Issues and Challenges of Small-Town Water Supply and Distribution: A Case Study of Leh Town in UT Ladakh

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Abstract Leh-Ladakh is one of the most sought-after tourist destinations in the country. The annual tourist arrivals have ever increased in Leh town without appropriate and necessary urban infrastructure evolving such as water supply and sewage system. This paper aims to highlight certain water issues such as availability, accessibility, and vulnerabilities in Leh town. The town depends on two sources for all its freshwater requirements, glacial melt water and groundwater. Glacier-melt water comes in the form of springs and surface runoff such as streams. Both Public and Private borewells are dug across the town so that the extraction of groundwater becomes easier and over the years it has become economically more viable for the locals. Leh Town has three spring sources and several major tube wells operated by the Public Health and Engineering Department (PHE), which oversees providing drinking water to the town. These sources and their Service Reservoirs (SR), where water is stored before releasing it into the distribution pipes, presently have the capacity of supplying 6.07 MLD in Leh Town, assuming all service reservoirs are functioning at maximum capacity (PHE, 2018). This maximum capacity of water supply is, however, less than the total water demand which stands at 7.5 MLD according to calculations done using population projection data of Leh Town of the year 2018. Further, this demand fluctuates when you consider the large amount of floating population which consists of tourists, service sector employees, migrant labourers, local migrants from other parts of Ladakh, and the defense forces. With regards to the quality of water, groundwater is getting more polluted due to anthropogenic reasons, mainly due to seepage from soak pits. This issue is especially highlighted in the wards of the town where clusters of hotels and guesthouses are close together and hence causes greater pollution of the groundwater. According to the PHE department, a private piped connection of water is presently being given at

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a flat rate of INR 2400 per annum for both commercial and household use. However, a very small percentage of these customers pay their tariffs (as per PHE) making the PHE supply water almost free of cost. This practice has led to the department having a poor CAPEX. Thus, an appropriate water pricing mechanism needs to be introduced to control water consumption and pollution.

Keywords Ladakh · Leh Town · Developmental challenges · Water · Sanitation · Groundwater · Glaciers · Tourism · Unplanned rapid urbanization

1 Introduction

Nestled in the high ranges of the Himalayas, at an altitude of above 3,500 m, the Himalayan region of Ladakh was recently declared as a separate Union Territory (UT) of India, bifurcating it from the erstwhile state of Jammu and Kashmir. UT Ladakh has two districts, Leh and Kargil. Leh town in Leh district is also the capital of the UT. The entire region is sparsely populated due to its harsh terrain and semi-arid climatic conditions and is often termed a 'cold desert.' There are no monsoons as the district is in the rain shadow region between the Karakoram and upper Himalayas and barely receives rainfall of 60–100 mm per annum. Traditionally precipitation takes place mostly in the form of snowfall in winters; however, changes in precipitation patterns can be observed where the number of rainy days in a year is increasing and snowfall in winters is decreasing.

Ladakh has traditionally been an agro-pastoral community. Subsistence food farming is still largely prevalent in the villages. Sustainable toilet practices such as the use of dry toilets in a 'cold desert' have helped negate the scarcity of water for centuries and the use of dry manure from these dry toilets has led to the traditional food being completely organic. Today, things have changed. Leh-Ladakh is one of the most sought-after tourist destinations in India and as such, the footfall of tourist in the region has increased at a great pace, especially in the last decade, bringing in unprecedented levels of economic development along with developmental challenges. Most of the residents of Leh town no longer practice agriculture and subsistence farming and instead have shifted to tourism-related businesses. Leh has become a service sector economy. This has led to many changes in the lives of the people, traditions, and systems. Agricultural fields have given way to big hotels, guest houses, commercial buildings, restaurants and cafes, etc. The age-old tradition of managing water through the 'Churpon System' (Chu = water, Spon = manager) where individuals/families were given charge of distributing water among all residents has completely vanished from the town.

The increasing number of tourists every year along with migration from other parts of India for work and local migration within Ladakh have rendered Leh town fall short of appropriate urban infrastructure including water supply and a proper wastewater disposal system. Leh Town has been dependent on glacier-melt water and groundwater for all its freshwater needs. Glacial-melt water in the form of streams and

springs has been the major source of fresh water for all domestic and agricultural purposes [1]. Today, however, groundwater is being extracted to meet the water demand of the town, which has increased over the years mainly due to tourism-related activities.

The quality of potable water in Leh has also come up as a major concern in the past decade as people are realizing that without proper wastewater disposal, their groundwater is getting polluted. Historically, water from springs and streams in Leh town was safe for consumption, as it still is in far remote villages and valleys of Ladakh. Within Leh town, however, these sources are now contaminated to drink directly from.

Hundreds of hotels and guest houses now provide western flush toilets and bathrooms which consume large amounts of water. It is to be noted that not all hotels or guest houses in Leh town have sceptic tanks; on the contrary, most of the hotels and guesthouses, especially the old ones, do not have sceptic tanks but rather soak pits. There seems to exist a confusion among the locals as to what exactly is the difference between a septic tank and a soak pit. They may think that they have a septic tank in use, but it often turns out to be a soak pit further complicating the issue of quality of water due to seepage of black and grey wastewater.

At present, there is no formal record of the exact number of private borewells in Leh and the exact volume of groundwater extracted. Without this information, any groundwater research of the town would be incomplete. The PHE department along with the Municipal Committee Leh is yet to collect data to quantify all existing private borewells in the town and develop a registration and permit system to control the number of borewells and groundwater extraction. The Municipal Committee has tried getting the official numbers from all different boring companies, and as of now, they have a record of around 700–800 new borewells in Leh. This is not the complete list as some of the old boring companies that have been digging over the last two decades are no longer operational and as such this data does not exist. Ladakh Ecological Development Group (LEDeG), which is one of the oldest NGOs in Ladakh, puts this number at around 1500–2500 borewells in Leh town.

This paper seeks to shed light on the drinking water issues of Leh town, water availability, accessibility, vulnerabilities, and appropriate policy approaches towards sustainable management of drinking water. The paper first outlines the research methods employed in this research. It then estimates water supply and demand in Leh Town. The paper also investigates the current water pricing policy in Leh Town as per PHE and suggests improved water pricing techniques to enhance PHE departments CAPEX.

2 Research Methods

Being a local of Leh town, the author conducted a preliminary round of household surveys in April 2018, after a detailed literature review. The household survey questionnaire was designed to gather information and views on potable water in Leh town,

issues including the source of water for domestic uses, and their perception of water quality and water pricing. In addition, semi-structured interviews were conducted in February 2019 with key stakeholders from various organizations. These include engineers from the PHE department Leh, The President of All Ladakh Tour Operators Association (ALTOA), and representatives from Ladakh Ecological Development Group (LEDeG). Semi-structured interviews were also conducted with residents in three wards of Leh Town namely Tukcha, Changspa, and Skampari.

Tukcha and Changspa are considered among the 'green' wards of the town with agricultural fields, trees, hotels, and cafes, whereas Skampari is an upcoming residential area on the side of a hill within the town with virtually no green fields, trees, etc. due to its elevation.

This research also makes use of survey data collected by LEDeG. In October–November 2017, LEDeG in partnership with the Technical University of Munich, Germany (TUM), conducted a survey in the town entitled '*Keeping natural water sources safe and available in Leh: Urban nexus project for water reclamation and reuse pilot project development*'. This study was designed to get an understanding of water supply, demand, quality, and issues in Leh Town under their larger study [2].

Leh Town encompasses a surface area of about 19 km^2 with an estimated local population of 30,870 (Census, 2011). Thus, the population density of Leh Town is about 1,625 persons per km^2 whereas the population density of Leh District is around 3 persons per km^2 [3]. Further, *Leh Town receives a massive floating population, especially in the five summer months (May-Sept) which consists of tourists, service sector employees, and migrant labourers from different states of India, as well as local migrants from other parts of Ladakh who come to Leh town in search of better livelihood opportunities, education,* etc. *as well as the Indian Army* [4].

There are only two sources of freshwater that cater to all the agricultural, industrial, commercial, and domestic needs of the town: that is glacier-melt water and groundwater. There is a lack of data and literature when it comes to Leh's glacier study. The information available is mainly on large glaciers or as a collective study of all the glaciers in the region but nothing specific to the Khardungla glacier that directly feeds the town. '*Despite the hydrological importance of glaciers for the adjoining lowlands, data on the glaciers of the Himalaya, Karakorum, and Hindu Kush ranges are sparse and inconsistent. There is a lack of long-term series and field investigations, especially for glaciers at higher altitudes*' [5, 6].

However, local NGOs such as *Ladakh Environment and Health Organisation* (LEHO) claim that the *Khadungla glacier has presently become a small version of its former past use to be a permanent glacier several decades ago* [7]. Similarly, locals are of the opinion that water shortages are becoming more common than ever before, especially during the spring season when water is needed most.

The PHE has three spring sources from which they provide water to the town, namely Gyalung Spring, Gyamtsa Spring, and T-Trench (PHE, 2019). Approximately 0.8 L of water from these springs are delivered to the residents through piped private connections and public stand posts (PSPs) [8]. The second source of freshwater is groundwater. The PHE department operates 6 tube wells distributed across the town;

out of these, the Indus Bank Lift station is the major source accounting for almost 33% of the water supplied to the town. About 1.3 million litres of water are extracted from these tube wells and distributed in Leh Town.

In order to meet their water demands, locals who can afford to do so have dug private borewells for both domestic and commercial usage. These private borewells extract groundwater from the shallow aquifer underlying Leh town, which is fed by glacial melt water and precipitation. *It was estimated that about 1 million litres of groundwater per day is being extracted in the tourist season* [8].

LEDeG estimates over 50% of all hotels and guest houses in Leh town use private borewells as their main source of water and are extracting more than 1.5 million litres of groundwater daily. *Even though the construction of a borewell actually requires permission, the groundwater extraction itself is not regulated and the total number of borewells, rates of extraction, and groundwater aquifer levels are currently not known* [9]. *Inhabitants of Leh believe that the drying of many springs might be related to the severe exploitation of the shallow groundwater and so far, no strategy exists to tackle the water demand issues in Leh Town* [9].

Presently, there are no regulations or policies that govern the usage and management of groundwater in the town.

3 Results and Discussion

3.1 Estimation of Water Supply and Demand in Leh Town

In order to calculate the total supply of water in Leh, the capacities of the service reservoirs were calculated based on the information provided by engineers of the PHE department. Assuming that the service reservoirs are functioning at maximum capacity, the total supply of water in Leh stands at 6.1 Million Litres Per Day (MLD) in summer and 2.3 MLD in winter, as presented in Table 1.

The total demand for water in Leh Town can be estimated against its projected population and water consumption per capita per day. The population fluctuates in Leh town by season because of tourist numbers and seasonal local migrants. According to the recommendations provided by the Central Public Health and Environmental Engineering Organization (CPHEEO) under the Ministry of Housing and Urban Affairs, if a town has piped water supply but no sewerage system then the max water supply should be considered at 70 L per capita per day (LPCD). Similarly in a town/city which has piped water supply as well as an existing sewerage system

Table 1 Estimate of water supply based on the seasonal operation of service reservoirs

Season	No. of service reservoirs in operation	Total capacity
Summer	14	6,137,100
Winter	6	2,273,000

Table 2 Estimation of water demand for local population in Leh Town as per CPHEEO norms

Season	Population scenario	Water demand scenario (litre per capita per day)	Total demand (litre)
Summer	60,000	70	4,200,000
Winter	40,000	70	2,800,000
Summer	60,000	135	7,800,000
Winter	40,000	135	5,200,000

or contemplating to get one, then the recommended water supply is 135 LPCD with 15% unaccounted for water. Leh presently has partial coverage of the newly built sewerage system. Therefore, calculations of water demand under both 70 LPCD and 135 LPCD are presented in Table 2.

On the other hand, water demand estimates of the town by LEDeG (Liveable Leh Project) are given in a different manner. According to the Livable Leh Project, water demand is calculated for the town based on different LPCD requirements among the locals (summer = 75l pcd, winters = 60l pcd), tourists (summers = 100l pcd, winters = 80l pcd), and the migrant workers (summers = 30l pcd and winters = 0, as there are no migrant labourers in winters.) This results in the summer demand of the town to be at 5.1MLD and the winter demand at 1.9 MLD.

3.2 Water Demand Estimates with Tourist Population Data for 2018 for All months

Month wise tourist data for the year 2018 was taken from the Department of Tourism, Leh, and is given in Table 3 below and the water demand for each month of 2018 was calculated. It is widely acknowledged that the summer months in Leh span from May to September hence for these 5 months, the local population was assumed at 42,680 which is the population as calculated by the PHE for the base year 2012 for their *water supply reorganisation project*. Similarly, for the winter months October–March, local population of 37,282 was assumed as per PHE estimations.

Assuming consumption at 135 LPCD + 15% unaccounted for water, and adding the tourist population given in Table 3, to the local population according to PHE (Summer at 42,680 and winter at 37,282), the following are the water demand estimates in Leh for all the months of 2018:

Months	Demand (in MLD)
January	6.6
February	5.9
March	5.9

(continued)

(continued)

Months	Demand (in MLD)
April	7.5
May	13.5
June	18.5
July	17.5
August	14.9
September	12.5
October	9.0
November	6.1
December	5.9

As we can see from the table above, these figures present a picture of the actual water demand in Leh when we consider real tourist figures. It must be noted here that the present total supply assuming that all the S/Rs work on maximum capacity in Leh is **6.1 MLD.** This is enough to meet the water demand of only three months, i.e. February, March, and December when the demand is **5.9 MLD.** For all the other months, the demand is estimated to be way higher than supply, especially for the summer months where the demand reaches as high as **18.5 MLD** in June. Thus, there is a clear gap between supply and demand of water in the town. The widest being in the month of June where there is a gap of **12.4 MLD.** However, these calculations are simply an approximation where demand is calculated at 135 LPCD consumption as well as assuming SRs working at maximum capacity; however, some of the SRs are not operational, especially in the winter months. Likewise, not all residents of the town consume water at 135 LPCD; as mentioned earlier, the literature points to the practice of less water use on the part of the locals. This lifestyle, however, is changing with new trends, increased sense of hygiene, and an overall shift towards modern/western water consuming lifestyle, thanks to the growth in the tourism industry.

Therefore, it is safe to assume here that the remaining water demand is being met through the extensive use of borewells and through informal water markets/suppliers.

3.3 Quality of Water in Leh Town

Traditionally Ladakhi toilets are dry toilets, but as tourism took up pace since 1974 people started building western/Indian styled toilets. Today, almost all houses/hotels/guest houses in the town have either only western toilet or a combination of both western and Ladakhi dry toilets. The problem here lies in the fact that people only used soak pits (dug in the grounds) for their toilet discharge and sceptic tanks are relatively new. In a survey carried out by the Ladakh Ecological Developmental Group (LEDeG) on the quality of groundwater in the town, about 64% of the specimen

Table 3 Month wise tourist influx 2018). (*Source* Tourism Department, UT Ladakh

Month	Tourists
January	5665
February	1136
March	1298
April	11,277
May	44,583
June	77,041
July	70,139
August	53,621
September	38,049
October	20,784
November	2416
December	1357
Total	3,27,366

collected from different areas of the town were found to have high levels of nitrate and E. Coli [10] (LEDeG, 2018).

In 2020, water samples from different reservoirs operated by PHE were sent for laboratory analysis to New Delhi and it confirmed the presence of E. Coli and Nitrate in some of them. This report has been submitted to PHE department and is available at LEDeG office library in Leh. (Water Audit Report, Liveable Leh-BORDA, Indian Institute of Sustainable Development, 2020).

3.4 Water Pricing in Leh Town

Currently, PHE provides water connection at a flat rate of Rs. 2400 per annum for both commercial and household use. This clearly is a major issue as a small household in the town does not consume water anywhere as much as a big hotel or guesthouse. Various public stand posts (taps) across the town provide free water. The PHE dept. also operates water tankers and provides this service to residents living in areas where piped connections haven't reached (due to geographical reasons or freezing of pipes in winters). Hence, compared to other residents of the town, such wards of the town (Skampari for example) face extra difficulties, especially during winters when even storing water becomes a challenge. Due to the shortcomings in water supply, especially during winters, there is a thriving informal market of water in the town. There are no water meters in Leh for households or for commercial establishments and as such people often consume more water than needed. According to PHE representatives, most households with PHE piped connection don't even pay their annual charge and therefore operation and maintenance becomes difficult for the department.

For religious places, schools, hospitals and other public institutions, etc., the PHE provides water for free.

Price of water provided by PHE		
Private connection domestic and commercial	PSPs	Water tanker service
Rs. 2400/annum	Free	Free
In reality as claimed by the PHE, 90% of the people don't pay and thus water to the town is being supplied for free	Only 150 PSPs work in winters and depending on where you live in the town the degree of dependence would change	The frequency of water tanker service has been brought down as the new connections are being laid. Having a new connection however does not guarantee water supply

Regarding the 'informal sources of water', the following is the analysis of the information provided by one of the persons that runs the informal Van Water service. They charge Rs. 450 per trip where they fit 13 cans of 15 L each, i.e. 195 L for Rs. 450. As claimed by the person, usually commercial establishments order three such trips, whereas households tend to order just one trip. Their customers include hotels, guest houses, restaurants as well as households. Even though their business tends to become more visible during winters, they are most busy during summers running water services at night to avoid traffic. At the time of this interaction, the person claimed he had 10 hotels/guest houses that he provides water to and that this number shoots up in summers.

4 Concluding Remarks

- PHE department is still in process of covering all households of the town with functional household tap connections. Providing water meters for each of these households would prove to be a good measure to reduce demand and recover water tariffs based on usage, as have been proven in many cities across India.
- The same is true of the centralized sewerage system which does not cover the entire town and is a major challenge for Leh where different wards of the town have different geographical challenges. India's first PPP model Faecal Sludge Treatment Plant (FSTP) has been built in Leh since 2018 to aid the STP. Decentralized sewerage treatment facilities can provide better service in Leh compared to one centralized unit.
- Under the Liveable Leh Project, multiple reports have been prepared (by the author) after extensive research and collaborative efforts between PHE Dept., LEDeG, LAHDC, BORDA, Technical University of Munich, Indian Institute of Sustainable Development, etc. These are Water Audit reports, Water Strategy reports, Water Safety Plan as per International Water Association standards, Integrated Urban Water Management Plans, Water-Energy-Food nexus reports, etc.

and have been submitted to the PHE department as actionable policies with short-term, mid-term, and long-term focus. It is now up to the Administration of UT Ladakh and PHE department to consider them seriously and implement the ones that they agree as feasible.

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BORDA is one of the funding agencies for the Liveable Leh project and is also revolutionizing wastewater management in Leh town by building India's first PPP model Faecal Sludge Treatment Plant and piloting other innovative solutions in the town.

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Ladakh Autonomous Hill Development Council (LAHDC).

References

1. Dolma K, Rishi MS, Lata R (2013) An appraisal of centralized waste water treatment plant with respect to Leh Town 4
2. Gondhalekar D, Drewes JE, Grambow M (2018) Risk and water management under climate change: towards the Nexus City. In: Wilderer PA, Renn O, Grambow M, Molls M, Mainzer K (eds) Sustainable risk management. Springer International Publishing, Cham, pp 85–101
3. District at a Glance | District Leh, Union Territory of Ladakh | India, https://leh.nic.in/about-district/ataglance/
4. Akhtar A (2010) Tourism and water resources in Leh Town (NW-India): aAnalysis from a political ecology perspective. University Heidelberg. Heidelb Ger
5. Armstrong RL (2010) The glaciers of the Hindu Kush-Himalayan region: a summary of the science regarding glacier melt/retreat in the Himalayan, Hindu Kush, Karakoram, Pamir, and Tien Shan mountain ranges. Glaciers Hindu Kush-Himal. Reg. Summ. Sci. Glacier Meltretreat Himal. Hindu Kush Karakoram Pamir Tien Shan Mt. Ranges
6. Schmidt S, Nüsser M (2012) Changes of high altitude glaciers from 1969 to 2010 in the trans-Himalayan Kang Yatze Massif, Ladakh. Northwest India. Arct Antarct Alp Res 44:107–121. https://doi.org/10.1657/1938-4246-44.1.107
7. Deen M (2009) Role of LEHO in managing water resources of LehAmruta Sudhalkar
8. Gondhalekar D, Nussbaum S, Akhtar A, Kebschull J (2015) Planning under uncertainty: climate change, water scarcity and health issues in Leh Town, Ladakh, India. In: Leal Filho W, Sümer V (eds) Sustainable Water Use and Management: Examples of New Approaches and Perspectives. Springer International Publishing, Cham, pp 293–312
9. Gondhalekar DD, Kebschull J, To centralize or not to centralize
10. Schwaller C (2018) Assessment of the impact of on-site sanitation systems on groundwater quality in Leh Town, India