (y-x)} \times \left(1 - e^{-k_j}\right)\right) \quad \text{Equation (1)}$$

S.No.	Parameter Description	Parameter Symbol	Value	Units	Remarks (If any)
1	Model correction factor to account for model uncertainties for year y	ϕy	0.85		Default value as per SWDS tool for wet conditions (Application-B)
2	Fraction of methane captured at the SWDS and flared, combusted or used in another manner that prevents the emissions of methane to the atmosphere in year y	fy	0.0		Used as referred from Meth AMS-III.AO v1, page 4/12
3	Global Warming Potential of methane	GWP CH4	25.0		As per AR4, IPCC 2007
4	Oxidation factor (reflecting the amount of methane from SWDS that is oxidized in the soil or other material covering the waste)	OX	0.1		Default value as per SWDS tool
5	Fraction of methane in the SWDS gas (volume fraction)	F	0.5	Volume Fraction	Default value as per SWDS tool
6	Fraction of degradable organic carbon (DOC) that decomposes under the specific conditions occurring in the SWDS for year y (weight fraction)	DOC f,y	0.5	Weight Fraction	Default value as per SWDS tool
7	Methane correction factor for year y	MCF	0.4		Default value as per SWDS tool

	Biomass residues (Waste Components)	DOCj	kj	%W j,x	
W1	**Fecal Sludge**	0.05	0.40		For Domestic sludge, 5% is recommended by SWDS tool. Reference to Pg16/25 of tool