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RESEARCH ARTICLE

WATER SECURITY: ASSESSING WATER RESOURCES AND BACKUP STRATEGIES FOR THE LEAN PERIOD IN DARJEELING MUNICIPALITY, INDIA

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ABSTRACT

Darjeeling Municipality, located in the Easter Himalayas is facing a growing water crisis despite receiving and annual rainfall of 2812 mm. The steep terrain, ageing water infrastructure, growing population and seasonal variation in water availability have intensified the challenges of securing sufficient water supplies mainly during the lean season. The qualitative methodological study explores the present status of water resources and examines backup initiatives implemented to address seasonal water scarcity. Through the field survey, interviews and municipal data, the research highlights critical limitation in the system, such as inadequate storage, leakage and dependency on ecologically sensitive zones. The study also evaluates alternative water sources and infrastructure initiatives including the Sindhap Lake, Rambi Catchment, Balasun River Project and the AMRUT scheme. These project provide crucial support, they often face operational, structural and administrative challenges that limit their full potential. The findings underline the urgent need for integrated water resource management, improved governance and adaptive infrastructure to ensure long term water security in Darjeeling Municipality

KEYWORDS

water security, urban water scarcity, water management, backup strategies, Darjeeling Municipality

1. Introduction

Water security has emerged as a global concern of the 21st century, particularly as urbanisation, climate change, and population growth continue to escalate the demand for water resources. Water security is the accessibility and reliability of water for production, ecosystems, livelihoods, and health, as well as a manageable level of hazards associated with water for people, economies, and habitats (UN Water, 2013). This concept underscores the need not only for access to water but for sustained, equitable, and resilient systems that can adapt to changing environmental and socio-economic conditions.

Despite having about 16% of the world's population, India only has 4% of its freshwater resources, despite having abundant water resources (Bhat, 2014). A concerning transition from water abundance to scarcity has been marked by the dramatic drop in per capita water availability over the last few decades, from 5,177 m^3/year in 1951 to roughly 1,486 m^3/year in 2021 (MoWR, 2021). These figures demonstrate the increasing need to reconsider water management in terms of a more complete approach of water security rather than just supply availability.

Darjeeling experiences continuous water shortages despite having a high annual rainfall, particularly during the lean season from October to May. The city's topographical constraints, reliance on spring-fed systems, aged infrastructure, and increasing population (resident and floating) strain its limited water resources (Water Works Department, 2010). Seasonal variability and a lack of adequate storage capacity result in overflows during monsoons and acute shortages in dry months. This imbalance undermines the stability of the municipal water supply system.

The water supply infrastructure of the Central Business District (CBD) was initially designed in the 19th century to serve a small British-era sanatorium. Today, that infrastructure struggles to support a vastly larger and more dynamic population. Official estimates suggest that while the daily water requirement is approximately 1.97 million gallons, actual supply during the lean season often falls short by nearly 30–40% (Water Works Department, 2023). The situation becomes even more critical when factoring in the city's floating population, which surges during peak tourist seasons. The water shortage in the city, exacerbates public to depend on private water vendors, private springs, and hand cart pullers, which sell water at higher rate. This study reveals water security by examining the seasonal dynamics of water availability in Darjeeling and the initiatives taken by the municipality and higher government authorities to overcome the water stress of the city, mainly during the lean period.

2. Study Area

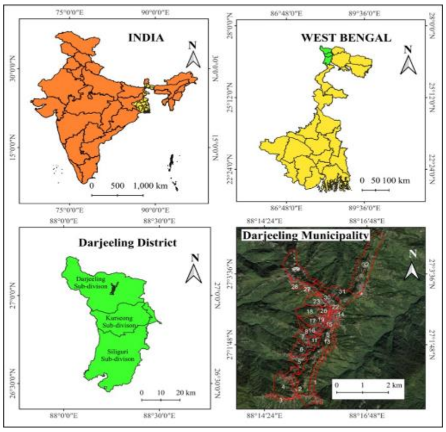

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Figure 1: Location Map of Study Area

The Darjeeling Municipality region lies within an extension of 26°31' N to 27°13' N and 87°59' E to 88°53' E (Dash, 1947). It is located at an average elevation of 6,982 ft. (2,128 m) with an area of 10.6 sq. km in the Himalayan region of Darjeeling-Jalapahar ridge that originates from the south of Ghum. The ridge is formed in a Y-shape, with the base resting at Katakpahar and Jalapahar and two arms diverging north of Observatory Hill. The north-east arm dips abruptly and terminates at the Lebong spur, while the north-west arm travels through North Point and ends in the valley near Tukver Tea Estate (E.C. Dozey, 1835).

The Darjeeling-Jalapahar ridge was originally under the Raja of Sikkim, which was later occupied by the Bhutanese and later by the Gurkhas. The Gurkhas invaded Sikkim in 1780 and annexed the Terai region. Simultaneously, there was a war between the East India Company and the Nepalese, which ended with the signing of the Treaty of Titaliya in 1817. The East India Company, which had taken the territory, agreed to return it to the Raja of Sikkim. This helped to maintain Sikkim as an independent state acting as a buffer between Nepal and Bhutan. A decade later, disputes along the Sikkim-Nepal border arose and were brought to the attention of the Governor General. In 1828, Captain Lloyd and Mr. Grant were appointed to address the dispute. In February 1829, Lloyd spent six days in what is known as the “Old Gurkha Station of Darjeeling” and recognized its potential as a site for a sanatorium due to its geographical location and cool climatic condition. Mr. Grant informed Governor General Lord William Bentinck about the benefit of establishing a sanatorium in Darjeeling and recommended it for military use, in order to have access to Nepal. The Court of Directors later approved the project. General Lloyd (formerly Captain Lloyd) was instructed to negotiate with the Raja, which happened when he was investigating as incursion from Nepal. He successfully obtained a grant from the Raja of Sikkim on 1st February 1835. In 1839, Dr. Campbell was appointed as Superintendent. He supervised the region's administration, political relations, and the establishment of a sanatorium for troops. Dr. Campbell also directed the construction of 70 European dwellings, a market, a jail, medical facilities in the depot, and a modest judicial administration system. The water supply system was designed with an estimated population of 10,000 in the sanatorium. These efforts culminated in the creation of the Darjeeling Municipality on July 1, 1850.Since late 20th Century, the Darjeeling city has developed as an important tourist destination due to its colonial historical background (e.g. UNESCO world heritage site Darjeeling Himalayan Railway), scenic beauty (Kanchenjunga, Tiger Hill, Tea plantation, etc.) and pleasant weather (14.9 °C to 8.9 °C). However, despite being in an area with an excess rainfall of 2812 mm per annually problems with managing water resources have surfaced in the last 20 years in supplying sufficient water for residents and visitors (Water Works Department, 2011; Lepcha I.L, 2024).

2.1 Water Supply and Scarcity in Darjeeling Municipality

The water supply infrastructure of Darjeeling Municipality is complex and ageing, further challenged by the steep terrain and limited natural sources. The system predominantly relies on 26 natural springs. However, only 23 springs are currently operating and during the dry season, the number sharply drops to only 7. These springs are located within the ecologically sensitive Senchal Forest and Wildlife Sanctuary, which is approximately 15 kilometres from the city. The water from these springs are first collected in an arrestor tank and then conveyed to North Senchal Lake and South Senchal Lake via an open conduit spanning 8 kilometres.

These lakes have a combined storage capacity of 33 million gallons, with North Senchal Lake holding 20 million gallons and South Senchal Lake accommodating 13 million gallons. Despite this substantial capacity, the absence of adequate storage infrastructure often results in overflow during the monsoon season (June to September). The collected water is treated at the Jorebunglow Filter House and channelled to two major distribution tanks- St. Paul Tank with a capacity of 2,35,812 gallons and Rock Ville Tank with 56,651 gallons. Each of these tanks supports 19 distribution mains that extend the supply to subsidiary tanks across various wards in the city.

As of 2021, Darjeeling Municipality maintains 2,689 water connections, catering 2,145 domestic connections, 144 commercial connections and 400 public hydrant connections (Water Works Department, 2021). The WHO recommendation, the water requirement is 15.5 gallons per person per day, based on which the city daily water requirement is estimated approximately 1,970,000 gallons (Darjeeling Municipality Report, 2011). With a resident population of 1,18,805 and an average floating population of 4,56,045 the city’s water demand consistently exceeds available supply (Census of India, 2011;Department of Tourism, 2024). This persistent imbalance highlights an ongoing and severe water crisis in Darjeeling Municipality.

3. METHODOLOGY

This study employed a mixed methods approach to access the water resources availability and management challenges in Darjeeling Municipality. Primary data were collected using three key methods: structure interviews, questionnaires and Key Informant Interviews (KIIs). The interview method water used to collect in-depth qualitative insights from residents across different wards of the municipality. Questionnaires were distributed among a representative sample of households to collect quantitative data on water access, usage patterns and public perception on supply reliability. Additionally, Key Informant Interviews (KIIs) were conducted with municipal officials, water works engineers, and local stakeholders involved in water governance to obtain expert insights on system performance, infrastructural constraints and policy response. This triangulation of data collection techniques ensured a comprehensive understanding of both community-level experience and institutional perspectives regarding water scarcity and lean period backup strategies.

3.1 Water Security and Backup strategies for Lean Period

Water security is an increasingly critical concern for urban settlements situated in ecologically fragile and topographically challenging regions. Darjeeling Municipality nested in the Eastern Himalayas, is grappling with chronic water scarcity particularly during the lean period. The primary water supply system in Darjeeling is heavily dependent on a limited number of natural springs located in Senchal Forest and Wildlife Sanctuary. However, this system has proven inadequate in meeting the increasing demand of both residents and a substantial floating population, which significantly increases during the peak tourist seasons. To support the city’s water supply and cope up with the growing demand of water, the Darjeeling Municipality has constructed has implement some major projects in collaboration with the state and the central governments.

3.1.1 Sindhap Lake

The growing pressure on existing water sources led the Government of West Bengal to initiate the construction of an additional reservoir Sindhap Lake under the supervision of the Public Health Engineering (PHE) Department. The lake was completed in 1980, designed to help 15 million gallons of water (Plate 1). However, since its commissioning the lake has struggled to perform at full capacity. Structural deficiencies, poor reservoir quality and persistent leakage issues have prevented Sindhap Lake from meeting its intended storage goals, especially during the dry months from November to May. As of the latest reports, the reservoir holds only about 50 percent of its original designed capacity (Darjeeling Municipality Report, 2011).

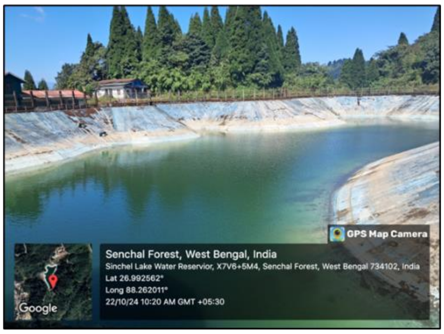

Plate 1: Sindhap Lake

Sindhap Lake receives its inflow primarily from two sources, Bangla Khola and Khong Khola (Plate 2) as well as perennial springs situated near the lake (Koner, 2019). During the lean season, it plays a supplementary role by contributing additional water to the North and South Senchal Lake, which remains the core component of Darjeeling’s water supply system.

Plate 2: Water source of Sindhap Lake

3.1.2 Rambi Catchment Area

In addition to the three primary reservoirs located in the Senchal catchment area, the Public Health Engineering (PHE) Department and Darjeeling Municipality have implemented several supplementary water supply initiatives to address the growing water demand in the region. One of the most significant of these is the utilization of the Rambi catchment areas. The first water supply scheme from Rambi was initiated by the PHE Department between 1969 and 1972. However, due to its limited effectiveness, the Darjeeling Municipality lunched a second phase under the name "Darjeeling Water Support Improvement Scheme", which was later taken over by the PHE in 1993 (Rasaily, 2014).

The Rambi Catchment has become a vital alternative source, particularly during the dry season. It comprises the Rambi Khola, Kali Khola and eleven additional perennial springs (Darjeeling Municipality, 2011). Water of these sources is collected and transported through a 10 kilometre iron conduit line to the Jorebunglow Filter House. The Rambi catchment currently provides an estimated 1,50,000 gallons of water daily. During peak water scarcity, especially in the dry months, additional water is transported by tanker and truck to support urban demand.

Despite its significance, the system's performance has limited. While the estimated potential of the Rambi system is approximately two lake gallons per day, actual daily output often fluctuates between 70,000 and 80,000 gallons. Moreover, water distribution is shared with the Army cantonment area, which receives about 60 percent of Rambi's supply, leaving only 40 percent of civilian use within the municipal (Ghatani, 2015). Nevertheless, the Rambi watershed remains a critical support system for Darjeeling's water supply, especially during the lean season.

3.1.3 Balasun River Project

In response to the persistent water shortage, Darjeeling Municipality, in coordination with the Public Health Engineering Department, the Government of West Bengal and the Central Government of India, has undertaken multiple initiatives to enhance water availability. The Balasun River Project stands out as a major intervention aimed at supplementing the existing water supply system. Despite the municipality's ongoing efforts, the overall water demand continues to outpace supply, highlight the challenges of ensuring water security in the urban area.

The Balasun River Project, located 13 kilometres away from the Senchal Lakes, was conceived as a large scare surface water supply scheme. With an estimated cost of Rs. 55.86 crore, it is one of the highest-budget water infrastructure project in the region, funded by the Government of West Bengal (Plate 3). The foundation stone for the project was laid on 19th February 2006 by then Chief Minister Buddhadeb Bhattacharjee. Presently, the project plays a vital role in supplementing the municipal water supply during the dry months (November to May) (Plate 4).

Plate 3 Balasun River

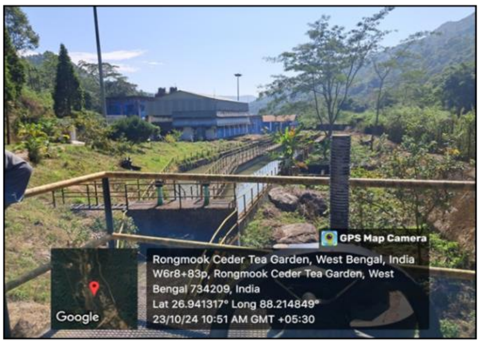

Plate 4: Balasun Intake, Ceder Tea Garden, 2024

The project sources raw water from the Balasun River, near Rongmook Ceder Tea Garden, located at an elevation of 806 metres above mean sea level (PHE, Government of West Bengal, 2014). Water is collected in two stages: in the first stage, water is collected at the Balasun Intake and transmitted through main pipelines at an intermediate station; in the second stage, the water is pumped from the Balasun Intermediate, near Kalej Valley Tea Garden, to the Senchal North and South Lakes. The Balasun River Project is specifically operates during the lean season (November to May), when spring water declines. Once the water reaches the Senchal Lake, it is transported to the Sindhap treatment facilities, where it goes filtration and purification. The treated water is then delivered via mainline pipes passing through the Jalapahar Cantonment to two major storage and distribution points: Rock Ville Tank and St. Paul Tank. This project has significantly enhanced the Darjeeling's water supply during the dry season, although it alone has not resolved the municipality's long-standing water crisis.

3.1.4 Atal Mission for Rejuvenation and Urban Transformation (AMRUT) in Darjeeling Municipality

The Water Supply Project under the Atal Mission for Rejuvenation and Urban Transformation (AMRUT) initiative marks a significant step toward enhancing urban water infrastructure in Darjeeling Municipality. Designed to address the increasing water demand of the city, the project adopts an integrated approach combining multiple surface water sources, modern filtration facilities, expanded pipelines networks and improved services connections to meet current and projected needs through the year 2035.

The projected daily water demand by 2032 is estimated at 6.07 MGD. To meet this target, the AMRUT water supply project was sanctioned with a total budget of Rs. 204.84 crore, funded through the contribution of; 50% by the Government of India, 45% by the Government of West Bengal and 5% by the Urban Local Body (ULB). Project implemented officially began on 21st March, 2018, following a lengthy tendering process that required rounds of bidding. The project sources it water primarily from Senchal North and South Lake. Additional water is draw from the Balasun River Project, which supplies 2 million gallons per day (MGD), and Sindhap Lake, with a capacity of 14 million gallons, both managed by Public Health Engineering Directorate (PHE Dte.) under the Gorkhaland Territorial Administration (GTA).

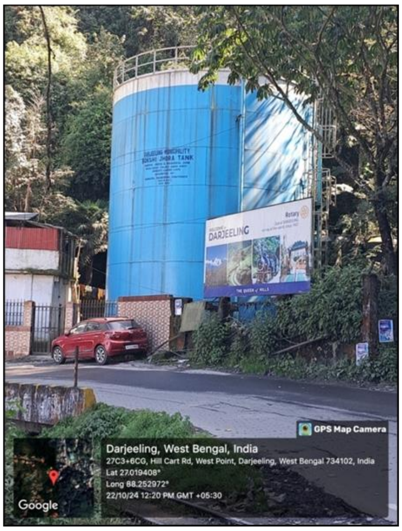

Plate 5: AMRUT Project, Darjeeling

Water from these sources is treated at two major filtration facilities. The Jorebunglow Filter House, operated by Darjeeling Municipality, is equipped with five pressure filter tank each capable of handling 16,000 gallons per hours, yielding a total capacity of 1.80 MGD. The Sindhap Filter House, managed by PHE Dte., includes six pressure filters with a total filtration capacity of 2.00 MGD. Treated water is conveyed through the Balasun pipeline to the St. Paul's and Rock Ville Tanks, which distribute approximately 1.0 MGD to various wards of the municipality.

Significant progress has been made, particularly in terms of physical infrastructure. As of the last update, approximately 97.4 km of Ductile Iron (DI) pipes has been procured. The pipelines installed is divided into two components; the rising main (from source to reservoirs), where 18 km have been laid, and the distribution network (from reservoirs to consumers), with 76km completed. Resulting to 94 km, this accounts for

57% of the planned 165 km network.

The project involves the construction of 23 Ground Level Reservoirs (GLRs). Of these, 20 tanks are currently under various stage of construction. Seventeen GLRs have completed their steel structure installations, while three are at the foundation stages (Plate 25. However, construction of the remaining three reservoirs are Senchal Tank at Tiger Hill Road and two tanks within the Darjeeling Himalayan Zoo compound has been delayed due to the absence of No Objection Certificate (NOCs) from the Forest Department.

Another critical component of the AMRUT project is the household services connections plan, targeting 23,310 connections by 2035. As of 15th March 2022, only 2,300 connections have been established, highlighting the lag in services delivery despite progress in infrastructure. Several challenges have hindered the project's timely completion, most notably delay in inter-departmental coordination and pending clearances. One major obstacle has been obtaining NOCs from the National Highway (NH) Wing of the PWD (Road) Directorate. In parallel, delays in clearance from the Forest Department of West Bengal have further stalled progress. Although communication for approval began as early as 8th December 2016, and some headway was made when rights under the Forest Rights Act (FRA), 2006 were granted on 10th August 2021, final clearance is still awaited. These administrative and procedural bottled necks illustrate the complex nature of executing critical infrastructure projects in ecologically sensitive and bureaucratically layered regions like Darjeeling.

4. Conclusion

The analysis of water resource and backup strategies in Darjeeling Municipality reveals a multidimensional water crisis shaped by fragility, infrastructure limitation and increasing demand pressure. The supplementary/additional water infrastructures such as Sindhap Lake, the Rambi Catchment System and the Balasun River Project have been developed to enhance water availability operational efficiencies including sedimentation, leakage, under-utilization of designed capacity and distribution constraints limit their effectiveness. For instance, Sindhap Lake function at only 50 percent of its designed capacity, and the Rambi system supplies merely 70,000 to 80,000 gallons daily despite a potential of 200,000 gallons, Moreover, the military cantonment receives a disproportionate share of Rambi's output, further reducing public access.

The AMRUT initiatives has made notable progress in augmenting infrastructure with construction of reservoirs, filtration unit and pipe networks; however, delay is obtaining forest and highway clearance have significantly hindered implementation. Only, 2,300 of the targeted 23,310 household connections were achieved as of March 2022, underscoring the disconnection between infrastructure expansion and water supply services.

This study highlights that achieving long-term water security in Darjeeling requires a supply centric approaches to integrate water resource management (IWRM). It necessitates the rejuvenation of springs, water shed protection, improved storage efficiency, equitable distribution mechanisms and active community participation. It is important to incorporate topographical complexity, ecological sensitivity and water planning. Without strategic and evidence based intervention, the municipality will continuously face seasonal water stress.

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