Water Safety Plan

Leh, UT Ladakh

LEDeG

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Executive Summary

Leh is beautiful and the objective of this document "Towards a Leh Water Safety Plan (WSP) is to keep it that way for many generations to come.

Since the early 1980's, Leh has seen a surge in the growth of tourism industry: huge increase in numbers of visitors, and in parallel opening of hotels and guesthouses. This has introduced to Leh previously unknown trend of water consumption: flush toilets and showers have become increasingly popular in tourist residences in order to push up guest room prices. As a result, Leh has aimed to supply far more water than before, a huge amount of private borewells have cropped up, and resulting huge amounts of wastewater. Leh has been grappling with water supply and wastewater management challenges and urgently needs to implement a strategy to address these issues comprehensively. The aim of this document is to design such a strategy, based on a comprehensive risk assessment

To achieve this, this document in its structure follows the commonly known Water Safety Plan methodology by the World Health Organization (WHO) to provide a basis for the formulation of such a plan, as the detailed content must be developed in a dialogue with all relevant stakeholders and actors. Further, the methodology is taken several steps further: Water Safety Plans usually address "only" water supply. This document however takes the stand that water supply is inextricably linked to the entire water cycle of a given locality, that is encompasses the catchment area and other aspects of the water system such as water availability also under climate change, wastewater management and water reclamation and reuse potentials, as well as climate change mitigation and adaptation opportunities. With this, the document aims to form the basis for the development of a ***Leh Water Security Plan,*** *and thereby support implementation of the* ***Jal Jeevan Mission.***

Hence, this study undertook a description of Leh and its water system, a comprehensive risk assessment using interview and questionnaire surveys of experts and PHE officials, suggested control measures to address key risks, as well as accompanying monitoring and validation strategies. Soak pits and water availability due to climate change and consumption by tourists are highlighted as key issues needing to be urgently addressed. Finally, this Towards a Leh Water Safety Plan document proposes an 11-point action plan and shows how this is embedded in the Leh Vision.

This "Towards a Leh Water Safety Plan" document is a basis or template for the creation of the Leh Water Security Plan. All relevant actors and stakeholders need to be directly involved in a participatory process and dialogue to identify existing and needed control measures and how to operationalize these. Also, the developed Leh Water Security Plan will be a live document, to be updated continuously, which will evolve over time and be a very valuable tool supporting sustainable development in Leh.

Abbreviations

ALTOA All Ladakh Tourist Operators Association
BORDA The Bremen Overseas Research and Development Association
CDD Consortium for DEWATS Dissemination Society
CMO Chief Medical Officer
CPHEEO Central Public Health & Environmental Engineering Organisation
DMA Decentralized Measuring Area
DPR Detailed Project Report
FHTC Functional Household Tap Connection
GDP Gross Domestic Product
IPCC The Intergovernmental Panel on Climate Change
JNNURM JawaharLal Nehru National Urban Renewal Mission
LAHDC The Ladakh Autonomus Hill Development Council (LEH)
LEDeG Ladakh Ecological Development Group
LPCD Liter per Capita per Day
MCL Municipal Committee of (LEH)
MLD Million of Liter per Day
NABL National Accreditation Board for Testing and Calibration Laboratories
NAC Notified Area Committee
PHE Public Health and Engineering Department (Leh)
PPP Public Private Partnership
PSP Public Standposts
PWD Public Work Department
PWS Piped Water Supply
RVWRMP Rural Village Water Resource Management Project
RWSSP-WN Rural Water Supply and Sanitation Project –Western Nepa
SCADA Supervisory Control and Data Acquisition
SOP Standard operating procedure
SR Service Reservoirs
TW Tube Wells
UIDSSMT Urban Infrastructure Development Scheme for Small and Medium Towns
UN United Nations
WHO World Health Organization
WSP Water Safety Plan
WSR Water Status Report

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CHAPTER 1
Introduction to Leh Water Safety Plan

Introduction to Leh Water Safety Plan

Water Safety Plan or WSP is one of the most common and widely used tools for ensuring drinking water safety - both in terms of quality and quantity. WHO Guidelines describe WSP as a health based water quality target, made on an evaluation of health concerns. According to the World Health Organisation, about 785 million people lacked access to basic drinking-water services in 2019 (WHO,2019 Drinking-water). Use of contaminated water and poor sanitation practices are also the root cause of many water-related diseases such as Cholera, Diarrhoea, Typhoid, Hepatitis A, etc. especially in the developing world.

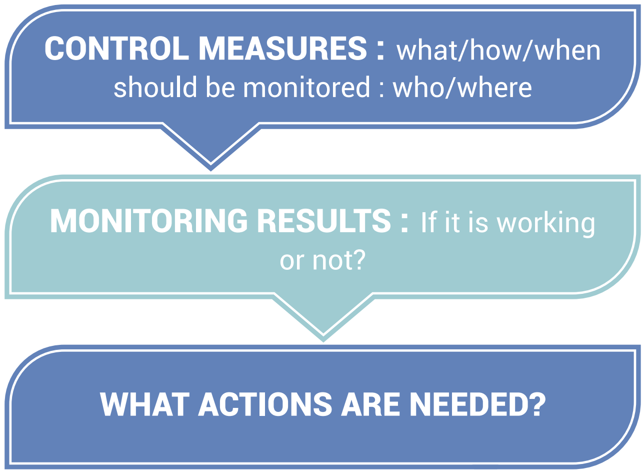
Why WSP : At its core, WSP is a Risk Assessment document that aims to identify all potential risks and hazards to the water supply system, both in terms of quantity and quality, from source to the end user, in order to establish appropriate Control Measures to tackle the identified risks. The advantage of following a Water Safety Plan is that they can be applied to all types and sizes of water supply systems. As such it can help mitigate risks that haven't been addressed before or even identified yet. These mitigation steps could be short-term, medium-term or long-term. A WSP is not intended to be just a document but rather a practical and dynamic operating procedure for ensuring good and enough drinking water quality. As part of the methodology, guidelines and procedures are developed which provide tools for future learning and upgrading. Today, more than 93 countries around the world have implemented WSPs to ensure quality and quantity of drinking water supply.

The WSP modules as recommended by the World Health Organization

The WSP methodology includes the description of the water supply system, the identification of risks that threaten the safety of the drinking water and the management and implementation of improvement measures, creating good practice guidelines and standard operating procedures (SOPs) in the process.

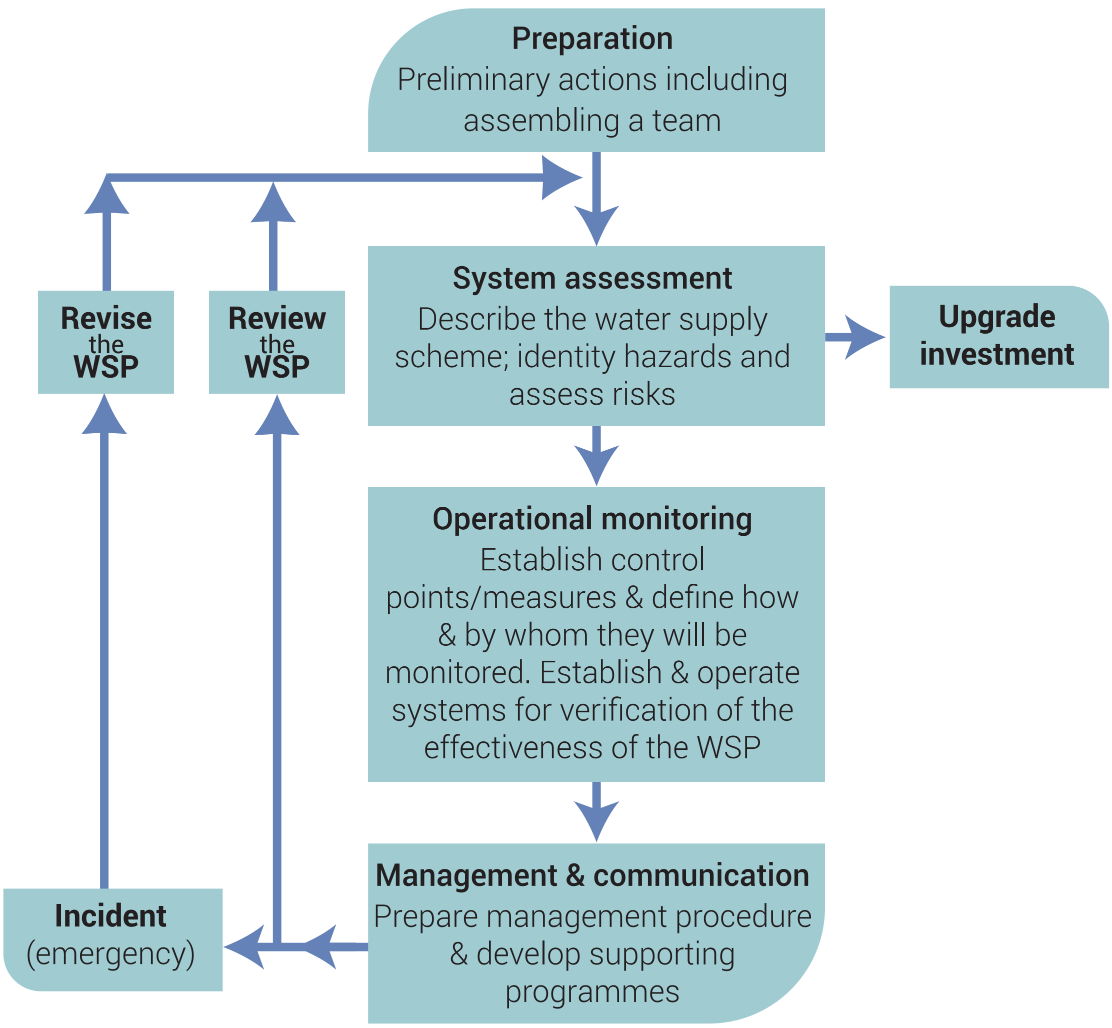
For this purpose, the WHO (WHO, 2009) has developed a series of cyclical modules to guide the WSP formulation for any city, region or country. They are the following:

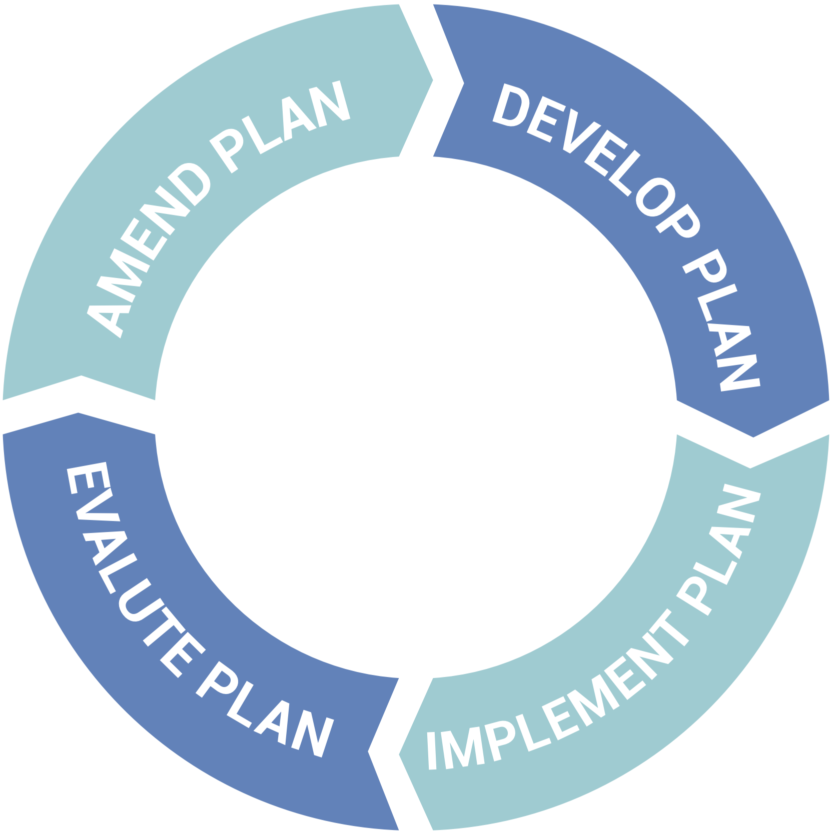
Module 1	Assemble	Preparation
Module 2	Describe the water supply system	System Assessment
Module 3	Identify hazards & hazardous events & assess the risks	System Assessment
Module 4	Determine & validate control measure, reassess & prioritize the risks	System Assessment
Module 5	Develop, impleament & maintain an improvement/upgrade plan	System Assessment
Module 6	Define monitoring of the control measures	Monitoring
Module 7	Verify the effectiveness of the WSP	Monitoring
Module 8	Prepare management procedures	Management & Communication
Module 9	Develop supporting programes	Management & Communication
Module 10	Plan & carry out periodic of the WSP	Feedback Improvement
Module 11	Revice the WSP following incident	Feedback Improvement



Following an incident, the WSP team determines its cause, its sufficiency of response, reviews WSP and updates the supporting program. The documentation about the incident must be comprehensive and transparent. As the introduction of new controls can expose the system to new risks, these should be documented and addressed, if the risk assessment indicates it.

For example: WSPs around the world should be updated following the COVID-19 pandemic based on how it affected the water supply system so that we are better prepared to face the next situation.



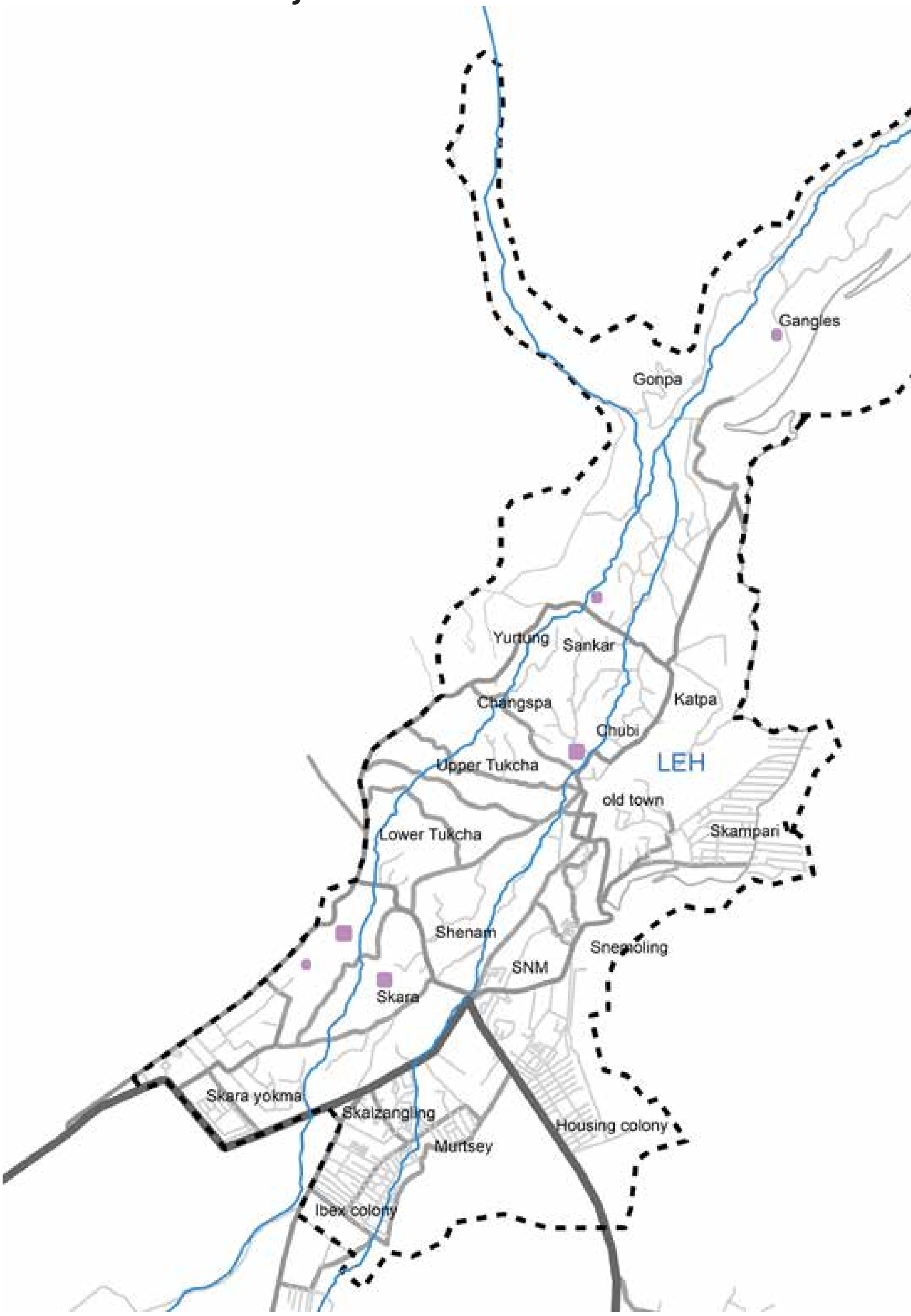


Therefore, this document aims to be the basis for development of a WSP. However, historically, WSPs have aimed to describe and optimize the running of the water supply system of a given locality. In Leh, we recognize and highlight the importance of planning water integrally as a complete loop: water consumption, concomitant wastewater production and in turn procurement of freshwater and guarding its quality and quantity need necessarily be closely interlinked if we are to consider urban localities as increasingly closed loop systems in our striving for a more circular economy in order to address climate change mitigation and adaptation. These interlinkages cannot be more obvious in a given town than in Leh, where water resources are limited and daily life and economy depend so much on its sustainable and equitable procurement and distribution.

Hence this Towards WSP document aims to go a step beyond the classical WSP methodology to address the whole system, thereby creating a holistic basis for Leh's future development pathway in terms of water. It incorporates the wider spectrum of a Water Security Plan which is currently being pushed under the Jal Jeevan Mission.

This is the reason why this document is structured in this manner.

1. **Introduction to WSP**
2. **Description of Leh study area**
3. **Our Objectives**
4. **Description of WATER system in Leh**
5. **Risk assessment and control measures**
6. **Control measures validation and**
7. **Vision of a Way Forward**



LEH TOWN

SHORT CASE STUDIES:
BHUTAN:

Almost 70% of Bhutan's population live in remote villages, which often complicates the efficiency of work of the Government in providing villagers with clean drinking water. Water Borne diseases such as diarrhoea still maintains its position as one of the top ten fatal diseases in the country. (WHO, 2015)

The officials from Bhutan have been working closely with the WHO to implement Water Safety Plan(s) since 2005. The country is blessed with many glacial melt rivers and lakes and some of them are considered 'Holy' and are therefore left untouched.

The emphasis was very much on decentralisation, shifting responsibility for water safety to communities to inculcate a sense of ownership and shared responsibility.

Drinking water safety for approximately 100,000 people has been improved since the application of WSP. (WHO, 2015)

SHORT CASE STUDIES:
MONGOLIA:

In Mongolia certain regions, especially that of the Gobi desert is almost completely dependent (80%) on underground water but the quality of water is sub standard due to high mineralisation. (WHO, 2018) The WHO Partnership on Water Quality, established in 2012, aims to promote water safety plans (WSPs) as an increasingly recognized cost-effective, management-oriented, preventive approach to drinking-water safety. Each province has established their own Water Safety Plan Team and technical assistance has been provided by national consultants in collaboration with WHO.

SHORT CASE STUDIES:
NEPAL:

WSP has been systematically applied in Nepal since 2008. On 25 April 2015, an earthquake of magnitude 7.8 hit central Nepal. Over 5 million people living in 31 districts were affected. 7,741 water supply schemes and approximately 388,000 sanitation facilities succumbed to the damages caused by the earthquake. (National Planning Commission, 2015)

The disaster revealed long-standing weaknesses in water and sanitation systems in the country.

Rural Water Supply and Sanitation Project- Western Nepal (RWSSP-WN), has developed a WSP Plus manual based on a six step process linking improvement works with O&M and climate factors in the hazard analysis process. Rural Village Water Resource Management Project (RVWRMP) has incorporated WSP concepts in the project cycle (Preparation, implementation and O&M) of project development. Water supply projects are constructed as safe water systems and maintained in view of the water safety plan.

CHAPTER 2
Description of the Study Area

In the context of rapid urbanisation and socioeconomic transformation such as growing of the urban population, a booming tourism industry and rising standards of living, an increased water consumption/wastewater production and changing relationships between traditional and modern water use patterns can be observed.

(Gondhalekar et al., 2013a; Schwaller, 2018)

Nestled in the high ranges of the Himalayas, at an altitude above 3500m (11'562 ft), the erstwhile Ladakh district was the second largest in the country in terms of area (45110 Sq.Km) behind only the Rann of Kachchh, Gujarat. In October 2019, Ladakh was officially declared as an independent Union Territory of India, separating it from the state of Jammu and Kashmir. The region is sparsely populated due to its mountainous terrain, semi-arid climatic conditions and is often referred to as a 'cold desert.' There are no monsoons as the valley is in the rain shadow region between the Karakoram and upper Himalayas and barely receives rainfall of 60-100mm per annum. Precipitation takes place mostly in the form of snowfall during winters.

Leh is the largest town in UT Ladakh and is rapidly urbanising thanks to a booming tourism industry. According to All Ladakh Tour Operators Association (ALTOA) President Mr. Tsetan Angchuk, tourism contributes more than 50% to the local GDP of Leh-Ladakh and as such is the most important economic driver in the region. With the establishment of Ladakh as a Union Territory, the new administration is now planning to promote Winter Tourism in Leh, which earlier did not have much traction. The town gets around 300,000 tourists yearly and most of them visit during the short 4-5 summer months.

This also creates massive pressure on the different infrastructure and service systems in Leh. For example, the drinking water supply system operated by the PHE was initially designed to serve potable water to the 30,000 - 40,000 residents of Leh town. So, where do the 300,000+ tourists visiting Leh get water for drinking, bathing, washing and other purposes from? It is because of this great need for water as well as the inefficiencies of the PHE system that the residents of Leh have resorted to digging private borewells. It is estimated that the town has anywhere between 1500 - 3000 private borewells. None of these are regulated by any department of the government, neither is there any concrete data on the exact number of borewells and how much water they draw daily. This has resulted in groundwater exploitation as well as pollution. A boom in tourism has led to the introduction of western toilets or flush toilets in Leh to cater to the needs of the tourists who more often than not find it difficult to use traditional Ladakhi dry toilets. However, what has not followed along with the flush toilets are wastewater management systems and practices - as such thousands of soak pits across the town are contaminating the groundwater.

Further, in order to cater to the needs of the tourism industry, there is also a yearly migration of people to Leh from all parts of the country to work as service sector employees. Construction workers, painters, plumbers, waiters, cooks, shopkeepers etc. - it is believed that more than 100,000 service sector employees come to Leh to work during the summer months. This further aggravates the pressure on the fragile environment and service systems of Leh Ladakh.
The ever-increasing presence of the Indian Army is another concern. It is estimated that the army posted in Leh draws double the amount of water daily than what the residents are served through the PHE supply line. However there is no formal data available regarding Army consumption.

A study analysing all the facts about the current water supply system geared towards understanding possible water scarcity in Leh found that *water management rather than water scarcity is the key issue to address in Leh* (Gohel et al., 2019).

Climate Change and Ladakh:

The Intergovernmental Panel on Climate Change (IPCC) in its various reports has made it clear that the effects of climate change will be especially serious in high altitude regions of the world. The special report on Oceans and Cryosphere by the IPCC clearly states that "*the Hindu Kush Himalayan* region *(which includes Ladakh), are projected to warm up by more than 2°C on average under the current 1.5°C global warming scenario. 64% of glaciers in this region will be lost by the end of this century as well.*" It must be noted however that with low international mitigation efforts and continuation of business as usual, the warming scenario is most likely to go over 1.5°C and regional temperatures will increase between 3.5° and 6°C by 2100. This will cause significant losses in glacier volume and directly impact timing of water flows and water availability. The rate of risk therefore is extremely high with present emission scenarios.

Ladakh and its people, having historically contributed almost nothing to the rise of global temperature and anthropogenic climate change, will have to bear the brunt of it and the poor section of the society will be the most vulnerable.

Being a semi-arid region, ***water is a scarce resource in Ladakh*** and clean drinking water is even more limited. Leh town currently is almost completely dependent on glacial meltwater (groundwater or surface water such as springs, streams etc.) for all its drinking water needs. Therefore, the town is already at a heightened risk of being affected by climate change related extreme events and changes in precipitation patterns. Chevuturi (2018) also describes why Leh is particularly vulnerable to the effects of climate change, as mountain cities rely entirely on the storehouse of water that the mountain glaciers provide.

"Water is the primary medium through which climate change influences Earth's ecosystems and thus the livelihood and well-being of societies." (The Pivotal Role of Water, UN Water) It is well understood by now that higher temperatures and changes in extreme weather conditions will affect availability and distribution of rainfall, snowmelt, groundwater, and river flows etc. It will also have negative implications on the quality of water. It becomes extremely crucial for a cold semi-arid town like Leh to improve its management of water resources and system as it is critical to ensure sustainable development.

Adaptation to climate change is closely linked to water as it affects almost all facades of the economy, security, food production, sanitation, energy, environment, etc. and as such if left addressed inadequately – management of water of water resources will hinder improvement on other socio-eco-environmental targets. (UN Water)

Climate Change is expected to have a range of adverse effects on populations where the water and sanitation infrastructure is inadequate to meet local needs. (IPCC)

"The amount of water available for withdrawal is a function of runoff, groundwater recharge, acquifer conditions (e.g., degree of confinement, depth, thickness and boundaries), water quality and supply infrastructure than on the quantity of runoff. However, the goal of improved safe access to drinking water will be harder to achieve in regions where runoff and/or groundwater recharge decreases as a result of climate change. In addition, climate change leads to additional costs for the water supply sector, e.g., due to changing water levels affecting water supply infrastructure, which might hamper the extension of water supply services to more people. This leads, in turn, to higher socio-economic impacts and followup costs, especially in areas where the prevalence of water stress has also increased as a result of climate change."

[IPCC, WGII 3.5.1]

CHAPTER 3
Our Objectives

Less industrially developed nations have incomplete water supply infrastructures such that even middle-income countries may have significant populations with limited access to piped drinking water supply at higher levels of service. As a result, significant proportions of their populations utilize water supplies of poor quality and reliability. Institutions responsible for both supply and oversight of water supply may be less 'mature' than elsewhere and supply of trained personnel of all types may be inadequate. As a result the efficiency of the water supply sector may be low.

(Bartram and Howard, 2003)

Ladakh is currently undergoing an administrative transitional phase. In October 2019, the region became a functional Union Territory of the country, breaking away from the erstwhile state of Jammu and Kashmir. Although this marked the beginning of a new Administrative era for the region, variations in lifestyle of the people particularly of Leh town as it becomes more urbanised, has been going on for some time now. In fact, Leh Town is considered to be one of the fastest growing small towns in the country. This change in lifestyle, income, land use pattern and modernisation is being boosted and in no small part carried by the ever-increasing Tourism Industry. However, these economic benefits come at the cost of environmental degradation and various trade-offs, some of which the local masses do not seem to be aware of on a larger scale. One such example is the issues revolving around "Potable Water or Drinking Water in Leh Town." A few decades ago, Leh was dependent almost completely (90%) on surface water such as rivers, springs and streams for all its drinking water needs but now is almost completely dependent on Underground Water (90%) (WSR 2018, BORDA).

This is further complicated by the fact that recent studies show degradation of the quality of underground water in Leh, mainly attributed to poor wastewater management practices or systems (Schwaller, 2018). In fact, waterborne diseases such as diarrhoea have already become a serious health concern. Data procured from the CMO (Chief Medical Officer) shows that over 10% of Leh's population suffers from acute diarrhoea especially in the summer months. This includes tourists who are susceptible to diarrhoea due to altitude sickness or unfamiliar bacteria. Meanwhile, the data also reveals that nearly 10% of children under the age of 5 experience diarrheal illnesses on a yearly basis (Gondhalekar et al., 2014). The control of microbial quality of drinking water should be the first priority given the existing waterborne health issues occurring in Leh (Schmoll, 2006).

This poses major health risks for the inhabitants of Leh. The current water supply system run by the Public Health and Engineering Department (PHE Leh) is also almost completely dependent on one source i.e. groundwater. However, the department lacks technical capabilities as well as systems and infrastructure required to ensure top quality drinking water supply to the town.

As a result, we currently have a system of water supply in Leh that needs immediate vision, planning and proactive action to secure potable water of good quantity and quality not only for the ***present generation but also for future ones.***

Under the Jal Jeevan Mission, the formation of Water Security Plans is stressed upon to ensure source sustainability and water availability. As such, this report goes beyond the traditional methodology of a Water Safety Plan and incorporates elements of a Water Security Plan.

A Water Safety Plan is a tool to systematically assess and manage risks; a Water Security Plan on the other hand has been defined as "the reliable availability of an acceptable quantity and quality of water for health, livelihoods and production, coupled with an acceptable level of water-related risks. It is realized to the degree that water scarcity is non-existent, or has been decreased or eliminated, and to the degree that floods and contamination of freshwater supplies are non-threatening."

Therefore, the primary objectives of this report are the following:

i) Identifying and assessing present and future risks and hazards to the current water supply network and wastewater management;

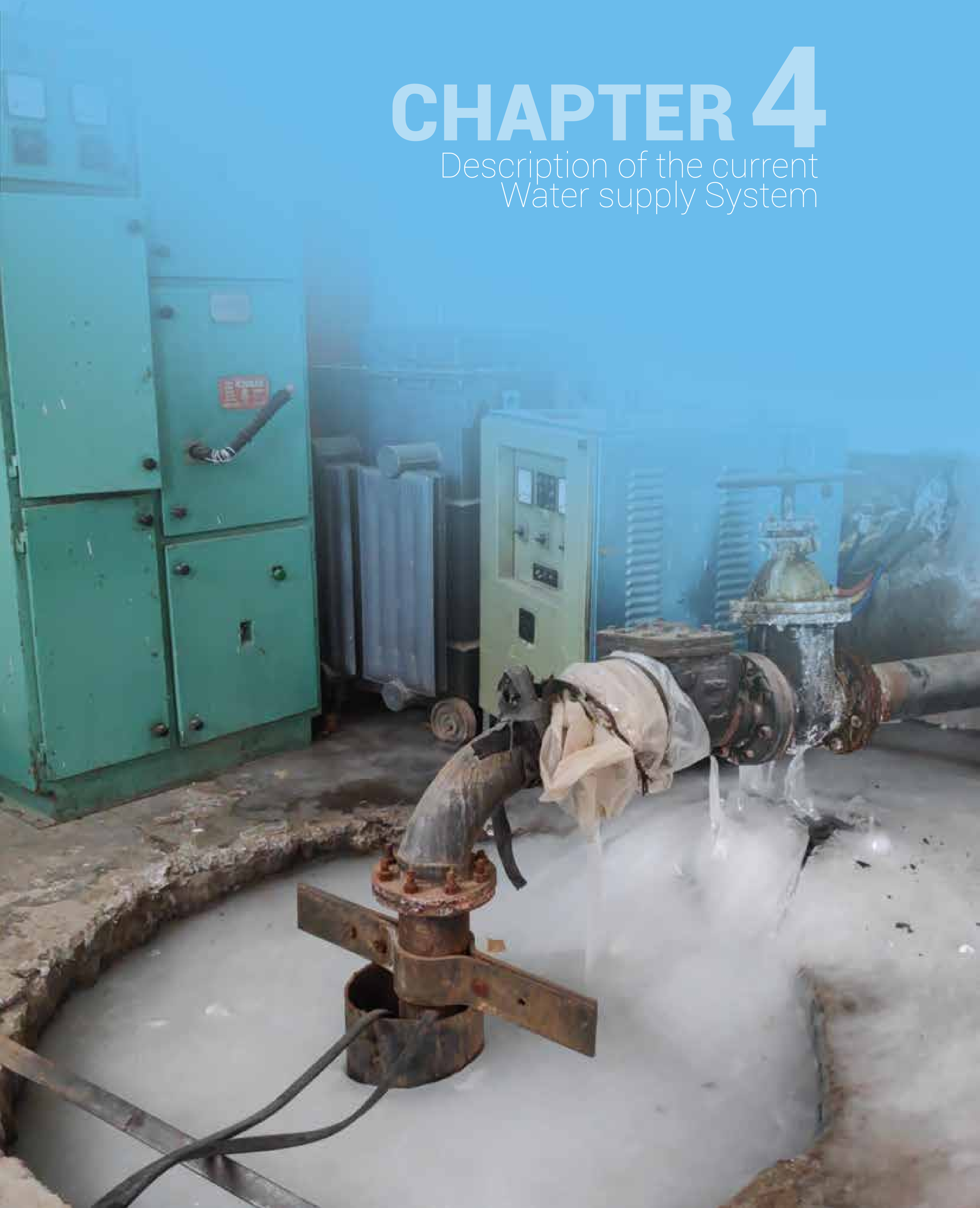
ii) Prescribing control measures to mitigate the mentioned risks and hazards;

iii) Initiate serious discussions for immediate upgradation of the current water supply and wastewater management system in the town and

iv) To initiate serious discussion and planning in order to create a safe, sustainable and secure water supply system in Leh that caters to the needs of future generations as well.

The aim of this document cannot be to prepare a completed WSP for Leh. A WSP is a document that must evolve with the active participation of those who will be involved in implementing it (Administration of UT Ladakh, PHE Department, LAHDC, Urban Local Bodies etc.) Yet this document aims to provide a blueprint for the development of such a 'Leh WSP': to give a background and risk identification, an assessment as a substantiated basis for such a development, and to offer guidance on the next steps needed to finalize and implement the Leh WSP.

CHAPTER 4
Description of the current Water supply System



This chapter aims to give a comprehensive overview of all elements relevant to Leh's water system whilst highlighting some key issues. These elements are divided into the following 3 categories:

1. Water supply
2. Wastewater management
3. Management and Institutional Aspects

4.1 Water supply

4.1.1 PHE public water supply

The most significant sources of water for people living in the Himalayan region are rivers, streams, and springs. Springs are the main source of drinking water for the majority, around 60%, of the Himalayan rural population (Gupta & Kulkarni, 2017). So similarly, most of the population of Leh town used to mostly depend upon availability of spring and stream water to meet their daily needs. Stream water was majorly consumed as drinking water and spring water was usually offered to the Gods since it was considered holy. There were very few houses which would be completely dependent upon the spring water.

With the passage of time, urbanisation and capitalisation took root among the society of Ladakh due to which the demand for clean drinking water supply skyrocketed. And hence, the department of PHE was handed the responsibility to meet people's demand for drinking water in 1984. Sources that are used by the PHE for potable water in Leh town are only spring water and groundwater.

In the event where groundwater dries out, surface water will be an important alternative. Therefore, efforts towards conserving our streams and rivers need to be initiated. Stream water flowing through Leh arrives directly from the Khardungla Glacier. Until 10-15 years ago, 90% of residents relied on these streams that are locally called Yuras (WSR, 2019). Traditionally, these streams were built such that every household could have access to freshwater from the vicinity of their house. However, recent studies indicate that 90% of domestic requirements are now fulfilled through underground sources such as tube wells operated by PHE and private borewells (WSR, 2019). Locals have reduced their dependence on stream water as over the years, the quality has deteriorated due to the immense presence of solid waste and wastewater discharged from households, restaurants, guest houses and hotels.

At present, households in the upper wards of Leh that are closer to the glaciers use stream water for their daily requirements such as drinking and irrigation. However, contamination in the upper wards has also severely reduced the quality of stream water for the lower wards of the town. Meanwhile, due to construction activities in the upper wards, migrant workers temporarily settled in make-shift camps are believed to be using stream water for meeting their needs. Excessive pollution of stream water in the upper wards has had major consequences on the residents living in the lower parts of the town. The same stream water is no longer fit for consumption. Households have limited their usage mainly to washing clothes and irrigation (WSR, 2019). At the same time, there are several incidents of Yuras being blocked due to construction, debris and roads which has reduced the supply for some households and also caused floods during the times of heavy flow.

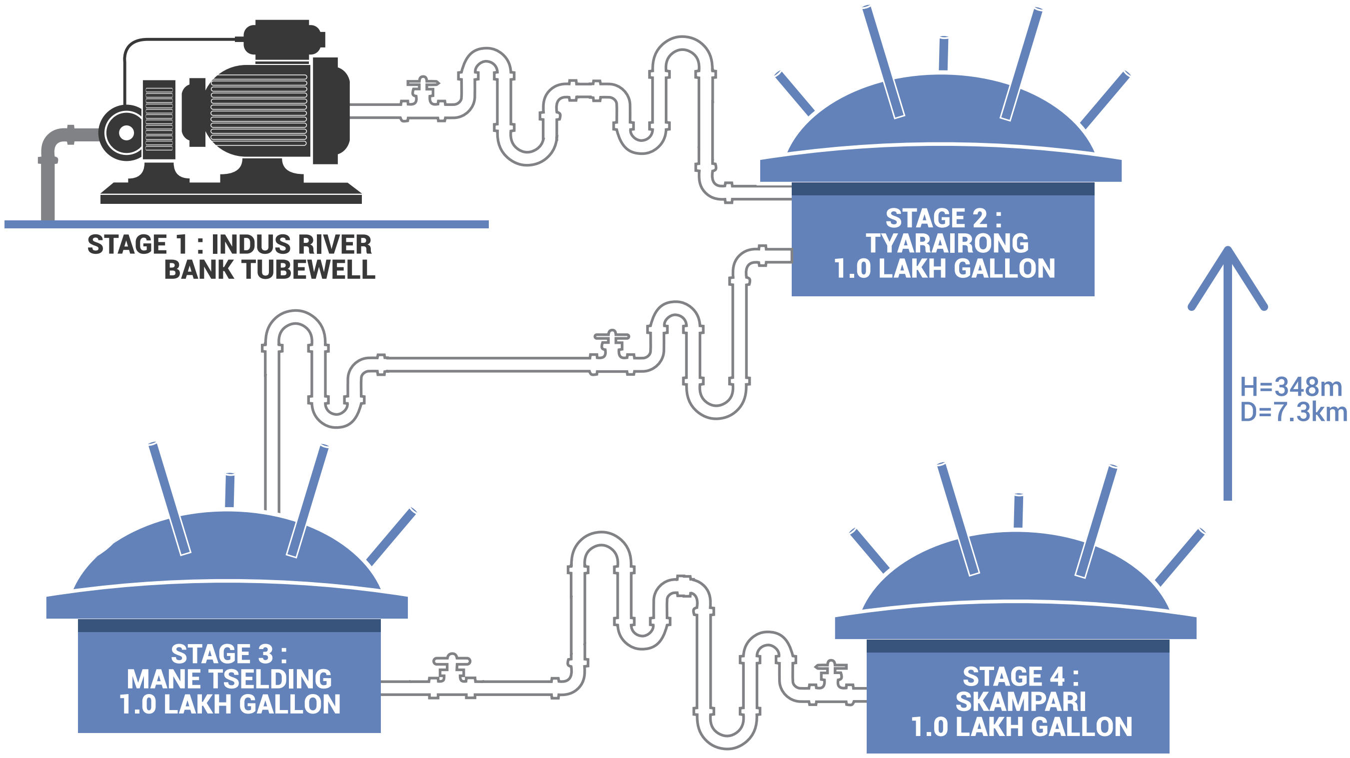
"We switched to borewells for watering our fields
because stream water is insufficient." *Resident of Sankar*

The PHE Department extracts water from three natural springs in Leh; Gyalung, Gangles and T-Trench. These springs continue to supply 10% or 0.5 MLD (WSR,2019) of the town's current water usage through service reservoirs. The quantity supplied by springs has diminished over the past few years. In fact, locals claim that several springs around Leh have dried out completely. It is believed that the increasing usage of private borewells is affecting the spring reserves. Excessive construction of borewells around the springs has disturbed its shallow aquifers. The quality of the spring water has also changed over time. Since locals no longer practice supervising the springs, multiple external factors such as contamination from animal faeces and agricultural runoff have become common and degraded the water quality. Other factors affecting spring water are natural events, e.g. recent floods have completely damaged some springs in a few wards of Leh.

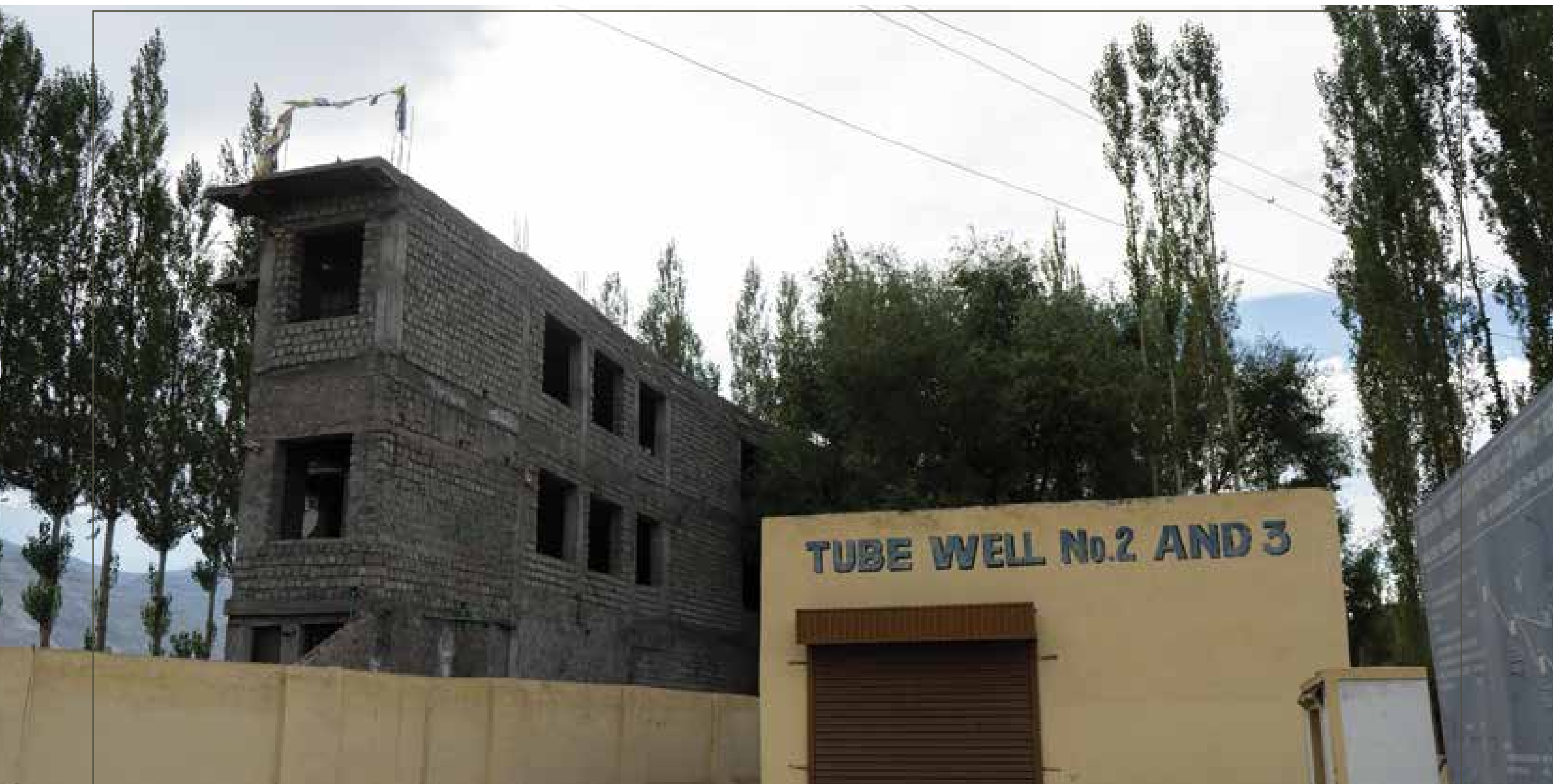
T-Trench spring/reservoir in Upper Leh

(This water is directly supplied to households in the Upper wards. The water quality tests results show this water as unfit for drinking purposes.)

In order to cope with the ever-increasing demand for water, the first tubewell was installed in 1996, and a three-stage lift scheme was introduced under which several service reservoirs were built and connecting pipelines laid. The project was completed in 2000 (Akhtar, 2010). Under the Indus Bank three-stage lift scheme, the water is extracted from the Indus River Bank tubewell with help of water pumps at Stage 1 and lifted to Stage 2, the Manali Road Lift Station (Tyararong point). Then it is further lifted to Stage 3, Mane Tselding Lift Station and from there it is pushed upwards to the final stage 4, Skampari Lift Station. From there the water gets distributed among the consumers via pipelines by gravitation.

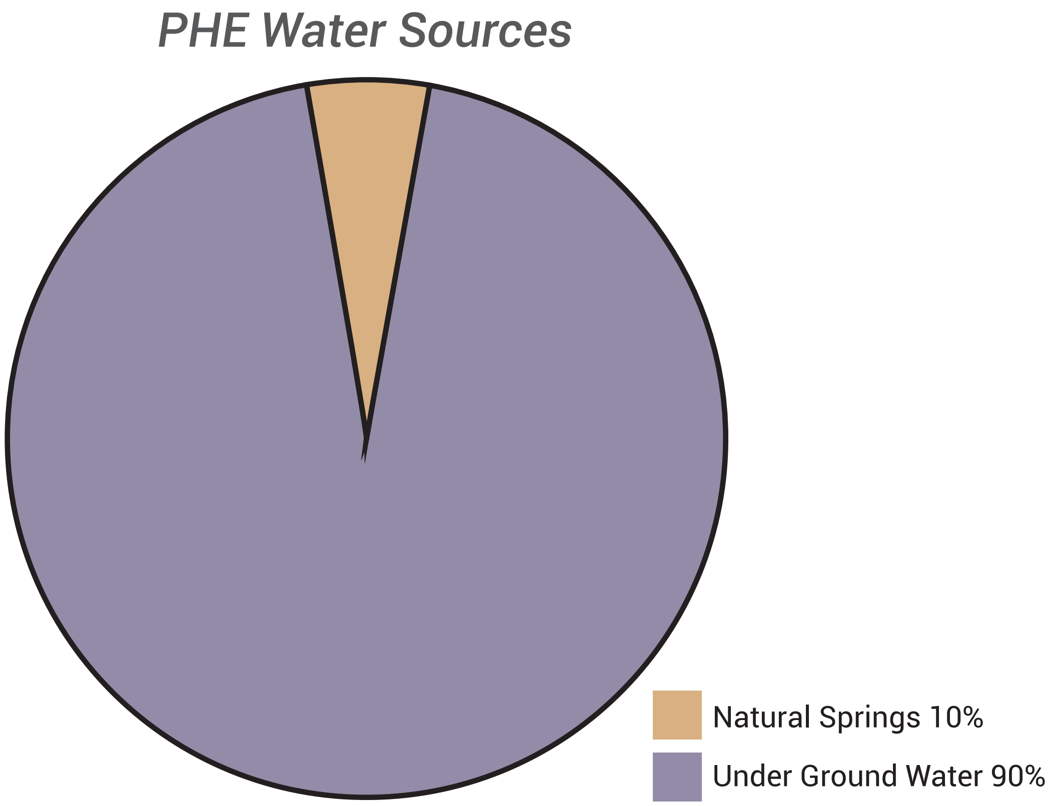


The Indus River tubewells are a major source for Leh's water supply as they contribute 32% to the entire supply system. Water gets lifted from 120 feet below the ground and is transported to the SR through rising main pipes (WSR, 2019). Initially, a total of 5 tubewells were to be constructed along the banks of the Indus river in Choglamsar, but only 3 were built. Of these, one serves the people of Choglamsar via water tankers while the remaining 2 serve Leh via lift scheme. To extract groundwater, the Indus River tubewells rely on power intensive motors and pumps which require a steady power supply to operate smoothly. Oftentimes, fluctuating voltage leads to breakdown of the motors. As per the operator the motors break or burn at least 10 times a year and it takes between 2-5 days to fix them, affecting the water supply for that many days.



A Newly Constructed Hotel/GuestHouse right next to the Indus Tube Wells

Other than the Indus River tubewells, PHE also has 9 public tubewells namely; Gompa, Murtsey, Skara, Badami Bagh, Sankar, Khagshal, Lamdon, Jumabagh and Tukcha. These provide 31% of Leh's water supply. From among these, Sankar and Murtsey are mainly used for delivering water through water tankers to areas without a functional household tap connection (FHTC) (WSR, 2019). There are 8 water tankers which are owned and operated by PHE (WSR, 2019).



These tubewells are managed by the PHE Department. Each tubewell is operated for 13 hrs per day. Around 2.05 MLD is drawn and then distributed to SRs which further feed the public stand posts and household taps. Overall the PHE department meets up to 90% of its daily demand from groundwater sources.

Gompa Gompa TW runs on diesal Generator throughout the year as it is not connected by electricity lines. Gompa SR or Nezer SR was the only SR with a Woman operator and also the only SR with a proper lock.

Murtsey Murtsey TW is mainly accessed by water tankers. This TW supplies water to Mini Sect. SR, however the quality of water from this TW was poor.

Skara Both Skara TW house and SR are in dire need of renovation. This is one of the only SRs which has no enclosures/fence/ etc and as such is vulnerable to vandalism.

Badami Bagh *Both the TW and SR are close to residential neighbourhoods and without any proper fencing.*

Sankar *Sankar TW is mainly used to fill PHE operated tankers. The pumphouse has proper walls and fence.*

Khagshal *Khagshal SR has a Ladakhi Traditional Toilet built right above it for its operator and family as can be seen in the picture on left. Khagshal TW is properly enclosed within walls, however the pumphouse is right next to another traditional toiet built for the operator.*

Lamdon *Lamdon SR is the only SR in the town which gets water from 3 different sources; Lamdon TW, Khagshal and T-Trench. Lamdon TW pumphouse had proper enclosure.*

Jumabagh *Perhaps the prettiest SR in Leh, Jumabagh TW and SR operator has taken the liberty to grow flowers and vegetables around the SR. The SR however is not enclosed within walls.*

Tukcha *Tukcha TW supplies water to Changspa SR. The SR has walls around it and so does the pumphouse.*

According to the Water Status Report (2019), total water extracted from various public sources including natural springs and tube wells is **4.7 MLD.** Out of this, total water that gets wasted in transit due to leaking pipelines and PSPs is **1.17 MLD** which is 25% of total water.

(Uninsulated, above ground broken pipes)

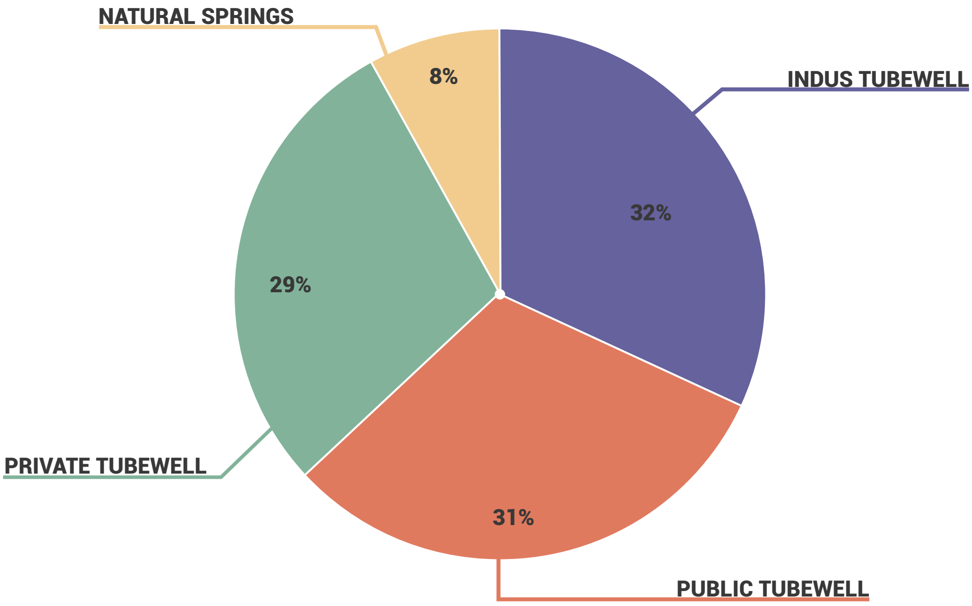
(PSPs in Leh usually don't have any Kno

PHE supplies water to the residents of Leh town through public standposts (PSPs), individual on-site taps, and water tankers. According to the PHE records, there existed 389 public standposts in Leh town in the year 2009, out of which only 150 run during winter. Also, during winters 60-70% of the total PHE water scheme is closed due to freezing of water in the pipelines. (Kaul, 2009)

The PHE tanker service provides water to households of those wards that do not have a regular PHE connection. PHE owns 8 tankers that make a total of 52 trips per day and supply an overall 0.5 ML to 2000 households (WSR, 2019). Residents that rely on tanker supply store water in large storage tanks outside their house.

Skampari residents with water storage containers outside their houses,locked and covered to avoid stealing and freezing. Below, residents of Housing Colony, unable to maintain social distancing norms in order to secure water for their families.

Residents have often complained that the tankers do not have a designated time schedule due to which some households are unable to collect water. Other issues observed in the tanker service is wastage from spillage and irregular service due to defaults in payment of wages or fuel bills. The operational and maintenance cost of the tanker supply does not appear feasible. Presently, the tanker water supply costs Rs.49 per KL which is 4.5 times more than the piped water system. The annual operational cost comes to Rs.60 lacs. The same amount could be saved if the tankers were replaced by the piped system (WSR, 2019). Meanwhile, residents have also complained regarding the water quality. Irregular cleaning of tankers can lead to build-up of sediments and lining of algae on the surface of the interior that can contaminate the water and create a possible health hazard.



Sources of Water in Leh (WSR, 2019)

4.1.2 Private groundwater extraction

The remaining demand of the water is met through private borewells, which gained popularity since 2002. In 2010, 42% of the hotel owners and guest house owners had implemented private borewells in order to sustain their guests (Akhtar, 2010). There has been immense digging of private borewells since then. The governmental authorities have no say in regards to private borewells moreover, there are no provisions to control either its digging procedure or its volumetric extraction. Due to these loopholes in the system, people have been becoming greatly dependent upon their private borewells to meet their needs be it drinking water, agriculture, washing, cleaning etc. According to the recent water status report, 2019 about 29% of the water demand is met by these private borewells, which is almost close to the amount of water supplied by PHE through their public tubewells (31%).

According to the Borewell association, around 1500 private borewells were dug in the past 5 years within Leh. Unregulated extraction of groundwater through private borewells in urban Leh can have an adverse impact on the quantity supplied by the public tubewells if the groundwater reaches unfavourable levels.

Land use patterns have changed severely over the last few years. Leh has witnessed a massive trend of urbanisation especially to cater to the tourism industry. In 2013, the number of hotels and guest houses in business was 420 within Leh district (Gondhalekar, 2015). According to the latest records from the Tourism Dept., the numbers have now increased to a total of **** hotels and guest houses (600). This drastic switch from agricultural or barren land to urban infrastructures has affected the water quantity and quality.

In terms of quantity, urban infrastructures require constant and excessive supply as compared to agricultural land. In most cases, a transition from agriculture to a commercial establishment also means a switch to private borewell. For agricultural purposes, locals relied on the traditional water distribution system called the Chhurpon system. A Chhur-pon is an individual appointed by the villagers who is in charge of distributing water for irrigation equally amongst the residents (Angchok & Singh,2006) This traditional practice ensures efficient utilisation and minimum wastage.

(The informal water market in Leh has not been studied or quantified yet. Informal water suppliers are ususally seen during the winter months due to acute shortage of water)

4.1.3 Planned water supply system augmentation

In 2005, Urban Infrastructure Development Scheme for Small and Medium Towns (UIDSSMT) was proposed under the main scheme of Jawaharlal Nehru National Urban Renewal Mission (JNNURM) which aimed in renewing and repairing the old towns of India. UIDSSMT is a scheme for small and medium towns under which the town receives support in actions such as urban renewal, water supply, sanitation, solid waste management, sewerage etc. The Leh Hill Council's project proposal under UIDSSMT was approved in 2013 (Muller et al., 2016).

Hence, in 2008, through the Public Works Department (PWD) the LAHDC tasked a consulting company "Tetra Tech India Ltd., New Delhi" with preparing a Detailed Project Report (DPR) for Augmentation and Reorganization of Leh's Water Supply. The DPR was to specify the project, calculate the water demands, collection of data through surveys and investigation, proposed water supply scheme, design engineering of proposed water supply system with cost estimates and engineering drawings etc. The project outlay was estimated at Rs. 70.48 Crores and proposed the following:

- Construction of 1 infiltration well at the banks of Indus River
- 5 new service reservoirs for meeting requirement of the upcoming year 2042
- Construction of 4 New Lift Stations
- Augmentation of 2 existing pumping stations (Indus Bank and Manali Road) for lifting water from infiltration well to upper reaches of Leh
- To lay 20 Kms of rising main of size 400 mm to 80 mm for water supply from Infiltration well to Service Reservoirs.
- To lay Distribution networks of size 250 mm to 80 mm for supplying water to consumers

Under the DPR, a design population was calculated for base year, mid-design year and design year as given below:

YEAR	SUMMER POPULATION	WINTER POPULATION
2012- BASE YEAR	42680	37282
2027- MID YEAR DESIGN	59913	51603
2042- DESIGN YEAR	82275	60419

The project aims to meet the water demand for the upcoming design population of 2042 which is estimated to be 12.77 MLD.

So, in order to meet this record, the PHE department has been expanding its connections under the project. New service reservoirs have been built. There are overall 18 service reservoirs all over Leh, out of which 12 are operational, 4 are under construction and 2 are non-operational as per records of Water Status Report, 2019. Under this new project, Leh has been divided into 12 zones based upon the location of old reservoirs and potential of the pressure gradient till the last serviceable point, since the distribution system is based upon gravity flow. To prevent PHE supply from stopping during the winters, the new pipelines are laid 1.5-2m below the ground.

As per the old scheme, there were records of 833 houses and 116 commercial sites under the registered documents of PHE. There are a further 2,985 unregistered but legitimate connections. The new project however aims to connect 100% of all the households with its water supply networks. The department is also planning to phase out all PSPs (100 operational currently) and achieve 100% piped connectivity. Currently about 3818 houses out of 5800 are already connected to the new supply line. (WSR, 2019)

4.1.4 Drinking water quality issues

As recent water quality tests indicate, two of Leh's primary public tube wells are potentially unsafe for consumption. In fact, waterborne diseases such as diarrhoea have already become a serious health concern. Data procured from the CMO (Chief Medical Officer) shows that over 10% of Leh's population suffers from acute diarrhoea especially in the summer months. This includes tourists who are susceptible to diarrhoea due to altitude sickness or unfamiliar bacteria. Meanwhile, the data also reveals that nearly 10% of children under the age of 5 experience diarrheal illnesses on a yearly basis (Gondhalekar et al., 2014). The control of microbial quality of drinking water should be the first priority given the existing waterborne health issues occurring in Leh (Schmoll, 2006). Schwaller, 2018

The Murtsey tubewell is one of the oldest and largest suppliers of water in Leh. It was built in 2010 and Mr Mohammad Abbas has been the operator since then. Apart from filling the Mini Secretariat SR, this Tube Well is also used as a major filling station for PHE Tankers, Notified Area Committee Tankers (NAC), Police Water Tanker and Fire Brigade Tankers. In total around 20 tankers are filled every day from this tube well. The TW is inside a properly built, gated compound where the operator also resides. Water is pumped to the Mini Sect.SR from 5am – 9pm.

A study conducted by the CDD society in 2019 reveals that the water from Murtsey tube well is highly turbid which implies that the water is not completely fit for consumption. Turbidity increases the chance of algae and bacterial growth and consuming turbid water can cause symptoms such as cramps and nausea. In addition, the results also indicate high concentration of nitrates and calcium carbonate. Likewise, a study conducted by Technical University Munich in 2017 identified high turbidity and calcium in the water around the Murtsey area. The Murtsey tubewell is an important source as it provides nearly 40% to the tankers that deliver water to those wards that do not have a PHE connection.
Similarly, the samples collected from the Sankar tubewell also showed unsuitable levels of iron and high turbidity (WSR, 2019). It is likely that the multiplying number of commercial establishments around tubewells are affecting the underground water quality as more pollutants from soak pits contaminate the aquifers. Furthermore, agricultural runoff from farmlands is also known to pollute groundwater.

Water audit report, lab test results, 4 out of 8 major service reservoirs showed traces of E. coli and total coliform above permissible limits. These were in particular the SRs fed from tubewells within Leh. Those fed from Indus River Aq. are relatively clean. On the other hand, **T-Trench** which is a spring source/reservoir had the worst quality of water among all others operated by PHE and had high levels of **E.Coli**, **Total Coliform** and **Nitrate contents**. - *Leh Water Audit,2020*

4.2 Wastewater management

Traditionally in Ladakh, the Ladakhi dry toilet is the common sanitation system. It works very well; no water needed to flush and the waste is used as an organic fertilizer. With the huge increase in water consumption in Leh since the early 1980's, concomitant increase in wastewater production has been immense. To raise the price of rooms, hotels and guesthouses have been increasingly constructing flush toilets and showers or even bathtubs in the bathrooms, sanitary infrastructure that was previously unknown in Leh. The use of this infrastructure, particularly by the tourist has pushed up the consumption of water immensely.

As a result, Leh is facing several challenges to manage these huge amounts of wastewater effectively. To start with, a majority of all households, hotels and guest houses in Leh have soakpits instead of sceptic tanks. Locals generally seem to be unaware of the difference between the two and as such this has led to ground water pollution due to seepage of waste water.

This was not proven until 2017-2018, when separate institutions: CDD Society Bangalore and Technical University of Munich conducted water quality tests which showed extensive ground water pollution.

FSTP Site near Bombgad, Leh

Further, the Water Audit Report 2020 by BORDA and LEDeG proves ground water contamination as samples from Major SRs of Leh were sent to a NABL accredited Laboratory in New Delhi (3 rounds of testing), through the Indian Institute of Sustainable Development, and 4 out of 8 major SRs failed bacteriological tests as they had E. Coli and Total Coliform above permissible limits. The sample from T-Trench spring/reservoir was found to be the most polluted.

Tetra Tech was also tasked with designing a centralised Sewage Treatment Plant for Leh. A majority of the pipes have been laid down for this however the Treatment Plant is yet to be constructed. Current discourse points towards the fact that for a town like Leh with its difficult geography and elevation, perhaps a more suitable idea would be to explore Decentralised Waste Water Management Systems. The Faecal Sludge Treatment Plant (FSTP) built by BORDA on request of Municipal Committee Leh stands as an example of decentralised waste water management options, with potential of water reclamation and nutrient recovery.

4.3 Management and Institutional aspects:

Leh's PHE supply system currently faces multiple managerial issues like inadequate infrastructure and equipment, absence of data, lack of funds (initially under the J&K government) as well as lack of knowledge, exposure and technical capabilities of the PHE staff. It is because of these reasons that the 'intermittent' supply system in Leh has failed to provide drinking water to all the residents of the town of desired quantity and acceptable quality.

For instance, in recent years, the PHE Dept. has witnessed major loss due to the inefficiency of tariff collection. Under the present structure, around 833 households pay an annual amount of Rs.945 while 116 commercial establishments pay Rs.1140. In 2018-19 the total annual tariff collected was estimated to be Rs.9, 54,225 however the Operation and Maintenance cost was around Rs.1.65 Crores: thus only 5.8% of the expenses were regenerated. Persistent failure of tariff collection can result in heavy debt and reduce the quality of service. The PHE must establish a systematic procedure to collect revenue in order to ensure minimum deficit.

Even though a Laboratory has been put in place since 2008 which the PHE uses to conduct water quality analyses tests on certain parameters such as turbidity, odour, colour, pH etc. it is to be noted that the present state of the Lab is dismal. Only some equipment exists and that too are not calibrated well. Now with the establishment of Ladakh as a Union Territory, having a proper NABL accredited Laboratory for both Leh and Kargil should be top most priority as only then will the administration be able to check the quality of water in Leh on a regular basis and ward of potential health hazards.

Leh town is currently not facing an issue of scarcity of water but a crisis in management of water due to lack of infrastructure and capacity, inadequacy of funds, lack of uniform approach in planning of water and development etc. This has resulted in conflict among different users. For example, in Leh, the consumption of water during summers by the tourists is around 100LPCD, locals use around 75-80 LPCD and migrant workers get 35 LPCD (Liveable Leh, 2019). It is important to recognize this huge gap between the consumption of water by tourists, households and migrant workers to be able to talk about equitable access to a safe and sustainable supply of water.

The major sector that uses water is the Army. Although the Army has their own infrastructure to extract water, they use the common resource of groundwater to meet their needs. There are around 25,000 - 30,000 army personnels deployed in Leh and is a major defence outpost. While talking about equitable access to water it is also important to include the consumption of water by the Army, however due to security issues they denied information. However, according to informal conversations held with the Army personals it was found out that they consume three times more water than what the PHE supplies to the rest of the town. There are three water points from where the Army deployed in Leh extracts water from namely, Zorawar Fort, Murtse and Gopuks, out of these only the first two locations come under the Leh Town administrative boundary.

There have been instances of conflict between locals and the Army in the Skara area. Here, they would release waste water into wetlands resulting in polluting the natural source of spring water. Skara area also has one of the major water points of the Army near Zorawar Fort. Water from here gets collected through trucks which is then distributed to different areas. In one hour, this tube wells extracts 30,000 litres of water (Akhtar, 2010). It has also been observed that due to excessive extraction of ground water from this water point, the wetlands nearby have been affected and are drying out.

(Skara spang)

The other major sector that uses water is the tourism sector. With rapid urbanization and decrease in agricultural land, there has been a change in the land use pattern. This has resulted in a shift from traditional agricultural practices to land being used for touristic or commercial purposes. The land which was earlier being used for agriculture is now being used as building plots to build infrastructures for tourism. This change is important to note as this has resulted in decreasing recharge of groundwater aquifer (Akhtar, 2010).

Tourism industry is heavily dependent on groundwater. The demand for water increases manifold during the summer season due to influx of tourists and groundwater has become the only source to meet this requirement. Also, with the change in wastewater and sanitation practices there has been a major shift from dry toilets to flush toilets hence increasing the demand for water and due to inadequate management of wastewater it deteriorates the groundwater. This puts stress on not just the quantity but also compromises the quality of water.

Moreover, an increasing number of aquifers are being contaminated with biological and chemical contaminants. Hence, there is an urgent need to regulate the groundwater both by the PHE as well as the communities so that the usage is sustainable and regulated.

Agriculture and households are the other two sectors that use water. It is important to note that agriculture is still prevalent in some of the upper wards of Leh. One of their demands is to revive the Churpon system. Leh and Ladakh in general has a traditional system of water management called the churpon system (Chu= water, spon= manager). It is an indigenous system of practice where the governance of water is community driven.

In order to revive this system and formalise it, in 1980s the MCL (earlier called as Notified Area Committee) selected churpons from the Leh town and sanctioned honorariums to them. This was done to make sure that there is smooth functioning of the irrigation system. However, due to lack of funds and inadequate management this was discontinued recently in 2008.

The traditional water sharing practices are dying and have been taken over by new systems. The land which was earlier used for agriculture is being used as building plots to build infrastructures for tourism. With this the traditional water sharing system also took a backseat and groundwater came to be used in the place of surface water. For example, in the Chubi area, a resident claimed that streams are being diverted by locals for their own personal use due to which some households do not have access to stream water.

Now the approach to water has become more state centric than community driven. The water crisis therefore is not just of water but of the loss of traditional and indigenous knowledge systems that governed the limited water available in this cold desert. The Supreme Court has repeatedly ruled that water must be understood as a public trust and it is far too important a resource for any institution or person to control (Model Bill, 2016). It is essential to understand this dynamic of water at the intersection of urban ecology and society.

CHAPTER 5
Risks Assessment &
Identification of Control Measures

Risk Assessment & Identification of Control Measures

The WSP methodology involves the identification of all potential biological, physical and chemical hazards that can affect water safety in every step of the drinking water supply system. This comprises the identification of the possible hazardous events that threaten a safe water provision, as well as the assessment of their associated risk in terms of likelihood of occurrence and severity of consequences. As a result, control measures that effectively address the risks and ensure the achievement of the water quality targets can be identified and/or defined for the system (Bartram et al., 2009). As a basis for the identification and prioritization of the key hazards and hazardous events relevant for Leh, the following steps were taken.

First, the complete water system was analysed for new and possible hazards. Here the study by (the) Bremen Overseas Research and Development Association et al. (2019) served as a basis as the document discusses all the facts about Leh's water system. Next, a comprehensive list of hazards and hazardous events was compiled based on the study of Rickert and van den Berg (2018), which identified an extensive record of about 300 possible typical hazards - including climate change aspects - in 5 categories relevant to the development of WSPs: Catchment, Abstraction, Treatment Process, Distribution system, and Consumer's Water Collection. From these, a defined list of Leh's potential hazards was identified.

In order to assess the risk associated with these hazardous events, evidence was collected using various surveys: LEDeG conducted an interview survey with several PHE officials which included broad questions related to climate change and technical aspects of the water system and infrastructure (i.e. pumps, pipes, storage reservoirs, tube wells and water tankers). LEDeG also organized a questionnaire survey for various experts focusing on the general water management situation in Leh. Both surveys also aimed to garner inputs on potential control measures for a variety of risks. In total, 8 PHE officials and 8 experts were interviewed. Each interview lasted approximately one hour, whilst the questionnaire was several pages long and took about 1 hour to complete. In addition, as visual inspections are equally important to desk research to understand the risks in the water supply system (Bartram et al., 2009), extensive field visits were also undertaken and documented by LEDeG.

In order to arrive at a comprehensive risk assessment, the outcome of the surveys with the PHE officials and experts were merged. A ranking system was developed whereby the risk value of each hazard was derived by multiplying its likelihood of occurrence and severity of consequences, which had been determined in the surveys. Through this ranking system, it was possible to compare the risks as each was classified as **high, medium or low,** and hence prioritize them based on how urgently they need to be addressed.

This risk assessment forms the basis of the Leh WSP which this document aims to contribute to developing. This chapter aims to present the most critical identified risks in order of their urgency and to describe for each risk the control measures with some hints towards their implementation. The risks are summarized into two broad groups, namely those associated with climate change and natural disasters -which cannot be directly addressed through the Leh WSP- and risks which can be directly addressed that pertain to Leh's water supply system.

All the control measures discussed below are suggestions only

The identification of control measures for implementation, as well as which exist and which additional ones are needed, have to be subject to discussion by all relevant parties. This chapter may act as a template to be used in a participatory process involving PHE and other key stakeholders and actors relevant to the water sector.

5.1 Risks related to climate change and natural disasters

The key climate change and natural disaster-related risks identified by experts and PHE officials are ranked as follows:

Hazard	Risk Value_ Expert	Risk Value_ PHE	Summation of Risk Values
Changes in precipitation patterns	16	13,1	29,1
Flash floods	14,5	13,6	28,1
Glacial melt	18,1	11,8	29,9
Earthquakes	11,4	7,2	18,6
Landslides	6,9	2,4	9,3

Overall, this result demonstrates that both groups ranked these risks similarly: changes in precipitation patterns and flash floods are seen by both PHE officials and experts as the most high-ranking risks, followed by glacial melt, earthquakes and landslides.

As control measure generally for the risks associated with climate change and natural disasters in Leh, regular ***systematic updating of available information on specific climate change trends at regional scale*** and liaising for this with organizations like ICIMOD is recommended, in parallel with regular updating of the WSP team.

Further, it is recommended that Leh engage in ***climate change mitigation and adaptation activities*** where possible. ***Some options within the control measures recommended to address risks pertaining to the Leh water system are highlighted below.***

5.2 Risks related to Leh water system

In terms of key risks identified pertaining to the Leh water system, these were ranked by experts and PHE staff as follows:

Hazard	Risk Value_ Expert	Risk Value_ PHE	Merged Risk Values
Soak pits	16	16	32
Water availability-Climate change	18,6	12,3	30,9
Water availability-Tourism related	19,1	10,6	29,7
Water extraction from private borewells	16	9,8	25,8
Changes in land-use patterns	14,5	9,4	23,9
Septic tanks	10,1	9,4	19,5
Fertilizer usage	11,8	7,9	19,7
Tanker water distribution	10,1	4	14,1
Open defecation	5,9	3,1	9

The surveys conducted demonstrate that experts and PHE officials alike see soak pits and water availability as key priority issues in Leh

In order to analyse these 8 identified key risks in more detail, in line with the structure of Chapter 4 the above risks are discussed in 3 categories:

1. Water supply
2. Wastewater management
3. Management and institutional aspects

The aim of all the control measures suggested below is to contribute to the safeguarding of drinking water / freshwater quality and quantity in Leh

Risk ranking		Control measures
Water supply		
Water availability (LEDeG, Experts & PHE ranking) Water availability related to climate change	**Water availability related to climate change**	• Groundwater quality control measures • Water conservation measures • Identification of another water source, e.g. water reuse
	Water availability with regard to tourist's consumption	• Water meters in hotels and guesthouses • Introduce tourist "water tax" to implement water conservation measures • Awareness-raising campaigns • Enforce hotels and recreation centers to regulate wastewater management • Higher prices for drinking water • Regulations on water consumption reflecting "equal right to water", requires an integrative approach beyond sectoral water use
	Water sources: Natural springs	• Barbed wire to prevent contamination through animal faeces • As springs are a community resource, a participatory mechanism enabling community ownership of spring water through continuous awareness campaigns and community forums with official bodies
	Surface streams	• Participatory mechanism to manage water, enabling community ownership similar to traditional Churpon system • Regulations ensuring construction activities do not affect the stream • A fine for diverting or blocking streams for personal purposes
	Tubewells (TW) & service reservoirs (SR)	• Locked, fenced compound to ensure water quality (e.g. animal dung) & prevent vandalism (TW, SR) • Reservoir routine inspection, cleaning & maintenance programme (SR) • Roof in good condition, covered with mud for insulation (SR) • Covered in-let and out-let pipes (SR) • Dry toilets located at minimum 30m distance (TW, SR) • Operator present on site or residing nearby (TW, SR) • Regulation for hotels, guesthouses and other commercial establishments at minimum 30m distance (TW, SR) • Coating on the inner walls to prevent corrosion and leaching of chemicals from the construction material into the water (SR) • Availability of spare parts for motors, or spare motors (TW) • Separate power line to avoid voltage fluctuations & motor burning (TW)

	Unregulated water extraction from private borewells	• **Survey** to catalogue / certify unregister borewells, e.g. cooperation with private mining companies • For high concentration of nitrate and turbidity in private borewells: • **Keep a minimum distance 30m from potential sources of contamination**, such as soak pit, septic tank, chicken coop, compost pile, garbage cans, refuse piles, herbicide or fertilizer use or storage, above and below ground storage tanks, parking areas • Periodically check the well cover or well cap on top of casing (well) to ensure it is in good repair. • Keep **records** in a safe place: construction reports, annual borewell systems maintenance and water testing results. Sources • Improve the centralised water supply system • Follow up detected cases with fines or penalties sufficiently severe to deter further illegal abstraction. Surveillance is also required to ensure continued compliance • Regular groundwater quality monitoring • Installation of **water meters** to monitor water use, using recycled water for non-potable urban uses such as toilet flushing • **Restricting sale of pumps** in the market
	Tankers	• **Tankers** can get contaminated due to settlement of particles overnight between trips which can affect water quality • Schedule for cleaning water tankers to avoid microbiological contamination and algae growth and water tankers should not be used for other purposes • Water quality needs testing regularly to ensure no contamination from rusting in water containers
Pipes (PHE)	**Bursts**	• Provide continuous supply to maintain the pressure within a range • Implement construction guidelines to avoid pipe burst (use of insulation for exposed pipes, underground pipes); • Consider different seasonal water supply systems; • Evaluate the possibility of implementing automated systems/software for real-time monitoring of pipe burst • Keep all mains buried to design depths or provide secure designs for over-ground pipes and recovering of pipes exposed due to erosion
	Leaks	• In cases where supply pressure drops, leakage can also imply a potential risk of bacterial contamination from surrounding ground • Water leakage repair often has long timespans and must be integrated with city planning for projects in other sectors, such as transport, telecommunications, gas and heating • Establish programs for pipe and fittings replacement as it is difficult to detect the leakage
	Not serviced/ checked as often as necessary	• Define a schedule to check piping systems according to the sanitary inspection form • Cleaning and disinfection the pipe after the repair and maintenance • Capped ending of pipes, remove debris and water that may enter pipes

Pipes (PHE)	**Valves, joints, and other connections not serviced/ checked as often as necessary**	• Cleaning and disinfection the pipe after the repair and maintenance • Regulations or standards to operation the valves after repairs • Ending of pipe should be capped and remove all the debris and water that may enter the pipe
	Water contaminatio n during distribution	• Fix septic tanks and soak pits, improve and develop maintenance plan
	Sediment build-up	• Operate valves and pumps to avoid rapid surges in flows • Routine main cleaning programme • A positive pressure and flows can be maintained only if continuous supply is provided in the system
Pumps (PHE)	**Not serviced/ checked as often as necessary**	• Operation and maintenance program for pumps: provide schedule to check and clean all pumps connected to distribution system
	Breaking down	• Separate electricity line to the Indus • Regulations or standards to operate the valves is a reason that pumps can break down • Appropriate distance from septic tanks to avoid contamination
	Water intake (of the pumps) being exposed to air	• Provide continuous supply system which will work 24 hours in order to maintain positive pressure and flow • Ending of pipe should be capped and remove all the debris and water that may enter the pipe. • Regulation to operate valves and other fittings
Wastewater management		
Experts & PHE	**Soak Pits**	• Replace soak pits with septic tanks • Regulation banning building of soak pits • Take precautions when emptying the pit contents (People who are working at a conveyance site should be training on the risk of working with sanitation systems. They should be able to handle wastewater or faecal sludge and be equipped to follow standard operating procedure, wearing gloves, masks, and waterproof footwear. Moreover, after coming in contact with faecal sludge workers should wash hands with soaps and never use those clothes in other places. Additionally, after emptying exercise, all workers should be provided with regular health) • The area should also be secluded from the passers-by due to possibility of infective aerosol that is accidentally released • Minimize the overflowing incidents, clean spillage when it occurs • Analyse groundwater quality

Experts & PHE	**Septic tanks**	• Heavy equipment / vehicles should not be parked over septic tank • If tank is exposed to vehicle traffic, use a barrier to prevent vehicles • The access opening should be sealed. In general, the user should have very little contact with the septic tank • Using strong chemicals such as floor cleaner can kill the bacteria that treats wastewater • Garbage disposal should be avoided, as it accumulates solids in the septic tank. In that case the pumping out should be more often • To avoid the contamination of drinking water building septic tanks at appropriate distance from water wells • Promote on-site wastewater management, and network-based wastewater disposal and reuse
	Open defecation	• Build more public toilets facilities with appropriate handwashing with soap facilities, • Inform, educate citizens about the impacts of open defecation on groundwater and about the adverse health effect with examples of incidents that have happened in Leh (Diarrheal diseases). • The community should organize seminars to inform citizens as well as in school provide a subject to educate the new generation.
Management and institutional aspects		
Experts & PHE	**Changes in land-use patterns**	• Protect water sources, distance from pollution sources • Evaluate if traditional water management practices can be recovered • Leh master plan and vision document strongly focused on environmental protection and its implementation • Regulation for land use and regulation for building / opening of new hotels and guesthouses
	Fertilizer usage	• Improve nutrient management practices by applying nutrients (fertilizer and manure) in the right amount, at the right time of year, with the right method and with the right placement • Plant trees, shrubs and grasses along the edges of fields; this is especially important for a field that borders water bodies. Planted buffers can help prevent nutrient loss from fields by absorbing or filtering out nutrients before they reach a water body. Also, install fence along streams, rivers and lakes to block access from animals to help restore stream banks and prevent excess nutrients from entering the water; Determination of water protection areas; implementing physical barriers to contaminated runoff. Nitrogen fertilizers contain nitrates which can lead to groundwater contamination because nitrate is highly soluble in water, so replace nitrogen fertilizers with organic fertilizers, native plants in gardens, which do not need fertilizer
PHE	**Adequate training for employees**	• Implement suitable training programmes

PHE	**Not having proper audits and inspections within the required time**	• Provide audits internal or external processes, to provide important input to the periodic review of the WSP
	No proper lab or equipment to test the water	• Build proper NABL accredited Lab with Lab technicians who can carry out water quality analysis • As an alternative, evaluate possibility for using field test-kits or paper-based (measure pH, temperature and turbidity) rolling programme
	Funding to support O&M	• Taxes for local population such as housing taxes, drinking water taxes / **water tariffs** to generate more founding
	Use of unapproved/ uncertified materials	• Approved products standards for material in contact with water and product list. New installations should use only materials and fittings that comply with these requirements • Determine which chemicals can migrate from different materials to drinking water that can contribute to contamination through compliance audits and material checklist, and select materials that are suitable for contact with drinking-water • Chemicals in drinking-water may also react with distribution system materials and their scales, causing the release of contaminants. Contamination from impurities in materials used in construction and maintenance of pipes, fittings and tanks (e.g. copper, iron, lead, plasticizers, bituminous lining) • Leaching can be reduced by selecting materials and fittings that are suitable for contact with drinking-water, whereas corrosion can be reduced by operational controls applied by water utilities
	No use of best management practices during construction, repair, and maintenance	• Disinfection of all equipment before commission and after the repair or maintenance of water mains • After the repair check the water quality (visual inspection turbidity) before turning on the water main • Cleaning and disinfection (flushing or chlorination) the pipe after the repair and maintenance

Climate change mitigation	• Use of renewable energy sources where possible in the water system, e.g. use of solar pumps, solar thermal energy, PV, etc. • Consider potential of renewable energy generation related to water system, e.g. biogas from sewage
Climate change adaptation	• Water conservation actions e.g. supported through volumetric pricing by installing meters to know how much water is being consumed and introduce fair pricing • Promote Leh as "Low water consumption desert tourist destination • Managed aquifer / groundwater recharge

CHAPTER 6
Monitoring of Control Measures

Monitoring of Control Measures

This step of the WSP involves the validation of the selected control measures to mitigate the risks identified in the previous stage. It also comprises the establishment of procedures to demonstrate the efficiency of these measures and to implement corrective actions when water quality and operational targets are not met. Consequently, the implementation and effectivity of the WSP can be verified and audited (Bartram et al., 2009).

For a structured overview and follow-up of this step, it is recommended to use the templates presented below to monitor existing control measures identified in the risk assessment (operational monitoring plan) and to verify that the WSP is working effectively (verification monitoring plan). These tables show examples of how the control measures and water quality targets can be verified for some of the risks identified for Leh, and it is a task that should be done for each of the defined control measures. **As such, they are intended to serve as a basis to guide the future work executed by the PHE department.**

To monitor the effectiveness of the WSP, key control points, critical limits and corrective actions must be defined depending on the likelihood and frequency of hazardous events in the system. **As this requires an extensive knowledge of the water supply system, this task is best defined directly by the PHE.** Below we highlight three essential examples of the operational monitoring of the control measures suggested for the three action areas identified in Chapter 5, as well as the relevant performance indicators for evaluating their effectiveness.

6.1 Operational monitoring plan

Key risk and Control measure	How will this existing control measure be monitored/inspected?		When is the control measure considered to be not working?	What needs to be done if the control measure is not working?
Water Supply				
Water availability – tourist consumption: water conservation (e.g. water metering for hotels and guesthouses)	What needs to be monitored?	Extensive installation of water meters according to the established schedule	This indicators need to be defined individually in the project front-end development (e.g. When water meters are not installed or not done according to the schedule)	Corrective actions need to be defined in the project front-end development. Communication measures also need to be developed in case of failure (e.g. Notify WSP leader and PHE department)
	How will it be monitored?	Visual inspection		
	When will it be monitored?	Needs to be defines in project plan		
	Where will it be monitored?	Hotels & Guesthouses		
	Who will it be monitored?	Needs to be defined in project plan (eg. PHE department)		
Water availability – climate change related: water conservation (e.g. groundwater protection measures)	What needs to be monitored?	Implementation of groundwater source protection zones or wellhead protection areas based on hydrogeological research	This indicators need to be defined individually in the project front-end development (e.g. When defined water protection areas are not being properly managed)	Corrective actions need to be defined in the project front-end development. Communication measures also need to be developed in case of failure (e.g. Notify WSP leader and PHE department)
	How will it be monitored?	Visual inspection		
	When will it be monitored?	Needs to be defines in project plan		
	Where will it be monitored?	Define specific areas in the Indus River watershed and/or Leh Town		
	Who will it be monitored?	Needs to be defined in project plan (e.g. PHE department)		
Water availability: evaluate use of alternative water sources (e.g. water recycling)	What needs to be monitored?	Evaluation and implementation of water reuse initiatives for decentralized water treatment and non-potable reuse	This indicators need to be defined individually in the project front-end development	Corrective actions need to be defined in the project front-end development. Communication measures also need to be developed in case of failure (e.g. Notify WSP leader and PHE department)
	How will it be monitored?	Visual inspection		
	When will it be monitored?	Needs to be defines in project plan		
	Where will it be monitored?	Define specific areas in the Indus River watershed and/or Leh Town		
	Who will it be monitored?	Needs to be defined in project plan (e.g. PHE department)		

Wastewater management				
Plan for replacement of soak pits with septic tanks	**What** needs to be monitored?	Extensive replacement of soak pits according to the established schedule	This indicators need to be defined individually in the project front-end development (e.g. When soak pits are not replaced or not done according to the schedule)	Corrective actions need to be defined in the project front-end development. Communication measures also need to be developed in case of failure (e.g. Notify WSP leader and PHE department)
	How will it be monitored?	Visual inspection		
	When will it be monitored?	Needs to be defines in project plan		
	Where will it be monitored?	Hotels & Guesthouses		
	Who will it be monitored?	Needs to be defined in project plan t		
Regulations for exclusive implementation of septic tanks by guesthouses and hotels as wastewater management	**What** needs to be monitored?	Enforcement of wastewater construction and operation regulations for guesthouses and hotels	This indicators need to be defined individually in the project front-end development	Corrective actions need to be defined in the project front-end development. Communication measures also need to be developed in case of failure (e.g. Notify WSP leader and PHE department)
	How will it be monitored?	Visual inspection		
	When will it be monitored?	Needs to be defines in project plan		
	Where will it be monitored?	Define specific areas in the Indus River watershed and/or Leh Town		
	Who will it be monitored?	Needs to be defined in project plan		
Management and institutional aspects				
Plan to recreate traditional water management practices where possible in Leh	**What** needs to be monitored?	Identification and implementation of traditional water management strategies (e.g. Churpon system)	This indicators need to be defined individually in the project front-end development	Corrective actions need to be defined in the project front-end development. Communication measures also need to be developed in case of failure (e.g. Notify WSP leader and PHE department)
	How will it be monitored?	Needs to be defined in project plan		
	When will it be monitored?	Needs to be defined in project plan		
	Where will it be monitored?	Needs to be defined in project plan		
	Who will it be monitored?	Needs to be defined in project plan		

Establishment of sanitary inspection procedure	**What** needs to be monitored?	Development and enforcement of standard SOPs for sanitary inspections, water supply system maintenance and construction	This indicators need to be defined individually in the project front-end development	Corrective actions need to be defined in the project front-end development. Communication measures also need to be developed in case of failure (e.g. Notify WSP leader and PHE department)
	How will it be monitored?	Needs to be defined in project plan		
	When will it be monitored?	Needs to be defined in project plan		
	Where will it be monitored?	Needs to be defined in project plan		
	Who will it be monitored?	Needs to be defined in project plan		
Establishment of a water tariff framework	**What** needs to be monitored?	Formulation and enforcement of a water tariff framework with sector-differentiate d taxes and other economic tools	This indicators need to be defined individually in the project front-end development	Corrective actions need to be defined in the project front-end development. Communication measures also need to be developed in case of failure (e.g. Notify WSP leader and PHE department)
	How will it be monitored?	Needs to be defined in project plan		
	When will it be monitored?	Needs to be defined in project plan		
	Where will it be monitored?	Needs to be defined in project plan		
	Who will it be monitored?	Needs to be defined in project plan		

6.2 Verification monitoring plan

This table involves the measurement of parameters and performance indicators that evaluate the performance of the control measures. As such, it includes the procedure and parameters for water quality testing, sanitary inspection of the water supply system, WSP implementation and consumer satisfaction. The parameters mentioned bellow are based on the values recommended by the World Health organization. The PHE department may extend this list depending on the knowledge of the system

➔ General background of what risks are being addressed here.

What needs to Monitored?	Why does it need to be Monitored?	What location will be checked?	How often & how many samples will be taken?	Who will do the checking?	What is the target outcome?	WSP team member to report the outcome to?
Water quality testing(compliance monitoring)						
Microbiological parameters - indicator organisms						
E. coli and total coliforms (World Health Organization [WHO], 2011)	Indicates faecal pollution, cleanliness and integrity of distribution systems Organization [WHO], 2011)	Household storage containers, storage reservoirs and water wells Water sources which are closed to soak pits or septic tanks Water tankers	The PHE department must define the frequency of the sampling as well as by whom. However, it is suggested to do sampling at least every six months and after incidents.	To be defined by the PHE (e.g. water supply operator)	0 CFU/100 mL	To be defined by the PHE (e.g. WSP Team Leader, Executive engineer, PWD Leh)
Algal growth		Water sources (springs and Indus River tube wells), distribution system	Sampling should be more often for water sources that are nearby septic tanks and livestock.			
Heterotrophic bacteria		Distribution system				
Physical parameters						
Conductivity	Indicates presence of ions and some dissolved solids in water	Water sources (springs and Indus River tube wells)			250 μS/cm	
Turbidity (World Health Organization [WHO], 2017)	Useful indicator to indicate the presence of pathogenic microorganisms and hazardous events in the water supply (e.g. biofilm	Water sources (springs and Indus River tube wells), Distribution system and storage, point of use and household	Springs and groundwater: Frequency depends on flow and extreme weather events. Distribution system and storage: daily to	To be defined by the PHE (e.g. water supply operator)	< 1 NTU at point of use	To be defined by the PHE (e.g. WSP Team Leader, Executive engineer, PWD Leh)

	formation, oxide scales, contamination through pipe breaking)	water storage. Specific control points to be defined by PHE.	weekly, depending on resource availability, intermittency of supply and variations in hydraulic conditions			
Chemical parameters						
Nitrate (World Health Organization [WHO], 2011)	Nitrate can be found in drinking water where latrines and septic tanks are poorly managed or from agriculture activities.	Water wells (Indus wells) or all water wells that are used for Water sources which are closed to soak pits or septic tank Take sample from tankers that are used for water storage	The PHE department can determine the frequency of the sampling as well as by whom. However, it is suggested to do sampling at least every six months.		< 50 mg/l at point of use	
Nitrite					< 3 mg/l at point of use	
Hardness (calcium and magnesium)	Affects the corrosion rate in the system.				< 200 mg/l	
pH						
Phosphate						
Sanitary inspection						
Sanitary condition	A good condition of the distribution system lowers the probability of hazards entering the system	Tube wells, service reservoirs, public stand posts	1 survey per month	To be defined by the PHE (e.g. water supply operator)	"Good" sanitary condition	To be defined by the PHE (e.g. WSP Team Leader, Executive engineer, PWD Leh)
		Household and guesthouse water storage facilities	Define a number of households to conduct a monthly surface	To be defined by the PHE (e.g. water supply operator)	"Good" sanitary condition	To be defined by the PHE (e.g. WSP Team Leader, Executive engineer, PWD Leh)

WSP implementation						
Water Safety Plan implementa-tion	A follow-up that the WSP is being implemented as planned is required to assess its effectiveness and to re-evaluate the risks, control measures and control points	Whole WSP from source to consumer	1 audit per year	PHE department	Audit pass	To be defined by the PHE (e.g. WSP Team Leader, Executive engineer, PWD Leh)
Consumer satisfaction (e.g. satisfaction survey)						
Level of consumer satisfaction	It is important to assess the satisfaction of consumers to the public water supply, to assure that an appropriate service is delivered and there is no additional incentive to the implementation of private wells	Households and guesthouses	Once a year at a specific number of households	PHE department	"High" level of customer satisfaction received from 80% of households	To be defined by the PHE (e.g. WSP Team Leader, Executive engineer, PWD Leh)

CHAPTER 7
Vision of a Way Forward

Leh Water Action Plan

With regard to risks and hazards emerging from Climate Change and Other Natural Disasters, Leh should very seriously start looking at building its 'Resilience' and 'Adaptive Capacity'. Local action plans cannot mitigate climate change issues, however we can build our adaptive capacity so that vulnerability to Climate Change related hazards and extreme events are minimised.

Structured to address key risks in order of priority:

Hazard	Risk Value_ Expert	Risk Value_ PHE	Merged Risk Values
Soak pits	16	16	32
Water availability-Climate change	18,6	12,3	30,9
Water availability-Tourism related	19,1	10,6	29,7
Water extraction from private borewells	16	9,8	25,8
Changes in land-use patterns	14,5	9,4	23,9
Septic tanks	10,1	9,4	19,5
Fertilizer usage	11,8	7,9	19,7
Tanker water distribution	10,1	4	14,1
Open defecation	5,9	3,1	9

However, for the above mentioned risks and hazards of the town's Water Supply System, this "Towards a Leh WSP" Document proposes an 11 point action plan which is categorised under the following three headings:

1. **Water supply**
2. **Wastewater management and**
3. **Management and institutional aspects and are as follows:**

7.1 Water Supply Recommendations:

1) A need to identify other sources of potable water:

Currently almost 90% of the PHE water supply in Leh town is dependent on underground water i.e. on one source. This makes the water supply in Leh extremely vulnerable to all sorts of risks and hazards ranging from source pollution to climate change induced events. Now identifying other sources like the Indus Bank Tube wells should be easy, however a more sustainable path would be to research and invest in technologies and systems that allows Leh to recycle its used water,

2) Overhaul Infrastructure/Winter friendly Infrastructure/Renovate infrastructure and improve services:

It can be concluded that the current water supply in Leh town is inequitable in nature. There are wards with access to multiple sources of water, at the same time there are wards with practically none. Tourists have access to and can consume a lot more water than migrant workers. Similarly among the local residents of the town, the economically well off families can access multiple sources of water or even get serviced by informal water providers such as private water tankers however other residents have to struggle to secure their water needs – and come winter, the water problems increase manifold.

It is time that the administration should take bold steps to improve the water situation in the town for the benefit of the people. A 24*7 water supply system for example would be more equitable in nature compared to the current intermittent supply system.

On the other hand, a simultaneous renovation of existing infrastructure is also needed. Non-revenue water, which is water lost in the system due to unbilled consumption, unauthorized consumption, meters inaccuracy, data handling errors, and leakages, reduces earnings, and therefore, renovating existing networks is crucial. This maintenance is intrinsic to any infrastructure so Leh town should not neglect it. Currently, its old network in operation shows high levels of leakage. Thus, after defining a responsibility for both operation and maintenance, the focus on renovation can significantly increase revenue and reduce the burden on water tariffs. In Shimla, for example, as soon as the utility assumed, they focused on changing old pumps and fixing reservoirs, which had a positive effect on their revenue.

Low payment rates are another problem in Leh town, but no user would pay for a low-quality service or product. Even with a well-designed water tariff, no revenue would be collected. Therefore, improving water quality and service provision is another key factor to water tariff effectiveness. That is what the Shimla utility also did along with renovating the old infrastructure. A daily quality control, distribution schedules, and a 24/7 hotline were established. By that, the sense of value per money increased as well as payment rates. Leh town could even bring back the traditional figure of Churpons for more credibility. However, conventional infrastructure is not aligned with water conservation and resources recovery.

Another constrain is the extreme cold climate. Hence, in winter, to reduce water demand the use of flush toilets could be banned, allowing only traditional dry toilets. In winter, the use of dry toilets becomes more prominent. This practice could be enhanced to reduce water demand by avoiding the use of flush toilets. Additionally, insulation methods should be considered to avoid frozen pipelines, pumps, meters, and taps.

3) Regulate Ground Water in Leh:

The rise of Private Bore wells in Leh town is worrisome. It is estimated that there could be anywhere between 1500 – 3000 private bore wells operating in a 9sq km town. Almost all hotels and guesthouses in Leh have one or more bore wells. This rise in bore wells is due to the fact that the water provided by the PHE department is not sufficient to take care of the needs of the large number of tourists that visit Leh each year. Since no laws or regulations exist in Leh regarding digging of private bore wells, no quantification is available on the exact number of bore wells or the amount of water they draw daily. An urgent regulation is needed to check overexploitation of underground water in Leh.

4) Sanitary Inspections:

There are a variety of hazards within any given water supply system. One common hazard identification method includes the use of sanitary inspections. Sanitary inspections are visual inspections in the field to assess the equipment or process of the water supply system from catchment to distribution. In Leh, currently there is insufficient record of the sanitary inspections done thus far, and according to the PHE survey, there is no unanimously known time for when the sanitary inspections should be done or are done. For this reason the idea for digitizing sanitary inspection provided a solution to the problem within the current process. This step in the WSP is tremendously important. Completing sanitary inspections allows you to identify the problem before it is a severe problem. Not only should the inspections be done, but the WSP team or water management should also keep a record of them. The record allows for looking back and comparing or identifying when the problem first occurred.

The administration should look into creating a user-friendly digital platform, accessible by login by computer, tablet, or smartphone in the form of a website or application. This platform would contain all sanitary inspection forms relevant to the water supply, in this case Leh's, with the option of downloading and printing for manual use as well. It would allow the user to complete the sanitary inspection on the platform while instantaneous saving the information into a database that can be accessed anytime. This software would also output reports and analyze data when possible. Email reminders would be sent to appropriate users for each sanitary inspection leading up to the due date of said inspection.

7.2 Waste Water Management Recommendations:

5) To Centralize or not to Centralize:

While the PHE department is engaged in tendering out and building a Centralized Sewage Treatment Plant and network in Leh, a rationale has emerged that perhaps Decentralized Waste Water Management solutions would be more appropriate and sustainable in a place like Leh. A centralized STP is both energy and water intensive. Such a system would require a lot more water in the sewage network to run and carry the waste down to the treatment plant. On the contrary, a decentralized system such as an FSTP is neither energy intensive nor water intensive.
The Rajkot experience shows positive results from decentralized wastewater treatment plant. The plant serves about 270 households and combines low investments with water conservation and energy recovery. Thus, pilot projects should be encouraged to analyze if positive outcomes are also reached. Also in reference to Rajkot, a Decentralized Measuring Area (DMA) associated with a Supervisory Control and Data Acquisition (SCADA) system is other relevant strategies that could be applied in Leh town. By that, reservoirs would be controlled and a first step to metered consumption and charges could be taken.

6) Mandatory Installation of Sceptic Tanks:

All New hotels, guesthouses, households and other commercial establishments in Leh must have sceptic tanks. The concerned government departments should rigorously check and only give building permission to those establishments that follow this.

7) A Program to renovate existing soak pits into sceptic tanks:

As mentioned before, a majority of all establishments in Leh have soakpits instead of sceptic tanks. Now their distribution is such that for many owners, it becomes economically unviable to convert the existing soakpit into a sceptic tank; therefore the administration must come up with ways and incentives where the residents of the town are encouraged to make this change.

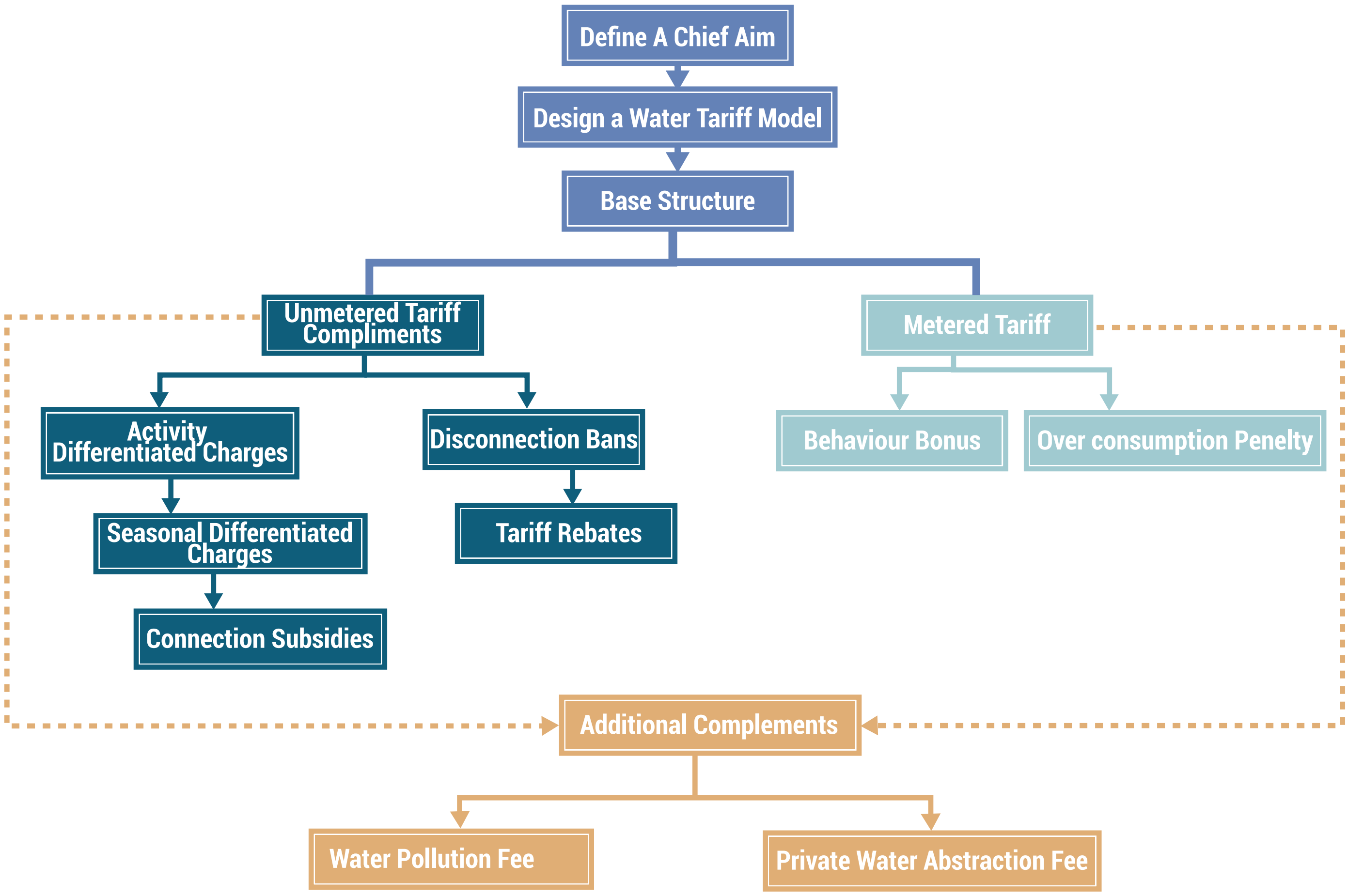
7.3 Institutional Recommendations:

8) Water Tariff Restructuring Urgently required:

The following contextual challenges are the base for the water tariff recommendation.

- **Water availability:** over extraction and contamination of groundwater;
- **Geographical disparities:** segregated areas without proper water supply and sanitation;
- **Exclusion of groups:** residents and migrants have less access to water than tourists;
- **Financial affordability:** low tariff collection and low expenditure recovery; and
- **Water governance:** ineffective institutional structure without clear responsibilities.

The next subsections describe steps to support an effective water tariff.



Define a chief aim

Tradeoffs between water tariff goals are natural. Experiences show that by focusing on water conservation, other goals are also achieved. It is recommended that Leh town adopts "Water Conservation" as its chief aim. Like other towns in India and abroad, Leh could implement an annual water audit and define use priorities, e.g. water for drinking and farming over other activities. After defining water conservation as a chief aim, Leh town can design a water tariff that fits this purpose.

Design a water tariff model

The water sector demands financial resources, therefore setting a price on water supply and sewerage services is important to help the revenue collection. The tariff model can comprehend a base structure and complements to target specific goals, as described in the following subsections.

Base structure

Volumetric tariff structures are more related to water conversation than unmetered structures. This metered volumetric charge was also the option pointed in the experts' survey. However, this tariff requires an infrastructure which Leh town does not have yet. So, to implement it, high investments might be required. In addition, the extreme cold temperatures require specific measures to install meters.

Thus, an immediate strategy could be to keep an unmetered tariff. By considering the experiences in cities like London, this becomes reasonable due to the limitations of installing meters in all households. So, relying on meters should not be the only solution to water tariffs. Meanwhile, the operator can investigate cold climate solutions, as applied in areas with extreme cold climate such as in Yellowknife, Canada.

Moreover, Leh could also investigate the possibility of having a HYBRID tariff structure: metered tariff in summer and an unmetered tariff in winter. However it is important to acknowledge that such a scheme may require high institutional and infrastructure capacity. The dynamics of switching from a metered tariff to unmetered tariff throughout the year should be well defined and communicated to users. The experiences gained from the current 24*7 water supply pilot projects run by PHE should be used to formalize the tariff structure. Thereafter, water prices should be redefined by considering future expenditures on both water supply and wastewater treatment. Nonetheless, the prices should be between 3-5% of the average per capita income. Moreover, the process of defining a water tariff is likely to be more effective when the community is involved. The experience in Shimla showed that as involving users in decision-making, they were more prominent to pay for water tariffs. This process also increases general public awareness and decreases the amount of non-revenue water.

Unmetered Tariff Compliments:

i) *Activity Differentiated Charges:* - The main aim of this complement is to reduce households' onus and target high demanding users.

This complement also has the following characteristics:

- Environmental sustainability: with higher prices to non-domestic users and domestic users' preference to local resources, it may induce large users to find alternatives to reduce water consumption.
- Social equity: equitable access is achieved if domestic use is set as priority to local resources access.
- Economic efficiency: there is a need to compensate average provision costs to avoid market distortions.
- Financial stability: revenue fluctuations may be affected by reduction in water consumption of large users.

ii) *Seasonal Differentiated Charges:*- The main goal of this complement is to determine water charges by considering the water availability and demand in different seasons through the year. Seasonal complements are mostly associated with environmental sustainability by taking in consideration the resources' limitation.

iii) *Connection subsidies:* - The main goal of this complement is to avoid illegal connections, raise revenue and secure access to all users. Connection subsidies consist in a direct financial income-support complement to households connecting into the system's network. Usual fixed quotas can be charged to every user which intends to connect to the network, but since low-income, vulnerable and marginalized groups may face difficulties to pay, this complement can efficiently benefit these exposed parcels of the population.

iv) *Disconnection bans*: - This complement works together with connection subsidies to, again, avoid illegal connections and secure water access to all. This complement is a non-tariff measure aimed on prohibiting operators to disconnect users who have unpaid debts in water bills. On the other hand, to avoid intentional non-payment operators can reduce service provision in limited volume or time in the day. Some dishonesty penalties could also be included (WHO, 2012).

v) Tariff rebates: - This complement has the objective to assist low-income families. Instead of defining a volume of minimum consumption free of charge, this complement focuses on giving a signal for water conservation before aiding them. Tariff rebates are an income-support complement acting as part of a uniform surcharge, but the difference here is that financial aid goes directly to consumers. A defined rebate percentage, e.g. 30%, 50%, 70% of the water bill, based on social-economic standards, can be provided in many manners.

Metered tariff complements

Further complements can be implemented when meters are installed in Leh town.

i) Behavior Bonus: - This complement enhances water conservation and benefits users that are water savers. Behavioral complements are also aligned to environmental sustainability and resources availability. However, on the opposite side from penalties, behavioral complements are linked to low consumption rewards as discounts in the total bill to consumers which maintain their use under a defined threshold. This complement can promote efficient water consumption and good behavior reducing average consumption level (Termes-Rife & Bernardo, 2015).

ii) Overconsumption penalty: - This complement also enhances water conservation, but it penalizes extreme demanding users. Overconsumption penalties, just as behavior bonus, are aligned to environmental sustainability and resources availability. In addition, it tends to cover the extra costs as the system would have to operate at its full capacity. This extra charge goes directly at the user's bill, giving a signal to water conservation too.

Further, additional complements can benefit both unmetered and metered tariff structures:

i) Water pollution fee: - This complement tends to make use of polluters' pay principle and enhance water conservation. The fee also aims on covering the extra costs for treating polluted water. However, it requires a minimal administrative and regulatory capacity from both regulators and operators.

ii) Private water abstraction fee: - This complement aims on regulating the private water abstraction to minimize over extraction of groundwater resources. The fee would be charged from users that choose to extract water from its own plot. By that, users tend to connect to the supply system instead of pursuing its own sources. In areas with no access to the supply system, this fee can be aligned with rebates to ensure water access and minimize geographical disparities.

Nevertheless, as the experiences show, water tariffs do not stand alone. Therefore, Leh town should explore other sources of revenue to support the water sector operation, maintenance and investments.

9) Explore other sources of revenue:

Taxes are another source of revenue that complements tariffs. The Great Barrier Reef in Australia uses tourism taxation to support water conservation. So, Leh town could also explore it and turn an issue into an asset. The ongoing environmental taxation, which is collected directly from the tourism industry, could be directed or partly directed to the water sector. This taxation could be collected directly from tourists or from hotels and guesthouses. By that, if US$1,00 or Rs.75.00 (Google Finance, 2020) was charged from each tourist arriving in Leh town in 2018, about Rs.24 million would be collected. This amount represents about 60% of the total expenditure estimated for a future scenario in the water sector. Furthermore, this taxation can include an appealing message to tourists that arrive in Leh town such as:

"Welcome to Leh town, we are happy to have you here! Nevertheless, you are entering a cold desert climate, which means that water conservation is our priority. This taxation is a form of you helping us to keep our ancient region aligned with its nature. Save water and enjoy your stay. - People of Leh."

Another strategy is to request governmental or external funding, which was also pointed as the main source for potential external funds on our experts' survey. Hiware Bazar in Maharashtra utilized funding from a state PWS program to boost their water management. While Shimla obtained funds from the World Bank to invest in infrastructure and water conservation strategies. These experiences show that transfers are a possible approach, but concerns involving refunding and interests should be analyzed. Moreover, most of the surveyed experts showed that the organized civil society, e.g. the Hotel Association in Leh, could potentially provide extra funds to the water sector.

An additional example comes from Karachi. There, the OPP scheme engaged residents of the Orangi neighborhood to invest on their own infrastructure. This initiative raised funds to construct household latrines and secondary pipelines in all streets of the neighborhood. Depending on the degree of local engagement, this approach can be replicated in Leh town by giving autonomy to villages and neighborhoods.

Furthermore, Lisbon experience includes a time-based peer to peer scheme not yet explored by any water sector. However, this approach could gather enough volunteers to help in urgent needs. Thus, in case of a lack of revenue, exploring this initiative might help Leh town adapt to changes.

Although promising, all these alternatives demand a high level of governance and institutional structures. Therefore, if water conservation is the main goal, an administrative reform might be required.

10) Reorganize institutional structures and define clear responsibilities:

The current institutional structure in Leh town does not define clear responsibilities in the water sector. In addition, the PHE department accumulates functions that overlap with the MCL. However, both do not have enough budget nor technical and administrative body to fulfill their responsibilities. Therefore, the following strategies can be adopted to improve their water management.

The return of experiences shows that in Shimla the first measure was to the operation, maintenance and billing responsibilities to a new utility. They decided that a Public Private Partnership (PPP) was the best solution for their case. On the occasion, the state government and the municipal council became responsible to define main goals, regulate and monitor the utility. This scheme describes a bilateral approach. In addition, users in Shimla have a clear idea of their responsibilities. Educational campaigns, willing to pay surveys and participative management strategies raised users' awareness and allowed them to share their opinion about water tariffs. Therefore, their awareness enhanced the likelihood of collaboration and payment for water services.

11) Annual/Bi-annual Water Auditing Exercise:

For any system, verification and auditing is very essential in order to ensure proper workings of its network. Verification confirms if the water quality targets are being met and maintained. Auditing helps in generate accurate data and increases understanding of the system while maintaining documents for future records.

Verification involves three activities which are undertaken together to provide evidence that the WSP is effectively working:

1. COMPLIANCE MONITORING
2. INTERNAL AND EXTERNAL AUDITING OF OPERATIONAL ACTIVITIES
3. CONSUMER SATISFACTION

These three activities build the assertion if the upgrade plan needs to be revised or not. Procedures of the WSP are kept clearly documented so that the operating staff would know "what actions" are to be taken, when they are under different operational conditions.

CONDITION	ACTION
Normal Condition	Standard Operating Procedures
Incident Condition	Corrective Action
Emergency Situation	Emergency Operating Procedures

Each action has defined roles and protocols prepared by a professional candidate.

Further, Supporting programs are activities that support the development of people's skills and knowledge, commitment to the WSP approach, and capacity to manage systems to deliver safe drinking water. For an effective WSP, there are different types and forms of supporting programs needed.


WESTERN





LEDeG's WatSan team members with PHE Leh officials during a WSP Stakeholder Meeting

Vision of a way forward:

Leh Vision 2030; envisions the following changes in the town with respect to Potable Water:

1. All water resources are used responsibly and protected from pollution. Water Security is assured for future generations.
2. Everyone in Leh receives potable water of adequate quantity and desired quality through Functional Household Tap Connections, 24-hours a day, to meet all health, hygiene and commercial requirements.
3. Water tariffs are affordable to all sections of the society and charged based on quantity of water used, such that total tariffs exceed the total cost of supplying water.

In order to achieve this vision, the following strategies are essential:

Strategy 1: Improve understanding of local natural water systems

Strategy 2: Create a structure and management plan to run potable water service and waste water management service in a sustainable and responsible manner – an integrated approach

Strategy 3: Expand and improve the piped water system to reach all users and improve service levels

Leh Vision 2030; envisions the following changes in the town with respect to Waste Water Management and Sanitation:

1. 100% of wastewater is collected and properly treated
2. Maximum treated Waste water reclamation and nutrient recovery
3. Full operation and maintenance costs of the sewer and FSM systems is recovered through user tariffs.

In order to achieve this vision, the following strategies are essential:

Strategy 1: Create a proper institutional structure for managing wastewater

Strategy 2: Use de-centralized STPs and FSSM to effectively cover all areas

Strategy 3: Treated wastewater should be re-used productively

Strategy 4: Regular Behavior change, Awareness and Training Programs

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