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Sustainable Planning of Water Distribution Network of Vikasnagar, Dehradun

Ritika Sinha[1], Anjali Dangwal[2]

[1]Student of Master's in School of Architecture, Planning & Design, Dev Bhoomi Uttarakhand University, Dehradun
[2]Assistant Professor, School of Architecture, Planning & Design, Dev Bhoomi Uttarakhand University, Dehradun

Abstract
This paper provides a comprehensive overview of the planning process for establishing a distribution network for water supply in Vikasnagar, Dehradun, focusing on the utilization of groundwater sources over surface water sources. It delves into the characteristics of groundwater source, discusses the infrastructure requirements, and addresses the projected water demand for Vikasnagar in the coming decades. Additionally, it highlights the current water scarcity issues faced by Vikasnagar and emphasizes the urgency of implementing sustainable solutions to ensure adequate water supply for the growing population.
The sustainable provision of water in Vikasnagar remains a critical challenge due to the depletion of surface water sources. To address this issue, ongoing research endeavors are exploring the utilization of groundwater as a primary source to meet the region's ultimate water demand.
Preliminary findings suggest the potential viability of groundwater as a dependable water source for Vikasnagar ultimate demand. However, challenges such as groundwater depletion, contamination risks, and socio-economic implications necessitate further investigation and intervention.
In conclusion, ongoing research on groundwater-based water supply in Vikasnagar shows promising prospects for mitigating water scarcity challenges. However, to realize a sustainable water future for the region, concerted efforts must be made to address existing limitations and pave the way for innovative solutions that prioritize both environmental conservation and societal well-being.

Keywords: Planning, distribution network, water supply, groundwater, infrastructure requirements, ultimate demand, groundwater depletion.

1. Introduction

Vikas Nagar is a town and a municipal area in the Dehradun district within the Indian state of Uttarakhand. It is also referred to as Pachawadoon (Western Doon) because it is the second major financial and economic center of the Dehradun district, following the city of Dehradun. Vikas Nagar is renowned for its tea plantations, which export tea to countries in America and Europe.
The town is also noted for its production of Basmati rice and fruits like litchis and dussehri mangoes. Vikas Nagar, along with Herbertpur, serves as the primary market for the Jaunsar Bawar region (including Village Sakani, Khat Shilgaon Tehsil Kalsi).

Key tourist attractions in Vikas Nagar include the Dakpathar Barrage, Katta Pather, Gautam Ashram, and Koti Dam. The nearest hill station is Chakrata, approximately 45 kilometers away by road. Vikas Nagar is also situated near Paonta Sahib and Dehradun.

However, the newly incorporated areas face water supply issues, with distribution being very irregular. Water is typically supplied for 2-3 hours daily, and on some days, there is no supply at all.

2. Literature Review

2.1 Water in India's development context

One of the most essential resources for all living things is water. Even though water is a renewable resource, there are still many places in the globe where there is a severe shortage of good water. Water is necessary for us to create food, maintain cleanliness, produce energy, put out fires, and—above all—to survive. But only 3% of the water on Earth is freshwater; the majority, about 97%, is saltwater. The amount of freshwater that is accessible is roughly two thirds frozen in polar ice caps and glaciers. A small amount of freshwater is present on the ground or in the air, but the majority is found underground.

Among its 1.4 billion inhabitants, 678 million do not have access to clean water. Extreme water stress, contaminated surface water, and restricted access to piped water supplies are the problems of the present. Families in India are also impacted by the consequences of climate change, such as droughts and increasing sea levels, on access to clean water and sanitary facilities.

a. Urban Water Supply Schemes:

The AMRUT stands for Atal Mission for Rejuvenation and Urban Transformation. AMRUT was established in 2015 with the goal of enhancing the standard of living in cities and towns by supplying essential urban infrastructure, such as water supplies. Its goal is to guarantee that every home has access to piped water, along with tap connections.

The Jawaharlal Nehru National Urban Renewal Mission (JNNURM) was a 2005–2014 initiative that upgraded water delivery systems and other city infrastructure in India. It provided funding for initiatives aimed at enhancing water treatment facilities, distribution networks, and conservation strategies.

The goal of the Smart Cities Mission, which was established in 2015, is to create 100 smart cities in India. This mission's emphasis on water supply includes initiatives to enhance water distribution networks, decrease non-revenue water, and advance sustainable water management techniques.

The mission of National Urban Drinking Water (NUDWM): NUDWM, which was proposed as a component of the Jal Jeevan Mission, seeks to supply all urban households with water on a universal basis. Its main objectives are to raise awareness of water conservation, improve the quality of water, and improve urban service delivery.

b. Rural Water Supply Schemes:

Jal Jeevan Mission (JJM): As previously indicated, JJM seeks to give piped water to every rural Indian family by the year 2024. Its main objectives are to guarantee that household tap connections (FHTCs) are operational and to encourage community-based water management techniques in rural regions. The National Rural Drinking Water Programme (NRDWP) was established in 2009 with the goal of giving rural people access to clean drinking water. In addition to efforts aimed at creating capacity for sustainable water management, it promotes the development of drinking water sources, distribution networks, and water treatment facilities.

The MGNREGA, or Mahatma Gandhi National Rural Employment Guarantee Act, MGNREGA is not just a water supply system; it also includes provisions for water management and conservation projects in

rural regions. In order to increase the availability of water, it provides funding for initiatives like building ponds, check dams, and water harvesting structures.

The goal of the Pradhan Mantri Krishi Sinchayee Yojana (PMKSY) is to improve rural irrigation infrastructure, including the creation of water sources and delivery systems. By using watershed management and micro-irrigation techniques, it encourages the efficient use of water in agriculture.

3. Study Area

3.1 Water Supply and Distribution System

The water supply system was introduced in Vikas Nagar in 1975. As the ground water potential and quality is good borewells are the prime source of the town water requirement. The existing water supply system in Vikas Nagar, which is more than 45 years old. Distribution system is covered for entire town. About 90% of households are connected by Municipal water supply for about 2 – 6 Hours. There are no discrete zones in the system. All water supply scheme of the city is implemented by Uttarakhand Pey Jal Nigam (UPJN) and maintained by Uttarakhand Jal Sansthan (UJS).

The service area for proposed sub-project is Nagar Palika Parishad of Vikas Nagar. Distribution system mainly consists of CI, GI and PVC pipelines which are very old and dilapidated. Existing system has outlived their service life. This system needs up gradation and improvement.

As per CPHEEO norms for per capita water supply to the consumers living in urban areas is 135 LPCD however existing per capita supply is only 40 to 70 LPCD. Water is being supplied for 2 to 6 hours in a day. The pressure at consumers point is in range of 2 m to 6 m due to bad condition (leaks and damages) of pipes. Therefore, there is need for improvement in overall system for fulfilling the gaps in service level standards.

3.2 Ward-wise division of the area

As per current scenario, the total Vikas Nagar- Nagar Palika is divided into 11 no. of wards.

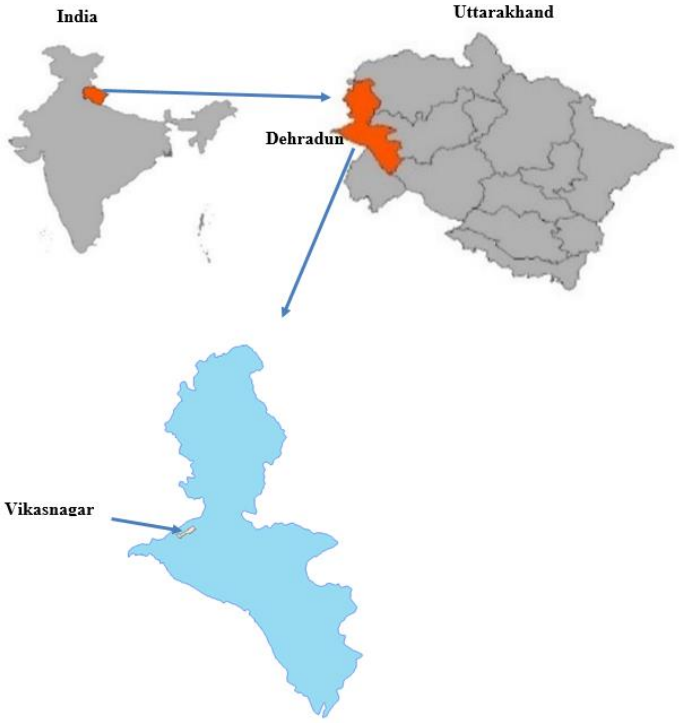


Figure 1: Ward-wise study area

3.3 Population Projection

Assessment has been made to estimate future population for Vikas Nagar. It is necessary to project the population for the year up to which water supply system, has to be designed. Accordingly, for planning and designing of water supply system for Vikas Nagar, population forecasting has been made. Normally, water supply is designed considering 30-year horizon with respect to the Base Year.

The Base Year is adopted as 2025. Accordingly, Intermediate Year of 2040 and Ultimate Year of 2055 have been considered in the subsequent analyses viz. population projections, water demand estimation and design of supply system.

a. Decadal Population:

The prerequisite data for population projection is decadal census population data. The ward-wise population as per census 2011 has obtained from Vikas Nagar Palika parishad. The decadal Census population considered for population projection are tabulated below:

Table 1: Census Population year-wise

Year	Census Population
1971	7066
1981	9001
1991	10991
2001	12485
2011	13927

After merging peri-urban areas into Vikas Nagar Palika Parishad the wards are increased from 9 to 11. Population of 2011 after merging is 24019.

b. Population Forecasting

Population projection has been carried out by using the different methods for the project horizon with Base Years 2025, Intermediate Year as Year 2040 & Ultimate Year as Year 2055. The projected population is 40805 for 2025, 58791 for 2040 and 76776 for 2055 as per Average Percentage Decade Increase Method (APDI). 10% floating population has been considered in population projection.

3.4 Demand Calculation

The Gross demand of water for base year, intermediate year and ultimate year has been calculation which is coming out as 7.55 MLD, 10.73 MLD, and 13.88 MLD respectively. To fulfil this demand, the infrastructure is required such as OHT, Tube Well, Treatment unit, if required etc.

3.5 Existing Infrastructure

Water problem exists in the outskirts and newly merged areas as the supply is very irregular. Duration of supply is mostly 2-3 hours per day. As there is low pressure at peripheries, Water quality is generally good. But in some taps muddy water flows.

Vikas Nagar city has been met using ground water extracted from tube wells.

The existing water supply infrastructures created during various period as early as 1975 by various schemes. As the existing capacity of OHTs are inadequate to cover entire nagar Palika area, mini bore wells are constructed and directly supplied by distribution. It was also seen that there is inadequate pressure in the distribution network. And there are many lines laid in haphazard way therefore it is very difficult from O&M point of view. As existing pipeline are very old and designed for village water supply.

It is proposed to completely discard existing distribution network and proposed new pipelines for a design period of 30 years.

There are five deep tube wells, and four mini tube wells cater the present water requirement of the town. As discussed with Jal Sansthan, the yield from the tube wells at Vikasnagar was very less, as such; the existing tube wells shall be replaced by new one with more depth and capable of accommodating higher capacity pumps.

Figure 2: Existing pump house

3.6 Water Treatment Facilities

There is no water treatment plant. The disinfection treatment in form of chlorination unit is provided at outlet of the tube well in the pumping station.

Figure 3: Chlorination unit

3.7 House Service Connections

Many of the existing connections doesn't have water meters or not working. These HSCs are provided with GI pipes. As these pipes are age old and rusted, there are leaks at many places. There are about 48% House Service Connections are present in the area.

Figure 4: House service connections

3.8 Proposed Improvement

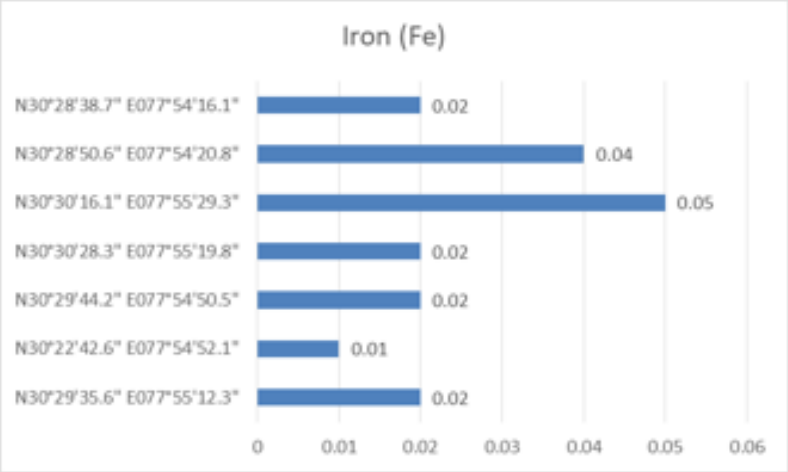
A comprehensive unde rstanding of the physical, topographical, and local environment provides the foundation to a well-executed sustainable water supply system. Hydraulic models were built using WaterGEMs for the existing water supply network and then analysed with the help of inbuilt modelling tools, to understand the existing system. Proposed diameter of pipe is coming out between 100mm to 350mm. The total length of the pipeline is around 119 km.

Figure 5: Map highlighting outer boundary of the study area indicating

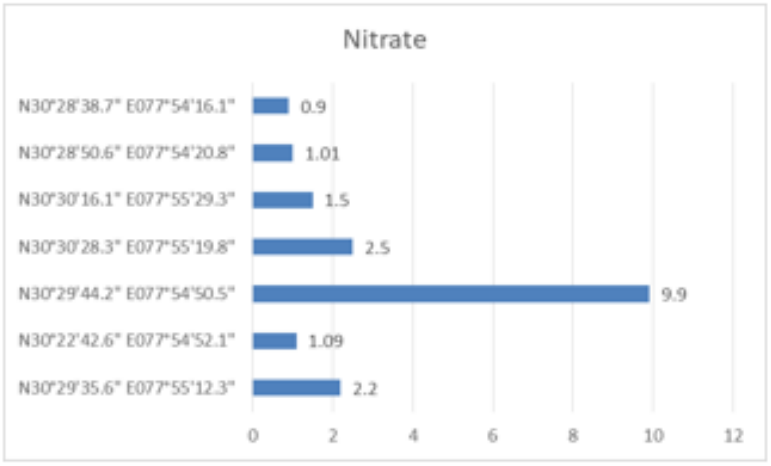
4. Result & Discussion

4.1 Drinking water quality parameters and water supply network

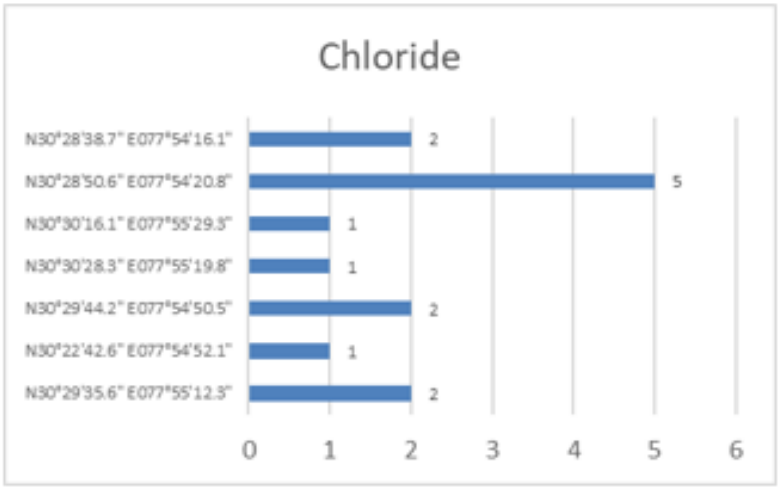
The water quality parameters are given below for the samples collected from different locations in Vikasnagar,



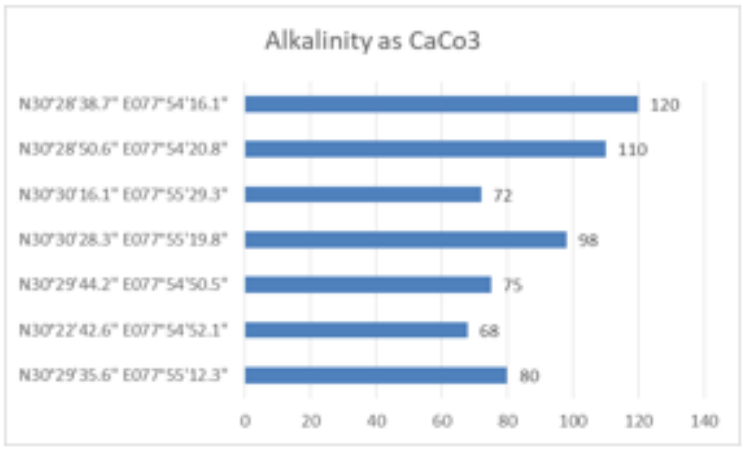
Measuring	mg/l
Acceptable	1



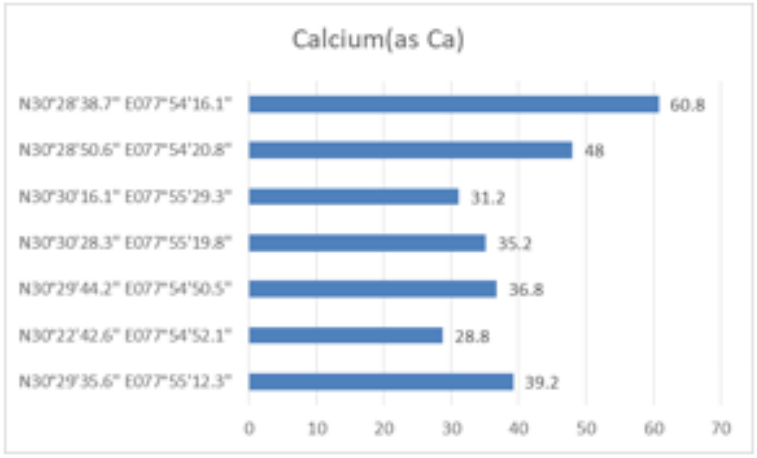
Measuring Unit	mg/l
Acceptable limit	45



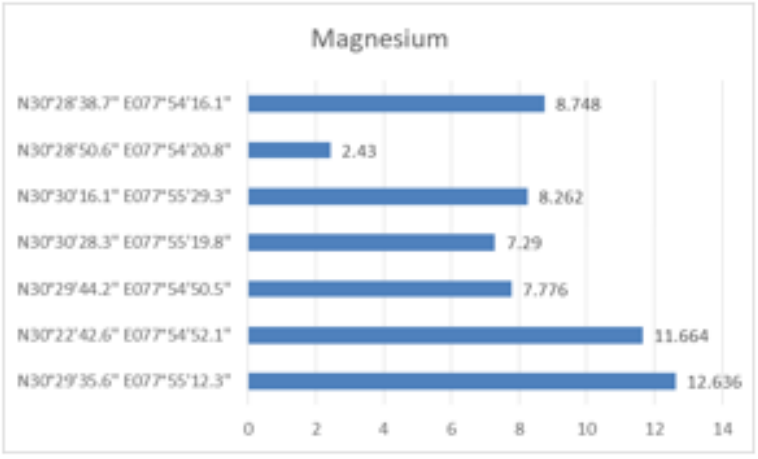
Measuring Unit	mg/l
Acceptable limit	250



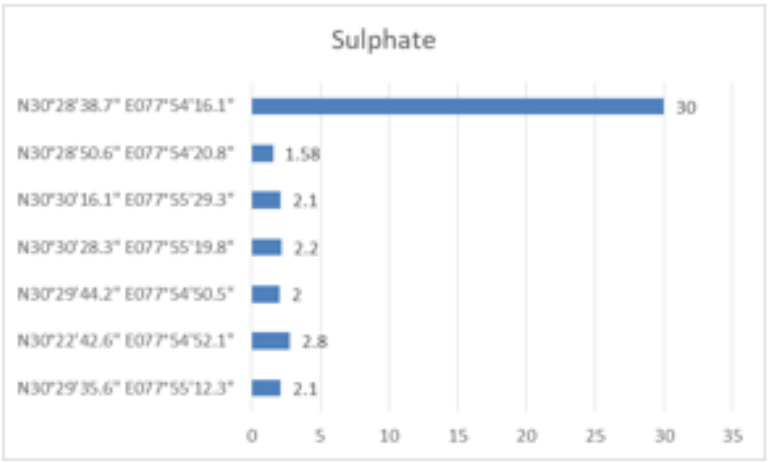
Measuring Unit	mg/l
Acceptable limit	200



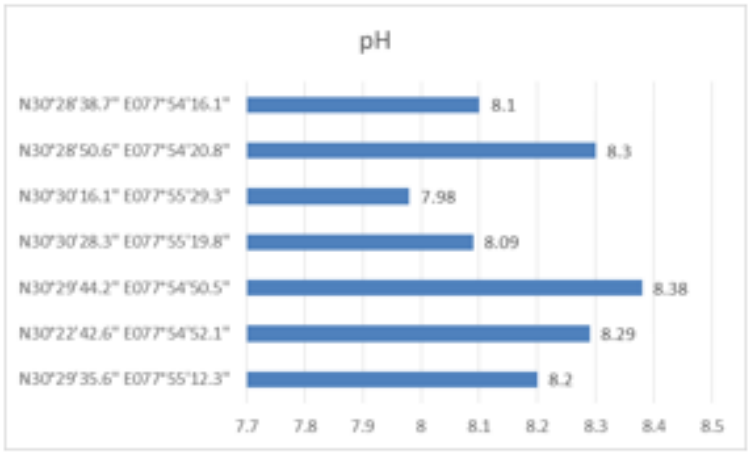
Measuring Unit	mg/l
Acceptable limit	75



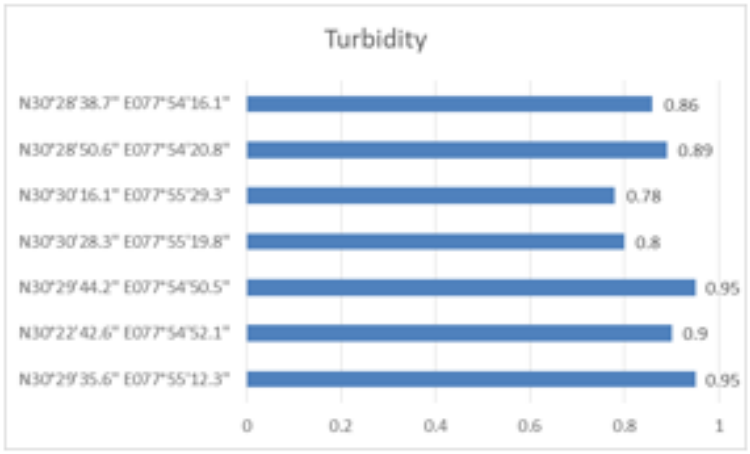
Measuring Unit	mg/l
Acceptable limit	30



Measuring Unit	mg/l
Acceptable limit	200



Measuring Unit	mg/l
Acceptable limit	6.5 to 8.5



Measuring Unit	NTU
Acceptable limit	1

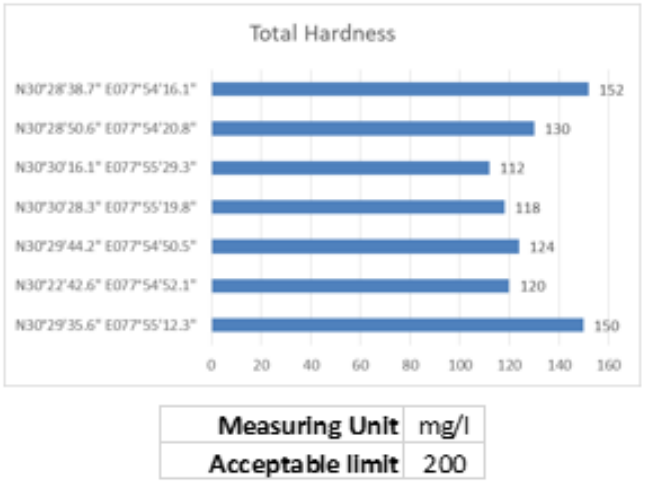


Figure 6: Water quality parameters with actual sample test values and their acceptable limits

Water Source Sustainability:

Based on the proposed water supply rate of 135 liters per capita per day (LPCD) for the service area of the Vikasnagar subproject, the total raw water demand is estimated to be 7.55 million liters per day (MLD) for the base year 2025, 10.73 MLD for the intermediate year 2040, and 13.88 MLD for the ultimate design year 2055. The installation of nine proposed tube wells (six new and three existing) with yields ranging from 800 to 2200 liters per minute (LPM) in Vikasnagar wards 1-11 is considered the source of water supply.

Abstraction and Sustainability:

The water supply system in Vikasnagar was introduced in 1975. The service area covered by this subproject includes parts of wards 1 to 11. Currently, there is an existing water supply network in the area, but its pipelines (made of cast iron, galvanized iron, and PVC) are over 25 years old and deliver an average supply of about 40-70 LPCD for 2 to 3 hours per day, which does not meet performance standards. The current water supply system relies on groundwater, which is extracted through tube wells, with additional new tube wells proposed to enhance the supply.

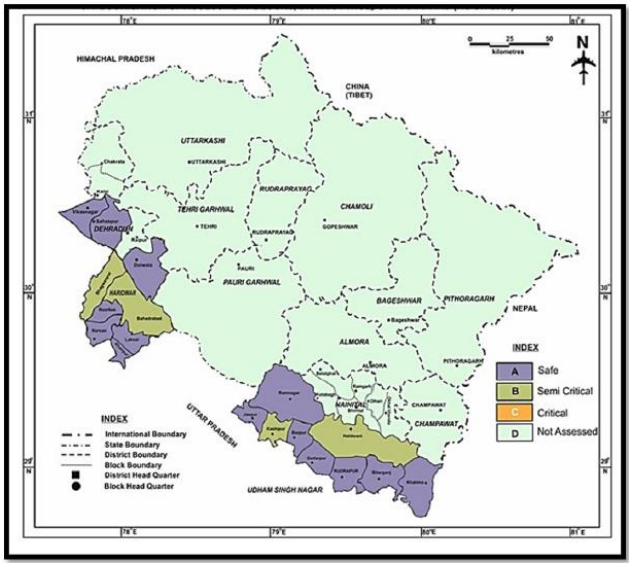


Figure 7: Categorization of Assessment Units of Uttarakhand State as per GWRE 2020

Vikas Nagar block is classified as SAFE according to the categorization used by the Central Ground Water Board (CGWB). This 'Safe' classification indicates that there is significant potential for further development of water resources for domestic, industrial, agricultural, and other purposes. The quality is also good for supplying as drinking water without treatment after disinfection.

The project area of Vikas Nagar water supply system covers area of about 610 Ha. The total road length is about 52 Kms. The town is partly covered by water supply system for about 32 Kms. The coverage is about 60%. Newly extended area is yet to be covered with town water supply system.

From the discussion it was concluded that existing distribution pipes are laid during various schemes with GI, PVC, AC pipes. Most of the pipes served its lifetime, there is a huge loss of about 50-60% due to leaks in joints. Bursting of PVC pipes are frequently happening due to breakage. The entire system is laid unplanned and the pressure distribution is uneven. So, the entire distribution system needs to be planned utilising metal pipe.

4.2 Disinfection

Disinfection of water is a critical process to ensure that it is safe for human consumption. It involves the removal, deactivation, or killing of pathogenic microorganisms that can cause diseases.

4.3 Distribution

Proposed distribution network has been divided into 7 Zones. The pipe diameter varies in the range of 100mm to 350mm with their different length of pipeline in order to cover the area as per modelling requirement. The distribution of pipeline is proposed as per the details given below,

Table 2: DMA wise distribution network Length (in m)

Pipe Dia (mm)	100	125	150	200	250	300	350	Grand Total Length (m)
Length (m)	90112	12596	3095	3407	5557	3761	283	118811

Also, the Water demand (MLD), population (Nos.) and house service connections (Nos.) are provided in the below given table.

Table 3: Demand, Population & HSC for the ultimate year 2055

Demand (MLD)	Population (2055)	HSC (2055)
13.007	76776	15355

5. Policy Recommendations:

- Establish a comprehensive policy framework focused on sustainable groundwater management to guide the design of the distribution system in Vikasnagar, emphasizing the prevention of aquifer depletion and degradation.
- Mandate the installation of a network of monitoring wells across the region to continuously monitor groundwater levels and quality, facilitating informed decision-making and proactive interventions.
- Incentivize the adoption of nature-based solutions such as rainwater harvesting and green infrastructure to augment groundwater recharge efforts and reduce reliance on extraction.
- Promote community engagement through educational programs and participatory decision-making

processes to cultivate a sense of ownership and responsibility among residents towards groundwater conservation.

- Enforce regulations mandating the integration of smart technologies and efficient infrastructure in the distribution system design to optimize resource utilization and ensure equitable access to clean groundwater for all inhabitants of Vikasnagar.

6. Conclusion:

The groundwater distribution design for Vikasnagar ensures a sustainable and reliable water supply by incorporating a comprehensive understanding of the local hydrogeology and current water demands. The design begins with a thorough hydrogeological survey, identifying the aquifer characteristics, recharge rates, and potential contamination sources. Strategic placement of wells and the selection of energy-efficient pumps are critical to preventing over-extraction and ensuring the long-term sustainability of the groundwater resources.

The distribution network is meticulously planned, utilizing either a grid or branched layout to maintain optimal water pressure and minimize losses. Durable materials like PVC or HDPE are used for pipelines, ensuring longevity and reducing maintenance costs. Water quality management is a priority, with treatment facilities addressing any identified contaminants and continuous monitoring systems ensuring compliance with health standards.

To enhance groundwater recharge, the design incorporates artificial recharge structures such as percolation tanks and recharge wells, along with promoting rainwater harvesting at both community and household levels. The integration of renewable energy sources like solar power into the pumping and treatment systems further enhances the system's sustainability and reduces operational costs.

Community involvement is pivotal to the success of the groundwater distribution system. Awareness programs educate residents on water conservation practices, while stakeholder engagement ensures the system remains adaptable and responsive to future challenges. This holistic approach ensures that Vikasnagar groundwater resources are managed effectively, providing a reliable and sustainable water supply for the community.

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