Integrated Water *and* Sanitation Safety Plan

Leh Town

2025

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केंद्र शासित प्रदेश लद्दाख का प्रशासन
ADMINISTRATION OF UNION TERRITORY OF LADAKH

LEDeG

BORDA

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This document has been prepared with financial support from BORDA (Bremen Overseas Research and Development Association). The contents of this report are the sole responsibility of the authors and implementing organizations and do not necessarily reflect the views of BORDA.

This report is intended as a strategic planning and risk assessment document. While due diligence has been exercised through field visits, stakeholder consultations, and analysis of available data, the findings and recommendations are based on conditions prevailing during the study period.

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Technical guidance and methodological inputs were provided by **World Health Organization (WHO) – India and Biome Environmental Trust, Bangalore.**

Author :

LEDeG:

Stanzin Odsal *(Urban Planner)*

Plannable Co.

Konchok Tashi *(Urban Planner)*

Faisal Qadir *(Environmental Engineer)*

Stanzin Mingure *(Field Expert)*

Editors:

Stanzin Skaldan *(Plannable Co.)*

Designer: Skalzang Otsal

Cooperation Partners

The preparation of the iWSSP was undertaken in cooperation with the following institutions:

Government and Statutory Institutions

- Ladakh Autonomous Hill Development Council (LAHDC), Leh
- Municipal Committee Leh / Urban Local Bodies (ULB)
- Public Health Engineering (PHE) Department, Leh
- Igo Phey Division, PHE
- Health Department, UT Ladakh
- Ladakh Pollution Control Committee
- Blue Water Company (BWC) – Faecal Sludge Treatment Plant (FSTP) operations
- Bionics Consortium Pvt. Ltd. – Sewage Treatment Plant (STP) operations

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- World Health Organization (WHO) – India
- Biome Environmental Trust, Bangalore

Lead and Technical Partners

- Ladakh Ecological Development Group (LEDeG) – Lead organization
- Plannable Co. – Technical planning, coordination, and documentation

TABLE OF CONTENTS

List of Tables

List of Maps

List of Figures

List of Abbreviations

iWSSP – Integrated Water and Sanitation Safety Plan
WSP – Water Safety Plan
SSP – Sanitation Safety Planning
STP – Sewage Treatment Plant
FSTP – Faecal Sludge Treatment Plant
PHE – Public Health Engineering Department
MCL – Municipal Committee, Leh
FLT – Fully Lined Tank
LPSPWB – Lined Pits with Semi-Permeable Walls or Bottom
DEWAT – Decentralised Wastewater Treatment
UIDSSMT – Urban Infrastructure Development Scheme for Small and Medium Towns
CPHEEO – Central Public Health and Environmental Engineering Organisation
NABL – National Accreditation Board for Testing and Calibration Laboratories
TUM – Technical University of Munich
IISD – Indian Institute of Sustainable Development
LEDeG – Ladakh Ecological Development Group
WHO – World Health Organization
UBA – German Environment Agency
RIVM – National Institute for Public Health and the Environment
AMRUT – Atal Mission for Rejuvenation and Urban Transformation
SBR – Sequential Batch Reactor
GFDL CM2.1 – Geophysical Fluid Dynamics Laboratory Climate Model 2.1
SPCB – State Pollution Control Board
LPCD – Litres Per Capita Per Day
MLD – Million Litres per Day
SR – Service Reservoir
TW – Tubewell
PSP – Public Stand Post
SCADA – Supervisory Control and Data Acquisition
GIS – Geographic Information System
RO – Reverse Osmosis
PPE – Personal Protective Equipment
GPS – Global Positioning System
O&M – Operation and Maintenance
BWC – Blue Water Company
TSS – Total Suspended Solids
COD – Chemical Oxygen Demand
BOD – Biological Oxygen Demand
FHTC – Functional Household Tap Connection
UPU – Urban Public Utility
MBBR – Moving Bed Biofilm Reactor
CPCB – Central Pollution Control Board
DPR – Detailed Project Report
OSS – Onsite Sanitation System
TSST – Sewerage System
ULFU – Landfill Leachate
TVTT – Vacuum Trucks
SSTS – Septic Tanks
SSPS – Soak Pits
SSS – Streams (for wastewater disposal)
SpS – Solid Sludge (from treatment)
W2W – Treated Water (used for irrigation or industry)
WC1 – Contamination of Groundwater
WC2 – Pollution of Rivers
ET – Extraction of Water from Tubewells
DT – Distribution of Water through Tankers
DRM – Transport of Water through Rising Mains
DN – Distribution Network
DP – Public Stand Posts Contamination Monitoring
UPU_PUP – Public Toilets
UHHU – Households using wastewater treatment
UHU_HUH – Hotels without STPs
URU_RUR – Restaurants wastewater sources

Executive Summary

The Integrated Water and Sanitation Safety Plan (iWSSP) for Leh is a pioneering initiative aimed at ensuring the safety and sustainability of the town's sanitation infrastructure, with a strong focus on wastewater management and contamination risks. Recognizing that improper sanitation poses significant environmental and public health challenges, this approach integrates water and sanitation systems into a unified framework to optimise risk management, improve service delivery and enhance resilience against infrastructural and climatic challenges.

While Leh's first Water Safety Plan (WSP) was prepared in 2020 under the Liveable Leh 2030 project, a comprehensive Sanitation Safety Plan (SSP) had never been developed, despite growing concerns over inadequate containment systems, untreated sewage discharge, and groundwater contamination. Given the high reliance on decentralised sanitation systems such as soak pits and fully lined tanks (FLTs), unregulated practices have led to the seepage of untreated wastewater into aquifers, threatening water quality and public health. The adoption of an integrated framework (iWSSP) was thus essential to holistically address both water supply and sanitation challenges.

This study examines the town's demographic trends, rapid urbanisation, climate conditions, and hydrogeological factors to assess sanitation-related risks. Extensive field visits, stakeholder consultations, and expert inputs have informed the assessment, ensuring a context-specific evaluation that aligns with regional needs.

Leh's sanitation system operates through a hybrid framework comprising a limited centralized sewer network and a dominant decentralised sanitation infrastructure. While some areas are connected to a Sewage Treatment Plant (STP), the majority rely on unregulated soak pits, lined pits with open bottoms, and onsite sewage treatment plants (STPs) in hotels and institutions. These containment methods, particularly soak pits, pose severe environmental risks, allowing the infiltration of contaminants into groundwater. The seasonal operation of Leh's Faecal Sludge Treatment Plant (FSTP), which shuts down during winter, further exacerbates challenges in managing wastewater safely.

The iWSSP follows a structured risk assessment methodology, identifying hazardous events within the sanitation system and evaluating their impact through a risk matrix. Major risks identified include groundwater contamination from soak pits, overloading of the STP, inefficient desludging practices, and lack of standardized containment infrastructure. The risk assessment framework has informed the development of targeted improvement plans focusing on infrastructure upgrades, regulatory reforms, and enhanced monitoring mechanisms.

This report analyses and presents a strategic roadmap for strengthening both sanitation and water supply infrastructure, mitigating contamination risks, and promoting safe and sustainable resource management. Without immediate intervention, the town's rapid urbanization will continue to strain existing systems, exacerbating environmental and public health vulnerabilities. Moving forward, institutional commitment, policy enforcement, and sustained engagement will be critical in translating this plan into concrete actions that secure Leh's future water and sanitation safety.

Introduction

Leh, the administrative and economic centre of Ladakh, is experiencing rapid urbanisation, placing significant pressure on its water supply and sanitation infrastructure. As the population grows and tourism increases, the demand for safe drinking water and efficient sanitation services has become more critical than ever. Ensuring the safety and sustainability of these essential services is crucial to safeguarding public health and protecting the region's fragile ecosystem.

The Integrated Water and Sanitation Safety Plan (iWSSP) is a strategic initiative aimed at addressing the interrelated challenges of water supply and sanitation in Leh. By integrating risk management approaches from both Water Safety Planning (WSP) and Sanitation Safety Planning (SSP), the iWSSP provides a comprehensive framework for identifying hazards, assessing risks, and implementing mitigation measures to enhance service reliability and environmental sustainability.

Sanitation Safety Planning (SSP) is a risk-based framework developed by the World Health Organization (WHO) to ensure the safe management of sanitation systems. It systematically identifies hazards, assesses risks, and implements control measures to prevent contamination and protect public health. In regions like Leh, where sanitation infrastructure consists of a mix of centralised and decentralised systems, SSP plays a crucial role in minimising groundwater contamination, improving sludge management, and ensuring the safe disposal of wastewater. By proactively addressing sanitation risks, SSP strengthens resilience against environmental and public health challenges.

Water Safety Planning (WSP) is a WHO-recommended approach designed to ensure the safety of drinking water through comprehensive risk assessment and management across the entire water supply chain.

It shifts the focus from reactive water quality monitoring to proactive risk mitigation by identifying potential hazards, improving treatment and distribution systems, and establishing verification mechanisms. In Leh, where water supply is largely dependent on groundwater and spring sources, WSP is essential in ensuring safe and reliable drinking water while addressing risks related to contamination, intermittent supply, and infrastructure limitations.

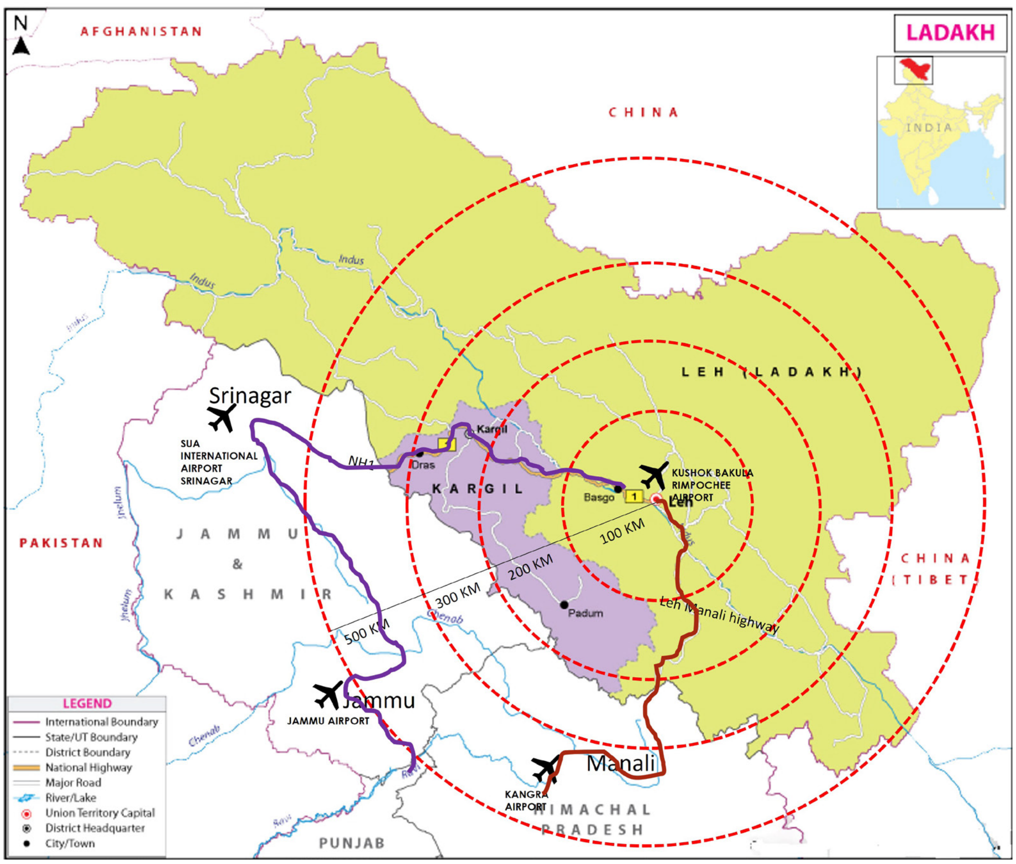
This report outlines the methodology, risk assessment findings, and proposed improvement plans. It serves as a roadmap for local authorities, policymakers, and stakeholders to enhance water and sanitation infrastructure, improve regulatory oversight, and strengthen community resilience against environmental and infrastructural risks. By adopting an integrated approach, the iWSSP aims to build a sustainable, safe, and resilient urban environment for Leh's growing population.

About Leh Town

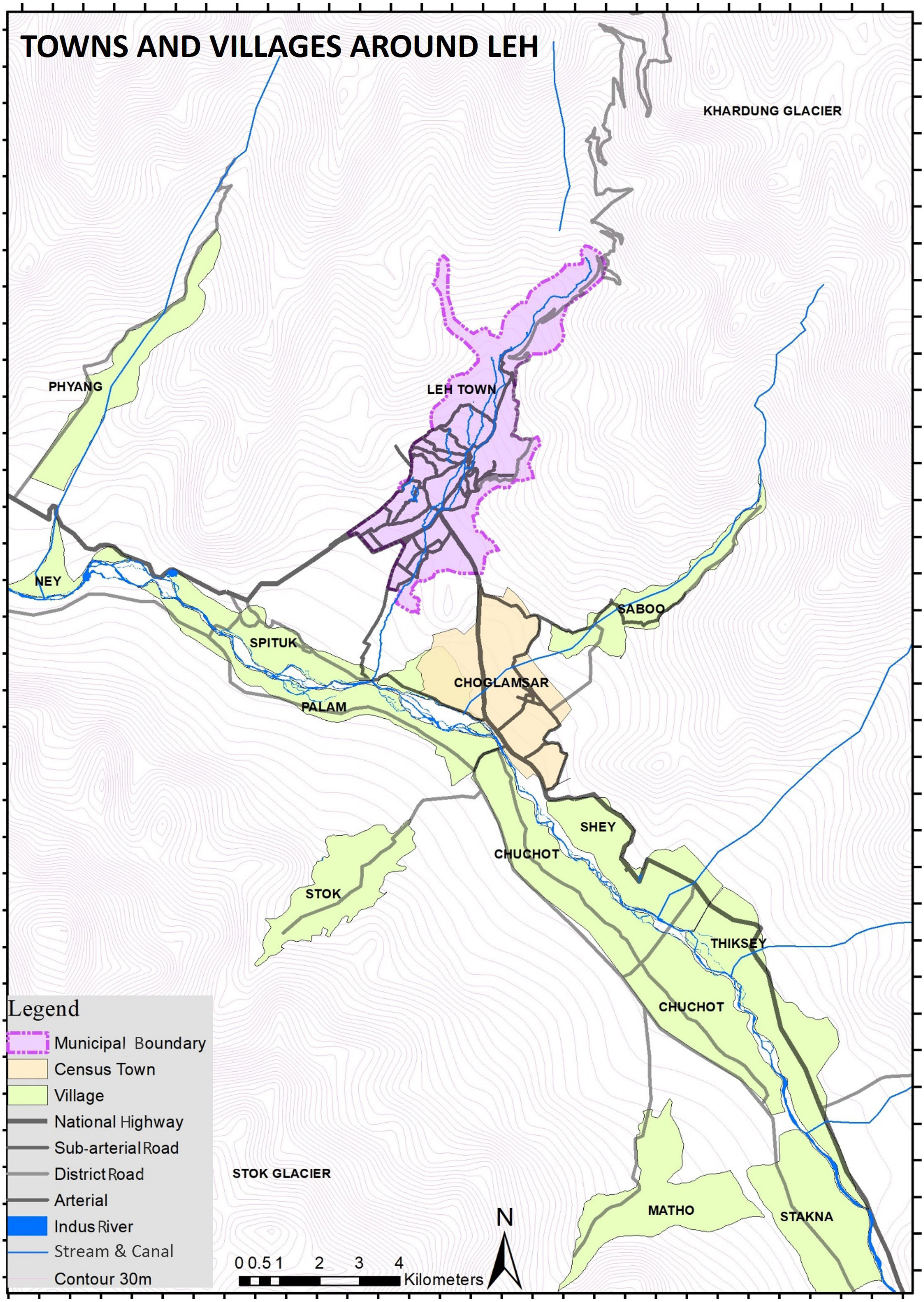
Geographical Setting

Leh town serves as the administrative and economic nucleus of Ladakh, situated in the scenic Indus Valley. The town is well connected to other settlements within the district through an extensive road network. It maintains seasonal connections to Srinagar, Jammu, and other states via National Highway 1, which operates between May and November. Similarly, the Leh-Manali Highway provides access to Himachal Pradesh during the same period.

Year-round connectivity to major cities such as Delhi, Jammu, Srinagar, and Chandigarh is facilitated by the Kushok Bakula Rimpoche (KBR) Airport, the only civil airport in Ladakh. This multi-modal connectivity plays a vital role in sustaining the region's socio-economic activities and ensuring access to essential resources and services throughout the year.



Map 1 Regional Context of Leh Town



Map 2 Peripheral Villages Around Leh Town

Town Profile and Characteristics

Leh town, the capital and largest urban centre of the Union Territory of Ladakh, holds immense regional importance. Situated in the scenic Indus Valley, the town spans an area of 17.6 square kilometres and has a population of 30,870, as per the 2011 Census. Classified as a Class III town with 13 municipal wards, Leh serves as the administrative, educational, political, and economic hub of the district.

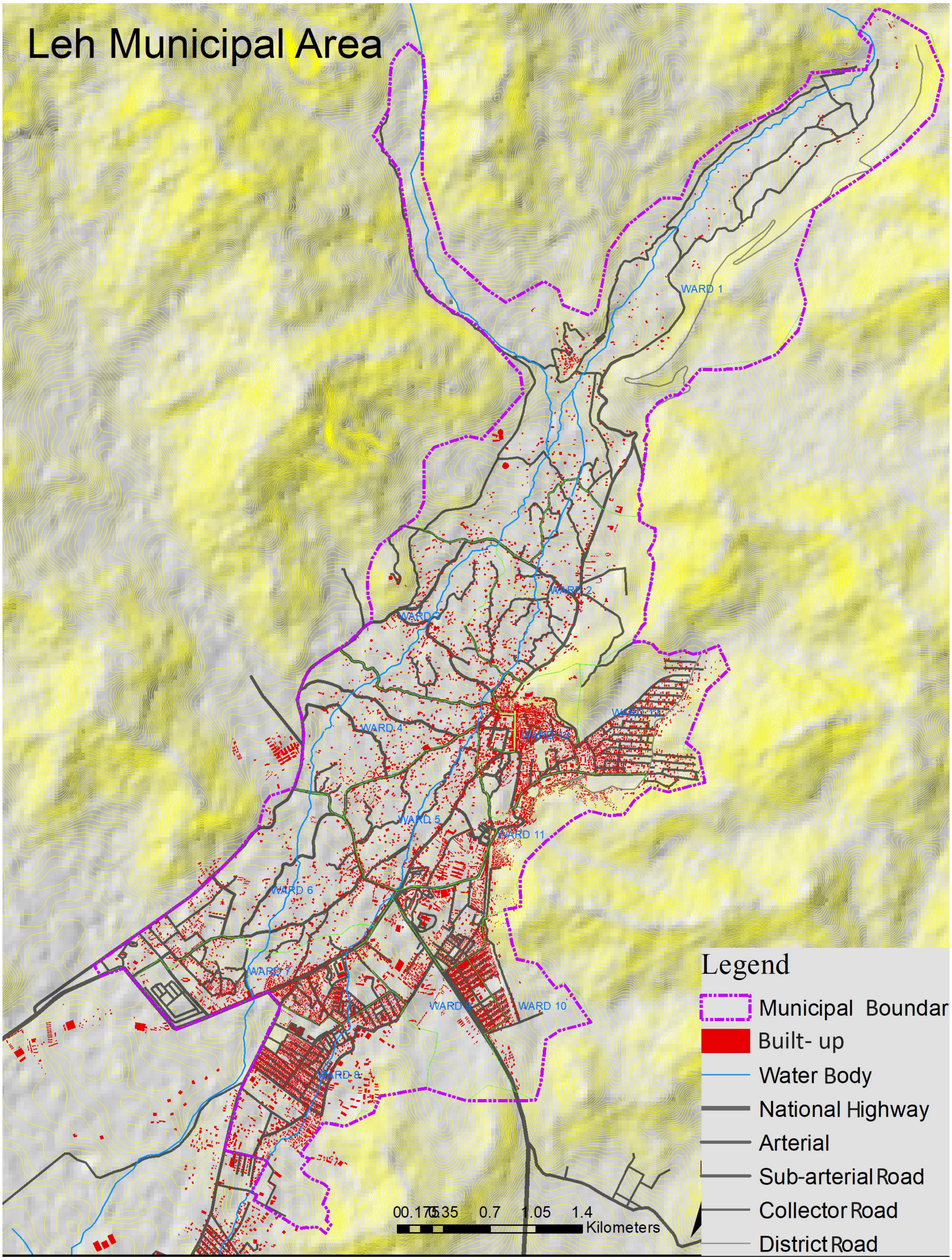
The town's growth is shaped by its unique geographical and topographical features. Surrounded by steep mountainous terrain and the Indus River, Leh follows a linear growth pattern, with an undulating landscape and elevation ranging from 3200 m to 4000 m metres above sea level. However, this growth has been accompanied by challenges.

Leh is increasingly facing the pressures of unplanned urbanisation. As the town continues to expand, its resources are being strained under the weight of its growing population and economic activity. Critical issues have emerged in areas such as sanitation, waste management, and water supply systems, which are struggling to keep pace with rapid urbanisation. The limited availability of flat, developable land further complicates urban planning and infrastructure development in the region.

Despite these challenges, Leh remains the nerve centre of the district, offering essential services such as healthcare, education, trade, and transportation. However, addressing the impact of unplanned urbanization is crucial to ensure the sustainable growth of this vital high-altitude urban centre. A balance between preserving its fragile environment and supporting its role as the heart of Ladakh is imperative for Leh's long-term development.

Town Profile		
Name of the Town/City	Leh	
Province/District/State/UT	UT Ladakh	
Area of the Town (Sq. Km)	17.6 sq. km	
Number of Administrative Divisions (Wards)	13 wards, MC Leh	
Total Population	2011 Census: 30870	2021: 42352
Population Growth Rate (%)	1.17%	
Floating Population	59140	
No. of Notified Slum	0	
No. of Non-Notified Slum	0	
Literacy Rate	90.29 %	
Sex Ratio	987	

Table 1 Leh Town Profile



Map 3 Leh Municipal Area

Demographic Profile

Leh's population, which stood at 30,870 in 2011, is estimated to have grown to 42,352 by 2021. The population distribution across the town is notably uneven, with 51.45% residing in Wards 11 and 13. In contrast, Ward 1, characterised by its predominantly agricultural land use, has a notably low gross density of just 1 person per hectare. Similarly, Ward 12 exhibits low population densities due to its steep slopes and uneven terrain. Wards 3 and 4, while having low gross densities overall, display relatively high residential densities because the presence of hotels and homestays in these areas has increased both demand and competition for residential land.

The sex ratio in Leh shows a significant imbalance, with males comprising 70% of the population. This demographic skew is largely attributed to substantial employment-related migration from rural parts of Ladakh to the town. Despite this imbalance, Leh boasts a high literacy rate of 90%, well above the national average of 76.32%. Based on current population growth trends and a growth rate of 1.17%, Leh's population is projected to reach 64,217 by the year 2047. Additionally, the town experiences significant seasonal fluctuations due to a floating population estimated at 59,140, primarily consisting of tourists and temporary workers. The town has no notified or non-notified slums, and maintains a sex ratio of 987 females per 1,000 males among the permanent resident population.

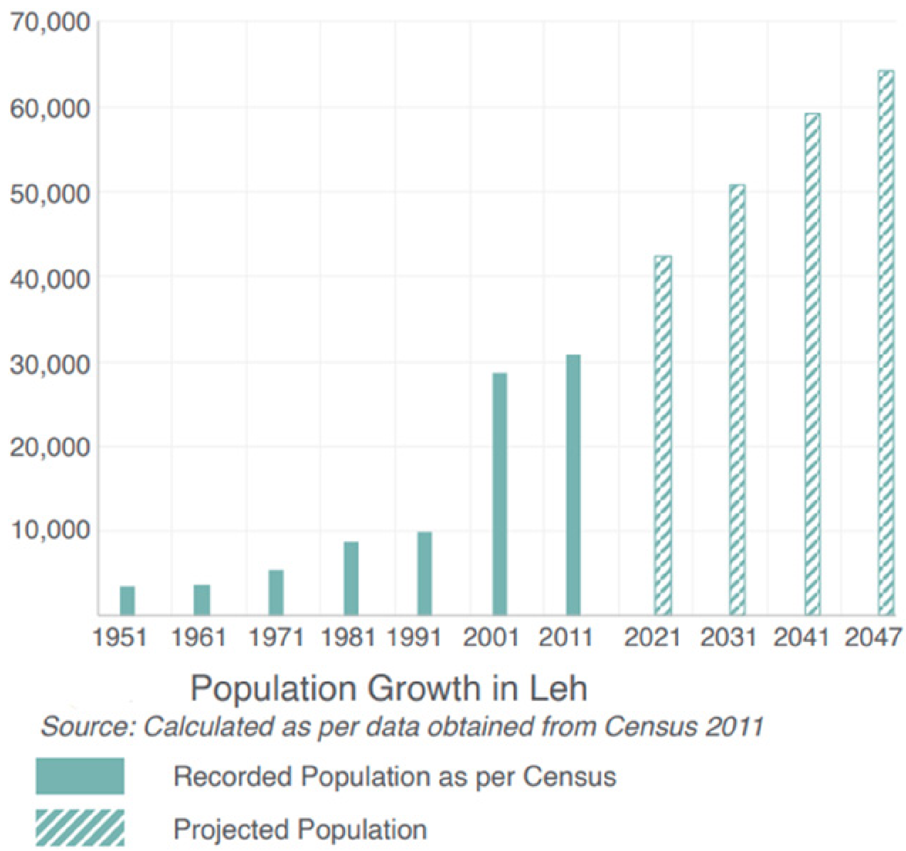


Figure 1 Demographic Profile of Leh Town

Urban Characteristics and Land Use

Leh is administratively divided into 13 wards, each serving distinct functions based on land use and purpose. Ward 13, the main urban centre, houses the town's commercial heart, including the primary market. It is home to the densest neighbourhoods and plays a pivotal role as the town centre, with a mix of diverse land uses, employment opportunities, and economic transactions.

Ward 1, on the other hand, is largely rural, dominated by agricultural activities, and characterised by its predominantly agricultural land use. Historical settlements of Leh are mostly concentrated within Ward 2, while Wards 3, 4, and 5 are the focal points for tourism, with a large concentration of hotels, guesthouses, and related businesses catering to the needs of visitors.

Ward 7 is the industrial hub of Leh, housing micro, small, and medium enterprises (MSMEs) that include small-scale industries, workshops, and automotive repair services. The remaining wards, particularly Wards 8, 9, 10, and 12, are predominantly residential, with Wards 9 and 10 experiencing significant new development. Ward 12 also caters largely to migrant workers, offering affordable housing and essential services for temporary residents. Leh's land use can be categorised into six primary functions:

1. Urban Centres: Ward 13 serves as the town's commercial and economic core, with a mix of diverse land uses, dense neighbourhoods, and significant economic activity.

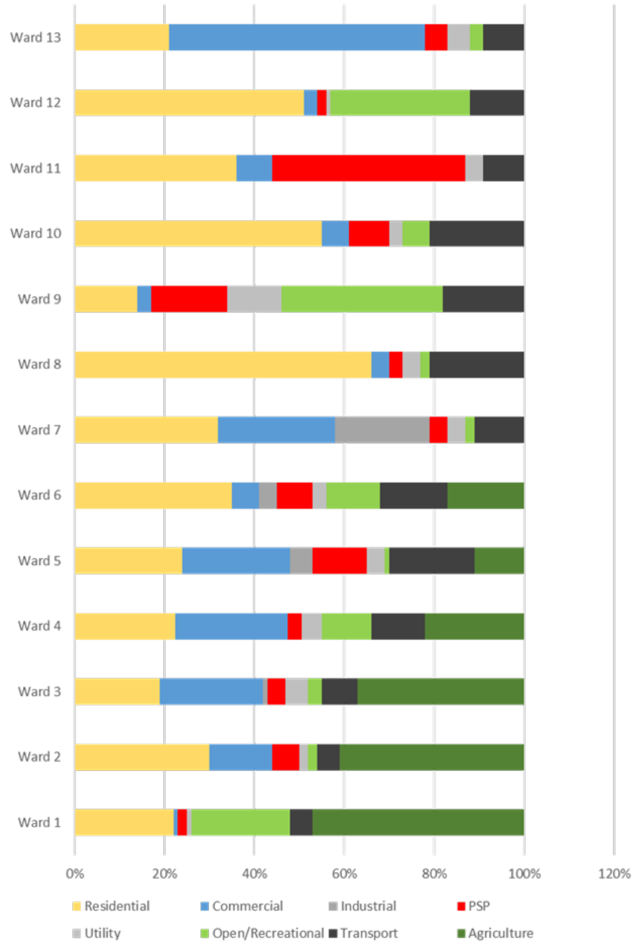
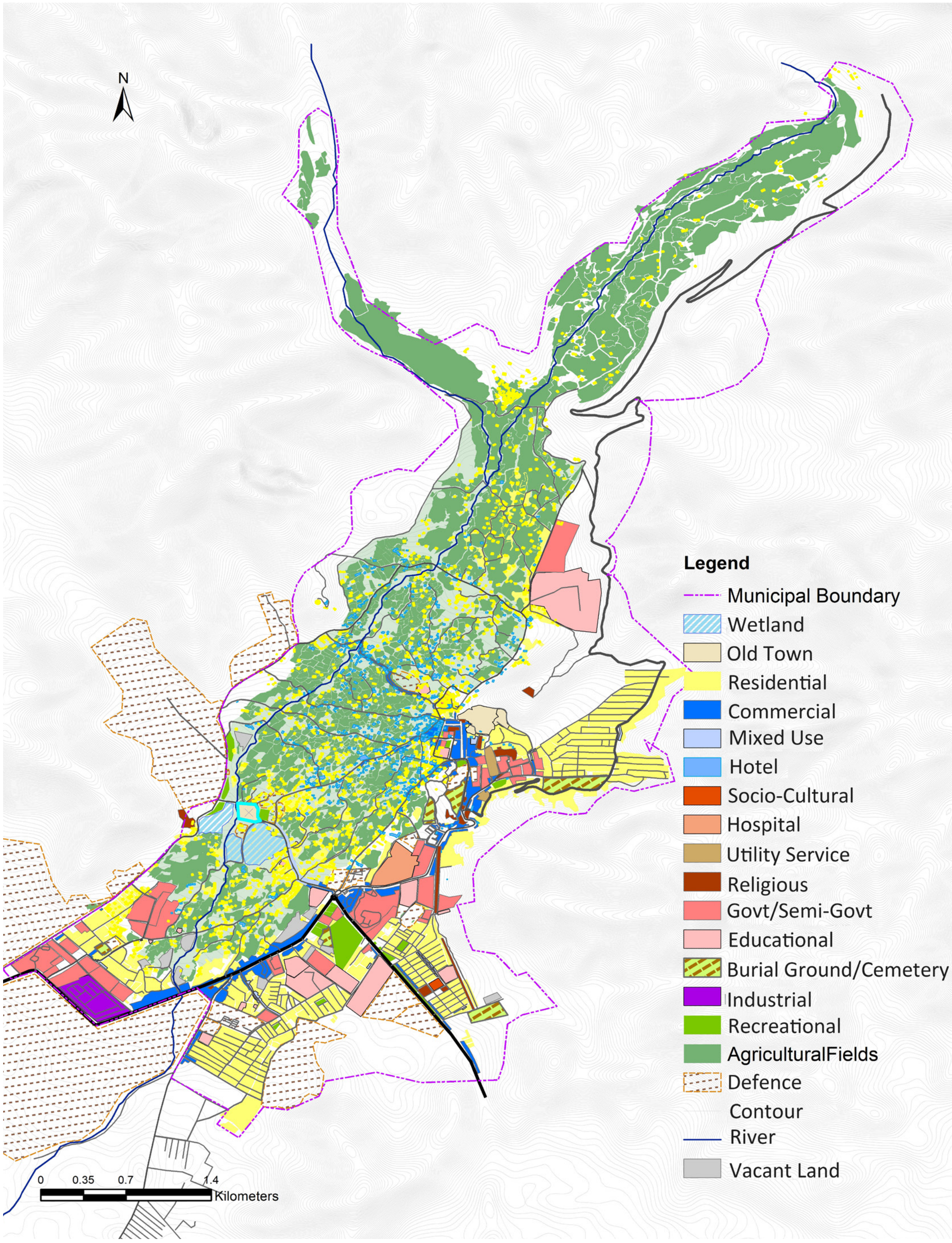


Figure 2 Ward-wise Land Use Characteristics

2. Residential Areas: Wards 8, 9, 10, and 12 are primarily residential, where around 70% of Leh's population resides, providing the bulk of housing for the town's residents.
3. Urban Villages: Ward 1, with its agricultural activities, represents the town's rural side, serving as a space for farming and related activities.
4. Tourist Areas: Wards 2, 3, 4, 5, and 6 cater to the tourism industry, with hotels, guesthouses, and other services specifically designed to accommodate tourists, forming the backbone of Leh's tourism sector.

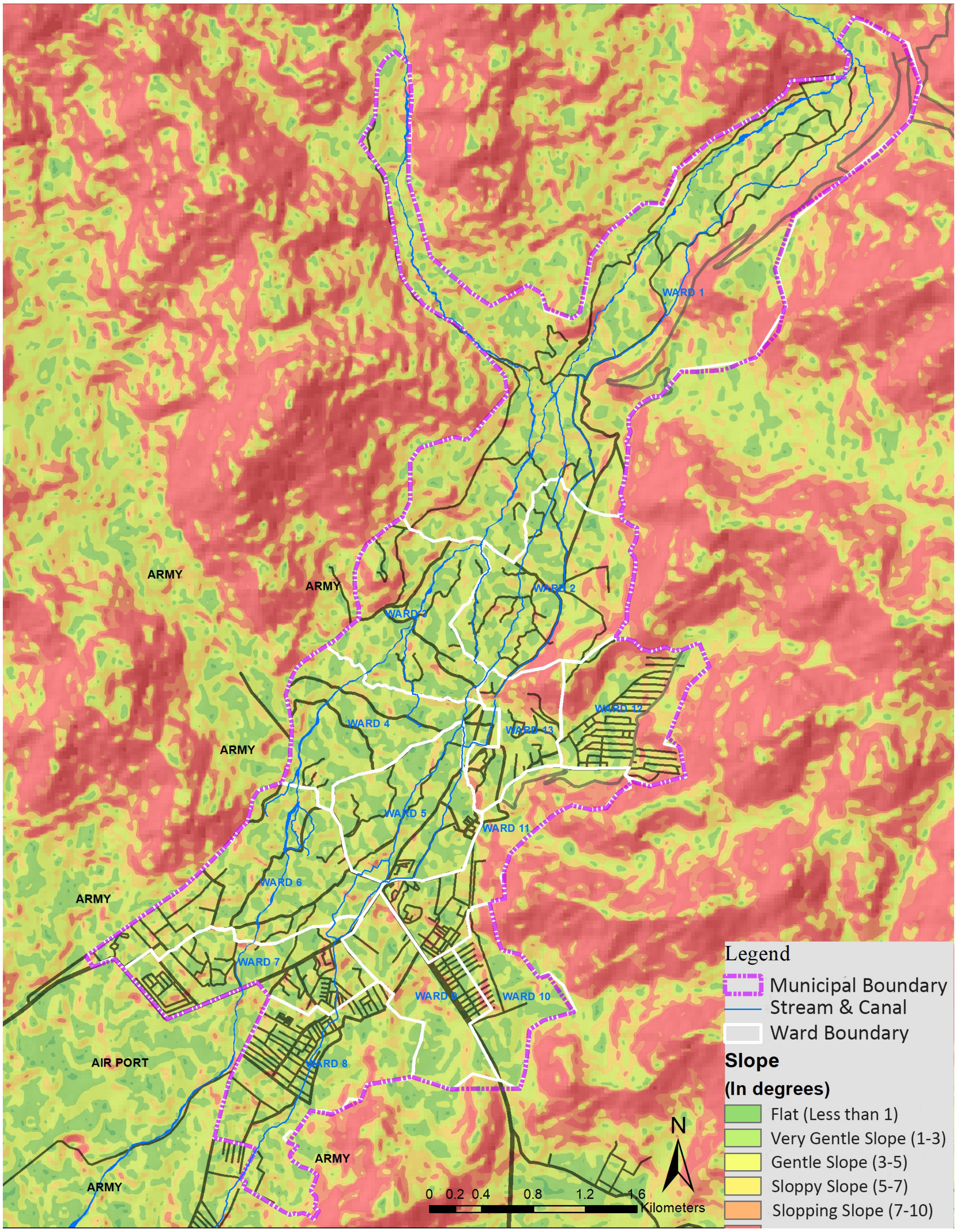
5. Institutional Areas: Ward 11 is dedicated to government and semi-government institutions, serving as the administrative centre for the region.
6. Manufacturing/Service Industry Areas: Ward 7 is home to the town's industrial zone, housing MSMEs involved in manufacturing, workshops, and service-oriented businesses such as automotive repairs.



Map 4 Existing Land Use Map of Leh Town

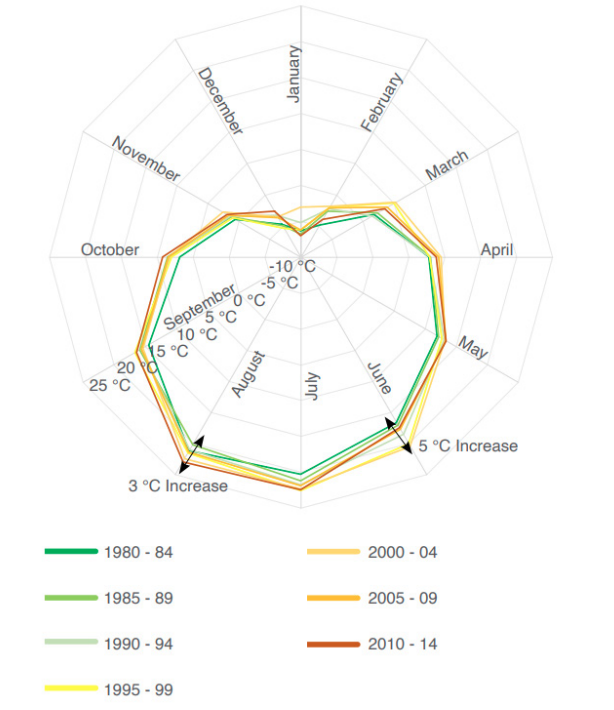
Geology and Topography

Leh town is situated in a U-shaped valley carved out by glacier moraines. The terrain in the valley part is composed of glacio-fluvial sediments surrounded by steep, jagged granitic terrain. The town is located in the Trans-Himalayas at an altitude of 3,310 m above mean sea level at its southern end and 3,915 m above sea level at its northern edge. It has an average slope of 10.1 degrees from north to south. Ward 11/Snemoling and Ward 12/Skampari are located at a higher elevation of the mountainside as compared to other areas of the town.

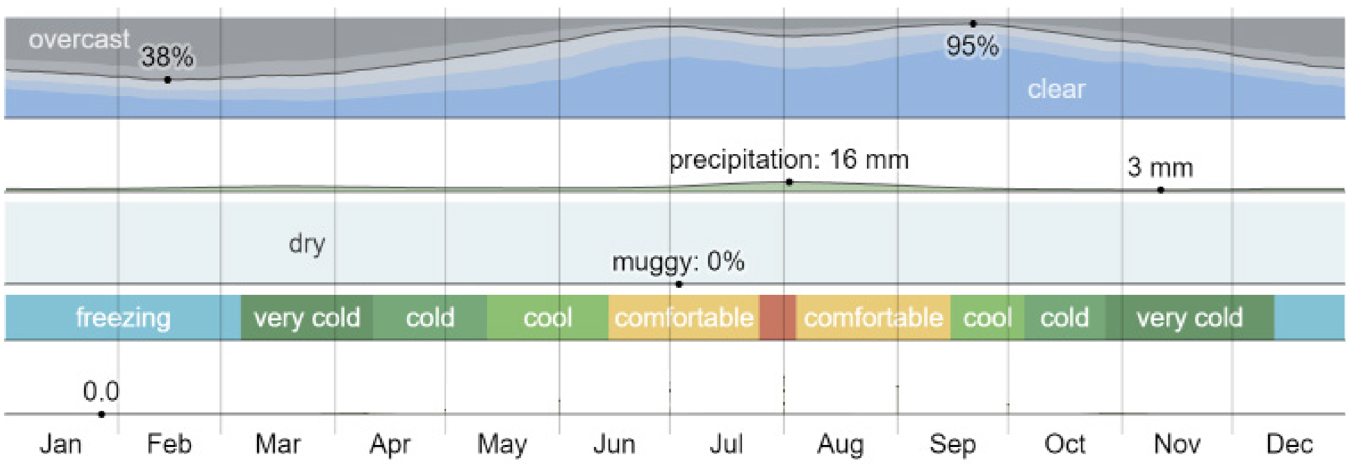


Climate

Leh, like the rest of the Union Territory of Ladakh, experiences a cold desert climate due to its high altitude and location on the leeward side of the Himalayan range. The region is characterised by extreme weather conditions, with harsh winters and relatively short, mild summers. Winter temperatures in Leh regularly drop well below freezing, often plummeting to -20°C or lower during the coldest months. In contrast, summer temperatures are more moderate, with average around 20 °C. However, the region has seen a notable rise in average daily highs, with an overall increase of nearly 2 °C. This warming trend is not uniform across seasons, with summer temperatures rising by over 5 °C in June while winter temperatures have remained relatively stable.



Temperature change in Leh 1980-2015

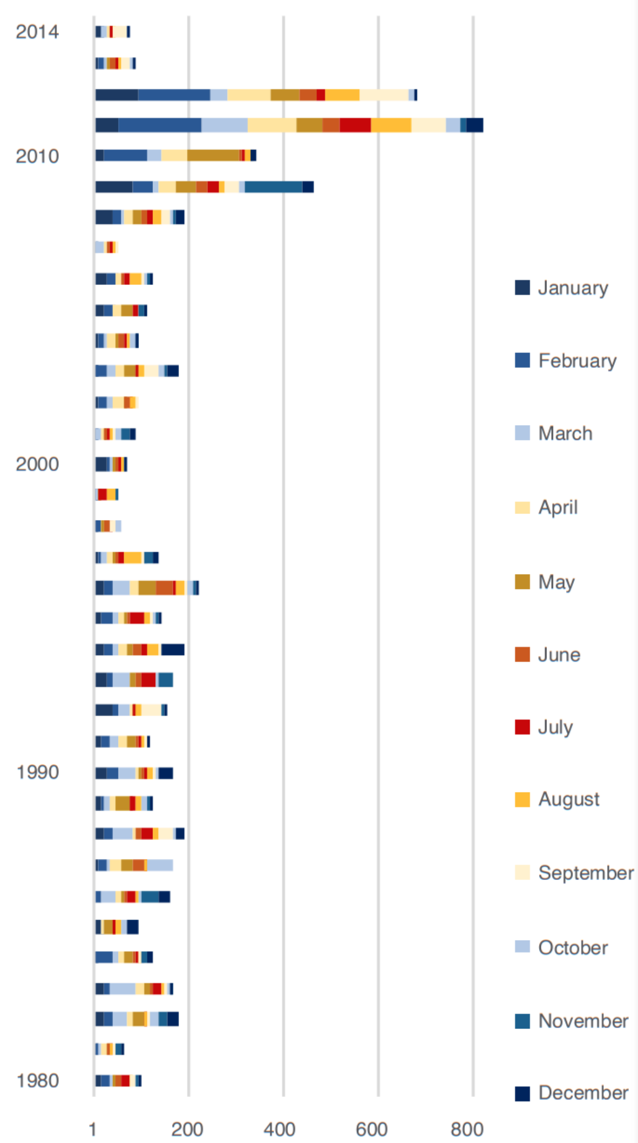


This rise in summer temperatures, combined with high solar intensity, has led to an increased need for cooling mechanisms, such as air conditioning, which were previously unnecessary in Leh. The region's high altitude also contributes to its extreme solar radiation, making sunlight particularly intense and exacerbating the heat during summer months.

Leh receives very low annual precipitation, consistent with its classification as a cold desert. The majority of this precipitation occurs as snowfall during the winter months, accounting for more than 50% of the total. Average annual precipitation in the region is approximately 125 mm, though it exhibits high variability, with significant deviations ranging from 142.5 mm in some years to as low as 18.2 mm, such as in 2007. Of this, only around 54 mm typically occurs as rainfall, mostly between May and October. Snowfall in Leh is also modest compared to other areas in Ladakh, averaging less than 50 mm annually.

Leh's weather conditions are further marked by its low humidity and sparse vegetation, resulting in a high evapotranspiration rate. The area experiences over 320 sunny days annually, emphasising its arid environment. Water resources in Leh are primarily derived from snowmelt, which forms rivulets that flow into larger streams within the valleys. However, this dependency on snowmelt makes the region's water supply particularly vulnerable to the impacts of climate change.

Monthly climate variations in Leh reflect its unique conditions. From October to April, the overall climate is extremely cold, with freezing temperatures persisting through December, January, February, and March. The period from June to September is more comfortable, with milder temperatures and occasional rainfall. The combination of low precipitation, intensive sunlight, and significant temperature fluctuations creates an environment that is both challenging and distinct, necessitating adaptive measures to manage water, energy, and infrastructure in Leh.



Rainfall Patterns in Leh 1980-2015

Climate Change in Leh

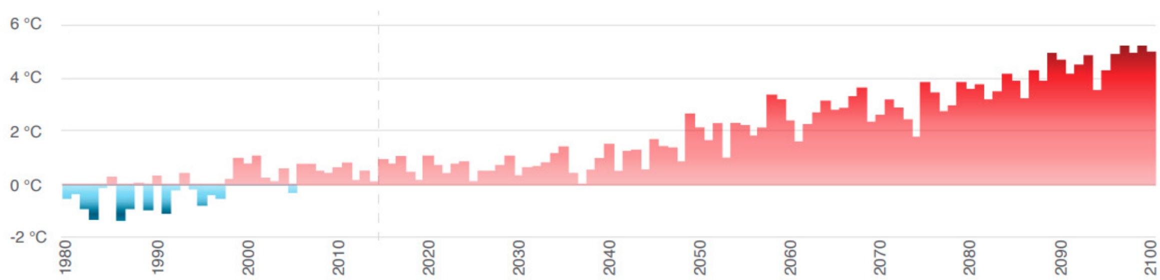
Understanding the impacts of climate change on Leh's weather patterns is crucial for developing resilient water and sanitation safety planning strategies. The Climate Action Plan for Leh (CAP) provides high-resolution multi-model climate projections for the baseline period (1980-2015), validated against local meteorological station data. These projections offer insights into future temperature and precipitation changes, which are vital for assessing risks to Leh's water resources, sanitation infrastructure, and overall environmental sustainability.

Projected Temperature Changes and Their Impact

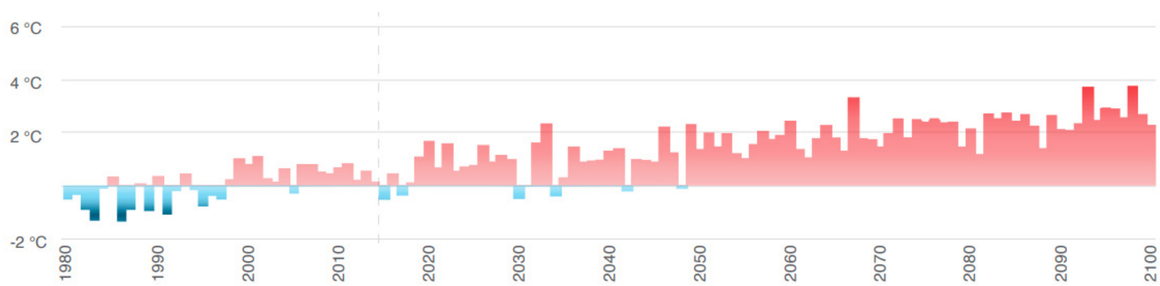
According to the Climate Action Plan Leh (2024), the climate models indicate that Leh is likely to experience significant temperature increases in the coming decades. These projections are based on different climate scenarios from the Intergovernmental Panel on Climate Change (IPCC) Sixth Assessment Report (2021):

- Under a moderate emissions scenario (SSP 2-4.5 scenario), temperatures are projected to rise by 2.0 degrees Celsius by 2060 and 2.7 degrees Celsius by 2100.
- Under a high emissions scenario (SSP 5-8.5 scenario), temperatures could increase by 2.4 degrees Celsius by 2060 and 4.4 degrees Celsius by 2100.
- Further projections show that Leh will experience significant warming by 2100. The GFDL CM2.1 model suggests an average decadal temperature increase of 4.67°C by 2100 under the SSP 5-8.5 scenario, and 2.77°C under the SSP 2-4.5 scenario. By 2050, temperatures are expected to rise by 1.38°C in the SSP 5-8.5 scenario and by 1.09°C in the SSP 2-4.5 scenario.

By the end of the century, Leh could see summer temperatures rising by 8 to 10 degrees Celsius, with winter temperatures increasing by approximately 5 degrees Celsius. The minimum winter temperatures could rise by nearly 10 degrees Celsius, affecting the freezing and thawing cycles of glaciers. This would have significant consequences for the replenishment of water sources that rely on glacial melt. A study conducted by Kashmir University suggests that if the temperature in Ladakh increases beyond 6 degrees Celsius, the region could lose up to 80% of its glaciers, leading to severe water shortages.



Projected Temperature Variation Compared to Average Observed Temperature Between 1980-2015 SSP 5-8.5



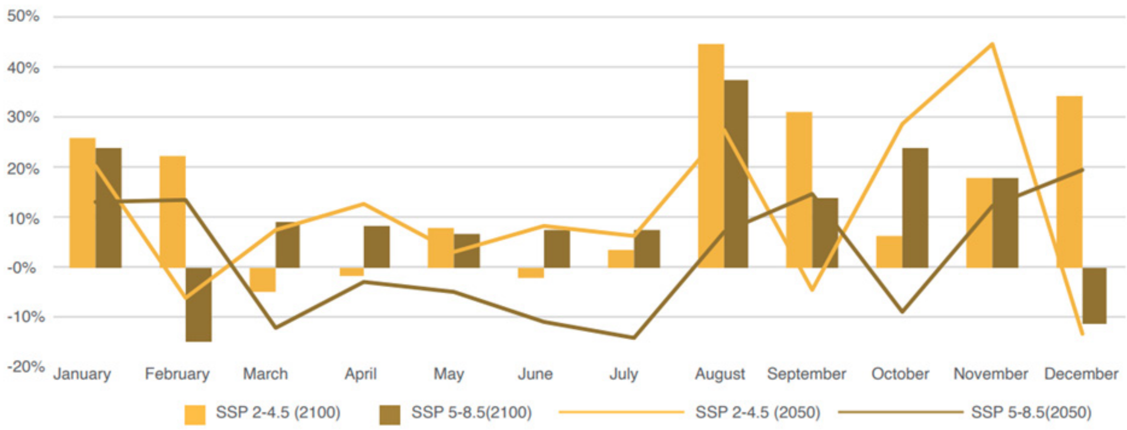
Projected Temperature Variation Compared to Average Observed Temperature Between 1980-2015 SSP 2-4.5

Projected Changes in Precipitation and Water Resource Challenges

According to the Climate Action Plan Leh (2024), the future climate projections indicate shifts in precipitation patterns that could directly affect the availability of water in Leh:

- Under the SSP 2-4.5 scenario, precipitation is projected to remain relatively stable with a minor average increase of about 10%.
- However, in the SSP 5-8.5 scenario, a more significant increase of around 30% is projected, primarily occurring after 2050.

This increase in precipitation, however, is expected to manifest predominantly during winter months as snowfall. The expected rise in winter snowfall could contribute to overall water availability, but it may not align with peak demand periods for agriculture and human consumption. The increase in snowfall rather than rain could also result in greater runoff losses, reducing the amount of immediately usable water. This highlights the need for effective water storage and management strategies to address potential shortages during dry months.



Monthly Variations in Precipitation

Effects on Water Supply and Sanitation Systems

Rising temperatures and shifting precipitation patterns will present new challenges for Leh's water and sanitation infrastructure:

- Fluctuations in Water Availability: Changing glacial melt patterns and altered seasonal precipitation could lead to irregular water supply, requiring improved storage and distribution systems.
- Increased Strain on Sanitation Infrastructure: Higher temperatures may accelerate the degradation of sanitation facilities, reducing wastewater treatment efficiency and increasing the risk of contamination.
- Greater Vulnerability to Extreme Weather Events: Unpredictable climate patterns emphasise the need for a strong adaptation framework within water and sanitation planning efforts.

Hydrogeology of Leh

Leh town is situated on glacio-fluvial sediments that provide favourable conditions for the movement and storage of groundwater. The hydrogeology of the region is governed by a combination of geological, hydrological, and climatic factors. A comprehensive understanding of these conditions is crucial for sustainable groundwater management in this unique and challenging environment.

According to the research paper by Guru et al. (2017) *(Frequency ratio model for groundwater potential mapping and its sustainable management in cold desert, India, August 2016 Journal of King Saud University)*

Key Hydrogeological Factors

Hydrology and groundwater of Leh town are dependent on key hydrological factors, which are:

Land Use and Land Cover

Land use patterns significantly influence groundwater recharge. Vegetative cover promotes infiltration and groundwater recharge, whereas impervious urban surfaces lead to increased runoff and reduced recharge potential.

Slope

Slope gradients play a critical role in groundwater dynamics. Gentle slopes allow slower runoff, facilitating infiltration and aquifer recharge. Conversely, steep slopes accelerate runoff, reducing infiltration and groundwater replenishment.

Geology

The geology of the area, including unconsolidated sedimentary deposits and fractured granitoid rocks, provides favourable conditions for groundwater movement and storage. These formations act as key zones for aquifer development.

Lineaments

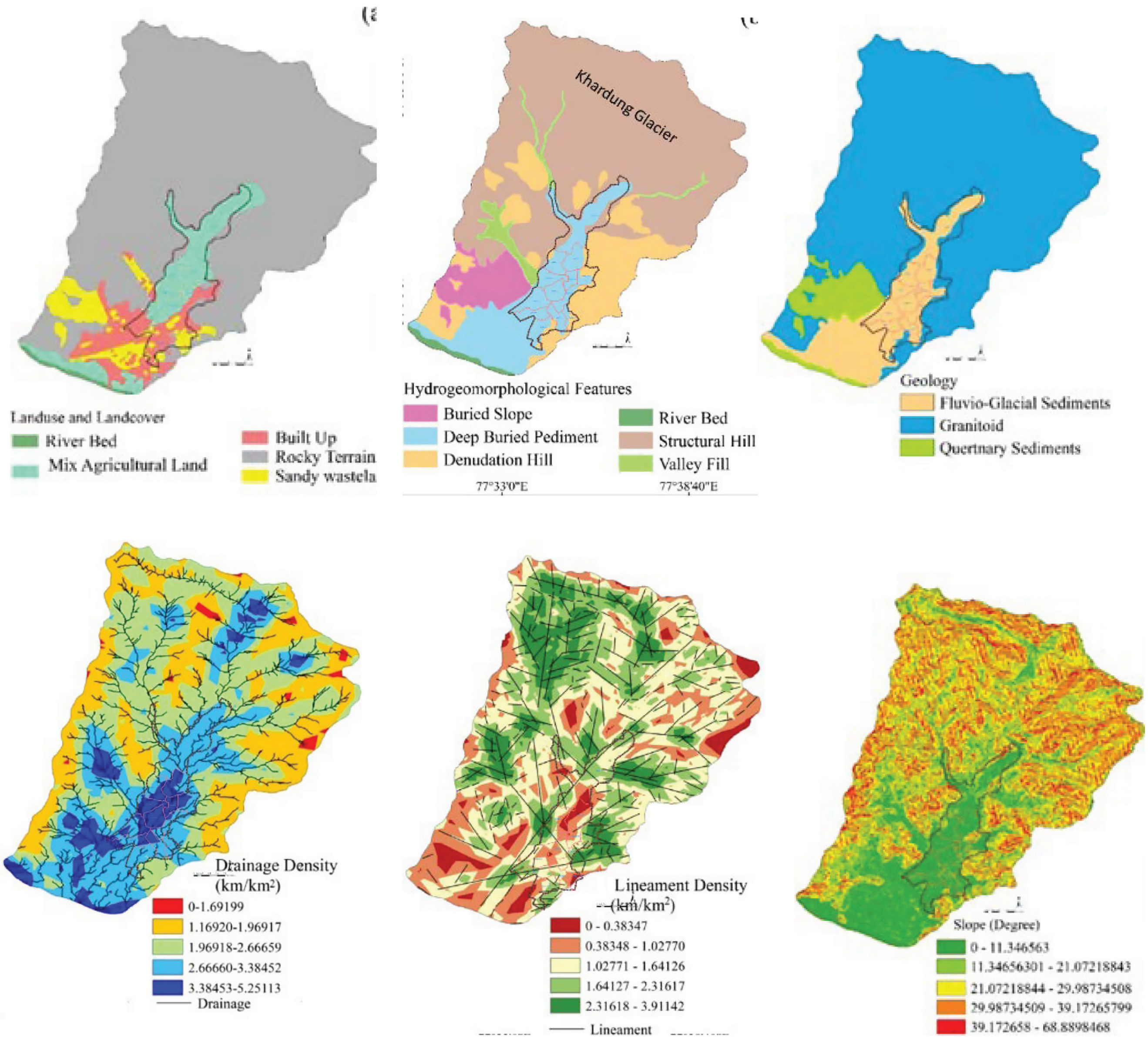
Structural features such as fractures and faults control groundwater infiltration and serve as conduits for water movement. These lineaments are especially important in hard rock terrains where primary porosity is minimal.

Hydrogeomorphological Features

Features such as valley-fill deposits enhance groundwater recharge by allowing percolation into subsurface aquifers. These formations often act as prominent zones for groundwater storage.

Drainage Density

The density and configuration of drainage systems, influenced by structural controls like faults and fractures, aid in the transmission of glacial meltwater to subsurface aquifers. Drainage systems also facilitate surface water movement, contributing to groundwater recharge.


Landuse and Landcover
River Bed
Mix Agricultural Land
Built Up
Rocky Terrain
Sandy wastela
Khardung Glacier
Hydrogeomorphological Features
Buried Slope
Deep Buried Pediment
Denudation Hill
River Bed
Structural Hill
Valley Fill
77°33'0"E
77°38'40"E
Geology
Fluvio-Glacial Sediments
Granitoid
Quertnary Sediments
Drainage Density
(km/km²)
0-1.69199
1.16920-1.96917
1.96918-2.66659
2.66660-3.38452
3.38453-5.25113
Drainage
Lineament Density
(km/km²)
0 - 0.38347
0.38348 - 1.02770
1.02771 - 1.64126
1.64127 - 2.31617
2.31618 - 3.91142
Lineament
Slope (Degree)
0 - 11.346563
11.34656301 - 21.07218843
21.07218844 - 29.98734508
29.98734509 - 39.17265799
39.172658 - 68.8898468

The Hydrological Cycle of Leh Town

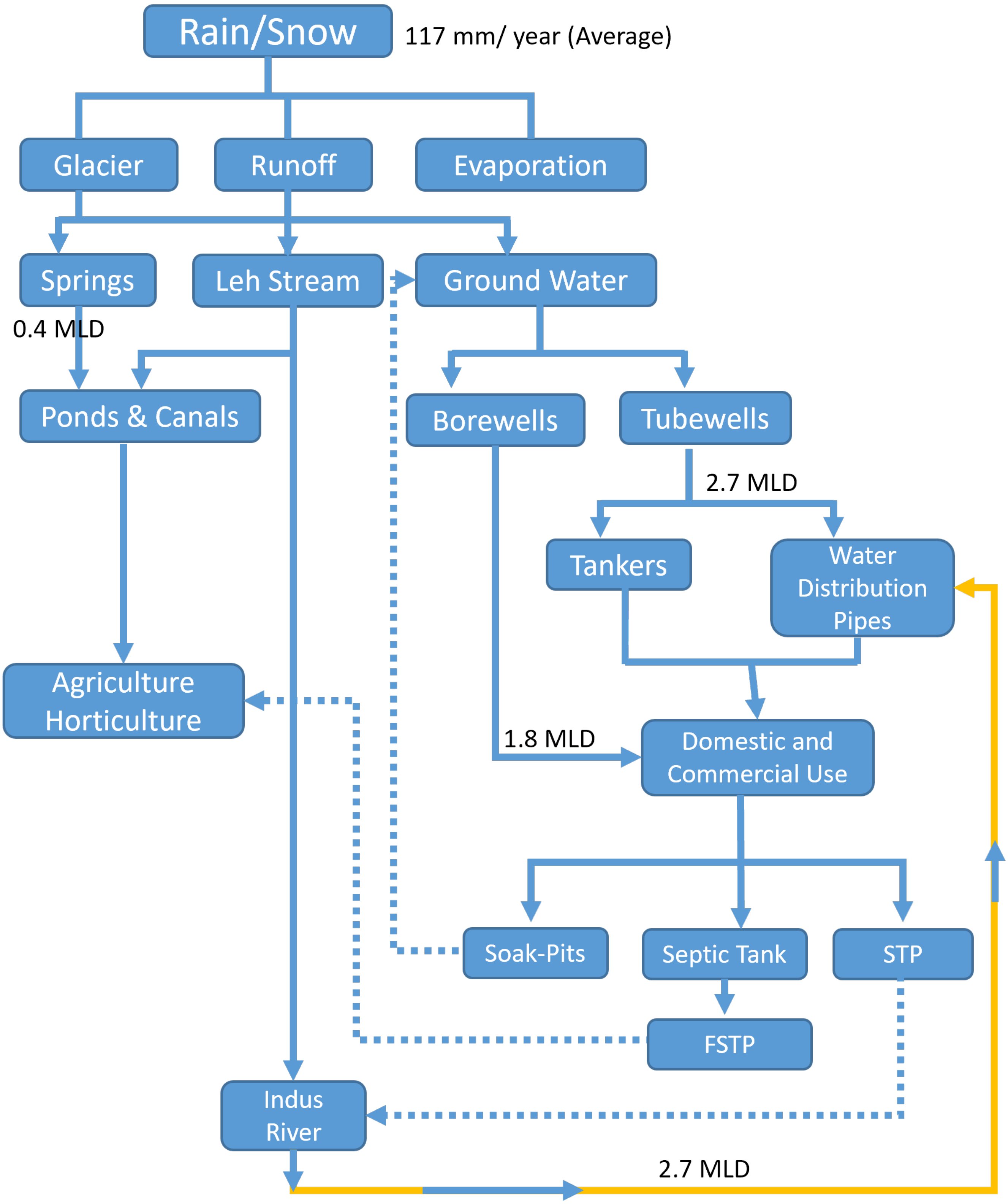


Figure 3 Hydrological Cycle of Leh Town

Sanitation Safety Planning

Sanitation Safety Planning (SSP) is a risk-based management approach developed by the World Health Organization (WHO) to ensure the safe handling, treatment, and disposal of wastewater and excreta. It provides a systematic framework for identifying hazards, assessing risks, and implementing control measures to minimise public health threats and environmental contamination. The objective of SSP is to improve sanitation service delivery across the entire sanitation chain—containment, conveyance, treatment, and disposal—by integrating proactive risk management strategies.

In Leh, sanitation infrastructure is characterised by a combination of centralised and decentralised systems. While some areas are connected to a sewerage network leading to a Sewage Treatment Plant (STP), a significant portion of the town relies on onsite sanitation solutions such as soak pits, fully lined tanks (FLTs), and dry toilets. These systems, if not properly managed, can contribute to groundwater contamination, creating severe health and environmental risks. The seasonal operation of Leh's Faecal Sludge Treatment Plant (FSTP), which remains non-functional during winter, further complicates the effective management of wastewater.

Importance of SSP

SSP is particularly crucial in regions like Leh, where rapid urbanization, climate vulnerability, and increasing demand for sanitation services have placed immense pressure on existing infrastructure. Poorly managed sanitation systems contribute to groundwater contamination, increased disease outbreaks, and environmental degradation. A structured SSP helps address these challenges by ensuring sanitation systems are designed, operated, and maintained safely.

Key Components of SSP

A structured SSP framework involves the following steps:

- System Assessment – Mapping existing sanitation infrastructure and service coverage, and identifying key stakeholders.
- Hazard Identification and Risk Assessment – Evaluating risks associated with sanitation practices, including groundwater contamination, overflow of containment units, and inadequate sludge management.
- Control Measures and Interventions – Implementing preventive and corrective actions such as improving desludging schedules, expanding sewer networks, and standardising containment infrastructure.
- Monitoring and Verification – Establishing regular assessment mechanisms to ensure compliance with sanitation safety guidelines and regulatory standards.
- Capacity Building and Community Engagement – Enhancing awareness among residents, local authorities, and service providers regarding sanitation safety and best practices.

Water Safety Planning

Water Safety Planning (WSP) is a comprehensive risk management approach recommended by the World Health Organization (WHO) to ensure the safety of drinking water from source to consumption. It systematically identifies potential hazards, assesses risks, and implements control measures to safeguard public health and improve the reliability of water supply systems. WSP emphasises proactive risk mitigation rather than reactive responses, helping to prevent contamination and infrastructure failures.

Importance of Water Safety Plan

WSP is crucial for safeguarding public health, particularly in regions like Leh, where the water supply relies heavily on groundwater sources such as tubewells and springs. The lack of a centralised monitoring system, coupled with ageing infrastructure and intermittent supply, increases the risk of contamination. By implementing WSP, Leh can ensure a more resilient and sustainable water management system that minimises public health risks and enhances service delivery. More than 93 countries worldwide have adopted WSP, reinforcing its effectiveness in maintaining safe and sufficient drinking water.

Key Components of Water Safety Plan

A well-structured WSP follows these essential steps:

- System Assessment – Mapping the existing water supply infrastructure, identifying sources, and engaging key stakeholders.
- Hazard Identification and Risk Assessment – Evaluating threats such as microbial contamination, chemical pollutants, and infrastructural weaknesses.
- Control Measures and Risk Mitigation – Implementing preventive strategies, improving treatment processes, and securing water sources.
- Monitoring and Verification –Establishing regular water quality testing, system audits, and compliance checks.
- Stakeholder Involvement and Capacity Building – Training water suppliers, authorities, and communities to uphold best practices in water safety management.

First Water Safety Plan of Leh Town

Leh had its first WSP prepared in 2020 under the Liveable Leh project funded by the European Union and supported by Technical University of Munich (TUM). The WSP for Leh identified key risks to the water supply system, including infrastructure challenges, water quality issues, and institutional gaps. It proposed mitigation measures such as improving source protection, upgrading treatment facilities, and strengthening water quality monitoring.

The WSP also highlighted the need for capacity building, stakeholder engagement, and emergency response planning to enhance the resilience of Leh's water supply. With the help of researchers from TUM, the WSP laid out a proposal for introducing water tariffs to tackle the issue of non-revenue water in Leh. The WSP was prepared based on the WSP manual 2009.

The WSP was supplemented by Leh's first water audit conducted by Indian Institute of Sustainable Development (IISD). The auditing team quantified the water loss in the system and helped pinpoint the processes that are responsible for leakages in the system. However, both WSP and the water audit were not followed up by the responsible organisations.

Integrated Water and Sanitation Safety Planning (iWSSP)

Integrated Water and Sanitation Safety Planning (iWSSP) is an innovative approach that merges Water Safety Planning (WSP) and Sanitation Safety Planning (SSP) into a unified framework. Instead of addressing these plans separately, iWSSP considers the inherent interconnections between water and sanitation systems to optimise resource use and enhance public health outcomes. This approach is particularly beneficial in rural and developing areas where financial and technical resources for independent safety planning are limited. iWSSP recognises that water supply and sanitation systems often share physical infrastructure, management structures, or operational responsibilities, making integration a logical and effective solution. Currently, iWSSP is most feasible for small-scale systems due to their relative simplicity and limited variables.

Significance of IWSSP

In towns like Leh, rapid urbanisation, climate variability, and infrastructure limitations pose significant challenges to water and sanitation management. Poorly managed sanitation systems directly impact water quality, increasing contamination risks and public health concerns. By adopting an integrated approach, iWSSP ensures that interventions in one system do not inadvertently compromise the other. This method fosters a holistic risk management strategy, improving overall service reliability and sustainability.

Case study of iWSSP in Serbia

A successful iWSSP pilot was implemented in several Serbian villages by the National Institute for Public Health and the Environment (RIVM), the German Environment Agency (UBA), and the Institute of Public Health Serbia. The project harmonised WSP and SSP elements into a replicable model, leveraging tools developed during the initiative. It identified key interdependencies between water supply and sanitation systems and addressed hazardous events that could impact both. This approach allowed for comprehensive improvement plans that simultaneously enhanced both services, making it particularly effective for small-scale infrastructures with limited resources.

Between September 2021 and May 2022, the pilot was tested in three villages with diverse system characteristics. Training materials and templates were developed, followed by capacity-building workshops and training for local facilitators. Multi-sectoral teams, comprising stakeholders from both water and sanitation sectors, collaborated on the iWSSP process. Challenges included differing responsibilities for water and sanitation management, limited physical overlap, and predominantly consumer-managed systems. Despite these obstacles, the initiative strengthened cross-sector collaboration and communication, highlighting the long-term benefits of integrated planning.

Adaptation of iWSSP for Leh

Globally, WSPs have been more widely adopted than SSPs due to the fundamental necessity of water supply. While water supply addresses an existential need for humans, sanitation safety ensures the population remains healthy and can prosper.

In the case of Leh, a WSP had already been prepared in 2020, but no SSP had been undertaken. A revision of the WSP was considered necessary, as the previous one had not been implemented by the concerned departments, the WSP manual had been revised, and the water supply and sanitation system had not undergone substantial changes since. Given the existing WSP and the need for a sanitation safety plan, an integrated approach was deemed suitable for Leh.

To adapt the iWSSP framework to Leh, the RIVM model was modified to suit local conditions. The latest WHO guidelines indicate fewer methodological differences between WSP and SSP, making integration more practical. Key modifications included simplifying tools and templates, adopting a streamlined 3×3 risk assessment matrix, and incorporating elements from the SSP manual to integrate climate change risk management. With the latest manuals for both WSP and SSP, the WHO-recommended methodologies for both don't differ as much anymore. For this reason, there is not a lot of alterations needed in the methodology when integrating the two.

As prescribed in the manuals, the iWSSP team made field visits to both the water supply and sanitation systems. Semi-structured interviews were carried out with officials from both the responsible management and engineering departments for water supply and sanitation systems and finally with experts in the field of geology of the region.

The iWSSP used the data collected from the field trips, research, past reports and studies, expert interviews, and their own expertise to create the first draft of the iWSSP. Finally, a workshop was organised, with stakeholders from both systems. The goal for the workshop was twofold; first, to train the relevant stakeholders on how to carry out iWSSP and understand its importance, and the secondary motive was to validate and add to the first draft of the iWSSP. This top-down approach was opted for due to time constraints.

Preparation of IWSSP

Identified Area for the iWSSP

While preparing the Integrated Water Supply and Sanitation Plan (iWSSP) for Leh, the municipal boundary was chosen as it provides a clearly defined jurisdiction that aligns with the governance and administrative framework of the relevant departments. This alignment facilitates seamless coordination and decision-making while ensuring that the interventions proposed in the plan are institutionally supported and feasible for implementation.

Additionally, the municipal boundary offers the advantage of having extensive existing data and literature from previous studies, surveys, and reports. This ready availability of baseline data eliminates the need for time-intensive groundwork, enabling the team to build upon and validate existing knowledge rather than starting from scratch.

Moreover, the urbanised nature of the MCL area allows the iWSSP to address critical challenges that are specific to densely populated regions, such as growing demand for infrastructure, stress on water supply systems, and gaps in sanitation services. Concentrating on this area ensures that the plan can deliver targeted solutions where they are needed most, impacting a significant portion of the population.

Another key benefit of working within the municipal boundary is the accessibility to relevant experts and stakeholders. The concentration of local governance bodies, technical experts, and community representatives within the area simplifies the process of consultation and collaboration. This proximity ensures that their insights, expertise, and feedback can be efficiently incorporated into the planning process, fostering a sense of shared responsibility and commitment.

Lead organisation

The iWSSP was initiated by the **Ladakh Ecological Development Group (LEDeG)** in order to integrate multi-barrier risk assessment in the water supply and sanitation system in Leh. This is the same organisation that pioneered Leh's first Water Safety Plan in 2020 and Water Audit in 2020-21. LEDeG plays a key role in every phase of the project, from baseline studies and community consultations to drafting the final plan and proposing long-term strategies for implementation. It ensures that the iWSSP is grounded in robust data, aligns with best practices, and incorporates inputs from local communities, field experts, and stakeholders. LEDeG mobilised its network of experts and organised stakeholders for the education and sensitisation workshop.

Formation of iWSSP Team / Steering Committee

To ensure the effective planning and execution of the iWSSP, a dedicated core team and steering committee were established. The core team was comprised of LEDeG and its technical partners, while the steering committee involved relevant government and private bodies. The core team was responsible for the groundwork, data collection, and research, whereas the steering committee defined the goals of iWSSP, provided valuable insights and data on the systems, and guided the iWSSP on the overall direction and priorities. This collaborative approach ensured that the iWSSP aligned with the existing policies, plans, and institutional frameworks, while also incorporating diverse perspectives and expertise.

The core team includes key personnel from both organisations who bring diverse skills and expertise to the project:

• LEDeG Team:

Stanzin Odsal, an experienced Urban Planner, brings valuable expertise in the WASH sector in Leh, ensuring the plan addresses the complex interplay of infrastructure, environment, and community needs.

• Technical Partners

Konchok Tashi, a town planner and the lead technical consultant, leads the coordination between LEDeG and technical partners and oversees the overall implementation of the project.

Faisal Qadir, an environmental engineering consultant, is responsible for conducting technical analyses, system documentation, and designing the framework for an integrated water supply and sanitation planning.

Stanzin Mingure, the field expert, plays a critical role in on-ground assessments, community engagement, and field data collection.

Steering committee

To verify that the iWSSP is comprehensive and integrates inputs from all key stakeholders, an extended team was formed, comprising representatives from relevant departments and organisations:

- **Public Health Engineering (PHE) Department:** Provides technical inputs, operational data, and expertise on existing water supply infrastructure and systems.
- **Igo Phey Division PHE:** Igoo Phey plays a crucial role in overseeing sewerage systems, contributing expertise on wastewater management and sustainable sanitation practices.
- **Municipal Committee Leh (MCL):** Offers governance and regulatory support, ensuring alignment with municipal policies and coordination with urban development efforts.
- **Blue Water Company (BWC):** The Blue Water Company plays a pivotal role in the operation and management of the Faecal Sludge Treatment Plant (FSTP).
- **Bionics consortium Pvt. Ltd.:** Responsible for the construction and functioning of the central STP.

External Support: The iWSSP team was also mentored by the expertise of Ms. Payden Dorji, deputy head for WHO India and Mr. Avinash Krishnamurthy, Director at Biome Environmental Trust, Bangalore. These experts guided and validated the innovative approach of the iWSSP while also fulfilling the role of resource person during the education workshop.

Stakeholders

The successful implementation of the iWSSP relies on the active involvement of diverse stakeholders and a detailed understanding of the region's water and sanitation systems. To ensure an inclusive and effective planning process, key stakeholders were identified, and critical areas within Leh's municipal boundary were assessed.

Stakeholders were mobilised to ensure a well-rounded approach to the planning process. **Elected representatives,** along with **ward members and Gobas,** were engaged to ensure that the plan reflects the needs and aspirations of the local communities, as they bring an essential understanding of on-ground issues and act as a bridge between the community and decision-makers.

Regional experts were also included as they bring scientific understanding and cutting-edge research about Leh to the table.

Workshops

Recognizing that Water Safety Planning (WSP) and Sanitation Safety Planning (SSP) are still in the early stages of adoption both locally and nationally, a targeted sensitisation workshop was held on the 9th and 10th of December 2024, hosted collaboratively by LEDeG and Plannable.co, with 20–25 participants in attendance in order to build awareness and engage stakeholders in these critical approaches.

The workshop also served the dual purpose of creating a platform for bringing together players involved in both systems, which was used to collect crucial data and insights. The workshop also encouraged discussions and collaboration between the two sides. Expertise was provided by resource persons from WHO India and Biome Environmental Trust.

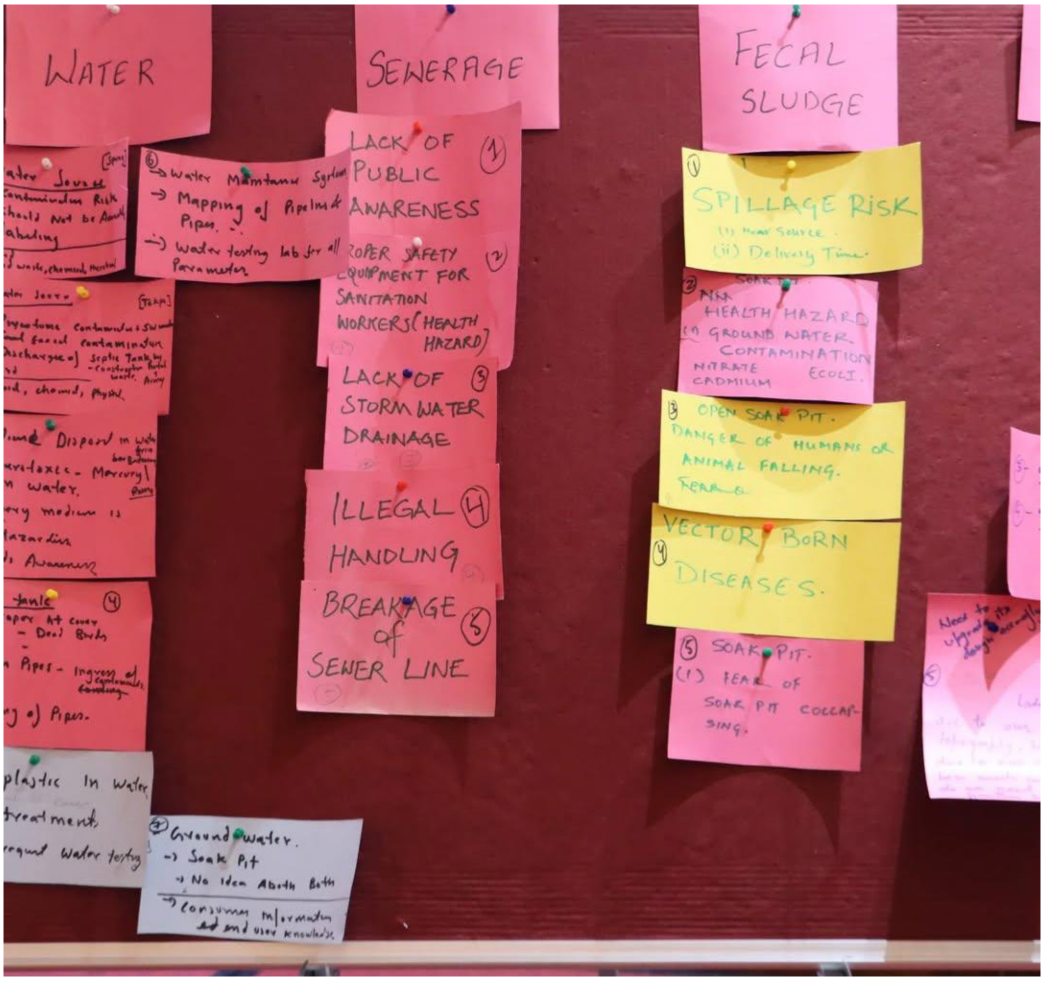
Participants were introduced to the core concepts, principles, and steps involved in developing WSP and SSP frameworks. Training materials, including guidance documents, templates, and tools, were shared to enhance understanding and build confidence among stakeholders. Lectures and interactive sessions fostered awareness of the importance of integrating water safety and sanitation planning into regional strategies. Stakeholders engaged in group discussions and risk assessment exercises, identifying hazards and potential areas for improvement in the systems.

The workshop successfully sensitised stakeholders to the iWSSP approach, creating a foundational understanding of WSP and SSP. It also provided a collaborative platform for exchanging knowledge and identifying region-specific challenges and opportunities. Given the growing pressure on Leh's water resources and sanitation systems, sensitisation efforts such as this play a critical role in ensuring that stakeholders are equipped to make informed decisions. By aligning their efforts with the iWSSP framework, stakeholders can collectively address challenges and ensure a sustainable future for the region.


THE GRAND DRAGON
2 DAYS
WORKSHOP
on
INTEGRATED WATER
&
SANITATION SAFETY PLAN
BORDA


WHY INTEGRATE WSP AND SSP FOR LEH TOWN?
Integrated Water and Sanitation Safety Plan
THE GRAND DRAGON


WORKSHOP ON
INTEGRATED WATER
&
SANITATION SAFETY PLAN
BORDA
THE GRAND DRAGON


WATER
SEWERAGE
FECAL SLUDGE
LACK OF PUBLIC AWARENESS
SANITATION WORKERS (HEALTH HAZARD)
LACK OF STORM WATER DRAINAGE
ILLEGAL HANDLING
BREAKAGE of SEWER LINE
SPILLAGE RISK
HEALTH HAZARD
GROUND WATER CONTAMINATION
OPEN SOAK PIT.
VECTOR BORN DISEASES.
SOAK PIT.
→ Water testing lab for all Parameter
Ground water.
→ Soak Pit


THE GRAND DRAGON
Ladakh

Stakeholder	Job title	Organisation	Role of the stakeholder
Tashi Gyalson	CEC	LAHDC	Political capital in local governing bodies
Stanzin Chosphel	EC	LAHDC	Political capital in local governing bodies
Stanzin Rabgais	Executive Officer	MCL	Responsible for consumer facing infrastructure of the sanitation system
Tsering Angchok	Executive Engineer	Igoo Phey-PHE	High-ranking official from the department responsible for O&M of the sanitation system
Iftikhar Ahmed	Assistant Executive Engr.	PHE	Water supply system in Leh
Eshay Tundup	Director	LEDeG	Head of the funding and executive body initiating the project
Konchok Tashi	Executive Director	Plannable Co.	Head of the executive team preparing the iWSSP
Tsewang Gyatso	FSTP Operations Manager	BWC	Responsible for the operations and management of the decentralised FSTP
Ishfaq Wani	STP Operations Manager	Bionics consortium	Responsible for operations and management of the centralised STP
Dolma Chuskit	Chief Medical Officer	Health department	Health risks posed by the sanitation and water systems
Tsering Mutup	Local Village Representative	Local elected bodies	Consumer perspectives of the sanitation and water supply services
Tundup Tsering	Local Village Representative		
Nawang Tsering	Local Village Representative		
Sonam Palden	Local Village Representative		
Ruksana Parveen	District Officer	Ladakh Pollution Control Committee, Leh	Control measures and measurement of pollution levels in the environment
Rigzin Wangmo Lachic	President	ALHGHA	Representing the largest economic sector in Leh
Lobzang Chorol	Researcher		Expertise in groundwater pollution and hydrogeology of Leh
Irfan Nazir	Junior Engineer	MCL	
Nazir-ud-Din	Assistant Engineer	Igo Phey	
Stanzin Dawa	Assistant Engineer	Urban Local Bodies	

System description

With a population of 42,352, the water suppy and sanitation systems are relatively small-scale. Leh's water supply relies primarily on groundwater and spring sources, and most of the sanitation system either directs its output, whether processed or unprocessed, into groundwater or the river. Due to this interconnection, ensuring a safe water supply in Leh must start with ensuring a robust sanitation system.

In terms of infrastructure, centralised and organised systems exist however, at the current stage, the centralised system has not scaled up enough to serve the entire population of Leh. Therefore, there exists privatized and decentralised systems that take care of the unserved fraction. The concerned authorities already have project plans in drafting to expand these services to the whole of Leh.

Groundwater and Surface Water Systems

Leh's groundwater and surface water systems are intricately linked and primarily fed by glacial meltwater, precipitation, and springs.

1. Precipitation and Recharge

Leh receives an average annual precipitation of approximately 117 mm, predominantly as snowfall in winter and rainfall during summer. This precipitation accumulates on glaciers, flows as surface runoff, and partly recharges aquifers through infiltration.

2. Groundwater Sources

- Borewells and Tubewells: Groundwater is extracted via borewells and tubewells. Borewell water is used directly for domestic and commercial purposes, while tubewell water is distributed through tankers and pipelines.
- Indus River: Groundwater from tubewells next to the Indus River is lifted and integrated into the town's distribution system.

3. Springs

Springs are critical for year-round water supply and serve both domestic and irrigation purposes. Historically, Leh had seven major springs:

- o Chubi Chumik
- o Chamshen Chumik
- o Changspa Chumik
- o Yurtung Chumik

- o Shar Chumik
- o Takma Chumik
- o Kertsey Chumik

Currently, only five remain active, with a total capacity of 0.4 MLD and yields ranging from 1.5 LPS to 290 LPS. These springs are primarily recharged by higher-altitude glaciers and are located along structural weak zones like fractures, faults, and thrust zones.

4. Streams and Canals

Surface water systems, including three major streams—Gangles Tokpo, Sheynam Tokpo, and Gyamtsa Tokpo—form a network that supports agriculture, greenery, and groundwater recharge. These streams have a combined capacity of 20 MLD.

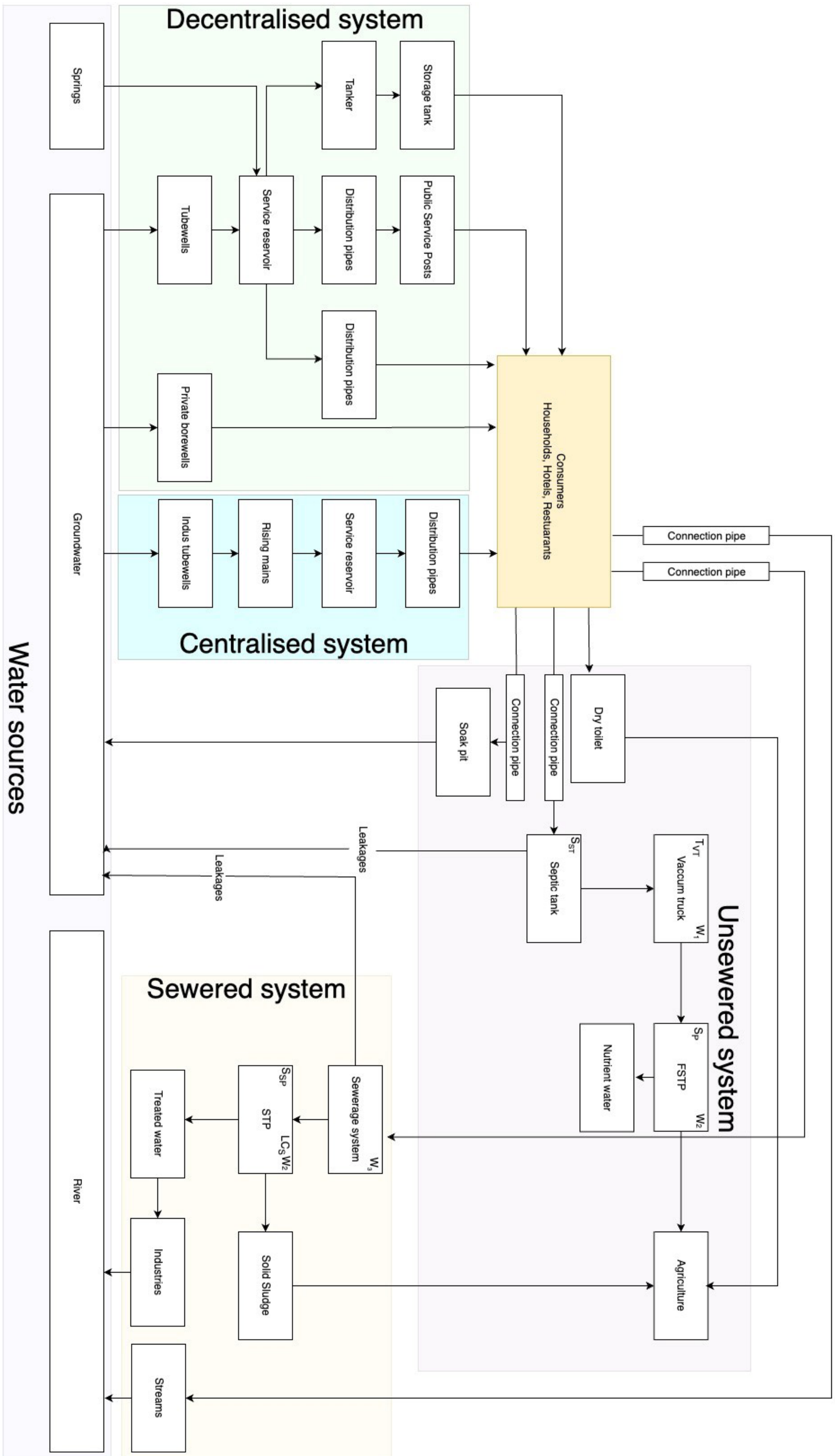


Figure 4 Sanitation and water System of Leh town

5. Wetlands and Bogs

Bogs are common wetlands in Ladakh that contribute to groundwater recharge and spring systems. Historically, Leh had nine major bogs supplying water for drinking and agriculture. However, these systems are increasingly threatened by glacial depletion and encroachments.

Water supply system

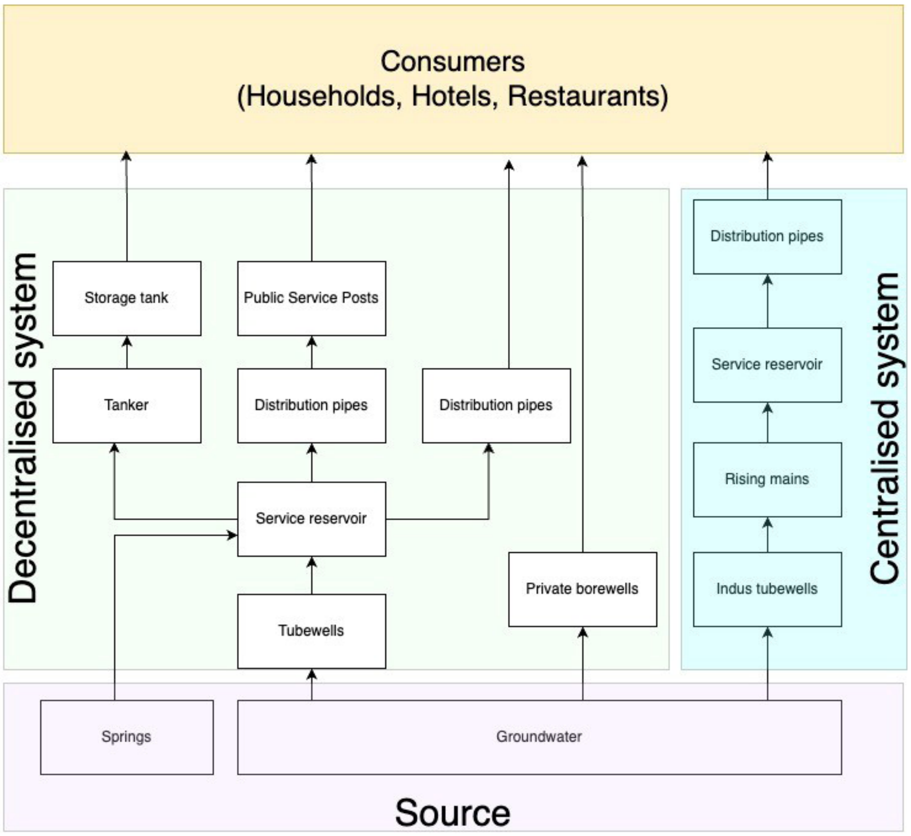


Figure 5 Water Supply System of Leh Town

Current Status

Currently, 90% of the population relies on groundwater extracted through tubewells. About 65% of the population of Leh is served by PHE water supply, while the rest of the population relies on private borewells and spring water (Water Status Report, 2019). While the population of Leh has been gradually moving towards government-supplied water, inadequate infrastructure and intermittent supply are reasons many people opt for private borewells.

Water consumption is closely tied to water availability. According to the guidelines set by the Central Public Health & Environment Engineering Organisation (CPHEEO) of the Government of India, the recommended benchmark for urban water supply in India is around 135 litres per capita per day (LPCD).

This standard is based on the water needs for comfortable and healthy living in towns with access to underground sewerage networks. The water consumption figures provided do not account for additional water usage for gardening, vehicle washing, or commercial demands from restaurants, shops, offices, construction, industry, or agriculture.

Water availability in Leh can be considered severely limited. According to estimates carried out in the WSR, the average daily water usage varies significantly across different user groups and seasons:

- During summer, local residents use around 75 litres per day, while tourists consume approximately 100 litres per day. Migrant workers, on the other hand, have access to only 25-35 litres per day.
- In the winter months, water consumption decreases, with local residents using around 50 litres per day and tourists using 60 litres per day.

			Summer	Winter
Type of Users	Current usage	CPHEEO	Current usage	CPHEEO
Locals	75 L	135 L	50 L	135 L
Tourists	100 L	135 L	60 L	135 L
Migrant Workers	30 L	135 L	-	-

Table 2 Water Demand

Based on the current water usage patterns, the total domestic water demand during the summer season is estimated at 5.0 MLD, while in the winter it drops to 1.6 MLD. However, applying the CPHEEO standards for urban water supply, the total summer and winter domestic water requirements would be 12.7 MLD and 4.2 MLD, respectively.

Projected Demand

- The project plan for the current water supply system was commissioned to Tetra Tech in 2008 to supply 12.77 MLD to an estimated population of 82,275 by 2024. However, the water audit found that the estimations are no longer relevant, as major developments since 2008 have changed the growth potential of Leh drastically. The report estimates water demand of 21.1 MLD based on CPHEEO standards and 12.2 MLD considering sustainable water usage.

Supply

- After accounting for all losses in the system, the real supply from PHE is estimated at 3.34 MLD. This leaves a demand of 1.66 MLD to be fulfilled through privatised means. While based on CPHEEO standards, this should be closer to 12.66 MLD.

Existing Water Supply System

The current water supply system in Leh was designed by Tetra Tech in 2008, under the Urban Infrastructure Development Scheme (UIDSSMT). The water supply system is multifaceted, including a central three-lift scheme from tubewells installed close to the banks of the Indus River (Indus tubewell system), several decentralised tubewell (TW) and service reservoir (SR) systems and spring sources.

The supply system functions by extracting groundwater from tubewells, which is pumped up for storage in SRs at an altitude higher than that of the supply region. Water from the SRs then flows through the distribution network to households through Functional House Tap Connections (FHTCs) or to localities through Public Stand Posts (PSPs). In some cases, water is also sourced from springs and distributed via water tankers filled with water from tubewells. The administration has no bulk water flow metering in its system, and the supply is estimated by the number of times each SR is filled throughout the day.

In the Indus tubewell system, the water is lifted in three stages using rising pipes, spanning up to 9 km and elevations as high as 400 metres, from Choglamsar to Skampari village. The **2.10 MLD** extracted from the Indus tubewells currently supplies about **32%** of the total water demand for Leh.

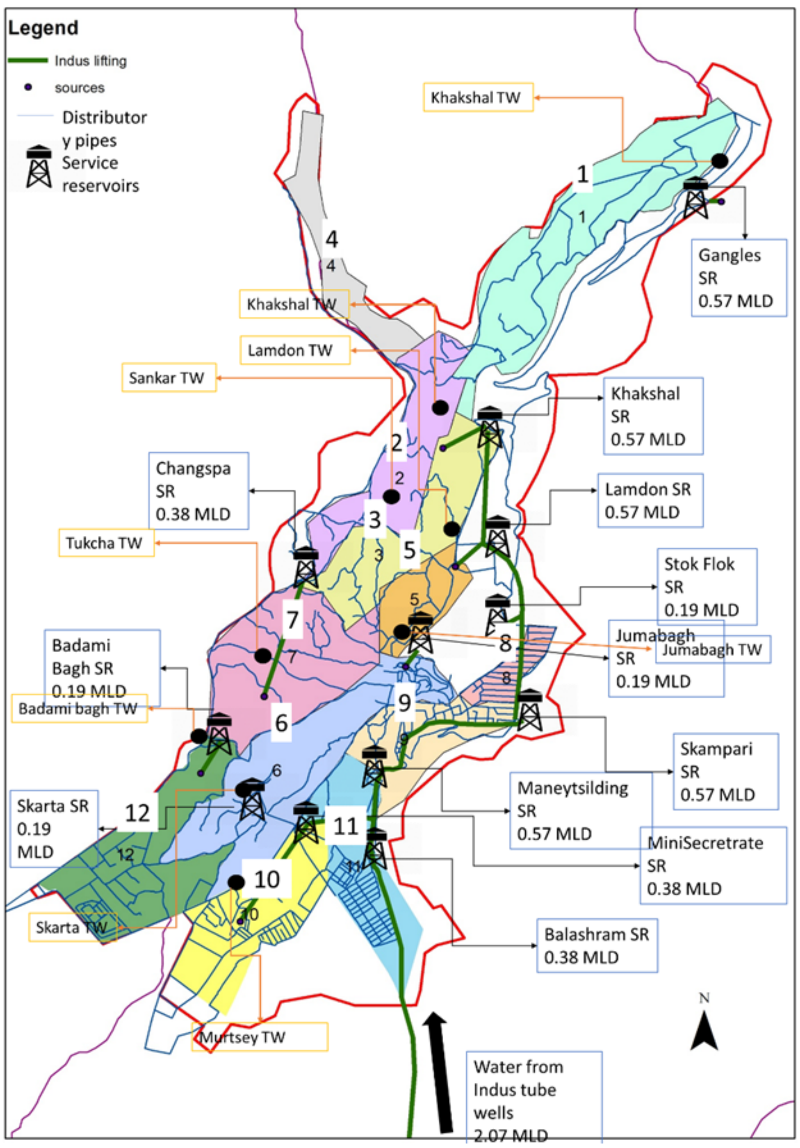


Figure 6 Water Supply System

The transmission system relies on rising mains, which are composed of **150-350 mm diameter Mild Steel (MS) pipes** and span a total length of **9.5 km.** These pipes are designed to handle up to **12 MLD** at an average discharge rate of **140 litres per second.** However, at present, only **18%** of the system's capacity is being utilised, as it is currently transporting just **2.1 MLD** from the Indus tubewells, indicating substantial potential for scaling up water supply to address future demands or expand coverage.

In addition to the centralised water supply system, Leh also relies on **decentralised tubewells** and **springs** as vital sources of water for the town. These decentralised sources play a crucial role in supplementing the water supply, especially in areas not served by the primary distribution network. The water supply in Leh currently consists of about 8 public TWs supplying water to SRs nearby.

Springs also form an essential part of the decentralised water supply system. Gyalung Spring, one of the oldest and most significant springs in Leh, provides a daily discharge of approximately 0.2 MLD, supplying water to areas such as Khakshal and Gonpa. Similarly, other springs like the Gangles Spring and T-Trench in the Gonpa area provide smaller, yet crucial, quantities of water to various localities. Combined, the spring sources contribute about 0.5 MLD, or 10% of Leh's total water demand. These natural water sources are tapped and distributed through storage tanks and service reservoirs.

Service Reservoirs are strategically placed all around Leh, ensuring enough gradient to supply water to the population through gravity. These are dome-shaped structures made of cement. Ideally, in a place with winters like Leh, they need to be covered with sand to prevent water from freezing inside. Currently, there are 15 service reservoirs across Leh, with a total daily storage capacity of 6.18 million litres. However, as only 12 out of the 15 SRs are currently operational, the effective daily storage capacity is reduced to 5.13 million litres. Only 5 of these SRs are insulated with soil to prevent freezing in winters.

Sources	Number	Quantity (MLD)	Potential capacity (MLD)
Public Tubewells			
Murtsey TW	1	0.43	0.86
Khakshal TW	1	0.35	0.69
Tukcha TW	1	0.35	0.69
Jumabagh TW	1	0.43	0.86
Lamdon TW	1	0.19	0.52
Sankar TW	1	0.19	0.38
Badami Bagh TW	1	0.19	0.38
Skara TW	1	0.19	0.38
Gonpa TW	1	0.06	0.12
Total		2.38	4.89

Table 3 Tubewells in Leh

During the field trips, it was found that most of the SR and TW infrastructure lacks substantial physical barriers to entry. SRs in Skara and Juma Bagh were also found in less-than-ideal condition. There is no maintenance schedule for the SRs.

From the storage tankers, water is distributed to the end users through three main routes: Functional House Tap Connections, Public Stand Posts, and water tankers.

- The primary distribution network comprises 100 km of 100 mm ductile iron (DI) pipes. As of 2020, there were 4,188 FHTCs in Leh town, which are registered with the PHE. Apart from that, PHE acknowledges that there are several illegal connections extracting water from the supply system. Due to the intermittent nature of the water supply, there are higher risk of contamination ingress caused by pressure drops.
- The distribution network also connects to about 269 PSPs across Leh that supply water to localities. With no tap on the other end, water flows out unrestricted. This is also to prevent water from freezing inside the pipe in winter.
- Finally, for zones not served through any of the above infrastructure, water tankers augment the water supply. PHE currently has 8 water tankers serving 2,000 households. Water from these tankers is usually stored by households in plastic tankers or plastic containers. The water tankers also replace the water supply in areas where the distribution pipes are prone to freezing in winter. Water from the tankers is flushed out once every day. Thorough cleaning inside the tanker, however, does not take place regularly.

In order to bridge the gap between the current supply and future demand PHE is taking several steps:

- Increasing number of tubewells in the Indus tubewells to 5.
- Increasing the length of the distribution network served by Indus tubewell in order to switch majority of the water supply in Leh to this source.
- Introducing water tariff in order to limit non-revenue water
- Installing a water treatment plant at the Indus tubewell—already under construction.
- PHE envisions the plans of supplying 12 MLD of treated drinkable water through the Indus tubewell system in the near future. Along improving the water supply to 24/7 in the near future.

Water Quality Testing

After meeting the water demand, the next priority for water suppliers is to ensure that the water quality meets national drinking water standards. In order to ensure this, PHE has accredited their lab to the National Accreditation Board for Testing and Calibration Laboratories (NABL) standards for a majority of the necessary parameters. As per the lab technician, tests are carried out before and after the monsoon and on a monthly basis at the storage level. It was shared that in case of testing positive for faecal contamination, the issue is immediately escalated to higher authorities, and steps for mediating the issue are taken immediately. For example, after faecal contamination was tested in Juma Bagh and Lamdon School SRs, auto chlorinators were installed at the outlet in order to ensure the consumers get treated water.

As for contamination in spring sources, the T Trench tested positive, after which manual chlorination started there. However, the labs lack any facilities for testing heavy metals in the water, the presence of which in Leh's drinking water supplies has been pointed out in multiple studies.

Sanitation System

Leh town has witnessed significant changes in its sanitation infrastructure over the years. Moving from a traditionally dry toilet-based system, there has been a gradual shift towards water-based sanitation solutions. This has increased the demand for infrastructure solutions that can meet these needs. Demand on the wastewater infrastructure varies seasonally due to fluctuations in population. During summer, the town generates approximately 7.97 MLD of wastewater daily from residents, tourists, and migrant workers. In winter, this volume reduces to 4.58 MLD due to seasonal migration and a decrease in tourism.

The sanitation system in Leh continues to evolve, incorporating a combination of traditional and modern waste management solutions to meet the town's needs and adapt to its unique climatic and geographical conditions. Leh employs a mix of waste disposal methods depending on land use and activity. Residential areas utilise fully lined tanks (FLT) for storage, or lined pits with semi-permeable walls or bottom (LPSPWB), and sewerage connections, while hospitals and larger hotels manage waste through Decentralised Wastewater Treatment (DEWAT) systems. Hotels and restaurants integrate septic tanks and sewerage networks for wastewater management. The municipal area contains 12 water-based public toilets, with dry compost toilets also serving as an alternative, particularly in winter.

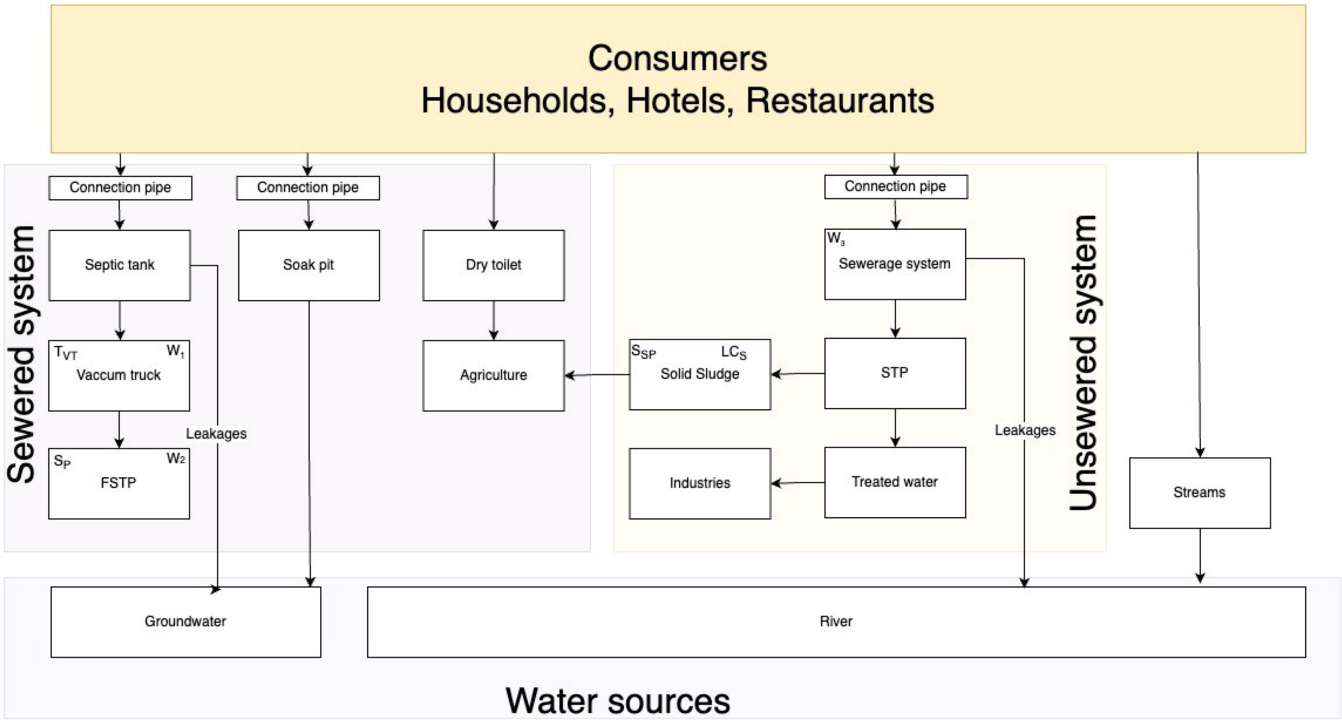


Figure 7 Sanitation System of Leh town

In 2016, under the Atal Mission for Rejuvenation and Urban Transformation (AMRUT), the Public Health Engineering Department (PHED) initiated the construction of a sewerage network to improve sanitation and wastewater management. The system caters to about 40% of Leh, which then connects to a 3 MLD sewage treatment plant at Agling.

The push is to move the system towards connecting completely to the sewerage network. The gap is filled either via storage in FLTs or seepage into the ground through LPSPWB. Sludge stored in FLTs is cleaned by vacuum trucks or honeysuckers about every 5 years and processed in an FSTP that operates for 8 months in the year.

The current system is a mix of sewered and unsewered infrastructure in response to the novel challenges of the change in sanitation practices, leading to a number of issues related to drinking water quality in the town. Due to the lack of standardised septic tanks in the existing built area, the only path forward in terms of ensuring sanitation safety is to expand the current sewerage system to access the unsewered locations. STP capacity will also be increased in order to keep up with the increasing inflow of wastewater as the water supply increases.

Components and Process Flow

1. Sources of Wastewater:

- Hotels without Sewage Treatment Plants (STPs) (UHU_HUH)
- Restaurants (URU_RUR)
- Public toilets (UPU_PUP)
- Households (UHHU_{HH}UHH)
- Leachate from landfills (ULFU_{LF}ULF)

2. Wastewater Flow:

All these sources generate wastewater (SFS_FSF or SLFS_{LF}SLF), which is directed to:

- Septic Tanks (SSTS_{ST}SST): Primary containment units that separate solids and partially treat wastewater.
- Soak Pits (SSPS_{SP}SSP): Structures that allow liquid effluent to percolate into the soil.
- Streams (SSS_SSS): In some cases, untreated or partially treated wastewater flows directly into natural water bodies.

3. Leakages and Environmental Impacts:

Leakages from septic tanks, soak pits, and streams may result in:

- Contamination of groundwater (WC1WC_1WC1).
- Pollution of rivers (WC2WC_2WC2).

4. Treatment and Reuse:

- Vacuum Trucks (TVTT_{VT}TVT): Faecal sludge is collected from septic tanks by vacuum trucks.
- Faecal Sludge Treatment Plants (FSTPs): Collected faecal sludge is processed into:
    - Treated Water (W2W_2W2): Used as nutrient water for irrigation.
    - Treated Sludge: Used as fertilizer in agricultural fields.

Centralised Sanitation System

The centralised system is designed to handle wastewater from densely populated areas, ensuring a streamlined process for collection, treatment, and disposal. This system relies on sewer networks and centralised treatment facilities.


PUBLIC CONVENIENCE
& CAFE


LADIES (TOILET)
GENTS (TOILET)


KAM-AVIDA
MUNICIPAL COMMITTEE LEH
KEEPING LEH CLEAN
LEDeG
BORDA
SWC


Happiness doesn't come from what we get,
but from what we give.
Give us yourshit. Be happy-
LEH BEAUTIFUL SUSTAINABLE RESILIENT

Components and Process Flow:

1. Sources of Wastewater:

- Hotels without STPs
- Restaurants
- Households

2. Wastewater Flow:

- **Sewerage System (TSST_{SS}TSS):** Wastewater from these sources is transported through a centralised sewer network (W3W_3W3).
- **Centralised STP (SpSpSp):** The collected wastewater is processed in the centralised Sewage Treatment Plant (STP).

3. Treatment and Reuse:

- Solid Sludge (SpS_pSp): Separated during treatment and repurposed as fertiliser for agricultural fields.
- Treated Water (W2W_2W2): Used for:
  - o Irrigation
  - o Industrial processes
  - o Discharge into rivers

4. Leakages and Environmental Impacts:

Leakages may occur in the sewerage network or at the centralised STP, resulting in:

- Groundwater contamination (WC1WC_1WC1).
- River pollution (WC2WC_2WC2).

Key figures		
S. No.	**Key figure**	**Details**
1	Population	
2	Toilet coverage	100%
3	Centralised system	40%
4	Decentralised system	60%

Onsite Sanitation System (OSS)

In areas without sewer connectivity, households and establishments use various forms of onsite sanitation systems for wastewater containment, treatment, and disposal.

Dry Toilets

Leh is a historically water-scarce region, leading to the widespread use of dry toilets as a sustainable solution for centuries. These waterless toilets, known as composting toilets, convert human waste into organic compost without requiring water for flushing. Dry toilets are deeply integrated into Ladakh's culture and environment. The system typically consists of a two-storey structure: a toilet on the upper level and a composting pit beneath it. After each use, users throw a shovelful of soil, ash, or agricultural waste into the pit to cover the waste. This accelerates decomposition and prevents foul smells. Over time, the waste decomposes naturally, transforming into nutrient-rich compost. This process is aided by the region's cold and dry climate, which slows bacterial activity but ensures odourless decomposition. A small window or vent provides ventilation, reducing odours and promoting aerobic decomposition. Once a year, the compost is removed from the pit and transported to agricultural fields. The decomposed waste serves as a natural fertiliser, enriching the soil for crops.

Most of the households in Leh (estimated 95%), predominantly in Wards 1, 2,3,6,7,8,9,10,11, and 12, have a dry toilet. Despite their benefits, the use of dry toilets in Leh has declined due to the influx of tourists and the demand for modern flush toilets. Many hotels and guesthouses have adopted water-based systems to cater to tourist preferences, leading to increased groundwater extraction and pollution. Constraints of the urban setting also hinder the use of dry toilets, namely odour from clearing windows facing public streets, animals entering the waste chute disrupting composting, lack of availability of covering material and difficulty finding cleaning personnel. Yet the trend of moving over to dry toilets continues in winter due to the lack of a continuous water supply.

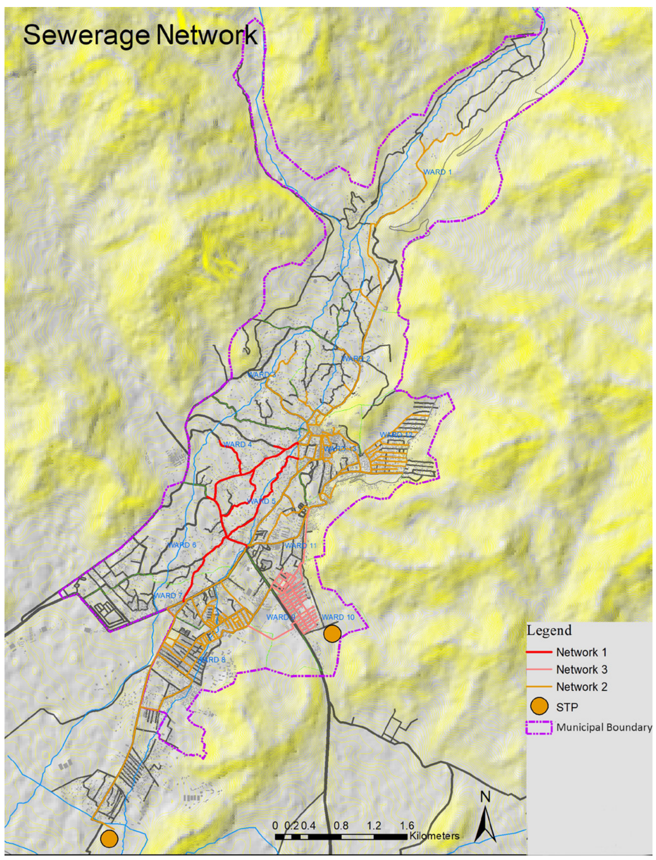
Soak Pits

Lined pits with semi-permeable walls or bottom (LPSWB) are used by the majority of households that are not connected to the sewerage system. These are commonly used in areas where centralised sewage systems are unavailable. In Leh town, LPSWB have been widely adopted due to their simplicity, cost-effectiveness, suitability for local conditions, and lack of knowledge to construct a proper containment system. Given the high percolation rate of Leh's geology, LPSWB are cited as the primary source of groundwater pollution. Wide presence of LPSWB is also due to the lack of knowledge in the construction community about constructing standard septic tanks, which leads to a containment system that lets the contamination from wastewater leak into the environment. Another reason for its popularity is that this is a flush-and-forget solution since LPSWB rarely needs any cleaning.

Off-site Sanitation System (OSS)

Sewerage Network

According to our analysis, Leh's sewerage network, initiated under the AMRUT scheme, covers approximately 40% of the area, consisting of 61.6 km of concrete sewer pipelines. A DPR has been prepared for connecting the left-out areas to the existing STP and a new STP of 12 MLD capacity. The system is designed to collect and transport wastewater to the 3 MLD Sewage Treatment Plant (STP) located outside the municipal area. Apart from Wards 1, 2, 3, and 5, all others have been connected to the sewerage network. The wastewater generated from households, hotels, and public facilities is directed into the network for treatment before discharge. As of now, most of the blockages in the sewers are cleaned manually. While robotic cleaners have been procured for cleaning manholes.



Map 5 Existing Centralised Sewerage System

Name	Proposed Length (km)	Achieved Length (km)	Areas Covered
Network – 1	12	6.05	Shenam, Fort Road, Tukcha, Skara
Network – 2	93	49.26	Gangles, Horzey, Katpa, Chubi, Changspa left side, Leh main Market, Skampari, Stalam, Old Leh Town, Katmochey, Maneytsilding, Old Road, Norgais Ling, Targais Ling, Murtsey Colony, Ibex Colony & Skalzangling.
Network – 3	7	6.28	Nimoling, Housing Colony & Govt Quarters.

Fully Lined Tanks

In Leh, predominantly hotels and guesthouses rely on fully lined tanks (FLTs) for wastewater containment. Soak pits, which allow wastewater to percolate directly into the ground, have been a major source of groundwater pollution in Leh. Untreated sewage from soak pits seeps into aquifers, contaminating drinking water with nitrates, heavy metals, and harmful bacteria such as E. coli. These tanks are impermeable structures designed to prevent leakage and groundwater contamination, making them one of the more secure onsite containment solutions in the region. Due to the lack of standard practices for the construction of septic tanks, we opt to refer to them as Fully Lined Tanks (FLT) here.

There's a higher rate of installations of FLTs in tourism-related establishments, as these are needed for regulatory compliance, which prohibits the use of soak pits for obtaining a business license. Desludging of these tanks is carried out on demand, typically every 5 to 15 years, depending on usage and tank capacity. The Municipal Committee Leh (MCL) provides desludging services using vacuum tankers of varying capacities. Since 100% of these tanks require periodic emptying, they contribute significantly to the town's faecal sludge management system. The collected sludge is transported to the Faecal Sludge Treatment Plant (FSTP) for further treatment and disposal.

Onsite Sewage Treatment Plants

Leh, being a major tourist destination, hosts a significant number of hotels and guesthouses that contribute to wastewater generation. Given the region's fragile ecosystem and limited municipal sewage infrastructure, the Pollution Control Board has mandated that all hotels with more than 20 rooms must install an onsite sewage treatment plant (STP) to ensure proper wastewater management and environmental sustainability. According to the latest data by the tourism department, there are 52 hotels with more than 20 rooms. However, compliance with the regulation has not been complete in the sector.

An Onsite Sewage Treatment Plant (STP) is a decentralised wastewater treatment system designed to treat and manage sewage at the location where it is generated. Unlike centralised sewer systems that transport wastewater to a distant treatment facility, onsite STPs process sewage directly within individual properties, such as hotels, institutions, or residential complexes.

These systems typically consist of primary treatment (sedimentation and separation of solids), secondary treatment (biological degradation of organic matter), and tertiary treatment (filtration and disinfection) to produce treated water that meets environmental discharge standards. The treated effluent can often be reused for landscaping, irrigation, or other non-potable purposes, reducing water wastage.

To support smaller establishments, the Tourism Department provides subsidies for hotels with 1 to 20 rooms, encouraging them to implement STPs and reduce their environmental footprint. Additionally, in an effort to promote inclusive economic growth, women-owned businesses receive an 85% subsidy for STP construction, making it more feasible for female entrepreneurs to comply with sanitation regulations.

Beyond commercial establishments, onsite STPs are also being developed for larger institutional areas such as schools, government offices, and public facilities. These initiatives align with Leh's broader sanitation strategy.

Sewerage Treatment Plant Leh

Leh town operates a Sewage Treatment Plant (STP) with a capacity of 3 MLD, located at the outskirts in Agling, to manage wastewater from the sewered areas. The plant plays a crucial role in treating domestic and commercial wastewater before final disposal, ensuring environmental sustainability and public health.

The Sequential Batch Reactor (SBR) technology is employed at the STP for wastewater treatment. This technology is known for its high efficiency in nutrient removal and sludge management, making it well-suited for regions with fluctuating wastewater loads like Leh.

The wastewater treatment process at Leh's Sewage Treatment Plant (STP) begins with the collection and screening of wastewater from households, hotels, and public facilities through a 61.6 km sewer network, removing large debris such as plastics and solid waste. It then undergoes primary treatment in a clarifier, where heavier solids settle and form sludge. The biological treatment follows with the Sequential Batch Reactor (SBR) process, where wastewater is aerated in cycles to break down organic matter by microorganisms. The system alternates between aeration and settling, separating clear treated water from sludge. Excess sludge is dewatered, stabilised, and either disposed of or reused as a soil conditioner. The treated water, meeting CPCB standards, will be reused for irrigation at an under-construction onsite park. The pollution board also mandates that the treated water be taken for use by crusher plants. Most of the water is ultimately discharged into the Indus River.

Name of STP	Treatment Technology	Installation year	Plant Capacity (MLD)	Operational status	O&M done by	Reuse arrangement
STP, Leh	Sequential Batch Reactor (SBR) technology	2020	3.0 MLD	Operational (under capacity)	PHE	Industrial use and Park to reuse the STP water is under process

Faecal Sludge Treatment Plant (FSTP)

In 2017, the Municipal Committee of Leh, in collaboration with Blue Water Company, established a Faecal Sludge Treatment Plant (FSTP) to address the pressing issue of groundwater contamination resulting from the widespread use of septic tanks and soak pits in areas lacking a sewer network. This facility employs the Upflow Anaerobic Sludge Blanket (UASB) process, an anaerobic digestion method where faecal sludge is introduced from the bottom of the reactor. Within the reactor, suspended solids and microbial activity form a sludge blanket, facilitating the breakdown of organic matter. The treated sludge undergoes further drying for potential reuse.

The FSTP in Leh has a design capacity of 12,000 litres per day and was constructed over a period of seven weeks at a cost of approximately ₹52 lakhs. Notably, the plant operates without the need for electricity or chemicals, relying instead on gravity-based natural and biological treatment processes. This eco-friendly approach ensures minimal odour and requires only simple, low-cost maintenance. However, due to Leh's harsh winter conditions, with temperatures often dropping below freezing, the FSTP remains non-operational during the winter months, limiting its functionality to the summer season. Since its commissioning in August 2017, the FSTP has treated over 2.2 million litres of faecal sludge within the first ten months of operation, significantly mitigating the environmental impact of untreated wastewater in Leh. The success of this initiative underscores the importance of localised, sustainable sanitation solutions in regions facing unique environmental challenges.

Name of FSTP	Treatment process / technology	Installation year	Capacity (KLD)	Operational status (Functional/ Non-Functional)	O&M done by	Reuse arrangement (Solid/Liquid)
Faecal Sludge treatment plant Leh	It is a gravity-based system on natural and biological treatment with no use of chemicals.	Aug, 2017	12 KLD	Functional but only in summer (April – October)	BWC (blue water company)	1.Soil conditione 2.Nutrient water

Hazard Identification and Risk Assessment (Module 3)

Hazard identification and risk assessment form the core of the iWSSP framework as this is where risks to the system are pre-emptively identified, which aids in developing improvement plans and control measures in the following module.

Methodology:

Stage	Activities Performed
Hazard Identification	Field visits, expert interviews, and stakeholder workshops
Data Collection	Review of reports, research papers, and hazard event databases
Risk Assessment	Likelihood and severity analysis using a 3×3 matrix
Validation	Independent risk evaluation and stakeholder feedback
Final Risk Rating	Weighted average applied to ensure objectivity

Hazard Identification and Risk Assessment in iWSSP

The process of hazard identification in the Integrated Water and Sanitation Safety Planning (iWSSP) framework follows an anticipatory approach, ensuring a broad range of potential hazardous events are identified and their risks assessed. Alongside this, existing control measures for potential hazards were documented. Field visits were conducted to visually inspect key components of the water supply and sanitation infrastructure, while semi-structured interviews were held with organisational executives, system operators, and experts in the field to gain further insights.

Stakeholder Engagement and Data Collection

A stakeholder workshop was organised with the dual objective of introducing participants to the iWSSP framework and gathering their perspectives on hazards within the system. In addition to these consultations, the iWSSP team utilised existing reports, research papers, and generic hazard event databases to supplement the identification process.

Risk Assessment Process

The identified hazardous events were subjected to a structured risk assessment process, where the likelihood of occurrence and the severity of impact were analysed using a 3×3 matrix. This matrix was selected to facilitate comparability across both water and sanitation systems, allowing for systematic prioritisation of limited resources in the next stage of planning.

Following field visits and research, the iWSSP team compiled a preliminary table of hazardous events with corresponding risk ratings. This table was subsequently validated and expanded upon by stakeholders, organisational executives, and experts. Independent risk assessments of these events were conducted with relevant parties to ensure a balanced evaluation. To further enhance objectivity, a weighted average method was applied to finalise risk ratings.

Field Inspections and System Validation

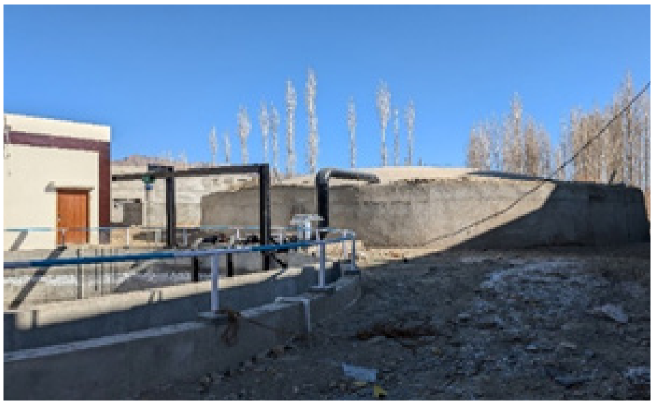
Since a significant portion of the system runs underground, the team focused on inspecting visually accessible components, selecting key sites based on system descriptions and stakeholder inputs. In the case of the water supply system, the initial Water Safety Plan (WSP) was reviewed to identify previously reported vulnerabilities and assess whether improvements had been made. This practice helped validate the system description, identify new hazards, and evaluate existing control measures. Operators were engaged in free-flow discussions during site visits to capture on-ground challenges.

The primary components assessed in the water supply and sanitation system included tubewells, service reservoirs, and the sewage treatment plant. Additionally, the team cross-referenced the system against existing hazard event databases and meticulously analysed the hazardous events documented in Leh's first WSP. The RIVM tools for iWSSP provided further structured lists of potential hazards, which were supplemented by research into vulnerabilities commonly observed in similar systems. While broad observations of the critical system components were documented, a detailed list of hazardous events was compiled separately to guide the subsequent risk mitigation strategies.

Findings and Observations

Tubewells (TW)

Due to the fact that 90% of Leh's water supply originates from groundwater, tubewells are the most crucial component of the water supply system. The Indus tubewell system is the most crucial part of this system as it is responsible for 32% of Leh's total water demand.



The two functioning wells of the system reside inside a building, inside a gated compound with an operator on site. The compound is also sufficiently isolated from dense habitation or industry that could pose a risk of contamination to the groundwater reserves the tubewells tap into. The operator reported that the submersible pump breaks down almost every month, in which case a spare pump has to be requested from PHE, which can take them 1-2 days to fully replace. In such cases, the functioning pump carries the load of the whole supply.

The conditions around decentralised tubewells are somewhat similar. All of them are contained inside a locked building and have operators living nearby. A few are further locked inside their own compounds. Water supply is also not measured at this stage—no water meter is installed.

All but one tubewell is sufficiently isolated from residence or hospitality infrastructure, which poses a risk of contamination of the source water from FLT and LPSPWB. The occurrence of anthropogenic contamination has already reported in literature and internal reports of PHE. The presence of heavy metals with considerable cariogenic risk has also been pointed out in several groundwater sources. So far, PHE doesn't have any control measures in place when it comes to ensuring water quality at this stage.

Service Reservoirs (SR)

Service reservoirs spread across the Leh MCL boundary are the backbone of the water supply in Leh. However, during the field visits, several hazards were spotted. There seems to be no standard followed when it comes to the state of SRs, as about half of them were inside walled premises, while others were openly accessible.

In order to prevent freezing in winter, there is also a need for insulating these SRs, which is not done in the three SRs. Almost all SRs don't have locked entrances, and residents around SRs have reported that children go inside for a bath occasionally. In two SRs, the walls of the tank were also found to be broken, which can be a source of contamination. While there are no bulk water meters installed here, the supply is monitored based on the number of times the SR is filled and the capacity of each SR.

Water quality is tested at the SR every month, and chlorination is done when tested positive for faecal contamination. Auto chlorinators are installed in two SRs at the outlet pipe.

Distribution Network

While it was not validated through field visits, literature claims that all of the distribution network from SRs is buried 5ft underground in order to prevent freezing in winters. There is no system for monitoring leakages in the network. Several spots of leakage were found across the town, but major pipe bursts were reported to be not so frequent. There is also a prevalent culture of installing pumps at the consumer level, which decreases the pressure for downstream users. PHE has a practice of surprise raids to find these culprits. Unregistered illegal connections are also present throughout the system, which leads to non-revenue water for PHE.

Leakage points in the supply system, along with the intermittent nature of the water supply system introduces the possibility of contamination entering the system once the pressure drops during downtime. While there is no validation for this, concerns have also been raised about cross-contamination of the water supply from the sewerage network, as these run next to each other.

Sewerage Network

About 40% of the sewerage needs are fulfilled by the sewerage network that ultimately connects to the centralised STP. Due to improper use at the consumer level, sewer lines get blocked quite frequently, in which case the lines need to be unblocked manually. In peak season, it is reported that there are somewhere around one to five reports of blockage every day. Robotic means of cleaning the sewer lines have been tried, but have not found wide success yet. The department claims there is no practice of manual entry into the sewer lines as it is illegal. While observing an instance of sewer cleaning, it was noted that the operators did not wear appropriate PPE kit. These operators are hired through a contractor who takes the responsibility of cleaning any blockages in the system. Sewer cleaning is also hindered due to the lack of properly marked manholes, as these tend to get buried under subsequent road construction.

Sewage Treatment Plant (STP)

Located in Agling on the outskirts of Leh, the STP has been an issue of contention due to its proximity to residential areas that often complain of odour and noise from the plant. The treatment plant handles the bulk of the sewage generated in Leh. However, due to improper handling of sewage at the consumer level, there have been issues regarding the quality of the inflow sewage. The composition of the inflow sewage is 60% sewage and 40% solid waste, whereas it should ideally be 90% sewage.

The dissolved oxygen is also critically low, which requires extra steps during the treatment. Due to inflow beyond the operational capacity of the STP, two buffer tanks have been constructed. Due to the high volume of solid waste being captured in the filters, the tanks need to be manually cleaned regularly during the season. The operators claim the cleaning is done wearing appropriate Personal Protection Equipment (PPE) and with oxygen cylinders on standby.

The treatment in the plant is carried out to meet the CPCB standards for type E water for release into a water body. The inflow and outflow water are tested onsite to match the standards on about 14 parameters. The solid sludge is sold as manure, while the treated water is either disposed of into the Indus River or taken by industrial users in order to reduce their reliance on freshwater resources. The plant maintains spares for critical machinery and heating tanks in case of freezing of water in winter, which however, has not been reported so far.

To strengthen the sewerage network, a Detailed Project Report (DPR) has been finalised for the extension of sewerage lines to cover the remaining 60% of the population. This expansion aims to deliver significant improvements in sanitation coverage, enhancing public health and environmental outcomes. Collectively, these initiatives demonstrate a strong commitment to maintaining robust sanitation systems while fostering sustainable water resource management for Leh's future.

Water-borne Diseases

Figures of water-borne diseases in Leh are at a concerning level.

Year	Typhoid	Hepatitis A	Acute Diarrheal Diseases	Dysentery
2021	2	4	1380	18
2022	3	1	2168	17
2023	45	6	1656	14
2024	136	37	1818	8

Table 4 Water-borne Diseases
Source: Disease surveillance data obtained from the CMO office.

Comparing with the documentation of this system from the previous WSP, the status of these tubewells remains unchanged, and the recommended improvements have not been implemented.

Hazard Identification and Risk Assessment for the Water Supply System

Hazard Identification			Hazard Type			Control Measures	Effectiveness				Risk Assessment				Under the most likely climate change scenarios:		Comments justifying risk assessment, under current conditions or climate chang scenarios, or the effectiveness of the control
ardous vent mber	Process step	Description	Microbial	Chemical	Physical	Specify the control measure	Effective	Not effective	Somewhat	Specify evidence (validation)	Likelihood	Severity	Risk rating	Specify category	Drought	Increased precipitation	
W1	E_t, E_{IT}, E_{PB}	Lack of water supply due to a breakdown in the submersible pump			x	Replacement submersible pumps are kept on standby		x		Field visit	2	2	4	Medium	=	=	
W2		Contamination of supply water due to animals or humans due to an insufficient barrier in the tubewell building	x	x							1	2	2	Low	=	=	
W3		Lack of water supply due to a power outage			x	Diesel generators are on standby at some tubewells	x			Field visit	3	1	3	Medium	=	=	
W4		Ingress of contaminants due to leaky pipes delivering water to service reservoirs	x	x							1	2	2	Low	=	=	
W5		Loss of water and energy due to leakages in pipes connecting the tubewells and SR			x						2	1	2	Low	=	=	

W6		Reduced groundwater quantity due to overextraction from borewells			x						1	3	3	Medium	+	-	Groundwater in Leh depends mainly on glacier resources. However, precipitation, however low, plays a crucial role in terms of water availability by balancing seasonal mass reduction with fresh accumulation. Drought conditions will exacerbate glacier melting and also reduce the tertiary component of groundwater recharge.
W8		Contamination of groundwater due to a cracked or damaged cover on the well representing a pathway for introducing hazards	x	x							2	2	4	Medium	=	+	Increased availability of water in the surrounding can form a medium for contaminants to enter wells.
W9		Lack of water supply due to breakdown of building where the tubewell is present			x	Inspection by the tubewell operator		x		Field visit	1	3	3	Medium	=	=	
W10	E_{PB}, E_T, E_{IT}, S_{ST}, S_{SP}	Exposure to contaminated water due to liquid fraction from faecal sludge from LPSPWB and broken FLT percolating into the GW	x			Municipal committee mandates making septic tanks mandatory		x		MCL mandate	3	2	6	High	+	+	Multiple groundwater quality reports indicate the presence of E. coli in various wards which indicates this phenomenon is taking place and leading to health concerns amongst citizens. Drought conditions lead to increased extraction of groundwater which in turn leads to higher percolation rates.
W11		Water loss due to minor leakages in pipes			x	Periodic water audit		x		Water audit 2020	3	1	3	Medium	=	=	
W12		Disruption in water supply due to burst in rising mains			x						2	3	6	High	-	+	
W13		Disruption in water supply due to burst in pipes due to freezing in winters			x	Pipe buried 5ft below ground				Water supply system DPR	2	1	2	Low			
W14	D_{RM}, D_N	Ingress of contaminants due to leakages in pipes running above ground	x	x	x						3	2	6	High			

W15		Non-revenue water supply due to illegal connections			x						2	1	2	Low			
W16		Loss of water supply due to undetected leakages in pipes			x						3	1	3	Medium			
W17		Reduced quantity due to illegal overextraction by households using pumps			x	Regular raids by PHE	x			Water audit 2020-21	2	1	2	Low			
W18		Biofilms in piped networks may lead to pathogen survival and growth of pathogens	x								1	2	2	Low			
W19	T_T	Exposure to pathogens due to accumulation in tankers not cleaned regularly	x	x		Daily flushing schedule for water tankers		x	x	Field visit	2	2	4	Medium			
W20		Lack of water supply due to breakdown of water tankers			x	Multiple tankers on standby	x				2	2	4	Medium			
W21		Damaged or lacking tank covers allow ingress of animals/vermin /faeces / roof drainage which may introduce contamination	x	x	x	Inspection by onsite operator		x		Field visit	3	2	6	High			
W22		Inflow of contaminants, animals, and humans due to damaged structure	x	x	x	Inspection by onsite operator		x		Field visit	2	3	6	High			
W23		Vandalism or sabotage by humans due to lack of fencing and barriers			x						1	2	2	Low			
W24	ST_{sr}, ST_H	Lack of access to water due to freezing in storage tanks not insulated adequately									1	2	2	Low			
W25		Exposure to pathogens due to accumulation of bacteria between cleaning of the storage tanks	x								1	3	3	Medium			
W26		Contamination of drinking water due to leaching of chemicals from storage lining		x							2	1	2	Low			

W27		Growth of algae or biofilms from inadequate cleaning	x									2	3	6	High			
W28		Lack of water supply due to blockage of flow pipes due to accumulation of sediments overtime			x							1	3	3	Medium			
W29	D_P	Contamination of PSP outlets due to mishandling	x	x								2	2	4	Medium			
W30		Lack of water supply due to freezing of water in the pipes in winter			x							2	2	4	Medium			

Hazard Identification and Risk Assessment for the Sanitation System

Hazard Identification			Hazard Type				Control Measures	Effectiveness				Risk Assessment				Under the most likely climate change scenarios:		Comments justifying risk assessment, under current conditions or climate change scenarios, or effectiveness of the control
Hazardous event number	Process step	Description	Microbial	Chemical	Physical	Exp groups	Specify the control measure	Effective	Not effective	Somewhat	Specify evidence (validation)	Likelihood	Severity	Risk rating	Specify category	Drought	Increased precipitation	
S1	T_C: Flow out from toilets	Exposure to sewage water due to the breakage/blockage of the plumbing system	x	x	x	U_{HH}, U_{HS}, U_P, U_R						2	3	6	High	-	+	Drought condition might introduce water budgeting which will lead to reduction in toilet use.
S2		Exposure to waste due to the breaking of the structure	x		x	U_{HH}						2	3	6	High	=	+	
S3	S_{DT}	Exposure to untreated waste due to manual scavenging	x	x	x	W	Empanelment of trained workers and liaising with MCL. Distribution of PPE to workers			x	Interview with the person in charge at MCL	3	3	9	High	=	=	

S4		Exposure to waste indirectly from dogs and flies that come in contact with waste due to inadequate enclosures	x			U_{HH}	Makeshift covering with metal sheets or plywood		x		Interview with the person in charge at MCL	2	2		4	Medium	=	+	
S5	SLF: Liquid fraction from faecal sludge and solid waste in LPSPWB, or broken FLT.	Exposure to contaminated water due to seepage of sewage into groundwater from faulty FLT, LPSPWB or open dumps	x			UHH, UHS, UP, UR	Municipal committee mandates making septic tanks mandatory Upgradation and improvement plan aiming to expand the network connected to the sewerage system		x		Interview with in charge at MCL		3	3	9	High	+	+	Multiple groundwater quality reports indicate presence of E. coli in various wards which indicates this phenomenon is taking place and leading to health concerns amongst citizens. Drought conditions lead to increased extraction of groundwater which in turn leads to higher percolation rates.
S6	SST: Containment/ storage of Faecal sludge.	Overflow of sewage water during flooding events due to lack of plastic cover and one-way valve on FLT	x		x	U_{HH}, U_{HS}, U_P, U_R						1	3		3	Medium			
S7	SSP: Containment/ storage and treatment of Faecal sludge in permeable tanks	Injury to body and possible asphyxiation after falling into an uncovered LPSPWB	x		x	U_{HH}						2	3		6	High			
S8	Ss: Dumping of wastewater into water bodies	Dermal contact with surface water contaminated with sewage due to open dumping into streams	x	x		LC_S, WC_1						3	1		3	Medium			

S9	TSS: Sewerage system delivering wastewater to the treatment plant STP	Injury to the body and possible asphyxiation while entering sewer lines	x		x	W3						2	3	6	High			
S10		Leaking of sewage into groundwater due to leakage in sewerage pipes	x			WC1, LC						3	3	9	High	+	+	Drought conditions lead to increased extraction of groundwater, which in turn leads to higher percolation rates. High precipitation increases the stress on the sewerage pipes, increasing the likelihood of leakages.
S11		Exposure to pathogens due to spillage of sewage water on roads and alleys due to breakage in pipes	x		x	LC						2	3	6	High	-	+	Prolonged precipitation increases the stress on the sewerage pipes, increasing the likelihood of breakages.
S12		Ingestion of pathogens after contact with wastewater during sewer cleaning and maintenance	x			W3	PPE available to use during operations		x		Worker health checkups	3	3	9	High	-	+	Prolonged precipitation leads to more wastewater being present in the sewerage system. Water in the system will decrease during droughts, which can lead to more blockages
S13		Stagnation of sewage in the system due to a lack of flow in the sewerage system, due to an inadequate amount of water flowing through the system				W3		x				2	1	2	Low	+	-	Due to the lack of pumping system the sewerage system relies on gravity for its flow. Decreased wastewater in the system leads to prolonged stay of wastewater in the sewerage system which can lead to faster corrosion rates the system is designed for. This phenomenon also takes place during winter months when usage of the sewerage system decreases.
S14		Ingestion of pathogens after contact with wastewater while cleaning the FLT	x			W1	PPE is available to use during operation. Vigorous training for cleaning professionals		x		Interview with the person in charge at MCL	3	3	9	High	=	=	

S15	TVT: Faecal sludge transported to FSTP	Injury to the body and possible asphyxiation while entering or falling into the FLT	x		x	W1	supervisors accompanying the cleaner	x			Interview with the person in charge at MCL	2	3	6	High	=	=	
S16		Ingestion after contact with raw sewage during vacuum tanker operation	x			W1	PPE available to use during operations				Interview with the person in charge at MCL	3	3	9	High	=	=	Field inspections showed that no PPE was worn by the workers.
S17		Dermal contact with pathogens while handling the solid waste fraction from the FLT	x		x	W2	PPE is available to use during the operation	x			Interview with the person in charge at MCL	3	3	9	High	=	=	There is no system in place for separating solid waste during collection. Solid waste is collected when it blocks the pipes.
S18	PSTP, PFS: Processing of wastewater in STP	Ingestion of pathogens in the form of bioaerosols	x			W2, W4	Wearing masks during the aeration phase				Field visit	3	1	3	Medium	=	=	
S19		Dermal contact with untreated wastewater	x			W2, W4	PPE is available to use during the operation	x				1	3	3	Medium	=	=	
S20		Dermal contact and ingestion of pathogens due to the outbreak of untreated wastewater from open-air reservoirs	x		x	LCP						1	3	3	Medium	=	=	
S21		Noise pollution due to the operation of machinery at the STP			x	LCP						3	2	6	High			
S22		Injury to the body and possible asphyxiation while entering the inflow storage tanks	x		x	W2	Full PPE kit worn during such operations oxygen cylinders on standby	x			Interview with the plant operator	2	3	6	High	=	-	Increased precipitation would lead to dilution of the solid waste coming into the system
S23	P: Industrial users	Ingestion of pathogens from contact with inadequately treated wastewater	x			C1	Treated water quality standards for wastewater reuse up to CPCB levels			x	Field visit	1	2	2	Low	=	=	Industrial users of treated wastewater report the water is not treated to safe standards.

Improvement Plan (Module 4)

The system is analysed through a meticulous and systematic process to identify the maximum number of hazards that can occur in a system. Risk assessment then helps identify which of these hazardous events are high enough on the risk rating scale to be dealt with immediately. Guided by the risk rating, expert interviews, and the team's own expertise, hazardous events were chosen for which improvement plans can be formulated. While most of the high-risk events were chosen, a few medium-risk events were also looked at that have a higher feasibility of being addressed. The improvement plan also creates a basis for informing which parts of the system would need new control measures and operations and management (O&M) protocols.

Not all improvement plans need to be high-resource interventions and upgradations. A lot of management and operational potholes were identified, the fixing of which can also significantly improve the system's safety. To start, due to the heavy reliance of Leh's water supply system on tubewells, operators play an instrumental role in the smooth functioning of the system.

Therefore, there is a need to install technology for automating the operation of tubewells while also tackling reliability by keeping spare motors and parts always on standby.

There is also a need to install separate electricity lines for tubewells to ensure that the water supply doesn't suffer due to electricity cuts. Furthermore, O&M protocols need to be developed for important components of the water supply system. Along with developing a schedule for regular inspections by water suppliers.

Since 90% of Leh's water demand is fulfilled by groundwater, it is imperative to install a robust groundwater monitoring system through monitoring wells. This should be supplemented by a regular water auditing schedule that can help water suppliers identify leakages and inefficiencies in the system and address them in a timely manner.

Finally, a crucial upgrade to the system would be the implementation of a 24/7 water supply system that can minimise pipe leakages and bursts due to stable pressure ranges.

When it comes to the quality of drinking water in Leh, the solution requires weaning the public off soak pits and connecting them to the sewerage system wherever possible and retrofitting septic tanks in areas yet unreachable by the sewerage network. The concerned departments also need to be encouraged to require plans for standardised septic tanks when approving new housing permits. Alongside this, water suppliers also need to upgrade their water quality testing infrastructure to include public information about water quality results. These results should be uploaded on their website on a regular basis to keep citizens dependant on private borewells informed. Finally, there should also be subsidies for installing household water filtration systems until the water suppliers are able to develop large scale water filtration capabilities.

The sewerage system has reported having frequent blockages and the occasional pipe bursts for which O&M schedules need to be developed in order to ensure the system remains in good condition. Installation of sewer level sensors centrally connected can also help the department tackle these situations before it gets too late.

Sanitation workers' safety needs to be improved. There should be a requirement for timestamped GPS-enabled photos of workers in full PPE kit before septic tank and sewer cleaning, along with criteria for supervision and a safety checklist if manual cleaning needs to take place. Sanitation workers should also be provided with life insurance in order to compensate their families in case of death. Finally, solid waste agitators should be procured in order to reduce contact with solid waste during septic tank cleaning. Adequate mechanical sewer cleaners are also a necessary investment for the sanitation departments.

Hazards identified as directly impacting human health are the most alarming, and improvements for these should be sought immediately.

Improvement Plans for High-Risk Health Hazards

Expansion of the Sewer Network

Due to the lack of appropriate wastewater conveyance infrastructure, consumers opt for LPSWB structures which are known to cause contamination of GW resources in Leh. At the current rate, we will get to a state where all of Leh's groundwater resources are undrinkable. While new constructions in unsewered areas are mandated to construct FLTs, in order to wean off existing buildings from LPSWB, the sewerage network needs to be expanded. Ideally, there should not be any unsewered areas remaining in the system and the few left out should be able to be serviced by FLTs. PHE is already at the drafting stage for an expansion project for the sewerage network along with construction of more STPs in Leh. This is a long-term intervention that will require large amounts of financial resources from the government.

Groundwater Testing and Reporting

Groundwater pollution is one of the biggest sanitation-related issues facing Leh, exacerbated by heavy reliance on groundwater resources. Apart from just bacterial contamination, heavy metals have also been reported in Leh's groundwater. While the issue as of now is limited to a few areas, sticking to the same trend could worsen the deterioration of groundwater.

While long-term holistic solutions are in the works, it is necessary in the meantime to implement infrastructure for regularly testing groundwater and publishing these results in the public domain so that the public can take necessary measures.

PHE's NABL-accredited water testing laboratory is responsible for carrying out water quality tests for the water supply system. The department needs to set up a portal where these results are published in a way that is understandable by the public. Since the water quality is already being tested, setting up a portal for publishing these results will not be cost-intensive and can be achieved in a short time frame.

An example of such a system in the country exists in Maharashtra, where water quality data is regularly updated for each district along with a Water Quality Index (WQI) that ensures the information about the water resource is promptly communicated to the public. An example closer to home is the Water Quality Management Information System (WQMIS) that publishes water quality status for Jal Jeevan Mission supply in rural areas.

Subsidy for Water Filtration Units

Due to the less-than-ideal status of the groundwater resources, there is a possibility of seeing a spike in water-borne diseases and even cancer cases. Leh has already been seeing a rise in such cases over the years. In order to aid with adding a barrier to exposure to contaminants, subsidies can be introduced helping households that want to install water filtration systems. The PHE can identify retailers for appropriate Reverse Osmosis (RO) or filtration systems with activated carbon and design a subsidy program. This is a medium-cost intervention and can be achieved in the short term, while the long-term solution of a centralised water treatment and distribution system is functional.

Documentation & reporting of sewage management

Sanitation workers, due to the nature of their work, are frequently in the vicinity of raw wastewater carrying pathogens and chemical contaminants. This is a serious hazard as lack of appropriate protection for the workers can lead to severe health issues. While the workers are already mandated to wear 44-piece PPE kits, additional supervision is necessary to ensure the protocol is complied with. Introducing the requirement of GPS-tagged timestamped photos of the workers wearing PPE kit before each cleaning will add additional guardrails ensuring safe sanitation practices. According to the AMRUT sanitation manual, wastewater cleaning practices without appropriate protection amount to illegality.

System-Related Hazards and Improvements

Groundwater Level Monitoring System

In a system with a high level of reliance on groundwater resources, the ability to monitor groundwater is indispensable. Without the knowledge of groundwater levels in the region, consumption and extraction, both private and public, cannot be regulated, which could lead to an unexpected 'zero day' for Leh.

There are several methods for monitoring groundwater levels, out of which the most appropriate would be the installation of observation wells at key locations with water-suspended piezometers connected to a telemetry system feeding regular data to PHE. With this infrastructure in place PHE can closely monitor the impact their extraction is having on groundwater resources and take timely actions when required. PHE should be responsible for carrying out this action at a moderate cost to its budget. Financial spending could be optimised by identifying and utilising abandoned wells which can be used for this purpose.

A cloud-based SCADA system installed in the municipality of Cape Cod in Massachusetts, helps the management keep a close eye on the water table in the storm-prone region where such instances can redraw the coastline in hours, putting additional stress on the water supply infrastructure.

Periodic Water Auditing

Leakages and illegal water extraction put an extra burden on the water supply infrastructure in Leh. While there are periodic raids for confiscating illegal pumps extracting from the public water supply, currently there are no checks for invisible leakages in the system. This leads to high amounts of non-revenue water which can quickly drain PHE budget and also disproportionally increase the price consumers pay for their water supply. An independent water audit showed that 0.644 MLD is lost to leakages in the system. Therefore, it is necessary to develop a protocol for conducting annual water audits which can point out areas of high leakages in the system. Another step could also be the installation of bulk flow meters at key points in the system in order to keep a constant check on the water supply system. PHE will be the responsible authority for carrying out this operation regularly and to make the results publicly available.

SCADA & Telemetry System

Besides structural issues facing the water supply and sanitation infrastructure, management processes are a significant source of hazards and inefficiencies in the system. As the overall system expands, it only increases failure points throughout the system. Therefore, SCADA and telemetry control systems need to be implemented in the system so that the operations can be controlled using real-time data. The operations for the water supply can be automated in order to deliver a consistent supply.

Groundwater level sensing piezometers in observation wells need to be connected to telemetry for centralising groundwater monitoring. Water meters installed at the pumping station transmit data about the water extracted for supply. Water level meters should be installed at key points in the rising mains and the distribution network in order to set baseline water flow characteristics that will be useful for identifying leakages and stresses in the system. Water meters and level meters should be installed in the SRs in order to record the water supplied and to prevent overflows.

The sensor network connects to a centralised control system that operates automatic valves and starter boxes to control the inflow and outflow of water throughout the network. The system is to be programmed to perform the functions according to the SCADA system monitored by engineers at a centralised control point, in order to be able to override operations as need arise.

The sewerage network is also to be fitted with flow meters at strategic points to monitor the inflow of sewage and identify any obstructions or leakages in the system.

Improvement Plan for the Water Supply System

Hazardous Event Number	Need for New Control Measures			Description of Improvement				
	Yes	No	Required Action	Details on What Needs to be Done	Responsible Agency	Implementation Due Date	Resources	Implementation Status
W1	x		Tubewell operator present during operating hours; repair mechanics on standby.	Availability of spare motors and motor parts on site	PHE	2024	PHE O&M budget	In progress
W3		x		Separate electricity line for tubewells	PWD, PHE	2025	PWD and PHE budget, long term	
W6, W7	x		GW level monitoring systems	Fill in	PHE		PHE, budget-intensive	Not started
W11	x		Periodic water auditing plan	Installation of strategically placed ultrasonic water flow sensors.	PHE	2026	PHE	In progress
W12		x		1. Provide continuous supply to maintain the pressure within a range. 2. Implementation of automated systems/software for real-time monitoring of pipe bursts.	PHE		Resource intensive	Not started

W13		x	Consistent pressure and continuous flow through the pipes	Keep all mains buried to design depths or provide secure insulation for over-ground pipes and recovering of pipes exposed due to erosion.	PHE		Operational budget of PHE	In progress
W20		x	Regular maintenance schedule for tankers	Trucks on standby	PHE	2025	Operational budget of PHE	In progress
W21, W22	x		Regular inspections by PHE engineers	1. Use of more robust and waterproof building materials. 2. Regular O&M schedule. 3. Develop an asset renovation or replacement timeline	PHE	2025		In progress

Improvement Plan for the Sanitation System

Hazardous Event Number	Need for New Control Measures			Description of Improvement				
	Yes	No	Required Action	Details on What Needs to be Done	Responsible Agency	Implementation Due Date	Resources	Implementation Status
S5	x		Expansion of the sewerage network to connect with more households	The solution to the ongoing groundwater contamination is to wean households off soak pits which is not feasible for existing households, therefore connection to the sewerage system ensures the population is no longer reliant on soak pits for their sanitation needs.	PHE, Igoo Phey	NA	Resource intensive, Long term	In progress
			Implementation of regular groundwater quality testing and public reporting infrastructure	Making the public aware of the groundwater conditions will ensure that the consumers can take necessary steps to protect their health While the regular quality testing regime is already in place, there is a need for public reporting infrastructure.	PHE	2025	Low resources needed, Short term	In progress
		X	Water filtration systems for households	Programme for subsidizing water filtration systems for households Water filtration at the consumer level will decrease risk of exposure to pathogens	MCL	2025	Medium resources, Short term	Not started
	x		Inclusion for plans of standardised septic tank mandatory for issuance of building permission	Consumers planning new buildings need to provide plans for how the septic tank will be built in order to attain building permits	MCL	2026	Low resources, Medium term	Not started
S17		X	Technology upgradation	Introduction of technological solutions like solid waste agitators to make it easier for the vacuum truck to suck out the solid waste fraction from the FLT	MCL	2025	Low resources, Short term	Not started

S15	x		44-part PPE kit as recommended by *CPHEEO* should be worn in case manual cleaning is absolutely necessary Safety checklist before initiating manual cleaning	Mandatory timestamped, GPS documentation of workers wearing PPE kit for every case of manual cleaning	Iggo Phey	2025	Low resources, Short term	Not started
		X		Procurement of mechanical sewer cleaning machinery	Iggo Phey	2024	Medium resources, Short term	Finished
	x		Life insurance for workers covering at least ₹ 10 lakhs, premium paid by the MCL or private operator		Iggo Phey	2025	Low resources, Short term	Not started
S11	x		Regular O&M of the sewerage pipes	Improvement and upgradation of the existing sewerage network to reinforce key areas and make the system more streamlined and resilient	PHE	2027	High resource, Long term	In progress
	x		Technology upgradation for identifying pain points in the sewer system	Sewer level sensors connected via GSM installed at key points	PHE	2027	Medium resources, Short term	Not started

Control Measures and Verification

A recurring theme in the water supply and sanitation system in Leh has been the lack of proper maintenance and preventative oversight of the system components. The organisational stakeholders employ a reactive rather than a proactive approach. For example, the submersible pumps in the Indus tubewell system do not have a maintenance schedule, and the current approach is to wait for the pumps to break down, which occurs about once every week before they are replaced.

Furthermore, hazard identification also highlights the lack of existing control measures in the system. Therefore, Module 6 focuses on establishing control measures and operations and management methods for key components of the system. Standard maintenance methods recommended in CPHEEO were referred for this in order to keep the recommendations in regulatory compliance.

New Control Measures for Water Supply System

What	Process Step	Frequency	Who	Limit Values or Target Condition	Method	Corrective Action
E. coli levels in the supply water	ET , EPB, EIT, STSR	Weekly	PHE water test labs	None acceptable	Membrane Filtration Technology (MFT)	Installation of Auto Chlorinators
Residual chlorine levels			PHE water test labs	1 mg/L	(IS 3025 (Part 26)	Inform the public Initiating repair works
Heavy metals	ET , EPB, EIT	Weekly	PHE water test labs	Cadmium mg/L: **0.003**	(IS 3025 (Part 41)	
				Lead mg/L: **0.01**	(IS 3025 (Part 47)	
				Total chromium mg/L: **0.05**	(IS 3025 (Part 52)	
Structural integrity of SR	STSR	Half-yearly	PHE engineers	Fully sealed to outside environment	Visual inspection	
Water table levels	ET , EPB, EIT	Monthly	PHE engineers	25% specific capacity of well	Piezometric measurement	1. Inform the public 2. Initiate well rehabilitation measures

New Control Measures for Sanitation System

What	Process Step	Frequency	Who	Limit Values or Target Condition	Method	Corrective Action
Dissolved oxygen in inflow sewage	PCS	Daily	STP operator	1.2 mg/L	Dissolved oxygen meter	Aeration
No. of blockages	TSS	Monthly	Igoo Phey engineers	<10 blockages/ month	Record keeping	Sewerage network inspection
Solid waste in inflow sewage	PCS	Daily	STP operator	>10%	Grit chamber inspection	Cleaning of buffer tanks

The maintenance protocol for the TW submersible pump includes taking out the pump for inspection or overhauling at least twice a year during periods of low water demand. Operators should also regularly inspect for abnormal noises coming from the pumps, since there are no visual checks possible for submersible systems. The operations protocol includes keeping a record of when water supply from the pump starts and when it stops, in order to be able to maintain a water supply curve for the system.

Service reservoirs are the most crucial component of the water supply in Leh. However, in the case of many SRs, the conditions are less than ideal, and it was found that no maintenance or inspection schedule exists for SRs. Water quality tests in the system are carried out at the SR level, and it was found that 2-3 SRs around Leh were contaminated with E. coli. The source could not be determined but was likely either the tubewell or external contamination due to the lack of a seal against the outside environment.

The maintenance protocol includes deep cleaning the SR at least once a year, clearing out any sediment buildup, and then disinfecting the inner surfaces. The operations protocol includes keeping records of SR filling and the supply of water from it.

The sewerage network is the most important part of the sanitation system and the step where most hazards occur or have the potential to occur. It is recommended that the sewerage network is visually surveyed at key points annually using the simple light and mirror technique. Comprehensive flow rate measurements should also be conducted throughout the system in order to ensure it is functioning as intended and to identify areas where blockages might be present, reducing efficiency.

Storage of sewage in underground FLTs forms a sizable percentage of households in Leh. These should be cleaned every five years, rather than only when the tanks are full.

Operations and Management for Water Supply System

Process Step	Operational and Maintenance Task	Step-by-Step Instructions	Who?	When?
DT: Distribution of water through tankers	Water tanker deep cleaning	1. Flush out all the water from the tanker. 2. Clean the tanker manually using drinking water safe cleaning solutions. 3. Disinfect the reservoir by applying an approved disinfectant solution, such as chlorine, to all interior surfaces. Allow the disinfectant to sit for the recommended contact time to ensure effective disinfection. 4. Pressure wash the tanker manually. 5. Leave for a few hours to dry off.	Water tanker operator, PHE	Once every month
	Water tanker routine cleaning	1. Flush out all the water from the tanker. 2. Pressure wash the tanker manually.	Water tanker operator, PHE	Daily, post operation
DRM, DN: Transport of water through rising mains and distribution network	Flushing of pipes to remove sediments and biofilms and improving water quality	1. Ensure all necessary equipment and tools are available, including hoses, valves, and flushing devices. 2. Isolate the section of the pipeline to be flushed from the rest of the system to prevent contamination and ensure effective flushing. 3. Close the necessary valves to prevent water from entering the section of the pipeline to be flushed. 4. Connect a flushing hose or pipe to the pipeline, directing it to a safe discharge area. 5. Open the flushing valve or hydrants to allow water to flow through the pipeline at a high velocity. 6. Continue flushing until the water runs clear, indicating that impurities and sediments have been removed. 7. Once the water runs clear, close the flushing valve and disconnect the flushing hose. 8. Reconnect the flushed section of the pipeline to the rest of the system and reopen the necessary valves to restore normal operation. 9. Record the details of the flushing process, including the duration, water quality observations, and any issues encountered.	PHE maintenance engineers	Annually

	Pipe leakage detection survey (visible leaks)	1. Gather necessary equipment such as leak detection devices, pressure gauges, and listening devices.	PHE maintenance engineers	Annually, during water audits
		2. Produce a map of the pipeline		
		3. Perform visual inspection for leakages along the pipeline.		
		4. Record the coordinates of the leakage along with severity of the leak.		
	Pipe leakage detection survey using noise correlator (invisible leaks)	1. Gather the necessary equipment, including the noise correlator, sensors (hydrophones or accelerometers), transmitters, and any required accessories.	PHE maintenance engineers	Annually, during water audits
		2. Turn off valves on the consumer side in order to increase pressure in the system.		
		3. Place sensors at two accessible points along the pipeline, typically on valves, hydrants, or other fittings.		
		4. Input the distance between the two sensors and calibrate the system according to the pipeline material and other specifications.		
		5. Activate the sensors to start recording the noise within the pipeline.		
		6. Review the correlation results displayed on the correlator unit, which typically include a graphical representation of the noise correlation and the calculated leak location.		
		7. Mark the identified leak location on the ground.		
		8. Excavate the area to visually confirm the presence of the leak and assess the extent of the damage.		
		9. Record the coordinates of the leakage along with severity of the leak.		

STSR: Storage of water in Service Reservoirs	Cleaning of Service Reservoirs	1. Gather necessary equipment, including cleaning tools, disinfectants, and water testing kits. Ensure all workers are wearing personal protection equipment (PPE).	PHE maintenance engineers	Annually, Pre-monsoon and based on water quality reports
		2. Isolate the reservoir from the water supply system by closing inlet and outlet valves.		
		3. Drain the reservoir completely using the drain valve or pumps.		
		4. Conduct a thorough inspection of the reservoir's interior, including walls, floor, and roof, to identify any structural issues, sediment buildup, or contamination.		
		5. Remove any debris, sediment, and sludge from the reservoir using shovels, brushes, or vacuum equipment.		
		6. Scrub the interior surfaces of the reservoir with brushes and appropriate cleaning agents to remove biofilm, algae, and other contaminants.		
		7. Disinfect the reservoir by applying an approved disinfectant solution, such as chlorine, to all interior surfaces. Allow the disinfectant to sit for the recommended contact time to ensure effective disinfection.		
		8. Rinse the reservoir thoroughly with clean water to remove any residual disinfectant and cleaning agents.		
		9. Conduct a final inspection to ensure the reservoir is clean and free of any structural issues.		
		10. Refill the reservoir with clean water and allow it to stand for a specified period.		
		11. Collect water samples and test for residual disinfectant levels, microbial contamination, and other water quality parameters to ensure the water is safe for consumption.		
		12. Once water quality tests confirm the water is safe, reconnect the reservoir to the water supply system by opening the inlet and outlet valves.		
	Water supply record keeping	1. Document SR level before filling each day.	TW/SR operator	Daily
		2. Document when the SR starts filling.		
		3. Keep track of how many hours the SR remains filled.		
		4. Document when the water supply starts.		
		5. Keep track of how many hours water is supplied for.		

ET: Extraction of water from tubewells	TW submersible pump maintenance	1. Listen for any abnormal noise or vibrations that might indicate mechanical issues. 2. Verify that the power supply voltage and current are within the manufacturer's specifications. 3. Remove the motor from the water and inspect for signs of wear. 4. Overhaul the motor if needed or according to the manufacturer's specifications.	PHE maintenance engineers	Half-yearly, low consumption period
	Water extraction record keeping	1. Document when the motor starts pumping water. 2. Keep track of how many hours the motor runs for. 3. Document when the motor stops pumping water. 4. Keep track of how many hours the motor was running that day.	TW operator	Daily

Operations and Management for Sanitation System

Process Step	Operational and Maintenance Task	Step-by-Step Instructions	Who?	When?
TSS: Sewerage system delivering wastewater to treatment plant STP	Inspection through mirror and light method	1. Locate two successive manholes 2. Vent for about an hour for proper ventilation. 3. Lower a long hand-held mirror secured at a 45-degree angle to the handle into the bottom of one manhole. 4. Focus a torchlight on the mirror from above so that the light beam is deflected by 90 degrees to travel horizontally through the sewer pipe. 5. Observe the light in the opposite manhole to determine whether the bore of the pipe is choked, clear, or laid straight. 6. Document the location of the inspection and file any identified leaks for further action.	Igoo Phey maintenance engineers	Annually
	Flow meter survey	1. Open the selected manhole and let it ventilate. 2. Calibrate the flow meter before inserting the flow meter inside. 3. Attach the sensor to the wading rod and lower it into the flow. 4. Record the flow rate and location of the manhole.	Igoo Phey maintenance engineers	Annually

SST: Containment/ storage of Faecal sludge.	Cleaning of FLT	1. Park the vacuum truck as close to the fully lined tank as possible. In case, the length and elevation exceeds the specified, intermediate pumping may be required.	Vacuum truck operators	Once the FLT is full or every 5 years (whichever comes before
		2. Break the mortar seal of the fully lined tank lid. Inspect the tank for cracks or damage before and after the emptying of the tank.		
		3. Engage the vacuum equipment and lower the end of the hose into the fully lined tank, and open the valve sufficiently such that the faecal sludge is drawn out of the tank or pit.		
		4. Break up faecal sludge that has agglomerated into a solid mass using a long handle shovel.		
		5. Drive the truck back to the FSTP.		
		6. Workers should change out of the clothes worn during cleaning before returning home.		

Supporting Programs

Water supply and sanitation systems are the supporting structures of the most basic of human functions and needs. Therefore, it is crucial to develop supporting programs that ensure the long-term sustainability and resilience of these systems. While these programs might not be directly connected to the drinking water supply or sanitation needs, they play a crucial role in the smooth functioning of the overall system.

To ensure the effectiveness of these systems, it is essential to invest in community education and awareness programs that promote responsible water usage and sanitation practices. Engaging local stakeholders and residents can foster a sense of ownership and accountability. Ensuring operational data is meticulously collected on a regular basis and made it available to the public through online portals will future-proof the system and establish transparency and trust amongst the consumers. Additionally, training programs for maintenance personnel should be established to enhance their skills in managing and repairing the infrastructure.

Furthermore, it is crucial to invest in infrastructure that can aid in making the system environmentally and financially sustainable. Water resources that the system relies on need to be closely monitored for exploitation and perturbations due to climate change. Financial sustainability at the water supply and sanitation level is also important to ensure the adequate funds for development and maintenance are readily available. Therefore, extraction of groundwater resources and the public water supply should be strictly monitored and tariffed to enforce judicious usage. Life cycle assessment of the system should be analysed on a regular basis so that the externalities of the service are also captured.

Training program for O&M Personnels

The training program for operations and maintenance personnel should encompass both theoretical knowledge and practical skills. This includes hands-on training in routine maintenance, troubleshooting techniques, and emergency response procedures. Workshops on the latest technologies and best practices in water management should also be incorporated. Regular assessments should be conducted to evaluate the effectiveness of the training and identify areas for improvement. Additionally, fostering a culture of continuous learning will empower personnel to adapt to new challenges and enhance system resilience. Finally, external audits of the operations and management practices will ensure accountability and transparency of the operations.

Awareness Programs for Ensuring Safe Drinking Water and Sanitation Practices

Ensuring that consumers understand how to effectively utilize the services provided is vital for the overall functionality of the infrastructure. This can be achieved through targeted outreach initiatives that educate the community about the importance of maintaining their water and sanitation systems. Additionally, regular feedback mechanisms should be established to gather input from residents, allowing for continuous improvement of services. By fostering a collaborative environment, stakeholders can work together to enhance the resilience and sustainability of water supply and sanitation systems in Leh.

Water and Sanitation Services Portal

Under the National Urban Digital Mission (NUDM), urban bodies in India have access to support and technology to digitise their services in service of citizens to come up with solutions to urban issues at scale and speed. The management bodies can harness this platform to create a portal for water and sanitation related services. This would include applications and forms for water and sewerage connections, database for publishing water quality reports, and a grievance redressal system. The platform could also carry teaching and learning materials in order to aid citizen led awareness programs.

Monitoring Usage and Tariff Structures

In order to steer consumers towards a water conservation mindset, pricing the water and sewage services is an essential tool that benefits both the consumers and service providers. Introduction of a usage monitoring and tariff model is in the long-term interest of the overall system, as it will also ensure financial sustainability for the water suppliers.

The PHE could enforce the unmetered water supply fees that could be capped at 3% of the average per capita household income. As the installation of water meters permeates through the system and management capacities are increased, there can be a gradual shift to metered water tariff, albeit alongside a package of tariff support measures in order to ensure equitable access to water supply. Furthermore, deficits in the revenue to the department could also be recovered by applying a water tax on tourist inflow as the demand from the sector on the water supply and sanitation services is only on an increasing trend.

Finally, there should also be strict enforcement of tariff on private extraction, recently introduced to ensure the common groundwater resources are not overexploited. The tariff model can begin similar to the public supply tariff model, with unmetered billing in the start, with gradual conversion to metered billing of water extraction.

Life Cycle Assessment of the System

Life cycle assessment documents and analyses the environmental impact of products and processes throughout the life cycle. Life cycle assessment for the infrastructure and operations of the water supply and sanitation system can inform the management about the areas in the system or life cycle that are causing the greatest number of adverse effects on the environment. It also aids decision-making process in thinking of a more sustainable solutions based on robust and holistic data. It ensures that the externalities of providing these services are accounted for and the potential impacts on local ecosystems are minimized.

By regularly conducting life cycle assessments, stakeholders can identify areas for improvement, implement best practices, and prioritize investments in sustainable technologies. This proactive approach not only enhances the efficiency of water supply and sanitation systems but also promotes environmental stewardship.

Conclusion

The Integrated Water and Sanitation Safety Plan (iWSSP) for Leh highlights critical health hazards associated with the region's water and sanitation systems. The interdependencies between these systems mean that failures in one can have severe consequences for public health. Contaminated water sources, inadequate wastewater management, and insufficient sanitation facilities pose significant risks, particularly in light of projected climate change impacts, which could further strain these essential services.

Through systematic hazard identification, stakeholder consultations, and field assessments, this report has identified key risks such as microbial contamination in water sources, poor wastewater disposal practices, and the spread of waterborne diseases due to inadequate treatment. Rising temperatures and shifting precipitation patterns are expected to exacerbate these issues, leading to increased incidences of gastrointestinal illnesses, vector-borne diseases, and antimicrobial resistance from contaminated water sources.

The key health-related findings of this report emphasize the need for:

- Strengthening water quality monitoring to detect contaminants and prevent disease outbreaks.
- Enhancing wastewater treatment and sanitation infrastructure to minimize exposure to harmful pathogens.
- Implementing climate-adaptive water management strategies to prevent shortages that could lead to compromised hygiene and sanitation conditions.
- Improving community awareness and stakeholder engagement to ensure safe hygiene practices and disease prevention.

By addressing these risks through the recommendations outlined in this report, Leh can safeguard public health and prevent future outbreaks of waterborne diseases. The success of iWSSP will depend on continuous monitoring, timely interventions, and strong collaboration among government agencies, local communities, and health professionals. A proactive approach to water and sanitation safety will not only enhance public health but also create a more resilient and sustainable environment for Leh's growing population.

NOTES

Integrated Water *and* Sanitation Safety Plan

Leh Town

2025

german cooperation
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