



TRIBHUVAN UNIVERSITY

INSTITUTE OF ENGINEERING

PULCHOWK CAMPUS

THESIS NO: PUL079MSUrP020

**Addressing Urban Water Scarcity through Community Engagement and
Decentralized Solutions: A Case of Dharan**

By:

Siddhartha Bhujel

A THESIS

SUBMITTED TO THE DEPARTMENT OF ARCHITECTURE
IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE
DEGREE OF MASTER OF SCIENCE IN URBAN PLANNING

DEPARTMENT OF ARCHITECTURE


LALITPUR, NEPAL

APRIL, 2025

COPYRIGHT

The author has agreed that the library, Department of Architecture, Pulchowk Campus, Institute of Engineering may make this report freely available for inspection. Moreover, the author has agreed that permission for extensive copying of this project report for scholarly purpose may be granted by the professor(s) who supervised the project work recorded herein or, in their absence, by the Head of the Department wherein the project report was done. It is understood that the recognition will be given to the author of this report and to the Department of Architecture, Pulchowk Campus, Institute of Engineering in any use of the material of this project report. Copying or publication or the other use of this report for financial gain without approval of the Department of Architecture, Pulchowk Campus, Institute of Engineering and author's written permission is prohibited.

Request for permission to copy or to make any other use of the material in this report in whole or in part should be addressed to:



.....



Head

Department of Architecture

Pulchowk Campus, Institute of Engineering

Lalitpur, Kathmandu

Nepal

DECLARATION

I hereby declare that the thesis entitled “Addressing Urban Water Scarcity through Community Engagement and Decentralized Solutions: A Case of Dharan” which is being submitted to the Department of Architecture, Pulchowk Campus, Institute of Engineering, Tribhuvan University. Under the direction of Professor Dr. Sangeeta Singh, I completed a research project as part of my master's degree requirements in urban planning (MsUrP). I declare that the work is my own and has not been submitted for a degree from another University.



.....
Siddhartha Bhujel

079/MSUrP/020

CERTIFICATE OF THESIS APPROVAL


The undersigned certify that they have read, and recommended to the Institute of Engineering for acceptance, a project report entitled "Addressing Urban Water Security through Community Engagement and Decentralized Solutions: A Case of Dharan" submitted by Mr. Siddhartha Bhujel (079-MSUrP-020) in partial fulfillment of the requirements for the degree of Masters of Science in Urban Planning.




Supervisor
Prof. Dr. Sangeeta Singh
Department of Architecture
IOE, Pulchowk Campus



External Examiner
Er. Chakravarti Kanth
Joint Secretary
Ministry of Urban Development, GON



Program Coordinator
Dr. Ajay Chandra Lal
Department of Architecture
IOE, Pulchowk Campus



External Examiner
Er. Saroj Basnet
Senior Urban Planner

April, 2025

ABSTRACT

In the 21st century, urban water scarcity has emerged as a critical challenge, exacerbated by rapid population growth, urbanization, and climate change. Dharan, a sub-metropolitan city in eastern Nepal, exemplifies these challenges, facing severe water shortages due to increasing demand, aging infrastructure, and inefficient water management systems. This research explores the role of community engagement and decentralized water management solutions in addressing urban water scarcity, using Dharan as a case study. The study aims to identify sustainable strategies for improving water security and resilience through community-driven approaches.

The research employs a mixed-methods approach, combining qualitative and quantitative data collection techniques, including household surveys, key informant interviews, and field observations. The study examines the existing water supply scenario in Dharan, the role of community participation in decentralized water management, and the effectiveness of policy and institutional frameworks in supporting these initiatives.

Findings reveal that community-led initiatives, such as Water User Committees (Upavokta Samitis), have played a crucial role in mitigating water scarcity by identifying local water sources, managing distribution, and fostering a sense of ownership among residents. However, these grassroots efforts often face challenges such as limited technical expertise, financial constraints, and inadequate support from governmental bodies. The study highlights the need for integrated approaches that combine technical expertise, community participation, and strong governance to ensure sustainable water management. The findings suggest that decentralized water management, supported by community engagement, offers a viable solution to Dharan's water crisis. By empowering local communities, enhancing infrastructure resilience, and aligning policies with local needs, Dharan can achieve long-term water security.

Keywords: Urban water scarcity, community engagement, decentralized water management, sustainable water solutions.

ACKNOWLEDGEMENT

First and foremost, I would like to express my deepest gratitude to my supervisor, Prof. Dr. Sangeeta Singh, for her invaluable guidance, encouragement, and support throughout the process of completing this thesis. Her insightful advice and expertise have been instrumental in shaping this research into its current form.

I extend my heartfelt thanks to Ar. Sanjay Roy, whose assistance in data collection was crucial to the success of this study. I am equally grateful to Er. Dipesh Thapa, Ar. Sandra Joshi, Ar. Prajina Shrestha, Er. Ronesh Shahi Thakuri, Ar. Rashmita Ghimire, and Er. Suraj Chapagain for their constant support, technical insights, and contributions throughout the course of this research. Your encouragement and collaborative spirit have been a source of motivation during challenging times.

I am profoundly thankful to my family for their unwavering love, patience, and encouragement throughout this journey. Their belief in my abilities has been my foundation of strength and perseverance. I want to express my sincere appreciation to my dear friend, Tabina Rai, for her unwavering emotional support, understanding, and inspiration during this endeavor. Your belief in me has made all the difference.

To all who have contributed in ways big or small, directly or indirectly, thank you for your kindness and support. This achievement would not have been possible without you.

Sincerely,

Siddhartha Bhujel

Table of Contents

COPYRIGHT	i
DECLARATION	ii
CERTIFICATE OF THESIS APPROVAL	iii
ABSTRACT	iv
ACKNOWLEDGEMENT	v
Table of Contents	vi
List of Figures:	x
List of Tables:	xii
List of Abbreviations	xiii
CHAPTER 1 INTRODUCTION	1
1.1 Background.....	4
1.2 Need of Research	8
1.3 Importance of the Research	9
1.4 Problem Statement.....	11
1.5 Research Objectives.....	12
CHAPTER 2 LITERATURE REVIEW	13
2.1 Urban Water Management Challenges	13
2.2 Role of Community Engagement	13
2.3 Community Management	14
2.3.1 Components of CM.....	14
2.3.2 Wash mentioned three basic components of Community management. ...	14
2.3.3 Levels of Community Participation	15
2.4 Decentralized Water Supply System	16
2.5 Sustainable Urban Water Management	17
2.5.1 Low Impact Development (LID)	17
2.5.2 Urban Water Supply Management	18
2.5.3 Urban Water Demand Management	19
2.5.4 Factors Affecting CP and Sustainability of Projects	20
2.5.5 Factors that Enhance the Sustainability of Water Project Service.....	21
2.5.6 Shortcomings of Participation Approach.....	21
2.6 Urban Water Security	22

2.6.1 Dimensions of Urban Water Security	22
2.6.2 Challenges in Achieving Urban Water Security	23
2.7 Integrated Water Resource Management (IWRM).....	24
2.8 National Water Policies and Guidelines	24
2.8.1 Constitutional Provisions in Nepal	24
2.8.2 Water Resources Strategy 2002.....	26
2.8.3 National Water Plan 2005.....	27
2.8.4 Water Resources Act 1992	27
2.8.5 National Water Resources Policy (2020).....	28
2.8.6 Irrigation Policy (2013)	28
2.8.7 National Climate Change Policy (2019).....	28
2.8.8 Water Supply and Sanitation Act (2022).....	28
2.8.9 National Water Policies,2077 (Rastriya Jalshrot Niti, 2077).....	30
2.8.10 Local Governance and Community Engagement	32
CHAPTER 3 METHODOLOGY	33
3.1 Paradigm	33
3.2 The Ontology	34
3.3 The Epistemology	35
3.4 The Methodology.....	36
3.5 Research Methods.....	36
3.5.1 Literature Review	37
3.5.2 Field Observation.....	38
3.5.3 Questionnaire Survey	38
3.5.4 Pilot Survey.....	39
3.5.5 In-depth Interviews	39
3.5.6 Key Informant Interviews	39
3.5.7 Limitations	40
CHAPTER 4 STUDY AREA	41
4.1 Overview.....	41
4.1.1 Physical Profile	43
4.1.2 Municipality Profile	44
4.1.3 Climatic Profile.....	45
4.1.4 Demographic Profile.....	46
4.1.5 Land Use Pattern.....	48
4.1.6 Rivers and Water Bodies	49
CHAPTER 5 FINDINGS AND ANALYSIS	50
5.1 Data Collection Framework.....	50
5.2 Current Water Supply Scenario in Dharan	51
5.2.1 Dharan Water Supply Management Board	54
5.2.2 Sources of Water Supply of DWSMB	56
5.2.3 Storage Infrastructure of DWSMB	58
5.2.4 Sub-Distribution Systems	59

5.2.5 Decentralized Water Supply in Dharan	62
5.2.6 Existing Water User and Sanitation Committees	64
5.2.7 IUDP Project highlights.....	66
5.2.8 Water Scarcity in Dharan.....	67
5.2.9 Area-Specific Challenges:	68
5.3 Community Engagement in addressing Water Security	70
5.3.1 Community Engagement and DWSMB	70
5.3.2 Sardu Watershed Conservation.....	75
5.3.3 Selected Case Studies	77
5.3.4 Findings from Interviews with 12 Water User Committees	78
5.3.5 Comprehensive Data Table for Upavokta Samiti in Dharan	79
5.3.6 Panbari Khanepani Tatha Upavokta Samitis	92
5.3.7 Observations on Practices	100
5.4 Community Perception	103
5.4.1 Community Perception on Community Management of Water in Dharan	104
5.4.2 Community Perception and Concerns of Ward 6	109
5.5 Institutional Framework and Policy.....	116
5.5.1 Policy Support for Decentralized Water Management	116
5.5.2 Role of Central, Province and Local Government under Water and Sanitation Regulations, 2081	116
5.5.3 Policy Review on Water User and Sanitation Committee.....	118
5.5.4 Licensing Requirement.....	119
5.5.5 Funds for Water User and Sanitation Committees in Dharan by Province and Central Government	120
5.5.6 Role of Local Government and Water User Committees	123
5.6 Key Informant Interview	124
5.7 DISCUSSION.....	128
5.7.1 Existing Water Supply Condition of Dharan	128
5.7.2 Review of role of community participation in addressing water security in decentralized water management in Dharan	128
5.7.3 Review of policy and institutional frameworks in supporting community- driven and decentralized approaches for sustainable water resource management in Dharan.....	129
CHAPTER 6 CONCLUSION AND RECOMMENDATION	129
6.1 Conclusion	129
6.2 Recommendations.....	131
REFERENCES.....	134
APPENDICES.....	137
Appendix A: List of Key Informant	137
Appendix B: Questionnaires for Water User Committee	137
Appendix C: Questionnaires for KII.....	139

Appendix D: Questionnaires for Survey.....	141
Appendix E: Questionnaire for Survey at Ward 6.....	147
Appendix F: IOE GC Paper Presentation Certificate	151
Appendix G: IOE GC	152
Appendix H: Plagiarism Test Report.....	160

List of Figures:

Figure 1 Map of Dharan.....	41
Figure 2 Physical Profile of Dharan	43
Figure 3 Municipal Profile of Dharan.....	44
Figure 4 Climate Chart of Dharan	45
Figure 5 Temperature Graph of Dharan	45
Figure 6 Population Density of Dharan	47
Figure 7 Ward wise population chart of Dharan.....	47
Figure 8 Land Use map of Dharan.....	48
Figure 9 Water bodies map of Dharan.....	49
Figure 10 Existing Centralized Water Supply map of Dharan (Source IUDP, 2017)	52
Figure 11 Decentralized Water Supply Map of Dharan	53
Figure 12 Clause for formation of water supply management board	56
Figure 13 Existing Water Infrastructure of DWSMB.....	58
Figure 14 Map of Water Distribution sub-system of DWSMB.....	61
Figure 15 Map Khanepani Upavokta tatha Sarsafai Samiti Projects in Dharan.....	63
Figure 16 Condition of Water Availability at Water User and Sanitation Committee of Dharan (<i>Municipality Dashboard - NwASH, n.d.</i>).....	64
Figure 17 Functionality and Sustainability of Water User and Sanitation Committee at Dharan (<i>Municipality Dashboard - NwASH, n.d.</i>).....	65
Figure 18 List of Khanepani Upavokta tatha Sarsafai Samitis recorded in Dharan SMC	66
Figure 19 Water collection chamber from Volunteer Campaigns.....	71
Figure 20 Flow chart of Volunteer Campaign conducted by DWSMB and Dharan's Mayor.....	72
Figure 21 Volunteer Works for Kokah-2 Project	74
Figure 22 Sardu Watershed Map	76
Figure 23 Panbari Khanepani Upavokta Tatha Sarsafai Samiti water supply map	77
Figure 24 Interviews taken from Different Upavokta Samitis of Dharan	90
Figure 25 Map of Panbari Khanepani Upavokta Tatha Sarsafai Samiti at Ward 6	92
Figure 26 Water collection chambers of Panbari Khanepani Upavokta tatha Sarsafai Samiti.....	96
Figure 27 Reservoir Tanks of Panbari Khanepani Upavokta tatha Sarsafai Samiti	97
Figure 28 Thematic map prepared by Thingabari Khanepani Upavokta tatha Sarsafai Samiti.....	102
Figure 29 Pipelines within the rivers	103
Figure 30 Monthly Household income of Survey 1	105
Figure 31 Daily supply hours from Survey 1	106
Figure 32 Monthly household water expense from Survey 1	106
Figure 33 Severity of Water Scarcity from Survey 1	107

Figure 34 Opinion on community involvement for water management outcome from Survey 1	107
Figure 35 Opinion on Volunteer efforts for water scarcity from Survey 1	108
Figure 36 Willingness to participate from Survey 1	108
Figure 37 Monthly household income from Pilot Survey	110
Figure 38 Monthly household expense in water from Pilot Survey	111
Figure 39 Affordability of Water from Pilot Survey	111
Figure 40 Severity of Water scarcity in dry season from Pilot Survey	112
Figure 41 Awareness of funds management	112
Figure 42 Water Quality and reliability from Pilot Survey	113
Figure 43 Willingness on contribution from Pilot Survey	114
Figure 44 Preference of Water supply from Pilot Survey	114
Figure 45 Opinion on Community Involvement from Pilot Survey	115
Figure 46 Opinion in Volunteer efforts from Pilot Survey	115
Figure 47 Projects by Water Supply and Sanitation Division office of Koshi Province of DWSMB and Khanepani Upavokta Samitis of Dharan	122

List of Tables:

Table 1 Overlap in Jurisdiction of Federal, Province, and Local Levels (Sharma et al., 2023)	26
Table 2 Demographic Chart of Dharan.....	46
Table 3 Land Use Chart of Dharan	49
Table 4 Framework for Data Collection	50
Table 5 Description of Surface Water Sources (Yadav et al., 2023).....	56
Table 6 Description of Groundwater Sources (Yadav et al., 2023).....	57
Table 7 Storage Reservoirs (Yadav et al., 2023)	58
Table 8 Summary of Sub-Distribution Systems (Yadav et al., 2023) (Unofficial Source: DWSMB)	59
Table 9 Demographic Chart of Ward-6, Dharan	78
Table 10 Data Collected from Questionnaire of 12 Khanepani Upavokta Samitis of Dharan.....	79
Table 11 Data Collected from Questionnaire of 12 Khanepani Upavokta Samitis of Dharan.....	84
Table 12 Demographics from Survey 1	104
Table 13 Demographics from Pilot Survey	109

List of Abbreviations

ADB: Asian Development Bank

CEI: Community Empowerment Initiatives

CM: Community Management

DSMC: Dharan Sub Metropolitan City

DWSMB: Dharan Water Supply Management Board

IWRM: Integrated Water Resource Management

IUDP: Integrated Urban Development Project

KII: Key Informant Interviews

LID: Low Impact Development

NRW: Non-Revenue Water

NWP: National Water Policy

NUDS: National Urban Growth Strategy

O&M: Operation and Maintenance

RVT: Reservoir Tank

SDG: Sustainable Development Goals

WASH: Water, Sanitation, and Hygiene

WDM: Water Demand Management

WRS: Water Resource Strategy

WUG: Water Users Group

WUCS: Water User and Sanitation Committee

CHAPTER 1 INTRODUCTION

In the 21st century, the development of water supply systems has become a significant issue for urban planners and policymakers around the world. Fueled by rapid increases in population, urban growth, economic development, and shifts in lifestyle, the need for water has surged, intensifying the pressure on current water resources. According to the United Nations World Water Development Report (2018), Almost 6 billion individuals are expected to face a lack of access to clean water by the year 2050. This looming crisis is further compounded by declining freshwater resources, pollution, and inadequate infrastructure (United Nations, 2018).

The development of water supply has become a significant challenge due to global urbanization, climate change, and growing population pressures. As cities around the world expand, the demand for clean and adequate water supply grows, often outstripping existing infrastructure and governance capabilities (United Nations, 2018). According to the United Nations, around 2 billion individuals residing in countries facing significant water stress, and urban regions are especially at risk for water shortages (United Nations, 2021). This crisis is exacerbated in developing nations, where institutional weaknesses and resource constraints significantly hinder effective water management (Pandey et al., 2019). Globally, the consequences of insufficient water supply go further than just lack of availability; they jeopardize public health, impede economic growth, and compromise environmental sustainability. Water-related challenges such as pollution, inefficient use of resources, and climate variability contribute to a complex web of issues that require integrated management approaches. The World Bank highlights the importance of investing in water supply infrastructure as essential for reaching sustainable development goals (World Bank, 2020). However, many countries struggle with outdated systems and fragmented governance structures that impede effective responses to these challenges (Gleick, 2000).

Globally, the population has grown by 4.4 times in the past century, whereas water extraction has escalated by 7.3 times during that same timeframe (FAO, 2016). This disproportionate increase is driven by greater demands in the food sector, both due to increased production and dietary shifts, and the energy sector, that depends significantly on water resources for its growth. Urban areas serve as catalysts for these needs by gathering the demand for food, energy, and water while concurrently generating

wastewater, a significant contributor to water contamination, particularly in developing nations. The acknowledgment of water as a limited and essential resource has become more pressing in light of the rising demand, positioning water as a fundamental human right and an economic resource to be managed sustainably (Boretti & Rosa, 2019).

A variety of projects are currently being implemented in Nepal to meet Sustainable Development Goal 6 (SDG 6) in the water sector by the year 2030. However, the path to this goal is fraught with challenges. In 2022, 92% of the population in Nepal had access to a basic water supply, but only 14% had access to a safely managed water supply that guaranteed safe water quality (WHO & UNICEF, 2023). Even though 50% of the population has access to piped water supply systems, issues related to operation, maintenance (O&M), and service quality continue to exist (Eigenbrod et al., 2011). To tackle these challenges, the Ministry of Water Supply and Sanitation has formulated a long-term development plan for the sector identifying priority areas and thematic approaches to reach the goals of the water, sanitation, and hygiene (WASH) sector by the year 2030.

Addressing these challenges necessitates an integrated approach that emphasizes community involvement. Community-driven projects spearheaded by local leaders have shown promise in enhancing infrastructure and cultivating a sense of ownership among community members. However, these grassroots efforts often lack adequate support from governmental bodies and face significant operational challenges. Studies suggest that enhancing community participation can lead to more effective water management practices and improved service delivery (Ghosh et al., 2022; Pandey et al., 2019). Water supply systems in Nepal have been defined by hierarchical governance structures that frequently ignore local requirements and expertise. Nonetheless, recent initiatives have focused on more inclusive strategies that enable communities to actively participate in the management of their water resources. The Water User and Sanitation Committees (WUSC) have been recognized as a means for local governance, promoting community involvement in the management and upkeep of water supply systems. These committees are vital in making sure that local viewpoints are incorporated into water management strategies, which can enhance service delivery and accountability (Pandey et al., 2019).

Over 42,000 water supply systems have been built in rural regions and small towns throughout Nepal through collaboration between the Government of Nepal and multiple

development partners. Rural water supply systems are generally small, straightforward, and based on public taps, whereas small-town systems are bigger, focused on individual households, and frequently necessitate intricate oversight because of the integration of electrical systems. The responsibility for managing these systems was delegated to the Water User and Sanitation Committee (WUSC), which faces challenges such as inadequate human resources, insufficient technical expertise, unreliable supply, and water contamination. Research shows that over 50% of water systems in small towns face challenges with maintaining financial stability, and 55% of urban water samples tested were contaminated with *E. coli*, presenting considerable public health risks (Dhimal & Dhakal, 2012; Ogata et al., 2024).

The difficulties faced by small-town water supply systems are not exclusive to Nepal, as similar issues have been observed in countries like Ethiopia, Mozambique, Nigeria, and Ghana. Deterioration in water supply services across these regions has been linked to inadequate management of water supply facilities (Eguavoen & Youkhana, 2008; Abdisa & Reddy, 2014; Sule et al., 2016). Research indicates that improving the quality of water services can boost the financial viability of water utilities (Ogata et al., 2024). Additionally, tackling disparities in access to better water and sanitation, as emphasized by Ghosh et al. (2022) in the Indian context, is imperative for ensuring equitable and sustainable water access.

Nepal, traditionally marked by a lower rate of urbanization relative to other countries in South Asia, is currently experiencing a notable change in its urban growth patterns. Urban centers such as Dharan exemplify this transition, with substantial population inflows and economic growth exacerbating water shortages, particularly during dry months (Mishra et al., 2018).

In Nepal, although it is endowed with abundant freshwater resources, having around 6,000 rivers and countless streams, the nation encounters significant difficulties in ensuring access to safe drinking water to its population. According to the Department of Water Supply and Sanitation, although roughly 86% of the population has access to drinking water, only around 15% obtain drinking water that meets quality standards (Department of Water Supply and Sanitation, 2020). Urban centers in Nepal are especially affected by inadequate water supply systems, leading to widespread rationing and reliance on unsafe sources. The complexity of governance frameworks

and the intermingling of duties across different organizations make it more challenging to attain sustainable management of urban water resources (Pandey et al., 2019).

Community participation has proven effective in addressing various challenges associated with water supply management. For example, community-led initiatives have effectively gathered resources for developing infrastructure, including constructing reservoirs and enhancing distribution systems. These local efforts not only improve the physical infrastructure but also cultivate a sense of ownership among community members, which is crucial for the enduring sustainability of water supply services (Ghosh et al., 2022). Engaging the community can result in improved decision-making procedures that accurately represent the varied requirements of the population, thus fostering fairness in access to water resources.

1.1 Background

Urban water supply systems are increasingly challenged by rapid population growth, urbanization, and climate change, resulting in significant water scarcity in various parts of the globe. Dharan, a sub-metropolitan area located in eastern Nepal, highlights these difficulties as it confronts severe water shortages intensified by increasing demand and dwindling supplies..(Yadav et al., 2023). The water supply system of the city, which was first established in the 1960s, has faced challenges in accommodating the rapid population growth and evolving lifestyles, leading to an uncertain situation for its inhabitants (Yadav et al., 2023).

Dharan, situated in the Sunsari district of eastern Nepal, is a sub-metropolitan area that has undergone significant urban development and population increase in recent decades. Dharan was first established as a municipality in 2014 and then became a sub-metropolitan city in 2017. It spans an area of 192.32 square kilometers and plays a significant role as a commercial and administrative center in the area. Situated at the base of the Mahabharata Range, Dharan's location provides access to various freshwater resources; nevertheless, these resources are not efficiently utilized for municipal purposes. The population of the city has seen a notable increase, rising from around 119,915 residents in 2011 to an estimated 137,705 today (Central Bureau of Statistics, 2011). The swift growth of urban areas creates significant demands on vital services, especially on current water supply networks.

Recent evaluations show that the water demand per person in Dharan has increased from 71 liters per capita per day (lpcd) to 100 lpcd, due to factors like urban growth and heightened domestic requirements. (Yadav et al., 2023). The increasing demand is further exacerbated by the city's topography, which includes steep hills that hinder the distribution and management of water. Moreover, the current infrastructure experiences substantial non-revenue water (NRW) levels, estimated to reach as high as 40%, signifying considerable losses from leaks and system inefficiencies (Yadav et al., 2023).

Climate change further complicates the water supply landscape in Dharan. Altered precipitation patterns lead to irregular water availability, with dry seasons often resulting in acute shortages. The reliance on surface water sources like the Sardu and Kharu streams has proven unsustainable, particularly during periods of low rainfall. Consequently, groundwater extraction has increased, raising concerns about overexploitation and long-term sustainability (Yadav et al., 2023). In every city examined, the increasing need for water has exceeded the available municipal supply, with the greatest shortages occurring during the dry season, which usually spans from October to May. Certain cities have started to enhance their water supply using different methods, such as extracting water from nearby streams and springs in Dhulikhel, as well as drilling additional deep tube wells for groundwater in Dharan (Bajracharya et al., 2019).

Historical Context

The initial piped water distribution system in Dharan was built by engineers from the British Army in 1961, drawing mainly from local surface water sources, specifically Sardu and Kharu streams (Yadav et al., 2023). This inaugural system signaled the start of organized water supply infrastructure within the city. In the 1980s, the operations were handed over to the Nepal Water Supply Corporation (NWSC), which enhanced the system by including groundwater sources from the Char-Koshe jungle, supported by funding from international entities like the International Development Association (IDA) (Integrated Urban Development Project, 2017).

In terms of water supply, the current system in Dharan is under considerable strain. The local government intends to deliver around 60 liters per person per day (lpcd); nevertheless, the current average supply is only close to 30 lpcd. This creates a significant deficit of approximately **30 lpcd** for many households. With an estimated additional

population of **46,000** by then expected by 2021, the demand for water is projected to increase substantially. To address this growing need, the project includes several key components aimed at rehabilitating existing systems and augmenting water supply. The proposed strategies under the IUDP include the rehabilitation of existing surface water sources and pipelines, construction of new tube wells and pumping stations, and expansion of the distribution network. Specifically, the project plans to rehabilitate **two existing surface water sources**, protect **5 kilometers** of transmission mains, replace **15 kilometers** of old mains, and install **2,000 new metered house connections**. Additionally, it will involve test drilling for **eight deep tube wells** and **ten shallow tube wells**, alongside constructing new pumping stations and transmission mains totaling **10 kilometers**. (IUDP, n.d.)

Despite these efforts, the existing water supply infrastructure has not kept pace with the growing population and changing lifestyles. The reliance on surface water sources has proven unsustainable, particularly during dry seasons when river flows decrease significantly. As a result, residents often face intermittent water supply and are forced to seek alternative sources, including unreliable streams that may dry up completely during drought periods. (IUDP, n.d.)

Current Challenges

Population Dynamics

Dharan's population has seen substantial growth, driven by both natural increase and migration from rural areas seeking better economic opportunities. The population was approximately 80,000 in 2001 and has grown to over 166,531 in 2021 (CBS, 2021), reflecting an annual growth rate of about 6.4% (Yadav et al., 2023). This rapid increase places immense pressure on existing infrastructure and services, particularly in terms of water supply. The demographic shift includes a growing number of households, which further intensifies the demand for water resources.

Land Use Changes

The urban landscape of Dharan has undergone significant transformation due to urban expansion. As the city grows, residential areas have expanded into previously agricultural or undeveloped land. This change in land use has resulted in increased impervious

surfaces, which can affect local hydrology and reduce groundwater recharge (IUDP, 2017). The conversion of land for housing and commercial purposes has also led to the encroachment on critical water catchment areas, further complicating water management efforts.

Recent assessments indicate that per capita water demand in Dharan has surged from 71 liters per capita per day (lpcd) to 100 lpcd due to urban expansion and increased domestic needs (Yadav et al., 2023). This inefficiency exacerbates the challenges faced by residents in accessing clean drinking water.

Moreover, the mismanagement of the NWSC has led to operational inefficiencies and inadequate maintenance of existing infrastructure. Residents have expressed their dissatisfaction through protests against high water bills, which are partially attributed to loan repayments for water supply improvements financed by the Asian Development Bank (ADB). These financial burdens have made access to clean drinking water increasingly unaffordable for many households.

Sardu Watershed

The acute water shortage in Dharan has forced many households to depend on unsafe or costly alternatives, exacerbating socio-economic disparities. Seasonal reductions in river flows have made surface water sources increasingly unreliable, pushing the city to overextract groundwater—a practice that risks depletion and threatens long-term sustainability (Pandey et al., 2019). Community-driven initiatives, led by Mayor Harka Sampang to source water from Kokah Khola and Sardu Khola, have offered temporary relief but lack proper technical oversight, raising concerns about water quality and environmental sustainability.

The Sardu watershed, a vital water source for Dharan Sub-metropolis, is currently under severe threat from land encroachment by organized land mafias, who have illegally occupied at least 42 bighas of this crucial area. These encroachments are occurring in Chotimorang Dada, where illicit land plotting and transactions are being conducted without proper authorization from local authorities. Despite the environmental significance of the watershed, which not only provides water but also supports biodiversity, local governance structures have largely failed to address these illegal activities. Reports indicate that local political leaders and civil servants may be complicit

in these transactions, undermining conservation efforts and exacerbating environmental degradation. The rampant use of heavy machinery for land development has led to deforestation and significant alterations to the landscape, impacting both the ecological balance and the aesthetic value of the region. This situation underscores a critical need for effective community participation and integrated management strategies to protect the Sardu watershed from further exploitation and ensure sustainable water supply for the residents of Dharan. (*Sardu Watershed Area Faces Existential Crisis*, 2024)

Community Initiatives

In response to these challenges, community-led initiatives have emerged, such as volunteering programs spearheaded by local leaders like Mayor Harka Sampang. These programs aim to build water reservoirs and improve local infrastructure. However, these grassroots efforts often lack sufficient support from governmental bodies and face challenges in scaling up to meet the broader needs of the population.

1.2 Need of Research

The need for research on water supply development in Dharan, Nepal, is underscored by several critical factors that highlight the urgency and importance of addressing water scarcity issues in urban contexts. Here are the key reasons for conducting this research:

- **Increasing Water Demand (Population Growth):** Dharan has experienced rapid urbanization, with a significant increase in population over recent decades. The per capita water demand has risen from 71 liters per capita per day (lpcd) to 100 lpcd, driven by urban expansion and changing lifestyles (Yadav et al., 2023). This escalating demand necessitates a thorough investigation into sustainable water supply solutions.
- **Infrastructure Challenges (Aging Water Supply Systems):** The existing water supply infrastructure, established in the 1960s, is inadequate to meet current demands and is plagued by inefficiencies. High levels of non-revenue water (NRW), estimated at up to 40%, indicate substantial losses due to leakage and management issues (Yadav et al., 2023). Research is needed to assess and improve the operational efficiency of these systems.

- **Groundwater Overexploitation (Sustainability Concerns):** Increased reliance on groundwater sources due to surface water shortages raises concerns about overexploitation and long-term sustainability. Investigating groundwater recharge methods and sustainable extraction practices is essential to prevent depletion of this vital resource (Mishra et al., 2021).
- **Community Needs and Engagement (Public Health Implications):** Access to clean drinking water is a fundamental public health concern. The current situation in Dharan often forces residents to seek alternative sources, which may be unreliable or contaminated. Research can provide insights into community needs and preferences, facilitating more effective public engagement in water management solutions.
- **Implementing decentralized systems encourages community involvement in water management.** Local participation can lead to better maintenance and operation of water supply systems, fostering a sense of ownership among residents. (Piratla & Goverdhanam, 2015).
- **Policy Development (Framework for Sustainable Management):** There is a pressing need for comprehensive policies that address urban water supply challenges in Dharan. Research can inform the development of frameworks that promote sustainable practices, community involvement, and innovative management strategies tailored to local conditions (Integrated Urban Development Project, 2023)

1.3 Importance of the Research

The importance of conducting this research on water supply development in Dharan, Nepal, is critical for several reasons that address pressing issues in urban water management.

- *Addressing Water Scarcity, a critical Urban Issue:* Water scarcity is a significant challenge in Dharan, where the per capita water demand has increased from 71 liters per capita per day (lpcd) to 100 lpcd due to rapid urbanization and population growth (Yadav et al., 2023). Researching this issue is essential for developing strategies that ensure adequate water supply for all residents.

- *Informing Policy and Planning as Evidence-Based Solutions:* The findings from this research can provide valuable insights for policymakers and urban planners. By understanding the complexities of the water supply system in Dharan, stakeholders can formulate effective policies that address current deficiencies and anticipate future challenges (Integrated Urban Development Project, 2023).
- *Enhancing Infrastructure Resilience Infrastructure Assessment:* The research will evaluate the existing water supply infrastructure, which suffers from high levels of non-revenue water (NRW), estimated at up to 40% (Yadav et al., 2023). Identifying weaknesses in the system will aid in developing resilient infrastructure capable of meeting the demands of a growing population.
- *Sustainability in decentralized water supply management is critical:* Localized solutions empower communities to address water scarcity effectively while protecting local ecosystems from over-extraction. Sustainable practices not only enhance community resilience but also promote environmental conservation, ensuring long-term access to clean water. Moreover, fostering community participation in decision-making processes enhances accountability and encourages the adoption of sustainable land use practices (Piratla & Goverdhanam, 2015).
- *Community Engagement and Empowerment Local Perspectives:* Engaging with the community to understand their experiences and needs regarding water access is crucial. This research can empower residents by incorporating their insights into water management strategies, fostering a sense of ownership and responsibility towards local resources (Mishra et al., 2019).
- *Economic benefits (Cost effective solutions):* Investing in decentralized water supply management can lead to long-term economic benefits by reducing the costs associated with transporting and treating water centrally. Localized systems can minimize infrastructure expenditures and operational costs while maximizing resource efficiency (Piratla & Goverdhanam, 2015).
- *Public Health Implications Health and Safety:* Access to clean drinking water is essential for public health. Research can identify health risks associated with inadequate water supply and inform interventions that ensure safe drinking water for all residents, thereby improving overall community health outcomes (Yadav et al., 2023).

1.4 Problem Statement

Since its establishment, Dharan has faced a chronic water crisis, a challenge that has defined its urban development and shaped the lives of its residents. Nestled in the foothills of eastern Nepal, this vibrant sub-metropolitan city has struggled to meet the growing water demands of its expanding population. Over the years, Dharan's residents have relied on a patchwork of solutions, often stepping in where institutional efforts have faltered.

In 2069 B.S., the Buddhasubba Khanepani Tatha Sarsafai Upavokta Samiti was formed by local communities, driven by a shared urgency to address water shortages. Through sheer determination, they sourced water independently from Gairigau's jaruwa, setting up a decentralized supply system that now supports 125 households. This grassroots effort demonstrated the resilience of Dharan's people, even in the face of growing challenges.

However, larger-scale efforts to solve Dharan's water woes have been less successful. A multi-million-dollar project, supported by loans and grants from the Asian Development Bank (ADB), aimed to modernize Dharan's water supply infrastructure. Yet, these interventions have failed to provide a lasting solution, burdened by inefficiencies, mismanagement, and a lack of community involvement. Meanwhile, the city's new mayor, Harka Sampang, launched an ambitious volunteer campaign, rallying residents to bring water from Kokah Khola and Sardu Khola. Although these initiatives have offered temporary relief, they lack the technical oversight needed to ensure long-term sustainability and safety.

Adding to these challenges is the crisis unfolding in the Sardu watershed, one of Dharan's most vital water sources. Encroachments by land mafias have fragmented this critical ecological asset, selling off plots for personal profit. Despite conservation efforts by local communities—reforestation projects, awareness campaigns, and grassroots monitoring—illegal land transactions continue to undermine the watershed's integrity. Legal battles are ongoing, with cases filed to reclaim encroached land and restore it for the community's benefit.

Dharan's water crisis is not merely a technical problem; it is a social and environmental struggle. Over-extraction of groundwater risks long-term aquifer depletion and land subsidence, while unreliable surface water sources force households to depend on unsafe alternatives. The socio-economic gap between those who can afford water and those who cannot continues to widen, further straining the city's cohesion.

If these trends persist, Dharan faces a future marked by resource depletion, heightened vulnerability to water shortages, and worsening inequalities. The stories of community-led efforts, court battles to protect the Sardu watershed, and the unwavering determination of residents

highlight both the challenges and the potential for solutions. Dharan's water crisis demands an integrated approach—one that combines technical expertise, grassroots participation, and strong governance—to secure a sustainable and equitable water future for all its residents.

1.5 Research Objectives

The main objective of this thesis is

- To explore the role of community engagement in decentralized water management solutions in addressing urban water scarcity, focusing on Dharan as a case study, to identify sustainable studies for improving water security and resilience.

Secondary Objectives

- To explore the existing water supply scenario of Dharan
- To explore the role of community participation in addressing water security in decentralized water management in Dharan.
- To analyze the role of policy and institutional frameworks in supporting community-driven and decentralized approaches for sustainable water resource management in Dharan.

CHAPTER 2 LITERATURE REVIEW

2.1 Urban Water Management Challenges

Urban areas worldwide face a growing water crisis driven by rapid urbanization, population growth, and climate change (UNESCO, 2021). Issues like water scarcity, aging infrastructure, and contamination disproportionately affect cities in developing countries, where resources are limited (Biswas, 2019). In Nepal, cities like Dharan confront additional challenges, including unregulated groundwater extraction, inequitable water distribution, and overdependence on traditional systems (Sharma & Bhattarai, 2020). Urban water crises often demand integrated approaches, as evidenced by the success of Integrated Urban Water Management (IUWM) in cities like Melbourne, Australia, and Cape Town, South Africa, which combine resource efficiency with participatory planning (UN-Habitat, 2019).

2.2 Role of Community Engagement

Community engagement is integral to sustainable water management, fostering inclusivity, ownership, and resource efficiency (Pretty, 1995). Arnstein's (1969) Ladder of Citizen Participation provides a framework for understanding the levels of public involvement, from tokenism to true empowerment. Successful examples of community engagement include the Pani Panchayat model in India, where communities collectively manage local water resources, and Kenya's water user associations that address equitable access (Kumar et al., 2018; Mwangi, 2020). However, challenges such as lack of representation, conflicting interests, and limited capacity building hinder effective participation (Ostrom, 1990).

In Nepal, traditional systems like *Guthi* (community-based irrigation governance) demonstrate the potential of collective action in managing shared resources, though they require modernization to meet contemporary challenges (Shrestha et al., 2019).

Community participation is crucial for the success of water supply and sanitation projects. Research indicates that when communities are actively involved in the planning and implementation of water initiatives, the sustainability of these projects significantly increases. For instance, the Community Empowerment Initiative (CEI) in Western Uganda demonstrates that local involvement leads to better maintenance of water sources

and improved health outcomes, such as a reduction in water-related diseases from 60% to 4% (Asuman, n.d.)

The compendium on community participation in urban water and sanitation highlights various successful models where community-driven initiatives have enhanced access to clean water. These initiatives often involve local organizations working alongside civil society to empower communities, particularly marginalized groups, to take control of their water resources (Dwivedi et al., 2022). Such participatory approaches have been recognized as effective mechanisms for improving accountability and fostering local leadership among women and youth in urban settings

2.3 Community Management

Community Management (CM) CM refers to the capabilities and willingness of the beneficiaries to take charge and determine the nature of development affecting them. In water and sanitation systems, community management means that the community exercises responsibility for decision making and control over the subsequent execution of these decisions during project development. Schouten and Moriarty defined community management to mean that a community took on the full range of management tasks related to maintaining (and some cases developing) a domestic water supply. These tasks include, setting tariffs and collecting payment, carrying out routine maintenance, and making decisions about system extension (Schouten and Moriarty, 2003:55). CM as defined above, is concerned with all issues pertaining to responsibility (ownership), decision making authority, and control over development project and system operations.

2.3.1 Components of CM

2.3.2 Wash mentioned three basic components of Community management.

1. Responsibility: The community takes on the ownership of and attendant obligation to the system.
2. Authority: The community has the legitimate right to make decisions regarding the system on behalf of the users.
3. Control: The community is able to carry out and determine the outcome of its decisions (Ibid).

2.3.3 Levels of Community Participation

CP discourse described different levels in which beneficiaries of any development initiative should be involved. This can be typically applied in rural water and sanitation projects (Schouten and Moriarty, 2003).

Levels	Responsibility	Authority	Control	Management Capacity
1	External agency, little community responsibility	External agency; informal community consultations	External agency; limited community participation	Insufficient
2	External agency, community is responsible for operation	External agency; limited formal role for community institutions	External agency; moderate community participation	Limited
3	Joint; community responsible for operation and maintenance	Joint; limited formal role for community and agency	Joint; strong community participation and limited community management	Moderate
4	Community; external support	Community; external support	Community; external support	Sufficient
5	Full community responsibility	Full community authority	Full community control	High

2.4 Decentralized Water Supply System

Decentralized water management solutions are increasingly being adopted as effective strategies to address local water challenges. By transferring decision-making powers closer to the communities, these solutions enable more tailored responses to specific local needs. The literature suggests that decentralized systems can lead to enhanced efficiency in service delivery and greater community satisfaction (Dwivedi et al., 2022).

Examples of Decentralized Approaches

In many successful cases, decentralized approaches have included the establishment of local water management committees that oversee the operation and maintenance of water facilities. These committees are typically composed of community members who are trained to manage resources sustainably. For instance, the formation of Village Water and Sanitation Committees (VWSC) has proven effective in various regions by promoting local ownership and responsibility for water services (Asuman, n.d.).

Decentralized water supply systems are usually perceived as more costly than centralized systems due to the misrepresentation of sunk costs and a lack of consideration of avoided costs (Fam et al., 2014). A study conducted in Australia demonstrated that the use of domestic rainwater tanks is more economically efficient than the use of conventional systems due to the reduced need for constructing new supplies and expensive stormwater infrastructure (Coombes et al., 2002). The cost perspective widely varies depending on the actor (water agency, developer, user, whole society) performing the economic analysis (Fam et al., 2014). A critical impediment to the installation of decentralized systems may be the perception by house owners that these systems are costly because house owners are frequently called to assume the full cost of decentralized systems (capital cost and maintenance cost). Furthermore, the subsidized price of water overshadows to some extent the benefits of decentralized systems. Decentralized systems shift the financial burden from the public sector to the users and as a result, they favor cost recovery. In contrast, large-scale water supply projects do not comply with the full recovery principle increasingly demanded in new water policies such as the Water Framework Directive in Europe. Large hydraulic projects are usually subsidized by governments and international organizations (Gleick, 2000; Kallis & Coccossis, 2003) and become highly capital-intensive and therefore inflexible.

2.5 Sustainable Urban Water Management

2.5.1 Low Impact Development (LID)

Impervious surfaces are a critical factor influencing the impact of urbanization on water resources in metropolitan areas. The increasing prevalence of such surfaces accelerates runoff, directing water rapidly into storm drains and transporting pollutants—including automotive fluids, fertilizers, and pesticides—into local waterways. This situation underscores the necessity of reducing impervious areas within urban contexts to mitigate these adverse effects (EPA, 1999). In cities where impervious surfaces dominate, implementing green infrastructure methods can effectively slow and manage runoff, allowing for natural filtration through soil and minimizing the volume of water entering combined sewer systems during peak events. Low Impact Development (LID) represents a paradigm shift in urban development that prioritizes water-sensitive design principles. LID strategies aim to manage and control stormwater through techniques that promote water infiltration and evaporation rather than relying solely on traditional end-of-pipe solutions. These methods include various innovative approaches such as green roofs, pervious pavements, rain gardens, and policy frameworks that encourage the adoption of these technologies (Thompson, 2007).

- *Green Roofs:* These living roofs incorporate vegetation that captures rainwater, reducing runoff while providing insulation and improving urban biodiversity.
- *Pervious Pavement:* Utilizing interlocking pavers or porous concrete allows water to infiltrate through the surface rather than contributing to immediate runoff. This approach helps recharge groundwater and mitigate flooding.
- *Rain Gardens:* Engineered vegetated areas designed to capture excess rainwater runoff from buildings can effectively filter pollutants before they reach storm drains.
- *Policy Implementation:* Governments can facilitate LID adoption by rewriting regulations and incentivizing developers to embrace these sustainable practices. For instance, Chicago has taken the lead in promoting green roofs by providing kits to residents interested in installation.

Cities like Seattle have successfully implemented various LID practices through pilot programs run by their public utilities departments, demonstrating the effectiveness of these strategies in urban environments (Thompson, 2007). The introduction of LID

practices was notably outlined in a manual by Prince George's County in 1999, which served as a foundational document for promoting sustainable stormwater management practices across urban landscapes (EPA, 1999). By focusing on infiltration and evaporation processes, LID not only addresses immediate stormwater management concerns but also contributes to broader environmental goals such as reducing urban heat islands and enhancing ecological resilience.

2.5.2 Urban Water Supply Management

Water management in urban contexts is primarily categorized into two approaches: supply-side management and demand-side management. Supply-side management focuses on increasing the quantity of water available from existing sources or developing new sources to meet growing demands. This includes large-scale projects such as dams, reservoirs, and long-distance water transfers, as well as alternative sources like rainwater harvesting and groundwater extraction (Kolokytha & Mylopoulos, 2002). However, the unregulated extraction of groundwater in rapidly urbanizing areas has led to significant depletion and pollution of aquifers, raising serious concerns about sustainability.

Traditional supply-oriented approaches have proven inadequate in addressing the challenges posed by increasing competition for limited water resources, rising per capita water use, urbanization, pollution, and financial constraints (Kolokytha & Mylopoulos, 2002). Historically, water planners relied on single forecasts to estimate regional growth over time and recommended developing new water sources to meet projected demands. This often involved tapping groundwater through wells or pumping surface water directly from rivers, streams, and lakes. Additionally, techniques such as aquifer storage and recovery have gained popularity; these systems capture excess water during wet periods and store it underground for later use during dry spells.

The overarching goal of supply-side management is to meet target water demands by enhancing the availability of water sources. This involves engineering the world's water resources to deliver adequate quantities of high-quality water that align with societal needs. However, the reliance on conventional supply-side strategies has become increasingly challenged by factors such as climate change, population growth, and urbanization (Yadav et al., 2023).

In urban areas like Dharan, Nepal, the existing water supply systems struggle to keep pace with rapid population growth and changing lifestyles. The city's initial water supply infrastructure was established in the 1960s but has not evolved sufficiently to accommodate current demands. As a result, residents frequently experience intermittent supply and are forced to seek alternative sources of water (Yadav et al., 2023). Furthermore, the increasing impervious surfaces due to urban expansion exacerbate runoff issues and reduce groundwater recharge capacity (IUDP, n.d.).

While supply-side management remains a critical component of urban water strategy, it is becoming clear that a more integrated approach that includes demand-side management is essential for sustainable urban water management. Demand-side management focuses on optimizing water use efficiency and reducing consumption through various means such as public awareness campaigns, pricing strategies, and regulatory measures. By balancing both supply and demand approaches, urban planners can develop more resilient water systems capable of addressing the complexities of modern urban environments.

2.5.3 Urban Water Demand Management

Urban water demand management (WDM) is a critical strategy for enhancing water efficiency and reducing misuse in urban areas. This approach encompasses various practices aimed at optimizing water use, which include the introduction of pricing policies, mandatory installation of water meters, promotion of water conservation, and the implementation of rainwater harvesting systems for direct use. By effectively managing demand, cities can decrease potable water consumption, increase wastewater recycling and reuse, minimize leakages, and enhance the installation of water-saving devices. Furthermore, maintaining consistent water pressure and providing 24/7 supply systems are essential components of a comprehensive WDM strategy (Kolokytha et al., 2002).

The reorientation of urban water policy towards sustainability is closely linked to the adoption of demand management practices. This transition necessitates an integration of engineering, environmental considerations, and socio-economic factors into water supply planning and management (Kolokytha et al., 2004). The primary objective of urban water demand management is to explore alternative growth patterns while accurately estimating the associated water needs. By influencing demand, this approach aims to utilize scarce resources efficiently and sustainably.

Often referred to as "soft path water management," the WDM approach emphasizes improved techniques over large-scale investments in new infrastructure such as dams or extensive piping systems. For instance, strategies may include raising water prices to curtail excessive consumption, offering rebates on water bills to incentivize xeriscaping in residential areas, and updating building codes to mandate the installation of low-flow toilets and fixtures (Agthe et al., 2003). These measures not only promote conservation but also encourage sustainable practices among residents.

To effectively implement these approaches, it is crucial for municipalities to consolidate management responsibilities within a single organization. This centralized governance can facilitate the borrowing of scientific and technological expertise from other agencies while ensuring that both structural and non-structural alternatives are evaluated for their benefits (Holtz et al., 1978). Identifying optimal combinations of these alternatives can lead to more effective water management solutions tailored to local contexts.

2.5.4 Factors Affecting CP and Sustainability of Projects

Parameswaran (1999) argues that a range of characteristics such as technology used to implement project activities can be effective to CP. The more complex the technology, the less participation. The question of technology has direct link with sustainability of project services especially when operational and maintenance costs are to be met by the beneficiary communities. Another factor according to Parameswaran is on human and financial resources, as they are vital when it comes to meeting operational and maintenance costs. Furthermore, transparency accounts for the degree of CP. For this matter community members will actively participate if benefits are clearly articulated and obtained immediately at the beginning of the project design. For the case of the water project, people expect to see domestic water points installed or boreholes drilled and in operation. Moreover, administration structure is equally important. Thus, if projects allow users' contribution and if they are flexible, well coordinated and managed well at the local level, with free flow of information then people will automatically participate. Women's involvement in project activities and capacity building are also essential to sustain project-initiated services. This is because in water projects women are the main stakeholders. Therefore, women participation and leadership positions in WC are inevitable for sustainable water projects (Mbugua et al, 1993: 14).

2.5.5 Factors that Enhance the Sustainability of Water Project Service

Brikke (1997) argues that sustainability of project services are to be realized if water sources are not overexploited, facilities for operation and maintenance are in place, and funds are readily available. And that both women and men are involved in the design, planning and management of the scheme, and technology choice corresponds to needs desires. Also projects are culturally accepted, spare parts are available and affordable, and support system is in place. Others include capacity building, technical assistance and availability of well-established institution for legal framework.

2.5.6 Shortcomings of Participation Approach

Claud (1998) observes that though CP is essential in ensuring sustainability of rural development projects, it has its own shortcomings. Participatory planning is time consuming and a complex process. The process takes about six months or more to be understood. As a result, beneficiaries expecting to get quick results get discouraged and, that participatory planning is a threat to experts and the community they are serving. The reason for this tendency being that some development experts tend to feel they know better than the community they are serving.

CP is never homogeneous. There are a number of problems that emerge in the cause of participatory approach, such as conflicts of interest among different social groups, cultural, and political constraints (Mbugua et al, 1993: 34). Moreover, suggested that too much mass involvement in decision-making impedes development growth of the on going project. The argument is that it delays decision-making. Thus, participatory planning needs to be facilitated by appropriate expertise so as to determine who should participate, how, what will be the scope of participation and also how much weight should be given to wishes and demands expressed as compared to priorities already set by official authorities (Martinusen, 1999: 22). David and Joseph (2001) also had the view that participation does not mean that all views from people should be taken into account when setting project activities.

There is also the fact that, both regional secretariat and districts councils do not have the capacities to support participatory planning at the lower council level. This situation arises from the fact that most of the staff at the Regional and District levels, have become

used to a top- down approach to development. Hence, they are used to planning for and not with the people (Kasiaka, 2004: 12).

2.6 Urban Water Security

Urban water security refers to the ability of urban areas to sustainably manage water resources to meet the needs of their populations while addressing risks such as shortages, flooding, pollution, and external dependencies. It is a subset of the broader concept of water security, which encompasses welfare, equity, sustainability, and risk reduction at various levels (household, state, or global (Aboelnga et al., 2019).

Urban water security also involves complex governance structures unique to cities. Municipalities often have distinct departments handling various aspects of water management, spatial planning, and public utilities. This governance complexity requires integrated approaches to balance competing priorities like flood protection, wastewater treatment, and equitable access. (Hoekstra et al., 2018).

The holistic definition integrates key principles from the United Nations Sustainable Development Goal 6 and the human right to water and sanitation, emphasizing that water security is not merely about supply but also about quality, accessibility, and the broader well-being of urban populations (Aboelnga et al., 2019).

2.6.1 Dimensions of Urban Water Security

The urban water security is divided into four key dimensions, often referred to as the DECS model:

a. **Drinking Water and Human Well-being**

This dimension focuses on ensuring that the urban population has reliable access to safe drinking water. Key factors include water availability per capita, the efficiency and reliability of water distribution networks, water quality standards, and the affordability of water services. It emphasizes that a robust water supply system is essential for protecting public health and supporting overall human well-being (Aboelnga et al., 2019; Bajracharya et al., 2019; Hoekstra et al., 2018).

b. **Ecosystems**

The ecosystem dimension underscores the need to maintain and protect the natural environment that supports urban water systems. Healthy ecosystems contribute to

water quality and availability by providing natural filtration, flood mitigation, and other essential services. This dimension calls for the protection of water bodies, sustainable management of wastewater, and the integration of green infrastructure—such as green roofs and urban green spaces—to enhance resilience (Aboelnga et al., 2019; Bajracharya et al., 2019; Hoekstra et al., 2018).

c. **Climate Change and Water-Related Hazards**

Urban water security is increasingly challenged by the uncertainties introduced by climate change. This dimension addresses risks such as extreme weather events, including floods and droughts, which can disrupt water supply and compromise infrastructure. It also highlights the importance of monitoring and mitigating greenhouse gas emissions from water and wastewater systems, as well as adapting urban infrastructure to withstand environmental stresses (Aboelnga et al., 2019; Bajracharya et al., 2019; Hoekstra et al., 2018).

d. **Socio-Economic Factors**

The socio-economic dimension evaluates the economic and governance aspects of water security. It examines the affordability of water tariffs, the financial sustainability of water utilities, cost recovery mechanisms, and the efficiency of regulatory frameworks. This dimension also considers issues related to water governance and stakeholder engagement, recognizing that equitable access to water is as much a matter of social justice and policy as it is of engineering. (Aboelnga et al., 2019; Bajracharya et al., 2019; Hoekstra et al., 2018).

2.6.2 Challenges in Achieving Urban Water Security

Urban water security faces a host of interrelated challenges that make ensuring a sustainable and resilient water supply increasingly complex (Aboelnga et al., 2019).

- i. Rapid Urbanization and Increased Demand
- ii. Climate Change and Water-Related Hazards
- iii. Governance and Institutional Challenges
- iv. Infrastructure Reliability and Intermittent Supply
- v. Dependency on External Water Sources
- vi. Water Quality Degradation
- vii. Socio-Economic and Financial Constraints

2.7 Integrated Water Resource Management (IWRM)

Integrated Water Resources Management (IWRM) is a cross-sectoral approach that promotes the coordinated development and management of water, land, and related resources to maximize economic and social welfare equitably while ensuring the sustainability of vital ecosystems (Environment, 2017).

Integrated Water Resources Management (IWRM) is not an end goal but a process designed to address the specific ecological, social, and economic contexts of different regions. Its primary aim is to balance and negotiate trade-offs between three key objectives: economic efficiency in water use, social equity, and environmental sustainability. These aspects are interconnected and require stakeholder engagement to ensure effective decision-making (Sharma et al., 2023).

2.8 National Water Policies and Guidelines

2.8.1 Constitutional Provisions in Nepal

The Constitution guarantees every citizen the right to a clean and healthy environment and mandates the state to manage water resources sustainably, ensuring availability for various uses including drinking, irrigation, and energy generation (Government of Nepal, 2015). Communal activities in the water resources sector have declined with the rise of formal government involvement, making water resource development primarily a government-led initiative, while hydropower remains open to private investment, and policies like the Water Resources Policy 2020 explicitly promote IWRM, with others aligning with its principles (Sharma et al., 2023).

Nepal's Constitution, enacted in 2015, established a federal governance system with three levels: federal, provincial, and local municipalities. It outlines various responsibilities concerning water resources and environmental protection. The Constitution guarantees every citizen the right to a clean and healthy environment under Article 30(1) and ensures access to safe drinking water and sanitation under Article 35(4). Additionally, it mandates that state policies incorporate provisions related to water management and sustainability

- Promote the multi-purpose utilization of water resources, prioritizing domestic investment and encouraging public participation in development projects.
- Ensure an affordable, reliable, and accessible energy supply, emphasizing the development and use of renewable energy to meet citizens' fundamental needs.

- Establish sustainable and efficient irrigation systems, implement measures to control water-induced disasters, and adopt effective river management practices for long-term resilience (Article 51).

Nepal's Constitution outlines actionable targets for water governance, ensuring a structured approach to managing resources. It establishes a federal system with seven provinces and 753 local government units, covering both urban and rural municipalities (Article 56).

The distribution of powers among the three levels of government is detailed in Article 57, with specific responsibilities listed in the Constitution's schedules (Sharma et al., 2023). Any matters not explicitly assigned fall under the jurisdiction of the federal government. Articles 59 and 60 define the framework for financial authority and revenue distribution among the different levels of government (Sharma et al., 2023).

Schedules 5 to 9 play a crucial role in the allocation and governance of water resources, clearly defining the responsibilities of different administrative levels (Sharma et al., 2023). Schedule 9, in particular, outlines areas where authority is shared among the federal, provincial, and local governments, with water management being a key area of concurrent jurisdiction (Sharma et al., 2023).

Table 1 Overlap in Jurisdiction of Federal, Province, and Local Levels (Sharma et al., 2023)

Entities	Schedule	Item No. and Item of the schedule
Federal Jurisdiction only	5	7. International treaties or agreements, mutual legal assistance, international borders, international boundary rivers 11. Policies relating to conservation and multiple uses of water resources 14. Central level: large electricity, irrigation, and other projects 27. National and international environment management, national parks, wildlife reserves and wetlands, national forest policies, and carbon services
Province Jurisdiction	6	7. Province-level electricity, irrigation, and water supply services, navigation 19. Use of forests and waters and management of the environment within the Province
Concurrent jurisdiction of the Federation and the Provinces	7	13. Province boundary rivers, waterways, environment protection, biological diversity 18. Tourism, water supply, and sanitation 23. Utilization of forests, mountains, forest conservation areas, and waters flowing between and across provinces
Local municipalities Jurisdiction	8	19. Water supply, small hydropower projects, alternative energy 21. Protection of watersheds, wildlife, mines, and minerals
Concurrent jurisdiction of the Federation, Provinces and Local Level	9	5. Services such as electricity, water supply, irrigation 7. Forests, wildlife, birds, water uses, environment, ecology, and bio-diversity 14. Royalty from natural resources

2.8.2 Water Resources Strategy 2002

In 2002, the Government of Nepal introduced the National Water Resources Strategy with the overarching goal of significantly enhancing the living standards of Nepali citizens in a sustainable manner (Sharma et al., 2023). This strategy set short-term (5 years), medium-term (15 years), and long-term (25 years) objectives, developed through extensive stakeholder consultations. The strategy was guided by key policy principles, including the adoption of Integrated Water Resources Management (IWRM), emphasizing resource conservation, environmental protection, and a holistic approach to river basin management (Sharma et al., 2023).

2.8.3 National Water Plan 2005

The National Water Plan (NWP) 2005 is a crucial guiding document for water resource management in Nepal. It aims to translate the National Water Resources Strategy (NWRS) 2002 into practical programs. The NWP 2005 emphasizes an integrated approach, acknowledging that various water uses like irrigation, water supply, and hydropower are interdependent, thus requiring coordinated planning. It promotes decentralization by delegating water management responsibilities to local levels and encouraging stakeholder participation in decision-making processes. The plan prioritizes sustainable development, balancing economic growth with environmental preservation. Sectoral integration is another key aspect, seeking to manage water resources across different sectors such as agriculture, energy, and urban development. Despite its comprehensive nature, the implementation of the NWP 2005 has faced several challenges. These include a fragmented institutional landscape, a lack of coordination among government agencies, and limited financial and technical capacities at the local level.

- **Integrated Approach:** The NWP 2005 emphasizes an integrated approach to water resource management, recognizing the interdependencies among different water uses and the need for coordinated planning and management.
- **Decentralization and Participation:** It promotes decentralization of water management responsibilities to local levels and encourages the participation of stakeholders, including communities, in decision-making processes.
- **Sustainable Development:** The plan underscores the importance of balancing economic development with environmental sustainability, ensuring that water resources are managed in a way that meets current needs without compromising the ability of future generations to meet their own needs.
- **Sectoral Integration:** The NWP 2005 seeks to integrate water resource management across different sectors, such as agriculture, energy, and urban development, to maximize the benefits from water resources and minimize conflicts

2.8.4 Water Resources Act 1992

Nepal's water resources management continues to be governed by the Water Resources Act, 2049 (1992), supplemented by the Water Resources Rules, 2050 (1993). Although there have been attempts to introduce a new legal framework aligning with the National

Water Plan 2005 and the constitutional changes brought by Nepal's new Constitution, these efforts have yet to succeed. The Water Resources Act currently in force consists of 25 sections, outlining regulations for water resource utilization and management (Sharma et al., 2023).

2.8.5 National Water Resources Policy (2020)

The policy aims to sustainably manage water resources while promoting economic prosperity and social transformation. It adopts IWRM principles and emphasizes the need for science-based planning and management approaches (Sharma et al., 2021).

2.8.6 Irrigation Policy (2013)

This policy focuses on improving irrigation systems to enhance agricultural productivity and resilience against climate change impacts. It supports community participation in irrigation management (Sharma et al., 2021).

2.8.7 National Climate Change Policy (2019)

The policy addresses climate change adaptation and mitigation strategies within the water sector, encouraging local communities to engage in sustainable practices that enhance resilience to climate impacts (Sharma et al., 2021).

2.8.8 Water Supply and Sanitation Act (2022)

The Water Supply and Sanitation Act 2022 of Nepal is a pivotal legislative framework designed to enhance access to safe drinking water and adequate sanitation services across the country. This act establishes the right of every citizen to access these essential services, mandating local governments to ensure their availability, particularly in underserved areas. A key feature of the act is its emphasis on decentralization, empowering local authorities to manage water supply and sanitation systems effectively. This decentralization not only fosters community involvement but also encourages public participation in the planning and implementation of water projects, ensuring that local needs and preferences are prioritized. The act also sets forth quality standards for drinking water and sanitation facilities, aiming to safeguard public health and improve living conditions.

1. Right to Water Supply and Sanitation (Section 3):

- Ensures every citizen's right to clean water and sanitation.

- Responsibilities for fulfilling these rights are shared between the Government of Nepal, Provincial Governments, and Local Levels.
- 2. Water Source Conservation (Section 5):**
 - Focuses on protecting water sources through flood control, pollution prevention, and regular maintenance.
 - Encourages sustainable practices like organic farming to safeguard water sources.
 - 3. Responsibilities of Local Levels (Section 8):**
 - Local levels are tasked with providing basic water supply and sanitation services.
 - Emphasis on maintenance and rehabilitation of water supply systems.
 - 4. Community Participation and User Organizations (Section 8, Clause c):**
 - User organizations are empowered to operate water supply services.
 - Promotes local community involvement in managing water resources.
 - 5. Tariff and Service Charges (Section 33):**
 - Provides guidelines for tariff fixation, allowing concessions for disadvantaged families.
 - Aims to make services affordable and equitable.
 - 6. Use of Technology and Data (Section 56):**
 - Mandates the creation of digitized maps for water supply and sanitation systems.
 - Focus on transparency and efficient resource management.
 - 7. Promotion of Rainwater Harvesting (Section 49):**
 - Encourages financial and technical support for rainwater collection systems in areas with insufficient water sources.

8. Public Awareness and Campaigns (Section 49, Clause 1):

- Governments at all levels can run sanitation campaigns to keep urban and rural settlements clean and healthy.

The framework encourages active involvement from communities in decision-making processes, which is essential for developing sustainable water management practices. Furthermore, the act's focus on ensuring equitable access to safe water directly supports your exploration of the impact of community-led initiatives on improving water supply and addressing urban water-related problems.

2.8.9 National Water Policies, 2002 (Rastriya Jalshrot Niti, 2002)

1. Community Engagement in Water Management (Aligned with - Policy 1.6):

- Encourage active participation of local communities in the management, operation, and maintenance of water supply systems.
- Support volunteering programs to construct reservoirs and rehabilitate water sources.

2. Decentralized Water Systems (Aligned with - Goal 1.5):

- Promote small-scale, decentralized water supply systems to meet local demands efficiently.
- Strengthen the role of local bodies in managing and monitoring water systems.

3. Water Conservation and Resource Efficiency (Aligned - Goal 3.7):

- Advocate for rainwater harvesting and groundwater recharge systems in urban areas.
- Encourage the use of water-efficient technologies and practices to reduce water wastage.

4. Equitable Access to Water (Aligned with - Goal 2.2):

- Ensure water access for marginalized and low-income communities by incorporating inclusive policies.
- Address socio-economic disparities in urban water distribution and supply.

5. **Integrated Water Resource Management (IWRM) (Aligned with - Strategy 1.2):**

- Integrate urban planning with sustainable water resource management to ensure resilience against climate change and population growth.
- Promote data-driven decision-making using GIS and water resource analytics for improved management.

Institutional Frameworks and Implementation Mechanisms:

1. **Formation of Water Management Committees (Aligned with - Strategy 4.3):**

- Establish ward-level water committees to oversee localized water supply operations.
- Create a central regulatory body to coordinate with local authorities and monitor urban water management systems.

2. **Policy Alignment and Review (Aligned with - Goal 5.1):**

- Amend outdated policies and harmonize them with sustainable urban water management strategies.
- Regularly review and update guidelines to align with technological advancements and environmental challenges.

3. **Public-Private-Community Partnerships (PPCP) (Aligned with - Policy 3.9):**

- Involve private stakeholders and NGOs in funding, implementing, and maintaining water infrastructure projects.
- Develop frameworks to encourage community participation and ownership of water projects.

2.8.10 Local Governance and Community Engagement

- Provincial Water Policies

With the federal structure established in Nepal, provincial governments are tasked with enacting their own water policies that align with national guidelines while addressing local needs. This decentralized approach is crucial for effective community engagement in water management (Sharma et al., 2021).

- Local Adaptation Plans

Local governments are encouraged to develop adaptation plans that incorporate community input, ensuring that local knowledge and needs are reflected in water management strategies (Sharma et al., 2021).

CHAPTER 3 METHODOLOGY

3.1 Paradigm

Research is defined as the systematic investigation into and study of materials and sources in order to establish facts and reach new conclusions. Doing research is not an easy task. The exact nature of the definition of research is influenced by the researcher's theoretical framework which is known as paradigm. As researchers, it is essential to comprehend and articulate our foundational convictions regarding the nature of reality, what can be understood about it, and the methodologies employed to attain this knowledge. These foundational beliefs constitute what is known as research paradigms. Many people have defined paradigm in their own way. Thomas Kuhn's defines Paradigm as the underlying assumptions and intellectual structure upon which research and development in a field of inquiry is based. Whereas according to Patton (1990) a paradigm is a world view, a general perspective, a way of breaking down the complexity of the real world. Similarly, Guba and Lincoln's definition seems most apt from the research point of view. They view a paradigm as 'a basic system or worldview that guides the investigator, not only in choices of method but in ontologically and epistemologically fundamental ways' (Guba, 1994).

A research paradigm is a foundational framework rooted in a researcher's worldview, influencing the choice of methodology, methods, and literature. According to Mertens (2007), research is a systematic process of collecting, analyzing, and interpreting data to understand, describe, predict, or control phenomena. The chosen paradigm profoundly shapes the research design—for example, a positivist paradigm often pairs with quantitative methods that emphasize objectivity and statistical analysis, whereas a constructivist paradigm typically favors qualitative methods that prioritize subjective experiences and meaning-making (Creswell, 2014). Fundamentally, paradigms are models derived from a belief system about the nature of knowledge and existence.

Pragmatism Paradigm:

Pragmatism focuses on addressing real-world problems by integrating diverse methodologies and producing actionable outcomes, making it particularly suitable for applied, interdisciplinary research. The pragmatic paradigm is a philosophical framework that emphasizes practical solutions to real-world problems by integrating both qualitative and quantitative research methods. This approach is particularly relevant in social

sciences, where complex issues like urban poverty require multifaceted solutions. Pragmatists believe that reality is continually changing amid the flow of constantly changing situations (Ulz, 2023). The study does not stick to a single research paradigm; instead, it uses the most fitting framework for the research question by combining positivist and interpretivist approaches. It is outcome-oriented, focusing on solving real-world challenges rather than following one theoretical perspective. This dual focus on understanding water scarcity in Dharan and proposing sustainable management strategies directly aligns with pragmatic principles (Morgan, 2014).

The research employs methodological pluralism via a mixed-methods approach, integrating qualitative data (from stakeholder interviews and focus groups) with quantitative data (such as geospatial analysis). This approach addresses Dharan's unique issues—rapid urbanization, aging infrastructure, and climate variability—by involving diverse stakeholders like residents, water authorities, and local policymakers (Patton, 2015).

By drawing on multiple disciplines—environmental science, governance, economics, and urban planning—this pragmatic strategy bridges theoretical insights and practical applications. Ultimately, it generates actionable knowledge to enhance the resilience of Dharan's water supply system, ensuring findings remain both academically rigorous and directly beneficial for decision-makers (Tashakkori & Teddlie, 2010; Biesta, 2010; Morgan, 2014).

3.2 The Ontology

Ontology refers to the nature of beliefs about reality, addressing fundamental questions about how reality exists and what can be known about it (Richards, 2003). Researchers' ontological assumptions influence their understanding of the phenomena being studied. These assumptions guide researchers to question whether reality is singular and verifiable or constructed through social, cultural, and contextual interactions (Patton, 2002; Crotty, 1998).

In this research on water scarcity in Dharan, the adopted pragmatic ontological stance recognizes that reality is both objective and socially constructed. Influenced by John Dewey's pragmatism, it views reality as dynamic and shaped by the interaction between

environmental, infrastructural, and governance systems, as well as human behaviors and perceptions.

The study values both measurable data and lived experiences. It will use qualitative methods—such as interviews, focus group discussions, and ethnographic observations—to understand how residents, policymakers, and authorities perceive and respond to water scarcity. At the same time, it examines systemic factors like governance, infrastructure, economics, and climate change that influence water availability and management.

This ontological view supports a mixed-methods approach, combining quantitative tools (like geospatial and statistical analysis) with qualitative insights to develop a holistic understanding of the issue. It also emphasizes collaboration with local stakeholders, involving them in identifying challenges and creating context-specific, inclusive, and sustainable solutions. This aligns with the pragmatic aim of producing knowledge that is both actionable and meaningful to the community.

3.3 The Epistemology

Epistemology, the study of knowledge and its acquisition, forms the foundation of this research on water scarcity in Dharan, Nepal. This study adopts a **mixed-methods approach**, combining quantitative data analysis with qualitative insights to achieve a comprehensive understanding of the factors contributing to water scarcity and the strategies required for sustainable water management.

Quantitative Knowledge Acquisition

Quantitative methods provide crucial statistical insights into the demand-supply dynamics, infrastructural gaps, and climate-induced variations affecting Dharan's water supply system. Data sources such as water distribution records, demographic trends, and meteorological data offer measurable evidence of the challenges faced by the urban water supply system. Techniques like geospatial mapping and statistical analysis further illuminate patterns of water availability, usage, and inefficiency, laying a strong foundation for evidence-based decision-making.

However, numerical data alone cannot fully encapsulate the multifaceted nature of water scarcity, which is influenced by social, political, and behavioral factors.

Qualitative Knowledge Acquisition

To capture these complexities, qualitative methods are employed, including interviews, focus group discussions, and stakeholder consultations. These methods explore the lived experiences of Dharan's residents, the operational challenges faced by water management authorities, and the coping strategies employed by communities. They also provide insights into institutional practices, governance structures, and local perceptions of water scarcity. By incorporating these narratives, the research goes beyond surface-level statistics to uncover the socio-political and cultural dimensions of the problem.

Context-Specific and Participatory Epistemology

This epistemological framework emphasizes the significance of local context in shaping knowledge about water scarcity. Factors such as Dharan's unique topography, the impact of urbanization, and the legacy of its water management infrastructure are critical in understanding the issue. By engaging local stakeholders—including municipal authorities, water supply operators, and residents—as co-researchers, the study ensures that the knowledge generated is both inclusive and reflective of on-ground realities. This participatory approach not only enhances the validity of the findings but also empowers affected communities by involving them in the research process.

3.4 The Methodology

The methodology for this research on water scarcity in Dharan is designed to align with the pragmatism paradigm, emphasizing a mixed-methods approach to comprehensively analyze the factors contributing to water scarcity and propose sustainable solutions. The combination of qualitative and quantitative methods ensures a holistic understanding of the issue, integrating empirical data with stakeholder perspectives to generate actionable insights.

3.5 Research Methods

The study follows an **exploratory sequential mixed-methods design with case study**, beginning with qualitative data collection to identify key themes and contextual insights.

Qualitative Phase

This phase involves semi-structured interviews with municipal authorities, water supply officials, and community leaders, as well as focus group discussions (FGDs) with local residents. These methods help uncover institutional challenges, community coping mechanisms, and perceptions of water scarcity. Additionally, document analysis of

policies, municipal records, and historical water infrastructure data complements the qualitative approach. Sampling strategies include purposive sampling to select relevant stakeholders and snowball sampling to expand participant inclusion.

Quantitative Phase

Building on the qualitative phase, the quantitative phase involves statistical and geospatial analyses to validate and expand on the findings. Geospatial analysis uses satellite imagery and GIS data to map water sources, distribution networks, and areas experiencing supply-demand imbalances. Statistical techniques, such as descriptive and inferential analysis, assess trends in water demand, supply, and infrastructure performance. This phase also incorporates climate data modeling to evaluate the impacts of rainfall and temperature variability on water availability. The infrastructure assessment examines the efficiency of existing water systems through technical audits and field inspections, with stratified sampling ensuring representation across different wards and socio-economic groups in Dharan.

Data collection tools are tailored to each phase. For qualitative data, interviews and FGDs are guided by open-ended questions, recorded with consent, and transcribed for thematic analysis. Quantitative data are sourced from municipal records, census databases, and meteorological stations, and analyzed using software such as SPSS or R. Geospatial data are processed with GIS software to visualize spatial patterns. The integration of qualitative and quantitative findings is achieved through triangulation, ensuring reliability and validity in the research outcomes.

Ethical considerations are central to the research process. Participants provide informed consent, and their privacy is safeguarded through anonymization of responses. The research maintains transparency by engaging stakeholders throughout the process, ensuring their views are accurately represented and respected. Reflexivity is employed to critically examine potential biases in data collection and interpretation, particularly in qualitative methods.

3.5.1 Literature Review

A comprehensive literature review was conducted to examine existing research on urban water scarcity, community engagement in water management, and decentralized water supply systems. Sources included peer-reviewed journals, government reports, policy documents, and case studies from both local and international contexts. The review focused on identifying key themes such as the challenges posed by rapid urbanization and

aging infrastructure, best practices in decentralized water management, and the role of community participation in enhancing water security. This process not only provided the theoretical framework for the study but also informed the development of the research instruments used in subsequent data collection phases

3.5.2 Field Observation

Field observations were carried out in various strategic locations throughout Dharan to gain firsthand insights into the operational status of both centralized and decentralized water supply systems. The observations focused on physical conditions of water infrastructure, the functionality of water distribution networks, and environmental factors affecting water availability. Detailed field notes and photographic documentation were maintained to record issues such as leakages, system inefficiencies, and the impact of urban expansion on water catchment areas. These observations served to validate and contextualize findings from the literature review and survey data

3.5.3 Questionnaire Survey

A structured questionnaire survey was administered to a representative sample of households across multiple wards in Dharan. The survey was designed to capture quantitative data on residents' perceptions, satisfaction levels, and concerns regarding the urban water supply system, as well as their awareness of ongoing improvement initiatives and willingness to participate in volunteer campaigns. The questionnaire comprised both closed-ended questions, to facilitate statistical analysis, and open-ended questions, to allow for more nuanced responses. Respondents were selected using random sampling techniques based on key demographic variables such as age, gender, socioeconomic status, a **Sample Size**

To calculate the sample size Cochran equation (1963) with a 95% confidence level and precision of 10% is adopted. The sampling method considers the entire population of passengers that travel during the 3 days of the survey.

$$n = \frac{z^2 * p * (1-p)}{e^2}$$

Where, n = required sample size

z = Z-score corresponding to the desired confidence level (for 95% confidence level, $Z \approx 1.96$)

p = Estimated proportion of an attribute that is present in the population. (50%)

N = Total population size of passenger

e = desired margin of error (precision), expressed as a proportion (e.g., 0.10 for 10%)

Calculate the sample size n

$$n = \frac{1.96^2 * .5 * (1-.5)}{0.10^2}$$

$$n = 96.04$$

Since the sample size n should be a whole number. Therefore, $n= 97$

and geographic location (Tole), ensuring comprehensive coverage and data saturation.

3.5.4 Pilot Survey

A pilot survey was conducted with a smaller sample size to test and refine the questionnaire and interview protocols. This initial survey, targeting 45 respondents from selected localities, helped identify potential issues with question clarity, response format, and overall survey structure. The pilot survey provided valuable feedback on the community's perceptions and concerns regarding water supply and sanitation services, particularly in relation to decentralized management by entities such as the Panbari Khanepani Upavokta Tatha Sarsafai Samiti. Adjustments made based on the pilot results ensured that the main survey would yield comprehensive and reliable data.

3.5.5 In-depth Interviews

Semi-structured, in-depth interviews were conducted with a diverse group of stakeholders, including municipal water supply officials, community leaders, and members of water user committees. These interviews provided an opportunity to explore in detail the institutional challenges, operational shortcomings, and potential strategies for improving water management in Dharan. The conversational format of the interviews allowed participants to discuss their experiences and insights in depth, thereby offering rich qualitative data that complemented the quantitative findings from the survey.

3.5.6 Key Informant Interviews

Key informant interviews were held with select individuals possessing specialized knowledge and significant influence over water management in Dharan, such as senior officials from the Water Supply Management Board and representatives of decentralized water management entities like the Panbari Khanepani Upavokta Tatha Sarsafai Samiti. These interviews focused on eliciting expert opinions regarding systemic challenges, policy implications, and the effectiveness of current water supply strategies. The detailed

insights garnered from these discussions were critical in identifying key intervention areas and shaping actionable recommendations to enhance the overall sustainability and resilience of Dharan's urban water supply system.

3.5.7 Limitations

The limitations of the research can be listed as follows:

- **Time Constraints:** Limited timeframe for data collection and analysis prevented deeper explorations limiting my case studies to only 12 Water user and Sanitation committees in Dharan, which might affect the comprehensiveness of the study.

CHAPTER 4 STUDY AREA

4.1 Overview

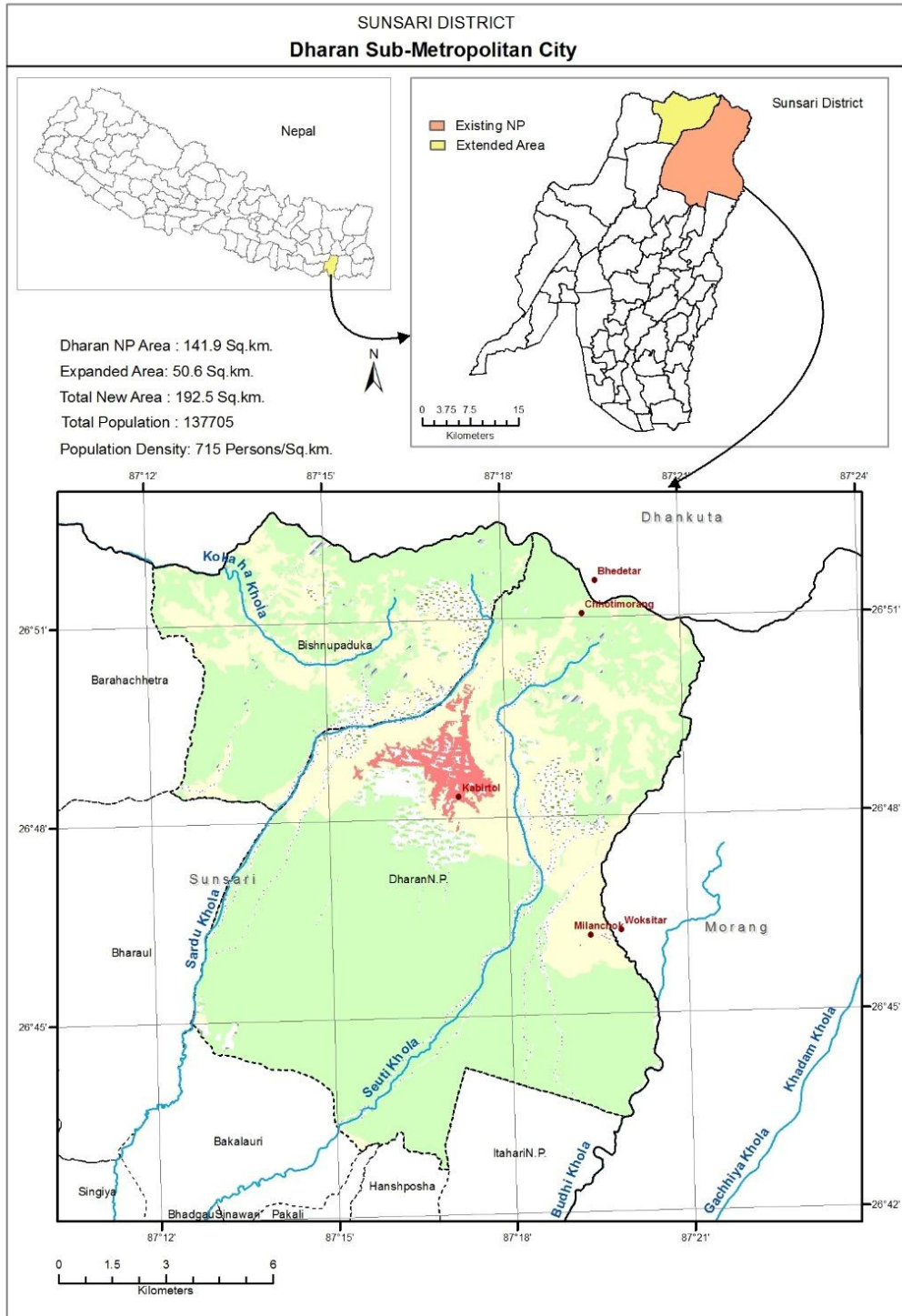


Figure 1 Map of Dharan

Dharan Sub-Metropolitan City, located in Sunsari District of Koshi Province, Nepal, is one of Eastern Nepal's rapidly urbanizing centers. The city has witnessed significant population growth and infrastructural expansion over the past decades. While a centralized water supply system exists, the increasing demand and operational challenges have led to the emergence of decentralized water management initiatives. These community-led systems, known locally as Khanepani Upavokta Samitis, have become vital in ensuring water supply and sanitation, especially in areas where the centralized network does not fully meet the needs of the population.

In this study, the broader landscape of decentralized water supply systems in Dharan is explored through an examination of sixteen different Khanepani Upavokta Samitis. Each of these committees plays a role in managing local water resources, addressing water scarcity, and ensuring sustainable sanitation practices. However, the detailed analysis in this research is focused on the Panbari Khanepani Upavokta Tatha Sarsafai Samiti, which is located in Ward 6 of Dharan. Formerly present at Panchakanya GaBiSa, now falls under the administrative jurisdiction of Dharan Sub-Metropolitan City.

The Panbari model exemplifies how decentralized, community-driven water management can effectively respond to urban water challenges. Its operational practices, financial management strategies, community engagement, and technical approaches provide valuable insights into the sustainability of localized water systems. By examining this model in depth, the study aims to understand how such systems can enhance water security and serve as replicable examples for other areas in Dharan where centralized services are either inadequate or absent.

4.1.1 Physical Profile



Figure 2 Physical Profile of Dharan

Dharan is positioned at the foothills of the Mahabharata Range, with its southern extremity reaching the edge of the Terai region at an elevation of approximately 349 meters (1148 feet). The city is traversed by the Koshi Highway, which not only cuts through its center but also links Dharan to Biratnagar—the provincial capital located about 41 kilometers to the south—and to the Itahari junction on the east–west Mahendra Highway, roughly 17 kilometers away. Additionally, the Nepal–China border near Kimathanka is situated around 115 kilometers to the north.

Historically significant routes have contributed to Dharan's connectivity. One such road, originally built for the British Gurkhas' Gopher Camp from Biratnagar, and another linking Dharan to Dhankuta—completed largely by 1982 with support from the UK—have played key roles in integrating the city with its surroundings.

The region is marked by several flowing water bodies; on the eastern side, rivers such as Seuti, Andheri, Shere, and Masane meander through the area, while on the western side, the Sardu River and Khahare Khola are prominent. The southern area of Dharan is largely enveloped by the Chaar Kose Jhadi forest, which is critical for sustaining local wildlife. To the north, the city is framed by the Mahabharata Range, which also serves as the threshold to the higher hilly regions.

The administrative boundaries of Dharan Sub-Metropolitan City are defined by neighboring municipalities including Kerabari, Sangurigadhi, Itahari, Ramdhuni, Baraha, Belaka, and Sundarhaicha, among others.

4.1.2 Municipality Profile

Dharan consisted of only 11 wards. In B.S. 2035, the municipality expanded to 19 wards by incorporating portions of the eastern Banjhagara Village Panchayat and the western Ghopa Village Panchayat. Later, as per the Council of Ministers' decision on Vaishakha 25, 2071, Panchakanya Village Panchayat was also merged into Dharan Municipality, increasing the total to 23 wards. On Mansir 16, 2071, the Government (Council of Ministers) further incorporated Vishnupaduka Village Panchayat, expanding Dharan to 27 wards and resulting in its declaration as a sub-metropolitan city. Finally, following the decision of the Federal Restructuring Commission, the current administrative structure of Dharan has been reformed to consist of 20 wards. (संक्षिप्त परिचय | Dharan Sub-Metropolitan, n.d.). Dharan has ward 3 as smallest and ward 20 largest on basis of Area.

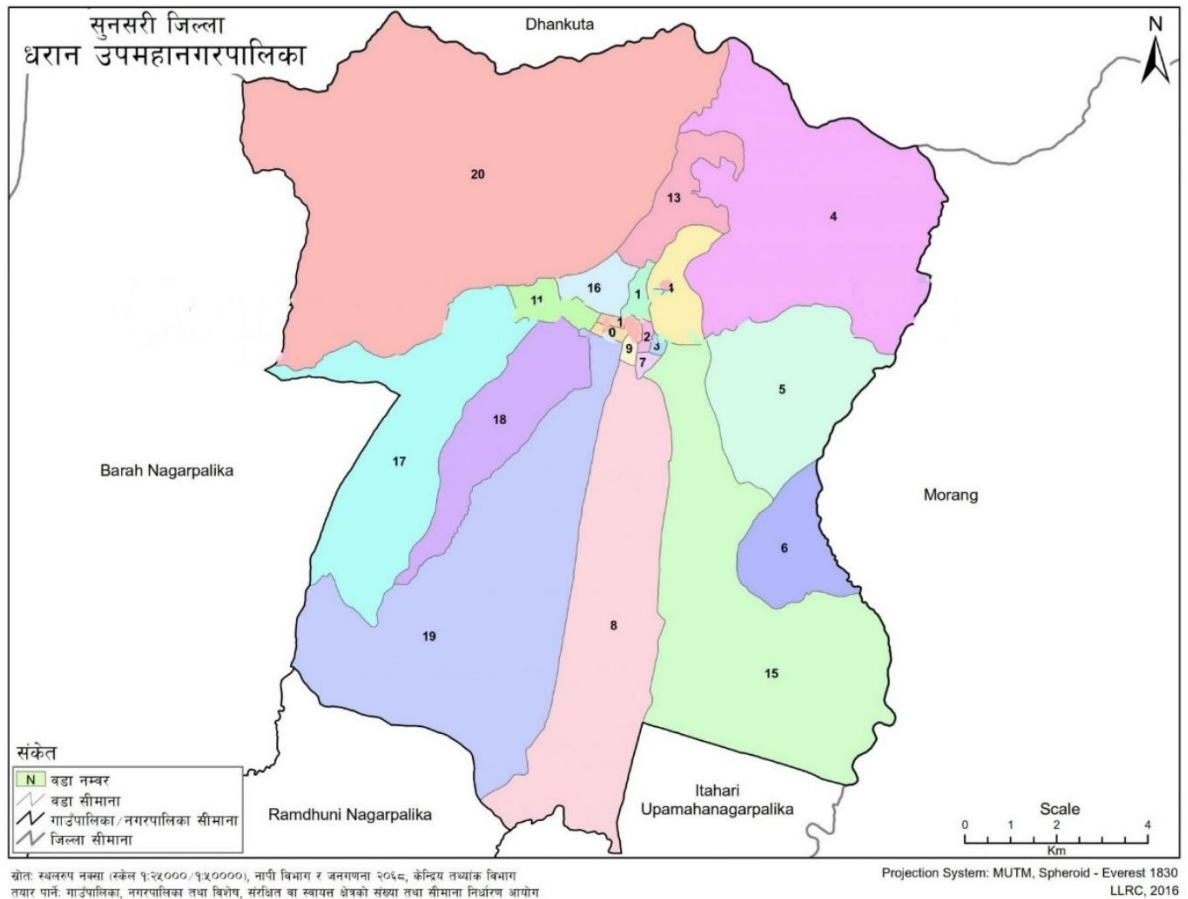


Figure 3 Municipal Profile of Dharan

4.1.3 Climatic Profile

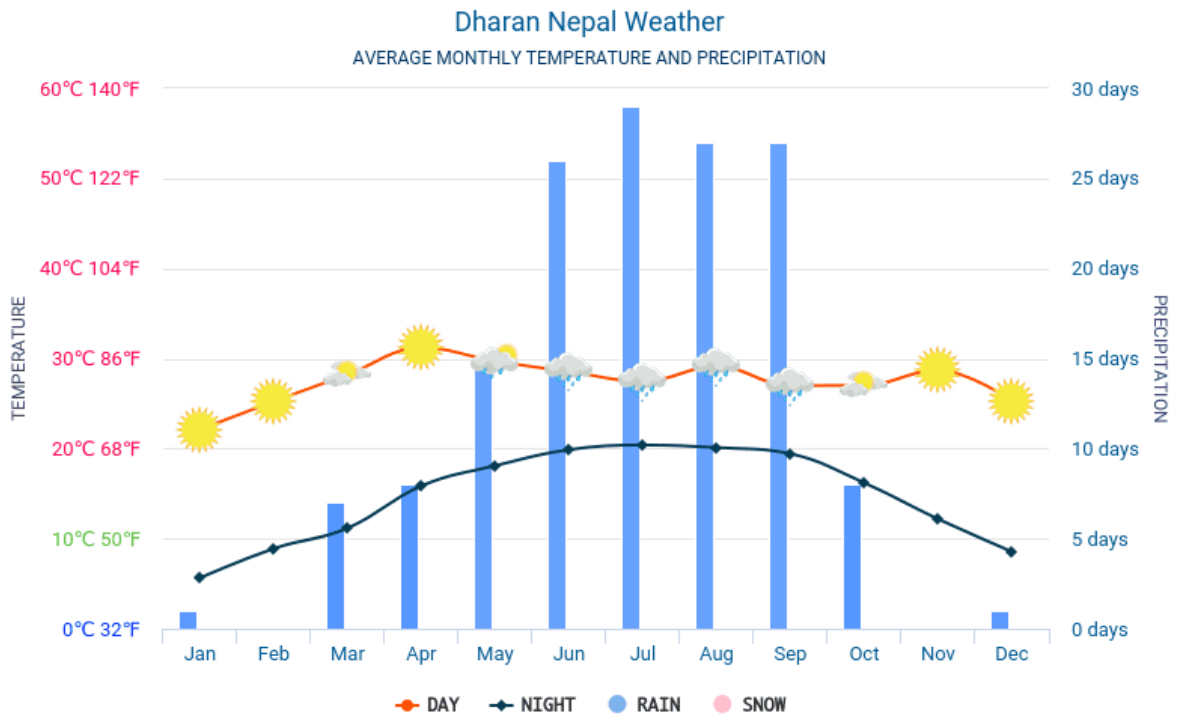


Figure 4 Climate Chart of Dharan

Dharan is characterized by a mild, moderate climate with significantly less rainfall during the winter than in the summer months. According to the Köppen-Geiger classification system, its climate is designated as Cwa. On average, the city maintains a temperature of about 21.6°C (70.8°F) and receives roughly 1796 mm (70.7 inches) of precipitation each year. December is notably dry with an average of only 6 mm of rain, whereas July experiences the highest rainfall, averaging around 490 mm. Being situated in the northern hemisphere, Dharan's summer spans from June through September, making the period from March to October particularly suitable for visitors due to the favorable weather conditions.

	January	February	March	April	May	June	July	August	September	October	November	December
Avg. Temperature °C (°F)	14.2 °C (57.6) °F	16.9 °C (62.5) °F	21 °C (69.8) °F	24.2 °C (75.6) °F	25 °C (77) °F	25.4 °C (77.8) °F	25.2 °C (77.3) °F	25.3 °C (77.5) °F	24.6 °C (76.2) °F	22.4 °C (72.3) °F	18.9 °C (66.1) °F	15.6 °C (60.1) °F
Min. Temperature °C (°F)	8.2 °C (46.8) °F	10.5 °C (50.9) °F	13.5 °C (56.3) °F	17.5 °C (63.5) °F	20.7 °C (69.2) °F	22.9 °C (73.2) °F	23.2 °C (73.8) °F	23.1 °C (73.7) °F	21.9 °C (71.5) °F	17.9 °C (64.3) °F	13.4 °C (56.2) °F	9.8 °C (49.6) °F
Max. Temperature °C (°F)	19.3 °C (66.8) °F	21.8 °C (71.3) °F	26.6 °C (79.9) °F	29.4 °C (85) °F	28.9 °C (84) °F	28.3 °C (82.9) °F	27.5 °C (81.5) °F	27.8 °C (82) °F	27.3 °C (81.1) °F	26.2 °C (79.1) °F	23.5 °C (74.2) °F	20.5 °C (69) °F
Precipitation / Rainfall mm (in)	10 (0)	15 (0)	17 (0)	46 (1)	136 (5)	334 (13)	490 (19)	383 (15)	273 (10)	78 (3)	8 (0)	6 (0)
Humidity(%)	71%	64%	51%	53%	71%	83%	87%	86%	85%	79%	71%	71%
Rainy days (d)	1	2	3	7	14	20	21	21	18	7	1	1
avg. Sun hours (hours)	7.7	8.3	9.8	9.6	9.0	7.8	7.3	7.8	7.9	8.8	8.6	7.9

Data: 1991 - 2021 Min. Temperature °C (°F), Max. Temperature °C (°F), Precipitation / Rainfall mm (in), Humidity, Rainy days. Data: 1999 - 2019: avg. Sun hours

Figure 5 Temperature Graph of Dharan

4.1.4 Demographic Profile

The Dharan Sub-Metropolitan City comprises of 166,531 total population with 47.1% male and 52.9% female. The population of Dharan has 1.6% annual growth rate on comparison to 141,439 population at 2011. The city has 886 population densities per km² and encompasses of 42,396 households, with 30482 owned and 10,2897 rented ownership (*Population / National Population and Housing Census 2021 Results, n.d.*)

Table 2 Demographic Chart of Dharan

Ward No.	Household (2017)	Population	Male	Female	Area (Sq.km.)	Density
1	1,199	4962	2413	2549	0.494	10044
2	540	2275	1124	1151	0.172	13226
3	1,034	4662	2304	2358	.0131	35587
4	713	3783	1822	1961	23.012	164
5	1,779	13651	6380	7271	10.632	1283
6	1,371	8455	3983	4472	4.589	1842
7	777	2967	1480	1487	0.194	15293
8	2,818	12126	5829	6297	19.616	618
9	1,022	3564	1727	1837	0.211	16891
10	1,384	4612	2144	2468	0.222	20774
11	2,708	17168	7904	9264	1.352	12698
12	796	3029	1468	1561	0.276	10974
13	2,034	9138	4167	4971	3.397	2690
14	851	4803	2286	2517	2.468	1946
15	4,726	27441	12845	14596	25.544	1074
16	2,763	14665	6835	7830	1.429	10262
17	2,610	15912	7509	8403	14.578	1091
18	1,620	4579	2072	2507	7.21	635
19	1,154	5313	2415	2898	28.297	187

Ward No.	Household (2017)	Population	Male	Female	Area (Sq.km.)	Density
20	784	3426	1703	1723	49.156	69
Total	32,683	166531	78410	88121	192.98	866

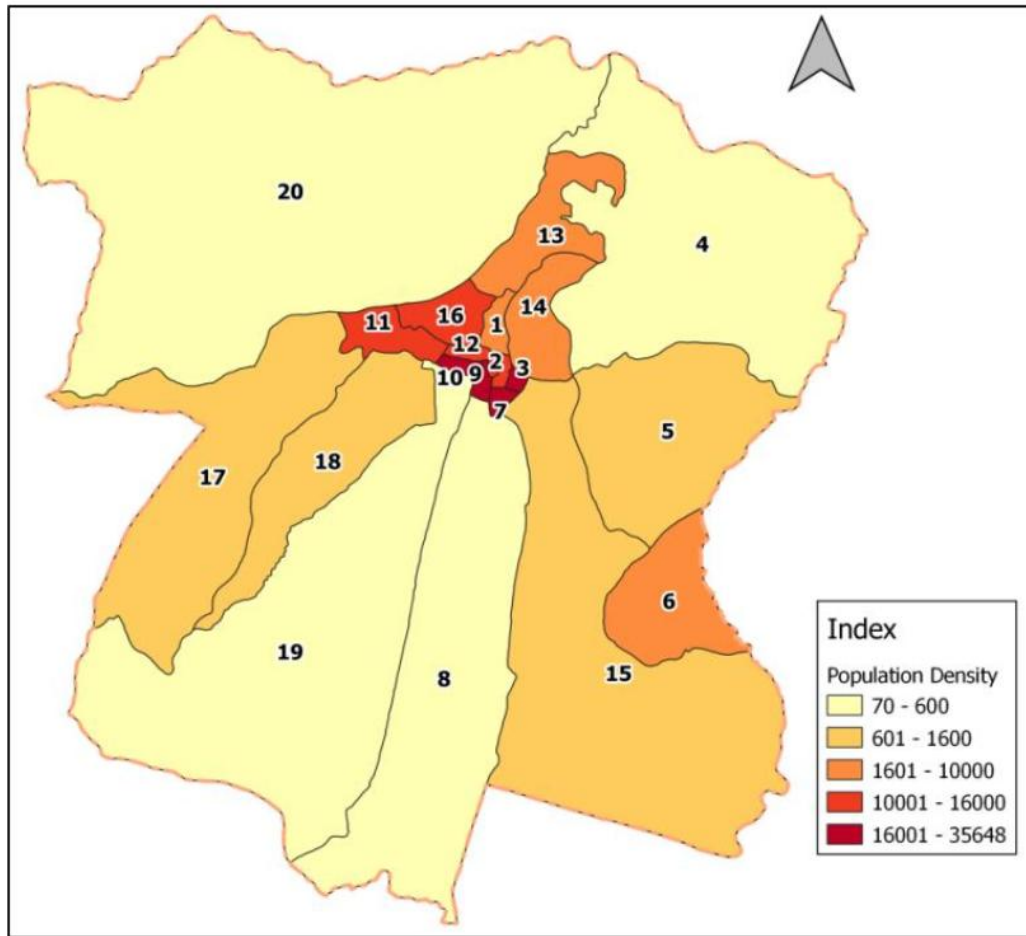


Figure 6 Population Density of Dharan

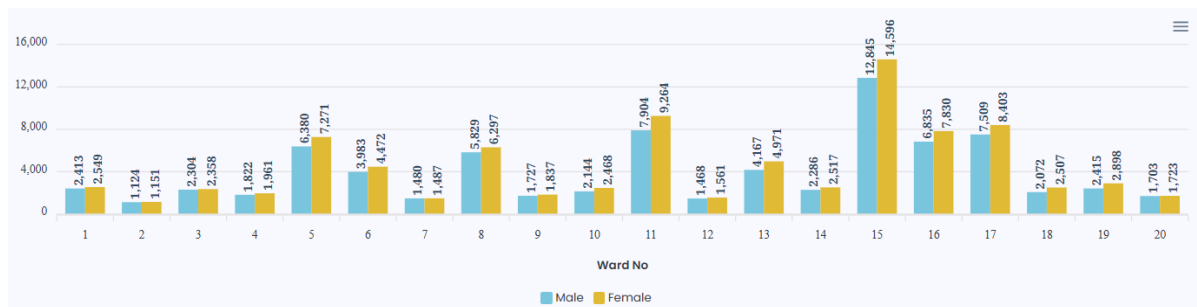


Figure 7 Ward wise population chart of Dharan

4.1.5 Land Use Pattern

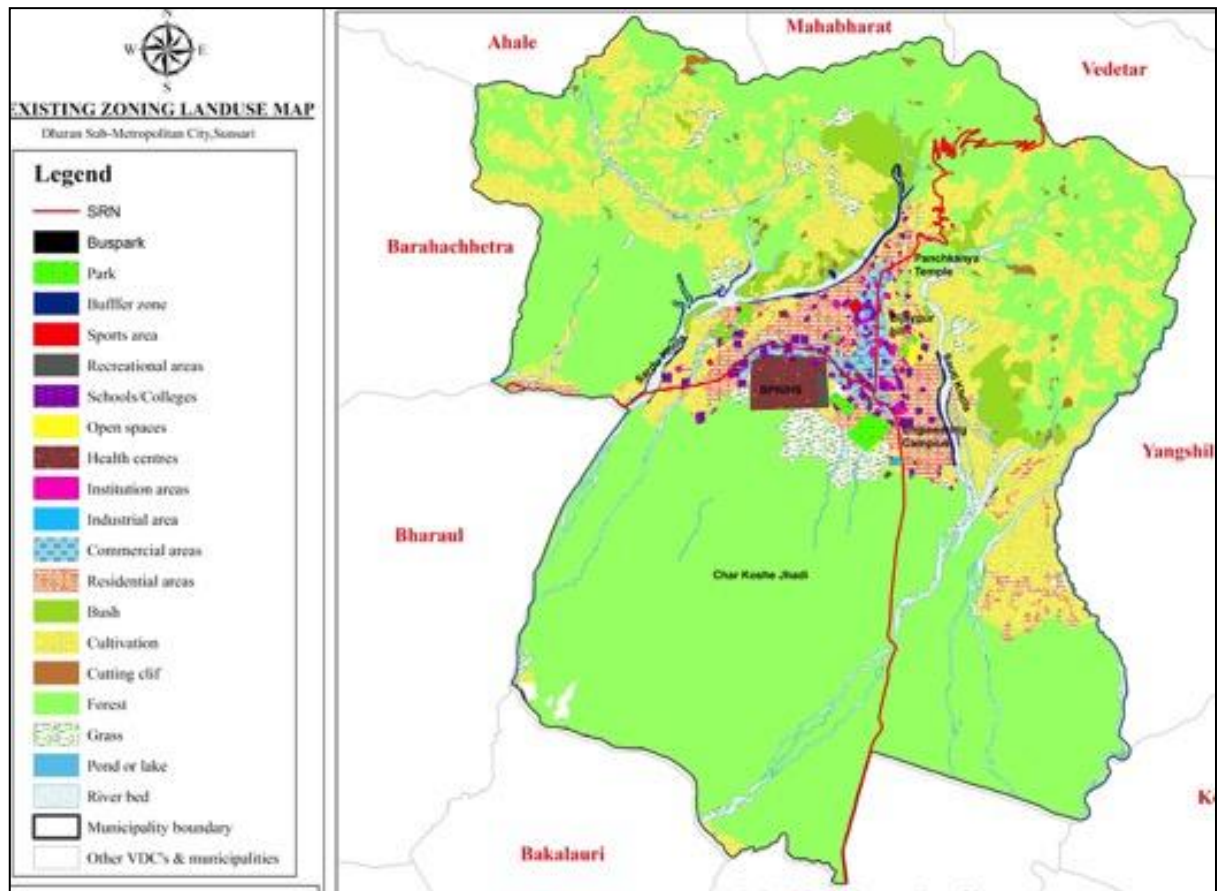


Figure 8 Land Use map of Dharan

Land use in Dharan is diverse, encompassing central urban zones, residential neighborhoods, agricultural lands, water bodies, forested regions, transportation hubs (such as roads and bus parks), recreational parks and gardens, as well as industrial and educational districts. The southern part of the city, characterized by flat plains, hosts much of the non-hilly terrain, while the slopes and elevated areas are largely forested. Notably, nearly half of Dharan's total land area is covered by the protected Char Koshe Forest. The main urban settlement is concentrated at the center of the current municipal boundaries and has gradually expanded westward. In contrast, a cemetery located in the northern section near the riverfront suffers from inadequate accessibility. Additionally, the areas on the eastern and western fringes—comprising recently incorporated Village Development Committees (VDCs)—are still lacking in sufficient urban infrastructure.

The southern plains of Dharan are primarily used for agricultural purposes, while the hilly regions are largely forested. Approximately 50% of Dharan's total area is occupied by the preserved Char Koshe Forest. The central area of the municipality serves as the core urban settlement, which has expanded westward over time. Forests make up a significant portion of the land, covering around 70.33% of the total area, while 23.82% is allocated for agriculture and cultivation. These gently sloping fields are well-suited for growing crops such as cereals, wheat, millet, and maize. Built-up areas account for only 1.78% of the total land, with water bodies covering 0.67%

Table 3 Land Use Chart of Dharan

Categories	Area (sq.km)	Percentage (%)
Built area	3.45	1.78
Forest	135.74	70.33
Water Body	0.01	0.67
Agriculture	45.98	23.82
River bed	7.09	3.67
Cutting cliff	0.87	0.45

4.1.6 Rivers and Water Bodies

Dharan lacks perennial river bodies, most of the water resources are seasonal. The major two seasonal rivers, Seuti Khola in east and Sardu Khola in west boundaries central Dharan, the peripheral regions of Dharan are connected to other rivers like Kokah Khola, Nishane Khola, Sera Khola, Kali Khola, which is the major source of water supply for Upavokta Samitis.

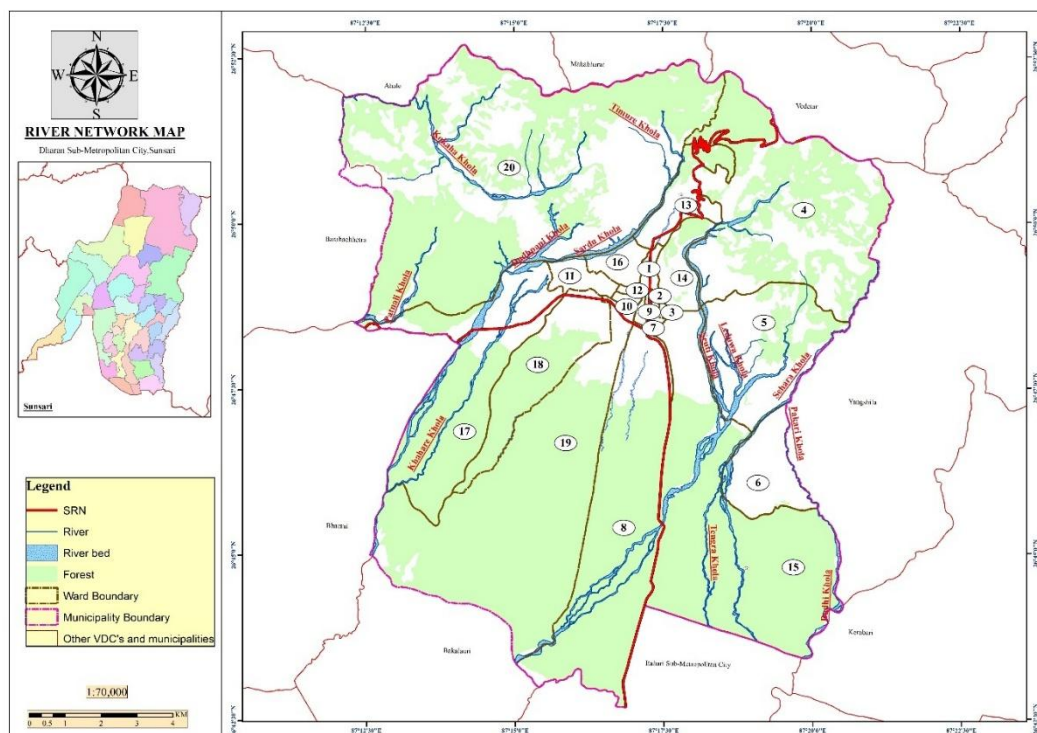


Figure 9 Water bodies map of Dharan

CHAPTER 5 FINDINGS AND ANALYSIS

5.1 Data Collection Framework

For the data collection, the main objective was classified into further sub-objectives or specific objectives. And from the primary and specific objectives, variables or research or research questions were derived. After establishing the variables, data were gathered from diverse sources, including Key Informant Interviews (KII), household surveys (HH's survey), observations, literature reviews, case studies, and more.

Table 4 Framework for Data Collection

Main objective	Specific Objective	Parameters	Sources
To explore the role of community engagement in decentralized water management solutions in addressing urban water scarcity, focusing on Dharan as a case study, to identify sustainable studies for improving water security and resilience.	To explore the existing water supply condition of Dharan	Water supply capacity, seasonal variability, and daily demand trends.	KII Literature Observation
		Infrastructure condition and reliability.	KII Observation
		Existing Numbers of Water User Committees	Dharan SMC
	To explore the role of community participation in addressing water security in decentralized water management in Dharan.	Level of community participation, perceptions, and willingness to engage in water management.	KII Survey Observation
		Community Perceptions and satisfactions	KII Survey

Main objective	Specific Objective	Parameters	Sources
		Willingness to engage	Survey
		Adoption of Decentralization system as a whole	Field Observation Questionnaire Literature KII
	To analyze the role of policy and institutional frameworks in supporting community-driven and decentralized approaches for sustainable water resource management in Dharan.	Policy alignment with community and decentralized solutions.	Secondary Data KII Field Observation
		Funding and resource allocation for decentralized projects	KII Secondary Data
		Clarity and effectiveness roles among institutions	Literature KII Field Observation
		Implementation effectiveness of policies	KII Field Observation

5.2 Current Water Supply Scenario in Dharan

The water supply system of Dharan has evolved over the years to accommodate the growing population and increasing water demand. Historically, the Nepal Water Supply Corporation (NWSC) was responsible for the distribution of water in the city. Alongside NWSC, several **Khanepani Upavokta tatha Sarsafai Samiti** (Water User and sanitation Committees) played a crucial role in distributing water at the community level. These committees adopted a decentralized approach, allowing communities to manage their own water supply systems based on local needs.

Due to geographical constraints and limitations in upgrading the old distribution system, the NWSC was unable to reach all areas of Dharan effectively. Consequently, local communities took the initiative to identify alternative water sources within their own regions. With co-financing and support: both technical and partial financial assistance from the Water Supply and Sanitation Division, these communities established and now operate their own decentralized water distribution systems. This proactive approach has enabled many areas to receive water independently where the centralized system could not adequately serve.

In recent years, the responsibility of centralized water management has been transferred from NWSC to the **Dharan Water Supply Management Board (DWSMB)**. This board now oversees the primary water supply system in the city, operating as a centralized authority that manages large-scale infrastructure, storage, and distribution networks.

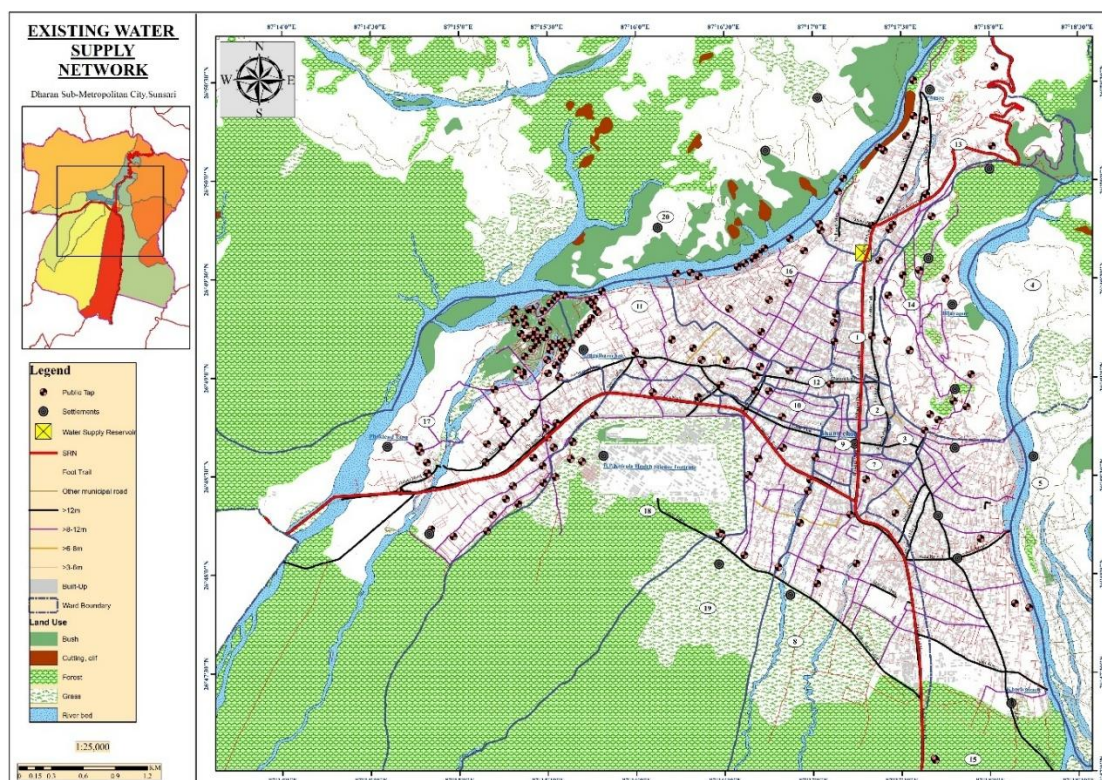


Figure 10 Existing Centralized Water Supply map of Dharan (Source IUDP, 2017)

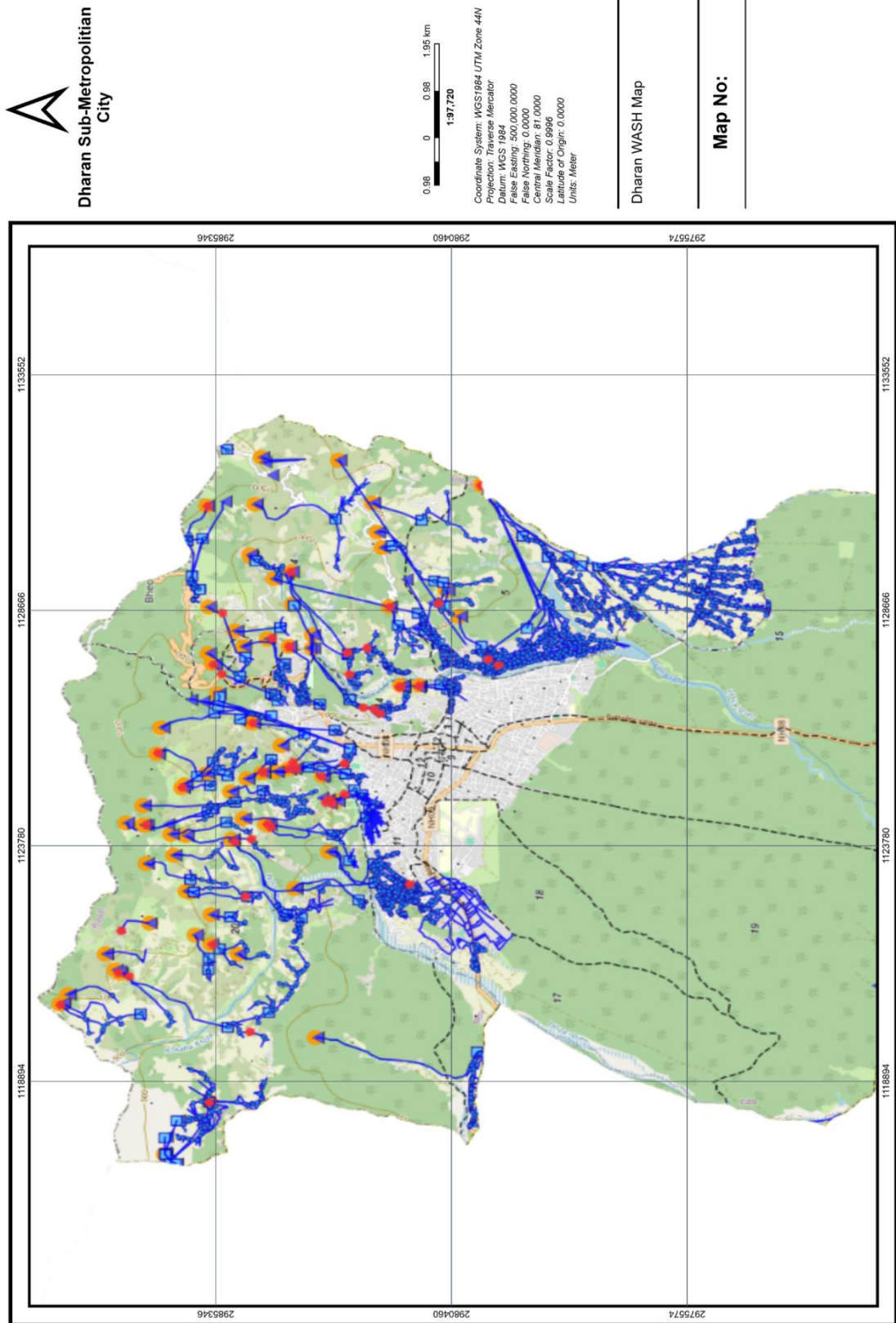


Figure 11 Decentralized Water Supply Map of Dharan

5.2.1 Dharan Water Supply Management Board

In 2071 B.S., the Government of Nepal established the Dharan Water Supply Management Board (DWSMB) under the Khanepani Byabasthapan Board Act 2063. Historically, water distribution in Dharan was managed by the Nepal Water Supply Corporation (NWSC) through a centralized system. However, with the implementation of the Integrated Urban Development Project (IUDP), critical deficiencies in the water supply infrastructure were identified. The IUDP highlighted the need not only for improvements to the existing system and the addition of new water sources but also for a structural change that would enable timely repayment of an Asian Development Bank (ADB) loan.

The heavy reliance of NWSC on government funding had long limited its operational flexibility. Recognizing these challenges, the government saw the necessity for a water supply management board that could function as an independent entity—one that could manage its own income and expenses rather than depend solely on governmental funds. This vision was materialized with the formation of the DWSMB in 2071 B.S., with the expectation that the new board would bring a more dynamic and self-sustaining approach to water management in Dharan.

Despite its official formation, the actual transfer of assets and liabilities from NWSC to the DWSMB did not occur until 2077 B.S. This delay was primarily due to a legal dispute; NWSC challenged the transfer by taking the matter to court. As a result of the prolonged litigation, NWSC did not proceed with rehabilitating or replacing the outdated pipeline distribution system—a move that was critical for the success of the IUDP-identified water supply improvement project. The inability to upgrade the existing infrastructure ultimately hampered efforts to meet the effective water supply demand in Dharan.

This situation underscores a number of critical points:

- **Institutional Transition:** The need for an independent, self-sustaining water management entity became evident due to NWSC's dependence on government funding and its limited capacity for proactive system upgrades.

- **Infrastructure Constraints:** The failure to rehabilitate the old pipeline distribution system, in part due to the ongoing court case, significantly affected the implementation of essential water supply projects.
- **Impact on Water Supply:** The delay in transferring assets and modernizing the infrastructure contributed to a scenario where the water demands of Dharan's growing population continued to be unmet, exacerbating existing water scarcity issues.

5.2.1.1 Committee Formation and Governing Issues

According to Clause 10 of the Khanepani Byabasthapan Board Act 2063, the formation of a comprehensive committee, including an executive committee with designated roles for decision-making, is mandated for the proper functioning of the board. This clause stipulates that the board should be composed of members representing various stakeholder groups to ensure balanced governance, regular board meetings, and effective decision-making processes.

However, in practice, the current structure of the DWSMB in Dharan falls short of these statutory requirements. At present, the board is effectively managed by only two individuals: the mayor, who serves as the head of the DWSMB, and Er. Raju Pokhrel, who functions as the secretary. The absence of a properly constituted executive committee has significant implications for the board's operational efficiency. Without the full complement of committee members as required under Clause 10, the DWSMB has not been able to convene regular board meetings, take collective decisions, or enforce the necessary policies and laws effectively.

This governance gap has a direct impact on the overall water supply management in Dharan. The inability to bring together a diverse and representative executive committee undermines the board's capacity to address critical water supply challenges, implement improvement projects, and ensure compliance with water management regulations. In essence, while the statutory framework envisions a robust and multi-stakeholder board to manage water supply issues, the current practice - with only the mayor and a secretary at the position - has led to inefficiencies and a lack of coordinated decision-making.

९. पानी उपभोग तथा वितरणसम्बन्धी अधिकार सन्ने : (१) संस्थानले सञ्चालन र व्यवस्थापन गरेको सेवा प्रणाली बोर्डमा हस्तान्तरण भएमा संस्थानले सेवा प्रदान गर्न उपयोग गरेको पानीको सम्पूर्ण स्रोतमा बोर्डको अधिकार हुनेछ ।

(२) उपदफा (१) बमोजिम संस्थानबाट हस्तान्तरण भएको सेवा प्रणालीको उपयोग, सञ्चालन तथा मर्मत सम्भार वा पुनर्स्थापन गर्ने क्रममा सार्वजनिक वा व्यक्तिगत घर जग्गामा पाइप राख्ने वा संरचनाको पुनर्निर्माण वा पुनर्स्थापना गर्ने सम्बन्धमा बोर्डलाई संस्थानलाई भएसरहको अधिकार हुनेछ ।

परिच्छेद-३

कार्यकारी समितिको गठनसम्बन्धी व्यवस्था

१०. कार्यकारी समितिको गठन : (१) दफा ३ बमोजिम गठन भएको बोर्डको तर्फबाट सम्पादन गर्नु पर्ने सम्पूर्ण काम कारवाही सुचारुरूपले सम्पादन गर्न एक कार्यकारी समिति रहनेछ ।

(२) उपदफा (१) बमोजिमको समितिमा देहायका सदस्यहरू रहनेछन् :-

(क) बोर्डको भौगोलिक क्षेत्रभित्रका नगरपालिकाको प्रमुख - सदस्य

(ख) प्रतिनिधि, भौतिक योजना तथा निर्माण मन्त्रालय - सदस्य

(ग) बोर्डको भौगोलिक क्षेत्रभित्रका गाउँ विकास समितिका अध्यक्षहरूले

आफूहरूमध्येबाट छानेको गाउँ विकास समितिको एकजना अध्यक्ष - सदस्य

(घ) स्थानीय उद्योग वाणिज्य संघको अध्यक्ष - सदस्य

(ङ) स्थानीय उपभोक्ता संघको अध्यक्ष - सदस्य

(च) खानेपानी वा सरसफाई सेवा क्षेत्रमा कार्यरत स्थानीय गैर सरकारी

संस्थाहरूमध्येबाट समितिले मनोनयन गरेको एकजना व्यक्ति - सदस्य

(छ) खानेपानी तथा सरसफाई सेवा क्षेत्रका विज्ञहरूमध्येबाट समितिले

मनोनयन गरेको एकजना - सदस्य

(३) उपदफा (२) को खण्ड (ग), (घ) वा (ङ) बमोजिमको सदस्यले प्रतिनिधित्व गर्दा सम्बन्धित क्षेत्रमा एकभन्दा बढी संस्था भएमा त्यस्तो संस्थाले आलोपालो गरी प्रतिनिधित्व गर्नु पर्नेछ ।

तर त्यस्ता संस्थाहरूबीच आलोपालो गरी प्रतिनिधित्व गर्ने सम्बन्धमा सहमति हुन नसकेमा त्यस्ता संस्थाहरूमध्येबाट प्रतिनिधित्व हुने गरी समिति आफैले मनोनयन गर्नेछ ।

(४) उपदफा (२) को खण्ड (च) बमोजिम सदस्य मनोनयन गर्दा उपलब्ध भएसम्म महिलालाई प्राथमिकता दिनु पर्नेछ ।

Figure 12 Clause for formation of water supply management board

5.2.2 Sources of Water Supply of DWSMB

A. Surface Water

The primary surface water sources for Dharan are the **Sardu Khola** and **Khardu Khola** streams. These sources have historically provided water for the piped supply system:

- **Sardu Khola** and **Khardu Khola** are utilized by NWSC through intake structures and transmission pipelines.
- During the **dry season**, the average yields are relatively low, whereas during the **wet season** the yields increase significantly due to higher runoff.

Table 5 Description of Surface Water Sources (Yadav et al., 2023)

Parameter	Sardu Khola	Khardu Khola
Dry Season Yield (MLD)	1.6	1.8
Wet Season Yield (MLD)	5.0	6.0
Transmission Pipeline Length	1.8 km (CI/DI)	3.0 km (CI/DI)

MLD: Million Liters per Day; CI: Cast Iron; DI: Ductile Iron

B. Groundwater

Groundwater is extracted from tube wells, primarily located in the southern part of Dharan near the Char Koshe jungle. This source supplements surface water—especially during the dry season when surface yields drop.

Table 6 Description of Groundwater Sources (Yadav et al., 2023)

Well Number	Approximate Depth (m)	Yield (Dry Season, MLD)	Yield (Wet Season, MLD)	Notes
1	30	–	–	Initial test well
2	152	1.5	<i>Damaged</i>	Partially functioning
3	225	3.0	1.0	
4	170	3.0	1.0	
5 (BPKH)	160–170	2.0	~1.0	Serves specific institutions

BPKH refers to a well primarily serving the BP Koirala hospital, with surplus water feeding the NWSC system.

Transmission and Distribution Pipelines

Water collected from both surface and groundwater sources is conveyed through a network of pipelines. The system includes:

- **Transmission pipelines:** These feed water from sources (streams and wells) to high-service pumping stations and reserve tanks.

- **Distribution pipelines:** An estimated 78 km of pipelines—comprising cast iron (CI), ductile iron (DI), galvanized iron (GI), and high-density polyethylene (HDPE) pipes—deliver water to approximately 16,000 taps across Dharan.

5.2.3 Storage Infrastructure of DWSMB

Water is temporarily stored in several reservoirs and tanks before distribution. These include high-service pumping stations (HSPS) and other storage facilities at strategic locations.

Table 7 Storage Reservoirs (Yadav et al., 2023)

Location	Capacity (m ³)
Phusre	1,350
NWSC Compound	3,000
HSPS1	500
HSPS2	500
Additional Tanks*	Varying sizes

*Additional storage tanks are installed at various nodes (e.g., Narayanchaur, Laxmi Chok, Chhata Chok) to assist in daily distribution.



Figure 13 Existing Water Infrastructure of DWSMB

5.2.4 Sub-Distribution Systems

Under the Integrated Urban Development Project (IUDP), the entire Dharan Sub-metropolitan area was organized into **five sub-distribution systems**. This classification reflects the natural topography, settlement patterns, and existing infrastructure. The systems are described below:

Table 8 Summary of Sub-Distribution Systems (Yadav et al., 2023) (Unofficial Source: DWSMB)

Zone (Subsystem)	Area (Ha)	Households (Approx.)	Ward Coverage	Reservoir Capacity (m³)	Source of Water	Notes
A (Phusre)	114.4	2,224	Wards 1,2, 13, 14	1900	Sardhu, Khardu	Core area; infrastructure is relatively established
B (Bijaypur)	220.2	2,640	Wards 14, 3, 7, 13, 15	600	Sardu, Khardu, Deep boring	Reserve tank not built; some areas experience intermittent supply
C (Sumnima)	584.29	13,481	Wards 1, 2, 3, 5, 7, 9, 10,11, 12, 16, 18, 19	3,000	Sardu, Khardu, Deep boring	Renovated system; covers the main market and dense residential areas
D (Railway)	296.99 8	3,349	Wards 11, 17	500	3 deep boring	Newly built subsystem;

Zone (Subsystem)	Area (Ha)	Households (Approx.)	Ward Coverage	Reservoir Capacity (m³)	Source of Water	Notes
					wells (Udaya Community forest)	covers larger areas in wards 11 and 17
E (Pindeswar)	351.5	7,147	Wards 7, 8, 15	1,500	Sardu, Khardu	Newly built subsystem; serves a significant portion of the population

The sub-distribution systems have been developed at different times. Zones D and E are more recent additions aimed at extending service coverage to expanding residential areas.

5.2.5 Decentralized Water Supply in Dharan

In many areas where the Nepal Water Supply system does not extend its services, local communities have taken the initiative to develop decentralized water management solutions. For instance, to legally establish an Upavokta Samiti, community members were required to visit the Sunsari district office located in Inaruwa. This committee was responsible for independently identifying potential water sources, while the district office played a supportive role by providing technical supervision and co-financing through allocated funds. This model empowered communities to secure their own water supply in the absence of centralized provision.

With the transition of Dharan Municipality to a Submetropolitancy, the structure of water management in the area has evolved. Two Gau Bikash Samiti have been established in locations such as Bishnupaduka Gabisa and Panbari Gabisa to better serve the expanded urban area. Despite these changes, water distribution continues to be managed through the established Upavokta Samiti framework. Moreover, supervisory responsibilities have shifted from the district office to the Dharan Submetropolitancy, ensuring that local governance is more directly involved. Under this system, adherence to water quality standards is strictly enforced, and the submission of annual audit reports is mandatory for the renewal of the Upavokta Samiti's operational license.

For further funding from Koshi Province and the Central Government, the process requires a formal recommendation from the local ward office, along with the completion and submission of the necessary application documents. In this decentralized arrangement, while the Upavokta Samiti is in charge of identifying water sources, the Water Supply and Sanitation Division Office of Koshi Province provides the technical oversight and necessary funds for constructing infrastructure such as the RVT. The remaining aspects of funding and construction are managed independently by the Upavokta Samiti, underscoring the community-driven nature of the water supply system.

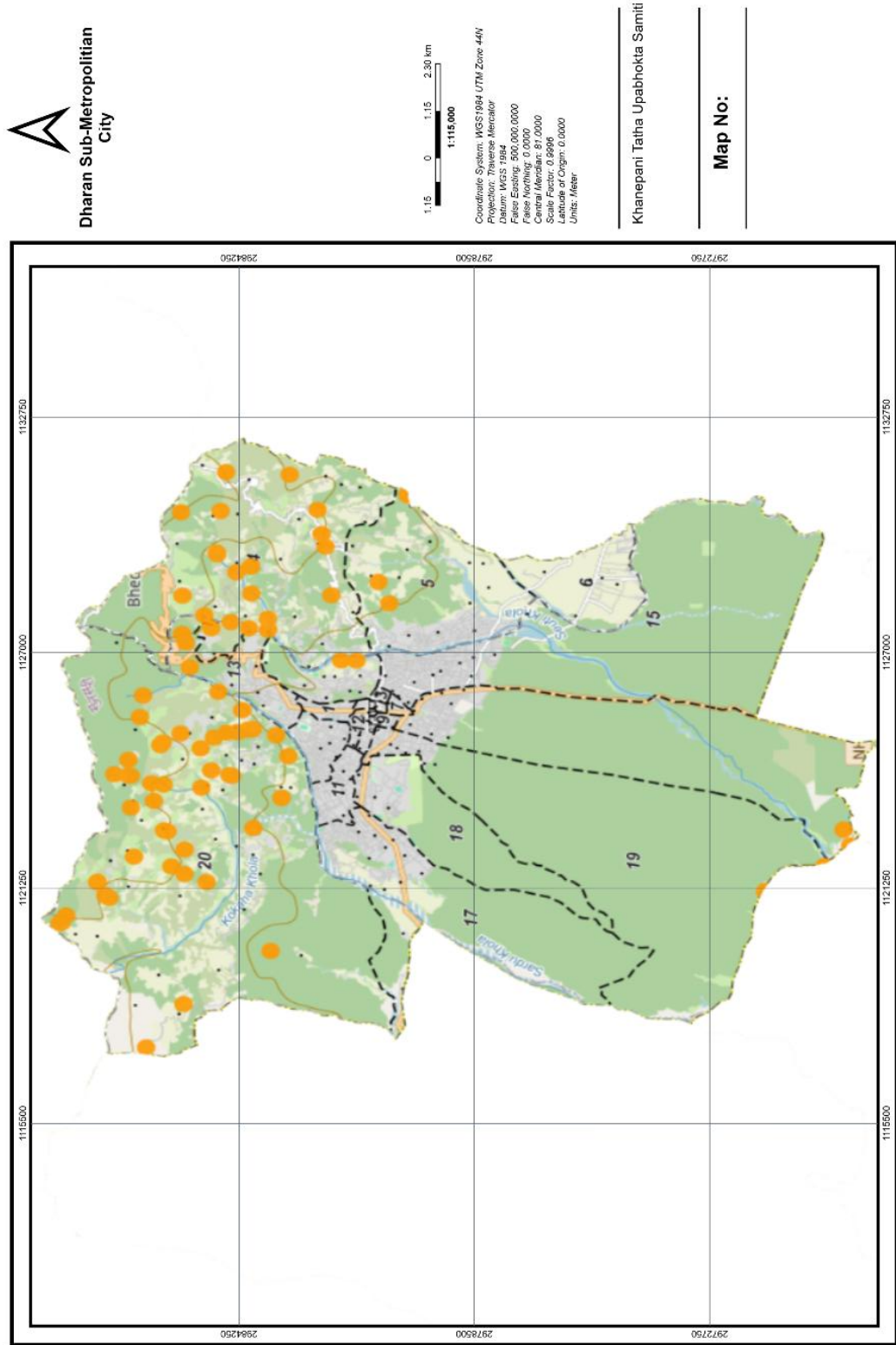


Figure 15 Map Khanepani Upavokta tatha Sarsafai Samiti Projects in Dharan

5.2.6 Existing Water User and Sanitation Committees

The centralized water delivery system in Dharan does not reach far enough to suit local needs in many places, especially semi-urban and periphery areas. Consequently, Khanepani Upavokta tatha Sarsafai Samitis, or community-based user committees, have stepped up to create decentralized water solutions. Of the 81 such committees that exist in Dharan at the moment, 35 are officially registered under the Dharan Sub-Metropolitan City (SMC), and two more are in the registration process, according to N-WASH data. Together, these committees provide water services to 11,008 houses (25.96%) and an estimated 59,245 individuals (35.58% of Dharan's population), addressing a significant shortage.







	Condition of Water Availability at a water point	No of Tap	Tap Percent	Population Served	Population Percent
	Sufficient for all daily needs	3598	39.46%	25760	43.48%
	Sufficient for drinking and cooking and washing	1984	21.76%	11406	19.25%
	Just sufficient for drinking	3462	37.96%	21660	36.56%
	There is water but not sufficient for drinking	1	0.01%	5	0.01%
	No water at all	73	0.8%	404	0.68%
	No Data	1	0.01%	4	0.01%
	Total	9119	100%	59239	100%

Figure 16 Condition of Water Availability at Water User and Sanitation Committee of Dharan
(Municipality Dashboard - N-WASH, n.d.)

The shared ownership and accountability that locals take on is a defining feature of this decentralized paradigm. In order to ensure that water distribution is more responsive to community demands, each Samiti usually oversees its own infrastructure, such as piped networks, small-scale reservoirs, or spring catchments. Ten committees have seasonal shortages for roughly two to three months, while the remaining 81 committees manage 117 distinct water sources, 107 of which provide water year-round. These interruptions

show how important it is to continue protecting sources, managing watersheds, and upgrading infrastructure in order to ensure reliable delivery.

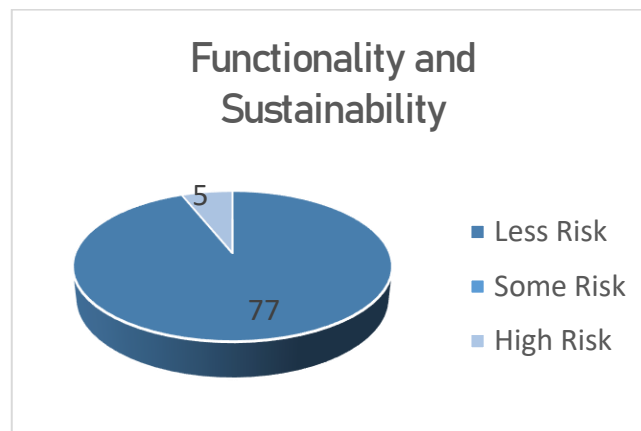


Figure 17 Functionality and Sustainability of Water User and Sanitation Committee at Dharan
(Municipality Dashboard - NWASH, n.d.)

In Dharan, two Upavokta Samiti have emerged as significant players in the decentralized water supply system by providing large-scale water distribution. One of these, the Panbari Khanepani Upavokta tatha Sarsafai Samiti, has been supplying water to over 2700 households. This initiative highlights the capacity of community-led efforts to address local water demands effectively, demonstrating how decentralized management can bridge the gap in areas not fully covered by centralized services.

Another prominent example is the Deurali Khanepani Upavokta tatha Sarsafai Samiti, which distributes water to more than 3200 households. Within this service area, however, only about 250 households are have lalpurja, while the remaining households primarily consist of squatter settlements. This situation underscores the complexities and challenges involved in legally formalizing water service provision in areas with significant informal settlement populations, while still ensuring that essential water services reach a broad section of the community.

धरान उपमहानगरपालिका क्षेत्रको खानेपानी तथा सरसफाई सम्बन्धी विवरणः

(क) धरान उपमहानगरपालिकाको रेकर्डमा रहेका/दर्ता तथा नविकरण भएका खानेपानी उपभोक्ता समितिहरूको विवरण :

क्र.सं.	खानेपानी तथा सरसफाई उपभोक्ता समितिको नाम	ठेगाना	सम्पर्क नं
१	लोकतान्त्रिक खानेपानी उपभोक्ता समिति	धरान- १६	
२	पकुवा खोला खानेपानी व्यवस्थापन समिति	धरान- २०	
३	ठुलो खैरे खोला संस्था खानेपानी तथा सरसफाई उपभोक्ता समिति	धरान- २०	
४	धार्ने खानेपानी उपभोक्ता समिति	धरान- २०	
५	ढाँडे-तेलनपुर खानेपानी उपभोक्ता समिति	धरान - ४	
६	सिम्ले -हर्दिया खानेपानी उपभोक्ता समिति	धरान - ४	
७	सुमनटार-मनुवाटार खानेपानी तथा सरसफाई उपभोक्ता समिति	धरान - ४	
८	शंखधारा खानेपानी तथा सरसफाई उपभोक्ता समिति	धरान - २०	
९	हर्दिया खानेपानी तथा सरसफाई उपभोक्ता समिति	धरान - ४	
१०	श्रीगाउँ-दानाबारी खानेपानी उपभोक्ता समिति	धरान - ४	
११	जुवाने खानेपानी तथा सरसफाई उपभोक्ता समिति	धरान - ४	
१२	गैरीगाउँ खानेपानी तथा सरसफाई उपभोक्ता समिति	धरान - ४	
१३	बुढासुब्बा खानेपानी तथा सरसफाई उपभोक्ता समिति	धरान - १४	
१४	काली खोला खानेपानी तथा सरसफाई उपभोक्ता समिति	धरान - १६	
१५	भालुखोला खानेपानी तथा सरसफाई उपभोक्ता समिति	धरान - १३	
१६	खानेपानी व्यवस्थापन उपभोक्ता समिति	धरान ११ र १७	
१७	पाँचकन्या डुम्रे शिखरबास खानेपानी तथा सरसफाई व्यवस्थापन समिति	धरान - ४	
१८	गौधारा खानेपानी तथा सरसफाई उपभोक्ता समिति	धरान - २०	
१९	बमधारा खानेपानी तथा सरसफाई उपभोक्ता समिति	धरान - १५	
२०	ठिङ्गाबारी खानेपानी तथा सरसफाई उपभोक्ता समिति	धरान - ५	
२१	पत्रडबारी सिरानटोल उपभोक्ता तथा सरसफाई समिति	धरान - ४	
२२	शिवधारा खानेपानी तथा सरसफाई उपभोक्ता समिति	धरान - १३	
२३	खैरेनीटार खानेपानी तथा सरसफाई उपभोक्ता समिति	धरान-४	९८१२३३२३६५
२४	पानबारी खानेपानी तथा सरसफाई उपभोक्ता समिति	धरान-६	९८१८५३२९२०
२५	श्री खानेपानी तथा सरसफाई उपभोक्ता समिति	धरान-१३	९८५२०४७२४४
२६	खत्रीधारा खानेपानी तथा सरसफाई उपभोक्ता समिति	धरान-१५	९८०२२३६०४२
२७	नहारे खानेपानी तथा सरसफाई उपभोक्ता समिति	धरान-४	
२८	श्री खानेपानी तथा सरसफाई उपभोक्ता समिति	धरान-२० र बराहक्षेत्र-१	९८४३८६९५१५
२९	श्री भोर्लेनी खानेपानी तथा सरसफाई उपभोक्ता समिति	धरान-४	९८६२१६४८९१
३०	शिवजट्टा खानेपानी तथा सरसफाई उपभोक्ता समिति	धरान-४	९७६५८७८८६९
३१	कोकाहा छिपछिपे सिमसार खानेपानी तथा सरसफाई उपभोक्ता समिति	धरान-२०	९८६२१८१९९२
३२	काम्फेक खानेपानी तथा सरसफाई उपभोक्ता समिति	धरान-४	९८१९००१३४०
३३	देउराली खानेपानी तथा सरसफाई उपभोक्ता समिति	धरान-५	
३४	नन्दपुर खानेपानी तथा सरसफाई उपभोक्ता समिति	धरान-२०	९८१९३१५९४३
३५	खैरेनी खानेपानी तथा सरसफाई उपभोक्ता समिति	धरान-४	९८०७०५९९६१

दर्ता प्रकृत्यामा रहेका:

१	गंगटे खोल्सी खानेपानी तथा सरसफाई उपभोक्ता समिति	धरान-१३	९८०४३५४५७५
२	खारसाङ खानेपानी तथा सरसफाई उपभोक्ता समिति	धरान-५	९८१३१४२३७४

Figure 18 List of Khanepani Upavokta tatha Sarsafai Samitis recorded in Dharan SMC

5.2.7 IUDP Project highlights

The Integrated Urban Development Project (IUDP), funded by the Asian Development Bank (ADB) and executed under the Dharan Water Supply Management Board

(DWSMB), was designed to address critical deficiencies in Dharan’s water supply infrastructure. One of the key components of the project was the rehabilitation and replacement of the aging pipeline network. However, as the DWSMB sought to implement these necessary improvements, a significant legal dispute arose.

Rather than the Nepal Water Supply Corporation (NWSC) directly implementing the project, the responsibility had shifted to the newly formed DWSMB. In response, NWSC filed a court case insisting that its assets—including the old pipeline system—must be vacated by the DWSMB. Due to the ongoing litigation, the rehabilitation and replacement of the old pipelines could not proceed as planned. This delay and inaction on updating the centralized infrastructure severely hampered the overall effectiveness of the IUDP project.

Furthermore, the project also intended to construct an additional reservoir tank with a capacity of 2000 cubic meters in the Bijaypur area to boost water storage. However, protests in the Bhata-Bhunge Darbar area disrupted this process, and the reservoir tank was never built. The combination of these setbacks has left Dharan’s water supply production at an average of about 19 MLD—substantially below the estimated demand of approximately 25 MLD. Consequently, residents continue to face acute water shortages and must resort to unreliable alternative sources, especially during the dry season

5.2.8 Water Scarcity in Dharan

Dharan faces acute water scarcity due to a complex interplay of infrastructural deficiencies, geographical constraints, and rapid urbanization. The historical and current performance data of the centralized system underscore a significant demand–supply gap:

i. **Supply Quantities and Performance:**

Initially, the Nepal Water Supply Corporation (NWSC) supplied an average of 14.41 million liters per day (MLD) from combined surface and groundwater sources to the older wards. Following interventions under the Integrated Urban Development Project (IUDP), overall production increased to about 19 MLD per season. However, with an estimated demand of approximately 25 MLD in Dharan, the shortfall forces residents to rely on alternative sources such as private water

tankers and sporadic natural sources during periods of low availability (Yadav et al., 2023).

ii. **Distribution Characteristics:**

- *Supply Hours:* In the wet season, water is available for 4–8 hours per day, but during the dry season, this drops sharply to 1.5–2 hours per day.
- *Non-Revenue Water (NRW):* Up to 40% of the water produced is lost through technical and management leakages caused by aging pipelines, corroded valves, and outdated infrastructure (IUDP, n.d.; Yadav et al., 2023).

iii. **Operational Challenges:**

Seasonal variability plays a significant role, with surface water yields varying dramatically between wet and dry seasons. Additionally, the aging infrastructure leads to considerable NRW losses, while the city's topography—characterized by a mix of flat lands and steep slopes—further complicates efficient water distribution. Rapid urbanization has increased per capita demand from around 71 to 100 liters per capita per day (lpcd), further straining the system.

5.2.9 Area-Specific Challenges:

1. **Older Wards (Wards 1–19):**

These wards have traditionally been served by the centralized NWSC system. However, due to infrastructural aging and operational inefficiencies, the actual per capita supply in these areas averages only about 30 lpcd—significantly below the municipality's target of 60 lpcd. The high NRW, estimated at up to 40%, exacerbates the issue by causing substantial water losses before reaching consumers (Yadav et al., 2023; IUDP, n.d.). But with continuous efforts and efficient management of DWSMB, NRW has reduced to about 35%, which is still high, this couldn't be further reduced due to old pipeline distribution system (Source: DWSMB).

2. **Peripheral and High-Elevation Areas:**

Geographical challenges such as steep slopes and scattered settlements significantly impede the effective expansion of centralized water distribution networks in Dharan. In these areas, supplying water through a centralized system is inherently difficult due to the elevation and the rapid urban expansion that further complicates infrastructure development. Even before these regions were integrated into the centralized network, the old GaBiSa areas in Dharan were already being served by decentralized systems. Local water user committees proactively identified and tapped into multiple local sources—with co-financing and technical support from the Water Supply and Sanitation Division—to ensure a more reliable supply during the dry season. This decentralized approach, which utilizes alternative sources such as Kali-khola, Tirke, Teendhare, and Devi Khola, has proven critical in mitigating water scarcity when centralized supply efforts fall short. Consequently, the experience from these areas clearly demonstrates the necessity of maintaining and expanding decentralized water supply models to address the unique challenges posed by elevation and urban expansion in Dharan.

3. Areas Dependent on Surface Water from the Sardu Watershed:

The Sardu watershed, once a critical source of surface water for Dharan, has suffered from environmental degradation due to illegal land encroachments and unregulated exploitation. For instance, while the Sardu stream can yield up to 11 MLD during the wet season, its output can drop to as low as 2.5 MLD during the dry season (Sardu Watershed Area Faces Existential Crisis, 2024; Yadav et al., 2023). This severe seasonal variability further intensifies water scarcity for communities that depend solely on these sources.

Implications for Decentralized Water Supply:

The combined effects of these challenges demonstrate that water scarcity is widespread across Dharan. The centralized water supply system, even after IUDP enhancements, is insufficient to meet the increasing demand. This situation has underscored the necessity of decentralized water supply systems. In many areas—particularly in the older wards, peripheral regions, and zones dependent on the deteriorating Sardu watershed—Khanepani Upavokta Samiti have stepped in. These community-managed systems

operate on a decentralized model, sourcing water from locally identified alternatives and providing a more tailored response to area-specific shortages.

By compensating for the limitations of the centralized system, decentralized approaches not only improve water availability but also empower communities to manage their resources more effectively. This shift is crucial for bridging the demand–supply gap and ensuring sustainable, equitable water access in Dharan (Mishra et al., 2018; Yadav et al., 2023; Sardu Watershed Area Faces Existential Crisis, 2024).

5.3 Community Engagement in addressing Water Security

5.3.1 Community Engagement and DWSMB

The failure of the IUDP project to effectively control water scarcity deeply disheartened the Dharan community. As water shortages began to intensify from the month of Kartik, residents experienced severe hardships that resulted in the inadequacy of the centralized supply system. This persistent scarcity sparked widespread concern and prompted community members to look for alternative solutions.

A change came when Mayor Harka Sampang Rai won the election. After being elected, he became the head of the Dharan Water Supply Management Board (DWSMB). Seeing the urgent need for water, the mayor worked with the technical head of the DWSMB to find new water sources that could help ease the shortage. He started a volunteer campaign to use these new local water sources to add to the existing supply.

The first volunteer campaign began on Ashar 4, 2079. It was very successful and was carried out in four different places:

1. **Pakuwa Khola** (in two phases)
2. **Nishane Khola**
3. **Bhalukhola**
4. **Kokah Khola**

These campaigns helped local communities tap into alternative water sources and manage them on their own. Now, a fifth volunteer campaign is currently running where the campaign is named Kokah-2.



Figure 19 Water collection chamber from Volunteer Campaigns

Flow chart of Volunteer Campaign

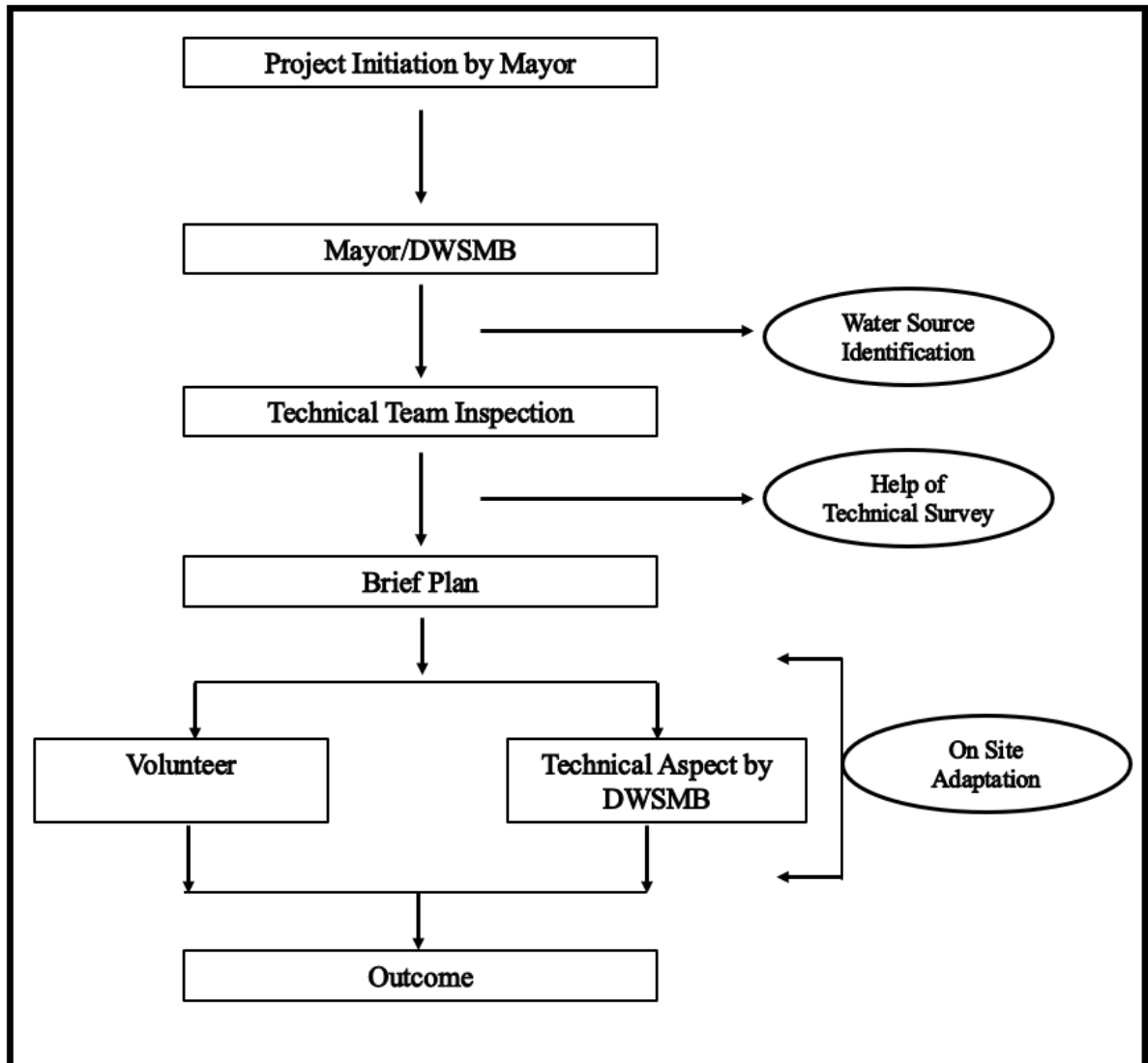


Figure 20 Flow chart of Volunteer Campaign conducted by DWSMB and Dharan's Mayor

The process begins with project initiation by the mayor, who is also the head of the Dharan Water Supply Management Board (DWSMB). Recognizing the urgent need to find new water sources to tackle the persistent water scarcity, the mayor sets the campaign in motion. This initial step is critical because it represents the leadership's commitment to exploring alternative water supplies when the centralized system falls short.

Following the initiation, the mayor holds discussions with the DWSMB staff. During these meetings, the team uses their observations and past experiences to identify potential new water sources. This collaborative discussion is essential for shortlisting promising sites based on local conditions and historical data, ensuring that only the most viable

options are considered for further evaluation. Once a potential source is identified, the next step involves a technical team inspection. The mayor, along with the DWSMB technical team, visits the site to conduct an on-the-ground assessment. If the team determines that a detailed survey is needed to fully evaluate the site's capacity or quality, they request additional assistance—typically from the Gurkha Welfare Trust. This step ensures that any decision to use a new source is backed by accurate, technical data.

After the technical inspection and any necessary surveys, a brief plan or rough estimate is prepared. This plan outlines the basic requirements, potential costs, and the feasibility of integrating the new water source into the existing system. It serves as a foundation for planning the volunteer campaign and provides a clear direction for the next steps. The following stage is the call for volunteers, which is led by the mayor. At this point, the mayor reaches out to the community to seek assistance in terms of funds, pipes, and labor. Meanwhile, the DWSMB takes responsibility for the technical aspects, including the installation of plumbing fittings and the layout of the pipeline track. This on-site adaptation ensures that the new system is properly integrated with the existing infrastructure, and that the technical requirements are met in a practical manner.

Finally, once the new water source is confirmed and the necessary equipment is installed, the water from this source is connected either directly to the distribution pipes or to a reservoir tank managed by the DWSMB. This final connection marks the completion of the volunteer campaign process and adds an additional water supply channel to help alleviate the water scarcity in Dharan.





Figure 21 Volunteer Works for Kokah-2 Project

5.3.1.2 Conflicts for Water Source between Volunteer Campaign and Upavokta Samitis

While identifying new water sources for the volunteer campaign, the DWSMB and the Mayor encountered conflicts over sources that were already in use by the pre-existing Khanepani Upavokta Samiti. In one case, the DWSMB proposed to use a source that had long been managed by the Upavokta Samiti. The Mayor suggested that they could work together—saying, “Let us use this source; we will supply water from the DWSMB to you.” However, the members of the Upavokta Samiti were not willing to accept this proposal. They believed that the DWSMB might not manage the source properly and were concerned that their existing rights to the water might be compromised.

After much discussion, both sides reached a compromise. They agreed that the DWSMB could take water from the downstream end of the intake channel that Upavokta Samitis were already using. In this way, the Upavokta Samiti could continue to manage and use the water from the original source point, while the DWSMB would add to the overall supply by tapping the water further downstream. This arrangement allowed both parties to benefit without one side completely taking over the water source.

A similar situation occurred with the Kokah Khola project. When the DWSMB tried to use water from Kokah Khola, locals and representatives from Barahchhetra Municipality

raised objections. The concern was similar: there was a fear that the new system might take water away from those who had been relying on it. To resolve the conflict, an agreement was made for the Kokah-2 project. Under this agreement, the DWSMB would also provide water supply distribution system to Barahchhetra, ensuring that the Upavokta Samiti of Barahchhetra and local communities still received their share of the water.

5.3.2 Sardu Watershed Conservation

Sardu Watershed, located in Dharan, Sunsari, Nepal, serves as a major water source for Dharan Sub-Metropolitan City. The watershed plays a crucial role in providing drinking water, irrigation, and other ecological services to the region. Historically, the watershed was protected under various land and environmental policies, but weak governance and inadequate enforcement mechanisms have led to its gradual degradation.

Efforts to conserve Sardu Watershed began in the late 20th century with interventions from local and international organizations. The International Union for Conservation of Nature (IUCN) Nepal, along with the Association for Protection of Environment and Culture (APEC) and the Center for Environment and Tourism Development (CETD), conducted studies and conservation programs to preserve the watershed.

5.3.2.1 Encroachment Issues and the Role of Land Mafias

In recent decades, land mafias have illegally occupied at least 42 bighas of land within the Sardu Watershed, primarily in areas like Chotimorang Dada. These encroachments have led to deforestation, soil erosion, and reduced water availability for Dharan residents.

Land mafias, often with political backing, have engaged in illegal land plotting and **sales**, gradually converting forested watershed areas into residential and commercial properties. Despite the importance of the Sardu watershed for the sustainable water supply of Dharan, local authorities have been slow to act, with some government officials allegedly complicit in these illegal transactions.

5.3.2.2 Community and Government Responses

In response to the alarming degradation of the watershed, local leaders, activists, and environmental organizations have launched **volunteer-led conservation campaigns**. These efforts include:

- i. **Afforestation drives** to restore lost forest cover.
- ii. **Public awareness campaigns** to highlight the importance of Sardu Watershed.

iii. **Legal actions** to reclaim encroached land.

The **Mayor of Dharan, Harka Sampang**, has actively supported these initiatives, advocating for sustainable water management and mobilizing community participation in conservation efforts.

Among various activist groups, **Swatantra Nagarik Samaj** has taken the strongest legal stand against encroachment. It is the **only organization that has filed a case in court** to reclaim the illegally occupied lands of the Sardu Watershed Conservation Area. The legal battle is ongoing, but it represents a significant step toward protecting the watershed from further degradation.

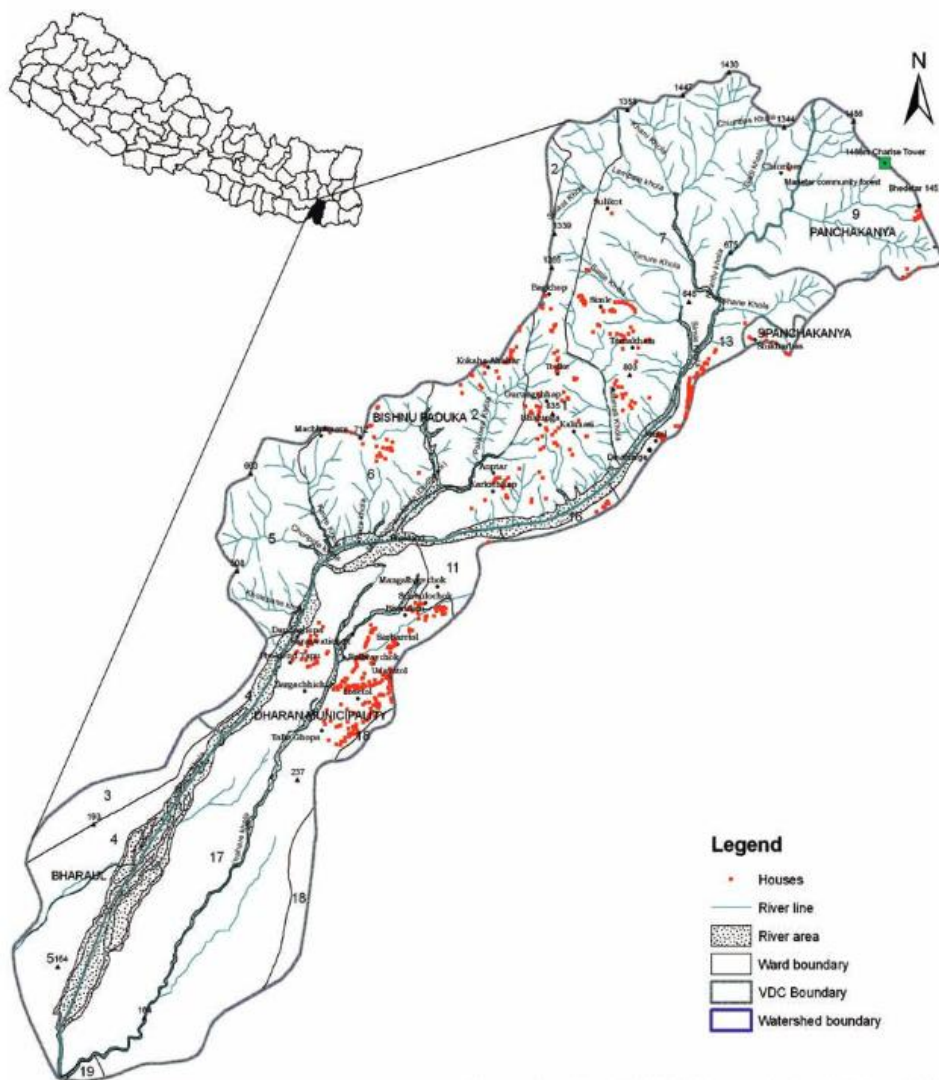


Figure 22 Sardu Watershed Map

5.3.3 Selected Case Studies

Although municipal records list 35 Water User and Sanitation Committees (Khanepani Upavokta tatha Sarsafai Samitis) in Dharan, practical field challenges—such as outdated contact information, unreachable committee members, and limited time—restricted the number of successful interviews to 12. Despite these constraints, a broader review was conducted on a total of 12 committees to understand community engagement in addressing water security through decentralized water management.

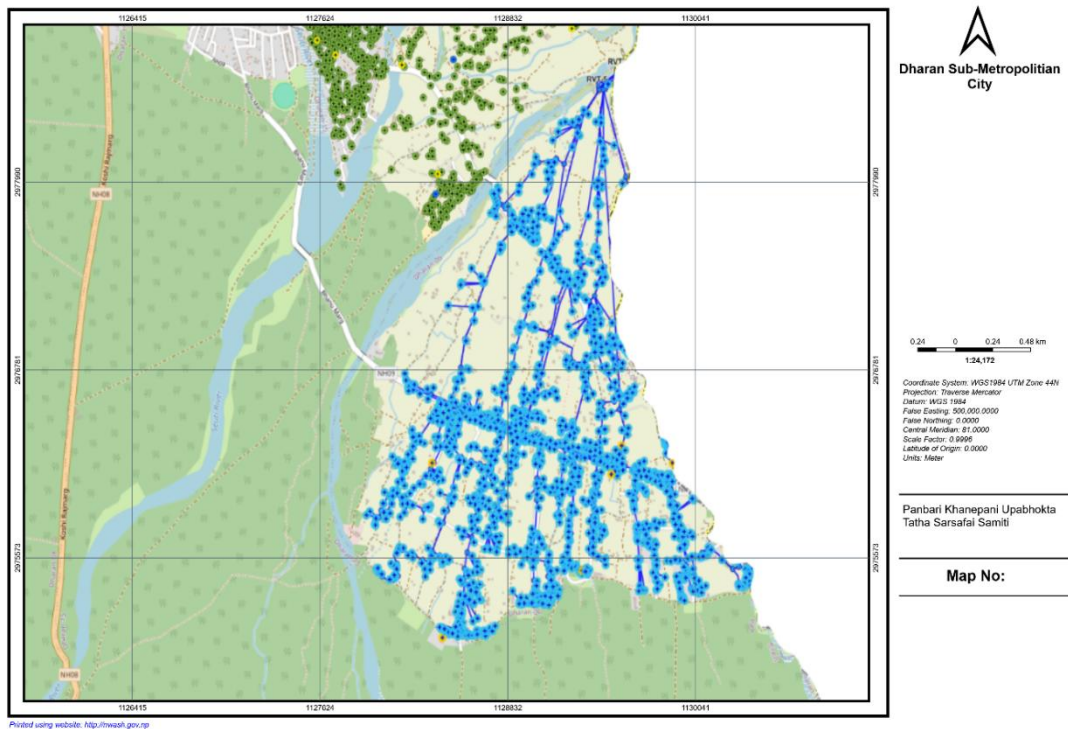


Figure 23 Panbari Khanepani Upavokta Tatha Sarsafai Samiti water supply map

From these 12, the Panbari Khanepani Upavokta tatha Sarsafai Samiti in Ward 6 emerged as the primary focus for detailed analysis, particularly regarding its engineering systems and management structure. Ward 6, which lies on Dharan's eastern periphery and was incorporated into the Sub-Metropolitan City more recently, is experiencing rapid population growth and new development pressures.

Over the past decade, Panbari Khanepani Upavokta tatha Sarsafai Samiti has been instrumental in supplying water to more than 2,700 households in the area, including those in Yangsila. The effectiveness of decentralized, community-driven models in providing reliable water services and addressing emerging challenges in urban water supply and sanitation This ward was later added to Dharan Sub Metropolitan city, and

lies on the Eastern peripheral region of Dharan. Ward 6 is experiencing rapid growth and emergence of new development. Panbari Khanepani Upavokta Tatha Sarsafai Samiti has been supplying water to this ward more than since a decade and now currently distributing to 2700+ households. It supplies water to households of Yangsila too.

Table 9 Demographic Chart of Ward-6, Dharan

Ward No.	Household (2017)	Population	Male	Female	Area (Sq.km.)	Density
6	1,371	8455	3983	4472	4.589	1842

Feature of Site context:

- Peripheral region, later added to Dharan SMC
- Ward area subjected to higher urbanization rate
- Clear example of Decentralized water management, provides local solutions amid increased population pressures
- Committee addresses uneven water distribution in a growing city

As the city expands, increasing water demand and pressure on the centralized system have become critical challenges. In response, the water user committee has implemented effective water supply and sanitation practices, ensuring that local residents actively participate in decision-making and management processes. Its adaptive strategies address infrastructure issues and uneven water distribution resulting from urban growth, aligning well with both national and local policies. Additionally, the availability of detailed and reliable data from this case study enhances its credibility. It is necessary to assess decentralized urban water supply system because it provides valuable insights into sustainable, community-driven solutions that can be replicated in other rapidly urbanizing areas facing similar challenges

5.3.4 Findings from Interviews with 12 Water User Committees

Although municipal records indicate the existence of 35 water user committees, practical challenges in the field meant that only 12 could be interviewed. Issues such as missing contact numbers, outdated SIM information, unreachable members, and time constraints made difficulties in meeting and ensuring continuous engagement with community organizations.

5.3.5 Comprehensive Data Table for Upavokta Samiti in Dharan

Table 10 Data Collected from Questionnaire of 12 Khanepani Upavokta Samitis of Dharan

S.N.	Name of Committee	Date of Establishment (B.S.)	Member Composition (Male/Female/Others)	Method of Member Selection	Households Served	Water Supply (Liters/Day)	Water Source	Is Water Treated Before Distribution?	Fund Collection Method	Tentative Initial Project Cost (NPR)
1	Panbari Khanepani	2064 B.S.	9 (2F, 7M)	Democratic Election	2700+	1200000	Mamphang, Shera khola, Jalkini	Yes	Government plus private	British Gurkha handed over its project
2	Deurali Khanepani	2057 B.S.	13 (4 F, 9M)	Democratic Election	3200+ (250 legal HHs)	350000	Self-identified	Yes	Sansad Bikash Kosh and private	Rs 7 lakhs

S.N.	Name of Committee	Date of Establishment (B.S.)	Member Composition (Male/Female/Others)	Method of Member Selection	Households Served	Water Supply (Liters/Day)	Water Source	Is Water Treated Before Distribution?	Fund Collection Method	Tentative Initial Project Cost (NPR)
3	Thingabari	2059 B.S.	9 (3F, 6M)	Consensus	238	100000	Mamphang	Sand filtration	Plan Nepal and Private	Rs3.5 lakh from plan Nepal and 1.5 lakhs from committee
4	Kali Khola	2064 (2069 legally)	11 (5F, 6M)	Consensus	40	10000		Sand filtration	Gurkha welfare trust plus private	60:40 financing
5	Loktantrik	2060 (2079 legally)	11 (5F, 6M)	Consensus	52	875	Gangate Kholsi	No	Private	5 lakhs

S.N.	Name of Committee	Date of Establishment (B.S.)	Member Composition (Male/Female/Others)	Method of Member Selection	Households Served	Water Supply (Liters/Daily)	Water Source	Is Water Treated Before Distribution?	Fund Collection Method	Tentative Initial Project Cost (NPR)
6	Shree	2056 B.S.	9 (5F, 4M)	Consensus	73	10000	Nishane Khole	Sand filtration	Unicef and private	Rs 19 lakhs (Rs 5 lakhs from Unicef)
7	BuddhSubba	2070 B.S.	11 (3F, 8M)	Consensus	145	300000	Private Land	Sedimentation	Private	Rs 10 Lakhs
8	Shivadhara	2059 B.S.	13 (4F, 9M)	Consensus	180	50000	Bhaluk hola, Nishan-Saranga community foest	Sand Filtration	Gurkha Welfare Trust plus private	Rs 5 Lakhs

S.N.	Name of Committee	Date of Establishment (B.S.)	Member Composition (Male/Female/Others)	Method of Member Selection	Households Served	Water Supply (Liters/Daily)	Water Source	Is Water Treated Before Distribution?	Fund Collection Method	Tentative Initial Project Cost (NPR)
9	Panch Kanya Dumre Sikharbaas	2074 B.S.	11 (4F, 7M)	Consensus	64	36000	Jordhara	Sand Filtration	Gurkha Welfare Trust plus private	60:40 financing, 60% GWT and% committee
10	Shree Gau Danabari	2078	7 (3F, 4M)	Consensus	65	55000	Jhyaure and Gogane Khola	No	Province plus private	Fundings of source to RVT by province, about Rs 40000 investment of committee
11	Nandapur	2051 B.S. (2061 legally)	11 (4F, 7M)	Consensus	351	25000	Patnali Khola, Kali Khola	Sand Filtration	Plan Nepal and private	Rs 5 Lakhs

S.N.	Name of Committee	Date of Establishment (B.S.)	Member Composition (Male/Female/Others)	Method of Member Selection	Households Served	Water Supply (Liters/Daily)	Water Source	Is Water Treated Before Distribution?	Fund Collection Method	Tentative Initial Project Cost (NPR)
12	Turke	2069 B.S.	7 (all Males)	Consensus	Past 22 now 6	5000	Turke Khola	No	Ward plus private	Rs 40000 donation and Rs 60000 private

Table 11 Data Collected from Questionnaire of 12 Khanepani Upavokta Samitis of Dharan

S.N	Name of Committee	Change in Quantity of Water overtime in source	Major for water Recharge	Monitoring or Watchdog mechanism of sources	Responsible for handling of project resources	Any dispute?	Fees Rate	Fees for New Installation (NRS)	Willingness to Pay	Is the amount collected enough to run operations and maintenance	Effectiveness and sustainability
1	Panbari Khanepani	Neutral	Afforestation annually, recharge zone	3 peoples hired with time schedule	Committee	No	Rs 50 for 15 unit (Rs 7.5 per extra unit)	Rs. 17,500	Yes	Yes	New sources identification to cater increasing demand
2	Deurali Khanepani	Depleted	Collaborative Afforestation annually	3 peoples hired with time schedule	Committee	No	Rs 100 for 15 unit (Rs 10 per extra unit)	Rs. 15,000	Yes	Yes	Deep boring project to cater demand

S.N	Name of Committee	Change in Quantity of Water overtime in source	Major for water Recharge	Monitoring or Watchdog mechanism of sources	Responsible for handling of project resources	Any dispute?	Fees Rate	Fees for New Installation (NRS)	Willingness to Pay	Is the amount collected enough to run operations and maintenance	Effectiveness and sustainability
3	Thingabari	Neutral	Collaborative Afforestation annually	No	Committee	No	Rs 126 for 20 units (Rs 6 per extra unit)	Rs. 40,000 for new and Rs. 11,000 for angsa	Yes	Yes, sometimes contribution for maintenance	New sources identification to cater increasing demand
4	Kali Khola	Depleted due to competition	Afforestation annually	No	Committee	No	No	No new Installation	No	Rs 100 per house collected for maintenance	Effective to cater scarcity
5	Loktan trik	Depleted	Collaborative Afforestation	Heralu (Rs2000 per month)	Committee	During source identif	No fees	No new installation	No	Equal contribution during maintenance	Increase in Demand

S.N	Name of Committee	Change in Quantity of Water overtime in source	Major for water Recharge	Monitoring or Watchdog mechanism of sources	Responsible for handling of project resources	Any dispute?	Fees Rate	Fees for New Installation (NRS)	Willingness to Pay	Is the amount collected enough to run operations and maintenance	Effectiveness and sustainability
						ication					
6	Shree	Neutral	Collaborative Afforestation	No	Committee	Recently with volunteer campaign	Rs 200 for 30 units (Rs 30 per extra unit)	Rs. 25,000	Yes	Yes, sometimes contribution for maintenance	New sources identification to cater increasing demand
7	Buddh Subba	Neutral	No	No	Committee	No	Rs 300 for 30 units (Rs 15 extra per unit)	No new Installation	Yes	Yes	Effective to cater scarcity, households now connected to DWSMB also

S.N	Name of Committee	Change in Quantity of Water overtime in source	Major for water Recharge	Monitoring or Watchdog mechanism of sources	Responsible for handling of project resources	Any dispute?	Fees Rate	Fees for New Installation (NRS)	Willingness to Pay	Is the amount collected enough to run operations and maintenance	Effectiveness and sustainability
8	Shivadhara	Neutral	Collaborative Afforestation	No	Committee	No	Rs 100 for 12 units (Rs 10 per extra unit)	Rs 1,00,000	Yes	Yes	New sources identification to cater increasing demand
9	Panch Kanya Dumre Sikhar baas	Neutral	Collaborative Afforestation	No	Committee	During source identification	Rs 100 for 10 units, (Rs 15 extra per units)	Rs. 25,000	Yes	Yes	Technical difficulty on slope gradient
10	Shree Gau Danabari	Neutral	No	No	Committee	No	Rs 150 for 25 units (Rs 5 extra per unit)	Rs. 35,000 for new and Rs.	Yes	Yes	Technical difficulty on slope gradient

S.N	Name of Committee	Change in Quantity of Water overtime in source	Major for water Recharge	Monitoring or Watchdog mechanism of sources	Responsible for handling of project resources	Any dispute?	Fees Rate	Fees for New Installation (NRS)	Willingness to Pay	Is the amount collected enough to run operations and maintenance	Effectiveness and sustainability
								6,000 for angsa			
11	Nandapur	Depleted due to landslide	Collaborative sanitation	No	Committee	No	Rs 75 for 15 units (Rs 1 per extra unit)	Rs. 5,000	Yes	Seek for funds and donation during maintenance	Small diameter pipe on intake making inefficiency on supply
12	Turke	Depleted	No	No	Committee	Yes, due to depleted source	No	No new Installation	No	Equal contribution during maintenance	Due to depleted source difficulty to cater demand, new supply of DWSMB no any future plans of committee.

The comparative analysis of the 12 khanepani Upavokta samitis reveals a range of practices and outcomes that underscore both the challenges and innovative approaches in decentralized water management.

The interviews reveal several specific findings that deepen our understanding of how these committees operate and manage water resources. For example, the Panbari committee, which serves a larger community, reported a daily water supply capacity of around 12,00,000 liters and employs a well-established sand filtration system, while a smaller committee like Loktantrik struggles with a more modest daily supply of approximately 8,000 liters and lacks advanced treatment measures.





Figure 24 Interviews taken from Different Upavokta Samitis of Dharan

- **Establishment and Households covered**

The date of establishment shows a wide range of operational histories. Panbari (2064 B.S.) and Deurali (2057 B.S.) have long-standing operations with democratic elections that likely promote transparency and accountability, while newer committees such as BuddhSubba (2070 B.S.) have quickly scaled up, delivering an impressive 300,000 liters/day to 145 households. In contrast, Loktantrik (2060 B.S., though legally 2079) serves just 52 households with a very modest output of 875 liters/day, indicating either resource constraints or a very localized operation.

Member composition and selection methods further differentiate these committees. Panbari and Deurali use democratic elections with a balanced gender mix (e.g., Panbari's 2 females out of 9 members), which may foster inclusive decision-making. Most other committees, like Thingabari, Kali Khola, and Shree, operate on a consensus basis, which, while promoting community ownership, might also slow down long-term planning and formal accountability. The variation in household numbers served—from as few as 40 households in Kali Khola to over 3200 in Deurali—illustrates the diverse scales at which these committees operate.

- **Source of Water**

Water sources and treatment practices also show significant differences. Panbari leverages multiple sources (Mamphang, Shera khola, and Jalkini) and treats its water before distribution, ensuring better quality. In contrast, committees such as Loktantrik and Turke do not treat their water, which may affect service quality and health outcomes. The choice of water source—from surface water bodies and community forests in committees like Shivadhara to private land sources in BuddhaSubba—directly influences the volume of water available. For example, Thingabari manages an extraordinarily high supply of 100,000 liters/day from Mamphang, underlining the potential of well-chosen sources when paired with proper treatment (sand filtration or sedimentation).

Funding and cost structures reveal another layer of complexity. Mixed funding approaches—combining government support, private contributions, and even aid from organizations like Plan

Nepal or Unicef-appear to underpin more sustainable operations. Panbari and Deurali benefit from such diversified funding, while committees like Loktantrik rely solely on private funds despite a low water output. Tentative project costs vary widely: Shree's project, costing Rs 19 lakhs (with Rs 5 lakhs from Unicef), is on a different scale compared to the modest Rs 5 lakhs reported by Loktantrik or Nandapur. Notably, Turke's situation is critical—its households served have dropped from 22 to 6, with only 5000 liters/day available, and no water treatment in place, reflecting a severe depletion that jeopardizes its future sustainability

In terms of the water source trends, committees like Panbari, Thingabari, Shree, BuddhSubba, Shivadhara, Panch Kanya, and Shree Gau Danabari report a neutral change, indicating that their water availability remains stable over time. In contrast, Deurali, Kali Khola, Loktantrik, Nandapur, and Turke are experiencing depletion-whether due to competition, landslide impacts, or overall dwindling supply-which directly challenges their long-term viability.

Across the board, recharge strategies play a critical role. Most committees adopt proactive measures: Panbari and others engage in annual afforestation (sometimes collaboratively), which helps sustain the recharge zone. However, a few, such as BuddhSubba and Turke, either do not emphasize recharge or lack any formal recharge strategy, which may be contributing to their depletion issues.

- **Community Governance and Monitoring**

Monitoring mechanisms also vary. While Panbari, Deurali, and similar committees employ dedicated monitoring teams (typically three personnel on a scheduled basis) to keep a close watch on source conditions, many committees lack any formal watchdog system. This inconsistency in oversight could lead to delayed responses when issues arise, ultimately affecting sustainability.

When it comes to the handling of project resources, all committees rely on an internal committee structure for management, ensuring centralized decision-making and resource allocation. Disputes are generally rare; however, there are instances-for example, Loktantrik experiences disputes during source identification, and Turke has disputes linked to its depleted source-suggesting that even well-organized groups can face localized conflicts.

- **Operation and Maintenance**

The fee structures show notable diversity. Panbari charges Rs 50 for 15 units (with an additional Rs 7.5 per extra unit), Thingabari levies Rs 126 for 20 units (Rs 6 per extra unit), while BuddhSubba and Shree have higher rates (Rs 300 for 30 units and Rs 200 for 30 units respectively). Such variability reflects differences in infrastructure costs, treatment processes, and the overall strategy for revenue generation. In many cases, the community exhibits a willingness to pay, especially where the quality or continuity of water supply is at risk. However, committees

like Kali Khola, Loktantrik, and Turke report low or no willingness to pay, which may undermine their financial sustainability.

Regarding the sufficiency of collected fees for operations and maintenance, most committees affirm that the revenue meets their needs, although some, such as Nandapur, rely on additional funds or donations to cover maintenance costs. Turke, facing a severely depleted source, struggles to collect any fees, indicating an urgent need for external intervention.

The overall effectiveness and sustainability of these committees vary. Many, including Panbari, Thingabari, Shree, Shivadhara, and Panch Kanya, are actively pursuing new source identification or deep boring projects to cater to growing demand. Yet, some committees face technical challenges—such as slope gradient difficulties in Panch Kanya and Shree Gau Danabari, or inefficiencies in water intake in Nandapur—that may hinder their long-term performance. Turke, in particular, lacks any future plans due to its severely depleted source, highlighting a critical case where intervention is needed.

5.3.6 Panbari Khanepani Tatha Upavokta Samitis

Institutional and Governance Framework

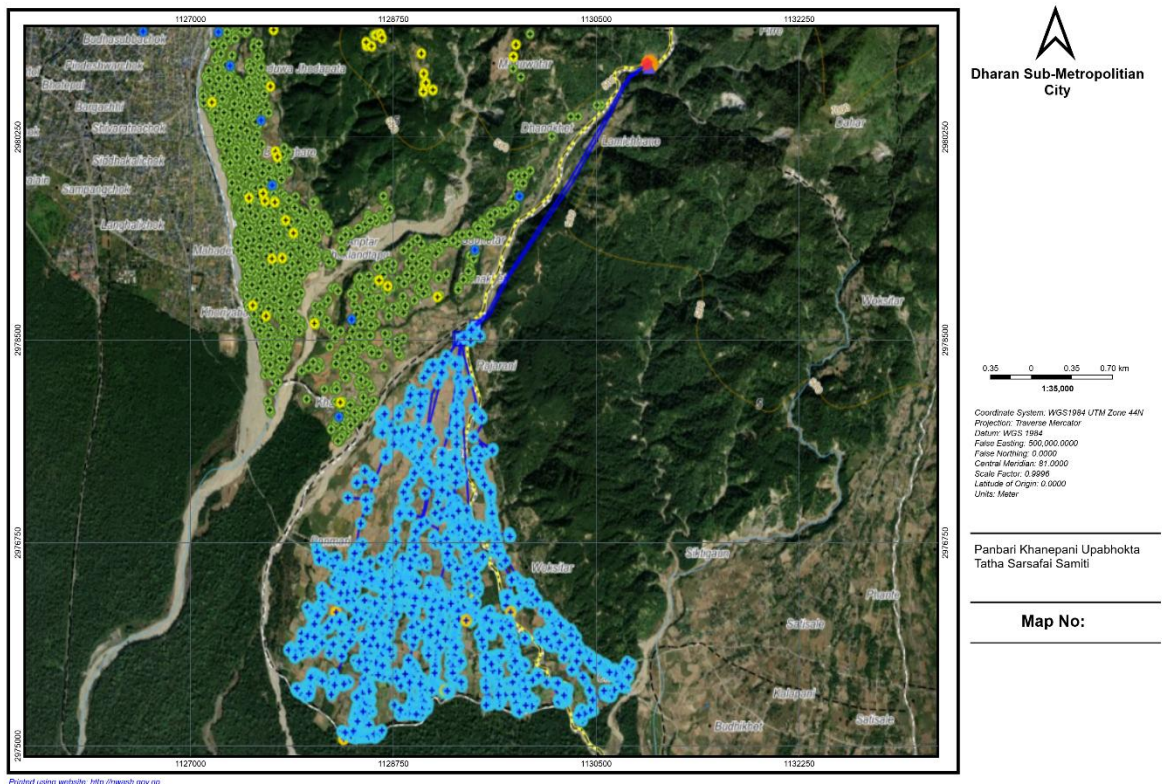


Figure 25 Map of Panbari Khanepani Upavokta Tatha Sarsafai Samiti at Ward 6

Located in Ward 6 of Dharan, before , the committee currently supplies water to around 2300 households out of the 2700+ households in the ward.

The committee's origins trace back to 2048 B.S., when it was initially formed to serve just 145 households, collecting Rs. 100 per household as a starting fund with help of ADB. By 2064 B.S., it was legally established under the District Gramin Khanepani Tatha Sarsafai Yojana. At that time, it had expanded its service capacity to around 1400 households. Over the years, this number grew steadily, reaching 2000 households by 2079 B.S. and over 2300 households by 2081 B.S., reflecting its significant role in addressing Dharan's water supply needs. Before 2048 B.S., the local residents of Dharan Ward 6 relied on fetching water directly from nearby local resources and public taps installed by the British Gurkha. These taps sourced water from Shera Khola, which was primarily intended to meet the water needs of the B.P. Koirala Institute of Health Sciences (BPKIHS).

1. Organizational Structure

The governance structure of the committee evolved alongside its growth. Initially, the 9-member committee was formed through general consensus, reflecting a community-driven and informal approach. However, with its formalization and expansion, the most recent committee formation was conducted democratically, signifying a shift toward a more structured and transparent governance model.

The **Panbari Khanepani Upavokta Tatha Sarsafai Samiti** operates under a structured governance model consisting of **nine committee members**, each designated with specific responsibilities to ensure the efficient management of decentralized water supply and sanitation services. This governance structure is designed to be **inclusive, participatory, and transparent**, reflecting the community-driven approach to urban water management in Dharan. The leadership framework includes **one Adakshya (Chairperson), one Upadakshya (Vice-Chairperson), one Sachib (Secretary), one Upasachib (Deputy Secretary), one Kosadhyakshya (Treasurer), and four general members**. Each of these roles plays a crucial part in the administration, financial management, and operational efficiency of the water supply system.

A key aspect of this governance model is the **mandatory inclusion of female members**, ensuring that gender diversity is maintained within the decision-making process. Specifically, **one seat for Kosadhyakshya (Treasurer) and one seat for a general member are reserved for women**. This policy promotes gender equity by allowing women to take active roles in financial oversight and broader management decisions. Given that women are often the primary users and managers of household water, their

inclusion in governance structures helps to align policies with the actual needs and challenges faced by households.

The **Chairperson (Adakshya)** serves as the head of the committee, providing leadership, overseeing strategic decision-making, and ensuring that the organization's activities align with community needs. The **Vice-Chairperson (Upadakshya)** assists in these responsibilities and steps in during the Chairperson's absence. The **Secretary (Sachib) and Deputy Secretary (Upasachib)** handle administrative duties, documentation, and communication within the committee and with external stakeholders. The **Treasurer (Kosadhyakshya)** is responsible for financial management, overseeing revenue collection, budgeting, and expenditure tracking, ensuring that the water supply system remains financially sustainable.

The four **general members** represent the broader community and assist in the execution of projects, maintenance of infrastructure, and resolution of local disputes. These members play a vital role in **bridging the gap between the committee and the users**, ensuring that the community's voices are heard in the decision-making process. The governance framework encourages **participatory decision-making**, where major policies, pricing strategies, and expansion plans are discussed collectively, either through consensus or voting mechanisms.

2. Water Resource Management

The Panbari Khanepani Upavokta Tatha Sarsafai Samiti has identified and utilized water from multiple sources to meet the water demands of the community.

Selection and Evaluation of Water Sources:

- Local Knowledge and Surveying:

The community conducted thorough local surveys and relied on traditional knowledge to pinpoint viable water sources. They recognized that rivers and natural spouts were integral to their water security, leading them to prioritize Mamphang Khola, Jalkini, and Shera Khola.

- Pipeline Installation from Mamphang Khola:

To effectively capture water from Mamphang Khola—a source located 4 km north—the community installed two robust 160 HDPE pipelines. These pipelines were chosen not

only for their durability but also for their ability to withstand environmental stresses over the long distance between the river and the reservoir tanks.

- **Collector Well and Pipeline Network at Shera Khola:**

Recognizing the proximity of Shera Khola, just 400 m north of the reservoir tanks, the community established a network of multiple pipelines. A collector well at Shera Khola was specifically constructed to efficiently gather water from this source, ensuring minimal loss during transit and optimizing water capture during peak flows.

- **Utilization of Natural Spout – Jalkini:**

Initially a reliable natural spout, Jalkini was integrated into the system due to its accessibility. However, natural events like landslides have since diminished its flow. Despite these challenges, it remains a component of the overall water system, underscoring the community's commitment to utilizing every available resource.

3. Water Sources

1. Mamphang Khola:

The community collects water from Mamphang Khola, a river located **4 km north** of the reservoir tanks.

To transport water, they have installed **two 160 HDPE pipelines** spanning the distance. These pipelines were laid to ensure a consistent supply to the reservoir tanks.

2. Jalkini (Natural Spout):

This source is a **natural spout** that originally provided a significant water supply to the community.

However, the flow of water from Jalkini has **reduced considerably** over time due to **landslides** in the surrounding area. Despite this, it continues to contribute to the overall water supply.

3. Shera Khola:

Located **400 m north** of the reservoir tanks, Shera Khola is another critical water source utilized by the community. Water is collected from Shera Khola through **multiple pipelines** at specific sections, and a **collector well** has been built at the source for efficient gathering of water.

4. Deep Boring

This is used only during dry seasons, when daily supply is decreased to about 50% from wet season and also when water supplied is disturbed.



Figure 26 Water collection chambers of Panbari Khanepani Upavokta tatha Sarsafai Samiti

5. Historical Progression and Multi-Sourced Storage:

Over time, the community enhanced its water storage capacity by constructing a series of reservoir tanks with a combined capacity of 12 lakh liters. Each tank represents a phase in the evolution of the water supply system:

- **RVT 1 (2018 B.S.):** Initiated by the British Gurkha, this tank originally served the water needs of the British Gurkha Camp (now BPKIHS). Its water intake was primarily from Jalkini.
- **RVT 2 (2039 B.S.):** Developed with UNICEF funding, this tank was specifically designed to store water sourced from Mamphang Khola, highlighting international collaboration and investment.
- **RVT 3 (2045 B.S.):** This reservoir, built under the ADB District Water Supply Project, further consolidated the community's reliance on Mamphang Khola. A dedicated collection chamber at Shera Khola plays a crucial role in channeling water into this system.

- **RVT 4:** Dedicated exclusively to water collected from Shera Khola, this tank emphasizes the community's effort to diversify storage by directly harnessing the closest available source.



Figure 27 Reservoir Tanks of Panbari Khanepani Upavokta tatha Sarsafai Samiti

6. Infrastructure and Technology

a. Water Extraction & Treatment

The committee has implemented a range of measures to ensure effective water extraction and treatment. In collaboration with the Water Supply and Division Office of both the Province and the Central Government, the system now incorporates sand filtration and slow sand filtration techniques. These methods help in removing impurities and improving water quality. Additionally, a chlorination machine-provided by the Province-is available and used when necessary to maintain safe water standards.

b. Distribution System

Water is distributed to households through a network of 20mm distribution pipes, ensuring efficient delivery throughout the community. The system has been upgraded

with a flow measuring machine that monitors both the intake and outtake, enabling better management of water distribution and early detection of any issues.

c. Innovations & Upgrades

In 2080 B.S., significant technological advancements were introduced:

Meter Distribution: The committee adopted a meter distribution system, allowing for more precise monitoring of water usage.

Online Payment System: Utilizing WaterMark software by Diyalo, the online payment system streamlines billing processes and enhances transparency.

Land Acquisition for Reservoir Tanks (RVTs)

Land management has played a crucial role in the overall water infrastructure:

Purchased Land: In 2050 B.S., the committee independently purchased a land parcel measuring **9 katha 11 dhur** to facilitate the construction and operation of reservoir tanks.

Donated Land: Additionally, the local community contributed by donating land that houses **two reservoir tanks**.

7. Financial and Economic Viability

a. Revenue Model

The water supply system is primarily funded through a combination of tariff collections and external financial support. The committee has implemented a tiered tariff structure where the base rate is set at Rs 100 for up to 15 units of water consumption, with an additional charge of Rs 7.5 for every extra unit consumed. For new installation of pipe, committee has rate for Rs.17,500 including meter. The pipe has to be self-managed by people applied for new installation. This model is designed to cover operational costs while encouraging efficient water use. Major capital investments, including the construction of Reservoir Tanks (RVTs), sedimentation tanks, and water reservoirs, have also been financed through external funding provided by the Province and the Central Government.

b. Affordability and Equity

The tariff system is structured to ensure that water remains affordable for all income groups. By setting a low base rate, essential water needs are met without imposing a significant financial burden on households. Provisions are in place to ensure equitable access, and subsidies or concessions can be extended to low-income families, thereby maintaining a balance between cost recovery and social equity.

c. Financial Sustainability

The system's financial sustainability is maintained through regular tariff collections that are reinvested into ongoing maintenance and system upgrades. While the revenue generated from water usage helps cover routine expenses and operational costs, external funding plays a crucial role in supporting major infrastructural developments and technological improvements. This dual funding approach ensures that the water supply network remains robust, efficient, and capable of adapting to future needs.

8. Community Engagement and Participation

a. User Participation:

The community plays a central role in the management, maintenance, and decision-making processes related to the water supply system. Annual meetings serve as the primary platform where all residents are invited to discuss and decide on key issues, ensuring that information flows freely among all stakeholders. Residents actively volunteer in various activities, including supplying pipes from the source, participating in construction projects, and undertaking the cleaning of reservoir tanks and related infrastructure. This hands-on involvement reflects a strong sense of community ownership and shared responsibility.

b. Capacity Building:

The committee prioritizes the enhancement of local capacity through regular training and awareness programs. These initiatives are integrated into the annual meetings, where community members receive updates on maintenance practices, technological upgrades, and operational procedures. Such efforts not only equip the residents with the necessary skills to manage the water infrastructure effectively but also foster a deeper understanding of the system's overall functionality. An example of collaborative engagement is seen in the support provided by the Drug Rehabilitation of Police facility, which not only receives water supply but also contributes volunteer labor annually and whenever needed.

c. Conflict Resolution:

The committee is fundamentally service-oriented rather than profit-driven, which has helped maintain a harmonious atmosphere with minimal disputes over water access, pricing, or quality. In cases where disagreements do arise, the committee addresses them through community dialogue during the annual meetings, ensuring that all voices are heard and that issues are resolved in a transparent and equitable manner. The consistent

participation of community members and the cooperative spirit—exemplified by the support from both local residents and police volunteers—further strengthens the conflict resolution process and reinforces trust in the management system.

9. Community Performance and Operational Challenges

a. Water Quality and Reliability:

Annual water quality tests are carried out in accordance with the Dharan Sub Metropolitan City's requirements for taxation purposes. These periodic assessments ensure that the water consistently meets established quality standards. Despite the annual testing frequency, the committee has maintained a reliable water supply that minimizes disruptions for households, reflecting a strong commitment to quality management.

b. Coverage and Accessibility:

The water supply network currently covers approximately 85% of the ward households. This high level of coverage underscores the committee's effective performance in delivering water services compared to broader municipal systems. Nevertheless, opportunities remain to expand the network further, ensuring that more households have consistent access to the water supply.

c. Operational Efficiency and Challenges:

Ongoing efforts to monitor and reduce Non-Revenue Water (NRW)—which may result from leakages, illegal connections, or other inefficiencies—are a key part of the operational strategy. Regular inspections and maintenance of the distribution infrastructure help to mitigate these losses. However, challenges persist in fully addressing NRW, and occasional system disruptions, especially during adverse weather events, highlight the need for continual improvement in operational practices.

5.3.7 Observations on Practices

Field observations reveal that decentralized water supply practices in Dharan are characterized by both commendable community resilience and significant operational challenges. Several Water User Committees (Upavokta Samiti) have independently established extraction points—often within 100 meters of each other—to secure water, demonstrating a strong sense of local ownership. However, this fragmented approach has also led to overlapping claims and disputes over water sources. In one notable instance, the Department of Water Supply Management Board (DWSMB) intervened to resolve a

conflict when it attempted to extract water from a source already in use by a local committee.

Community-driven initiatives, including volunteer campaigns and locally managed reservoirs, have been crucial in providing immediate relief during acute shortages. These efforts highlight the adaptability of decentralized systems, especially during the dry season when entities like the Panbari Khanepani Tatha Upavokta Samitis resort to borehole water extraction as an adaptive measure. Despite their effectiveness in emergency situations, many of these initiatives struggle with a lack of technical expertise and sustainable financial backing, which undermines long-term maintenance and resilience.

Thingabari Khanepani Upavokta tatha Sarsafai Samiti has tried to prepare a map to show the source, RVTs and distribution based on their experience, helping to visualize them the distribution pipeline area for future plans. Committee lack technical personnel, and tried to comprehend its own map. Some committees have managed part-time and full-time billing staffs based on their financial capability. Some committee members gather monthly for payment where some committees have schedule days for payment. Almost every committees that I studied or interviewed lack resource or fund to manage full time billing staffs, where only few committees has staff members for billing, office space, and plumbers. The technical staffs aren't available in all committees.

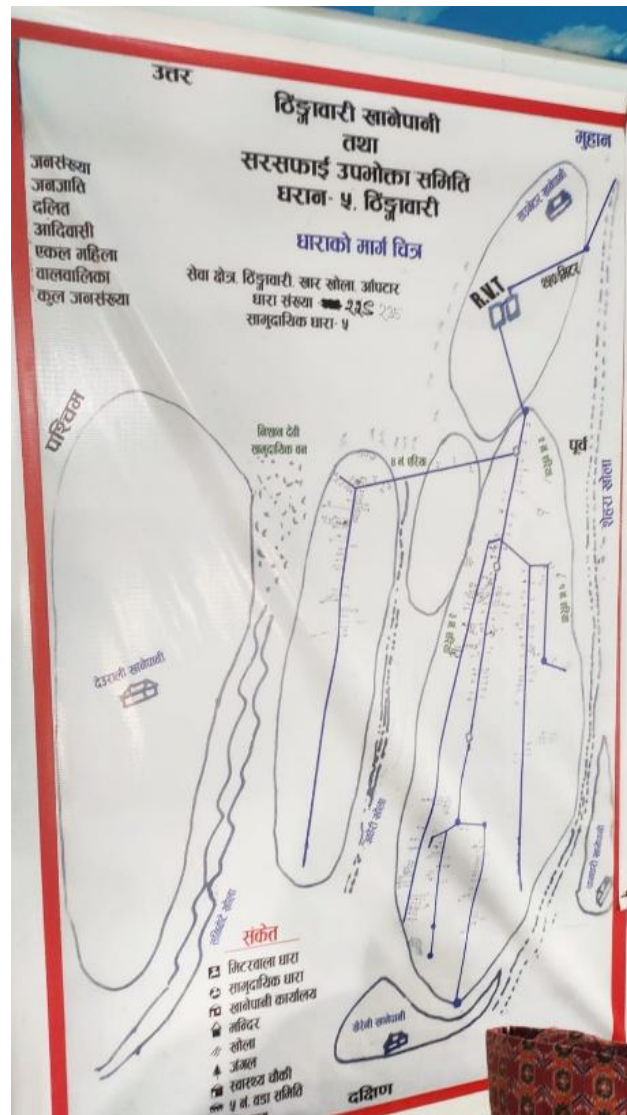


Figure 28 Thematic map prepared by Thingabari Khanepani Upavokta tatha Sarsafai Samiti
 A holistic review of the decentralized water supply system in Dharan indicates several areas in need of improvement:

- **Coordinated Planning and Governance:** There is a critical need for enhanced coordination between the DWSMB and local Water User Committees. A comprehensive, scientifically informed management plan would minimize overlapping extraction points and mitigate disputes by ensuring equitable water allocation.
- **Capacity Building and Technical Support:** Many community groups lack the technical skills and financial resources necessary for sustainable operation and maintenance. Structured capacity-building programs and financial incentives would empower local stakeholders to adopt modern water management techniques and maintain infrastructure over the long term.

- **Infrastructure Resilience:** Extraction points located near river systems are highly vulnerable to environmental disruptions such as floods and landslides. Diversifying the water sources and integrating robust infrastructural elements—such as groundwater recharge retention ponds, permeable pavements, and rainwater harvesting systems—could reduce the risk of supply interruptions and decrease additional repair expenses.



Figure 29 Pipelines within the rivers

- **Integrated Resource Management:** The current unplanned approach restricts the ability to effectively cater to future urbanization pressures. A holistic approach that includes demand-side management, sustainable infrastructural investments, and environmental protection measures is essential to enhance overall resilience and efficiency.

5.4 Community Perception

A two-pronged survey strategy was used to determine how the community felt about water management. First, a general survey was conducted utilizing random sampling in every ward of Dharan with the goal of gathering comments on the municipality's water management procedures. Concurrently, a pilot study was carried out in Ward No. 6 with a focus on Panbari Khanepani Upavokta Tatha Sarsafai Samiti beneficiaries. This pilot

survey focused on understanding the detailed perceptions and concerns of those directly served by the community-managed water system.

After few pilot surveys, it was found that the questionnaires needed to be improved in order to better capture the subtleties of community issues. Consequently, the questionnaires were revised and the pilot survey was put on hold for a while. After that, a targeted sample of 45 respondents completed the updated survey, guaranteeing a more accurate and focused evaluation of community attitudes regarding water management in Dharan.

5.4.1 Community Perception on Community Management of Water in Dharan

A survey involving 150 respondents from various wards of Dharan was conducted to assess the community's perceptions and attitudes toward the urban water supply system. In addition to evaluating satisfaction with current water services, the survey examined residents' awareness of ongoing improvement initiatives and their readiness to participate in volunteer campaigns aimed at enhancing water distribution. Although the calculated sample size—using a standard formula to maintain a 95% confidence level and a 10% margin of error—was 97, the survey was extended to 151 respondents to ensure comprehensive coverage and data saturation. Random sampling techniques were employed, with participants being selected based on key classifications such as age, gender, socioeconomic class, location (Tole), and household income. Data were gathered through household questionnaires, structured surveys, and face-to-face interviews. This approach provided in-depth insights for a detailed assessment of community involvement, including the challenges residents face with the water supply system, their perceptions regarding volunteer campaigns, and their willingness to engage in community-led initiatives to foster a more reliable and sustainable water distribution network

Table 12 Demographics from Survey 1

Category	Value	Number	Percentage (%)
Gender	Male	96	63.58%
	Female	55	36.42%
	Others	0	0
Age	≤20	9	5.96%
	21-40	48	31.79%
	>40	94	62.65%

Profession	Student	33	21.85%
	Homemaker	26	17.22%
	Civil Servant	8	5.3%
	Private Sectors	47	31.13%
	Others	37	24.5%
Education Level	Under SLC	14	9.27%
	SLC	18	11.92%
	+2	40	26.49%
	Bachelors	66	43.71%
	Masters and above	13	8.91%
Household Members	1-2	13	8.61%
	3-5	92	60.93%
	6-8	35	23.18%
	>8	11	7.28%

The data acquire from household surveys and interviews is presented in the provided charts.

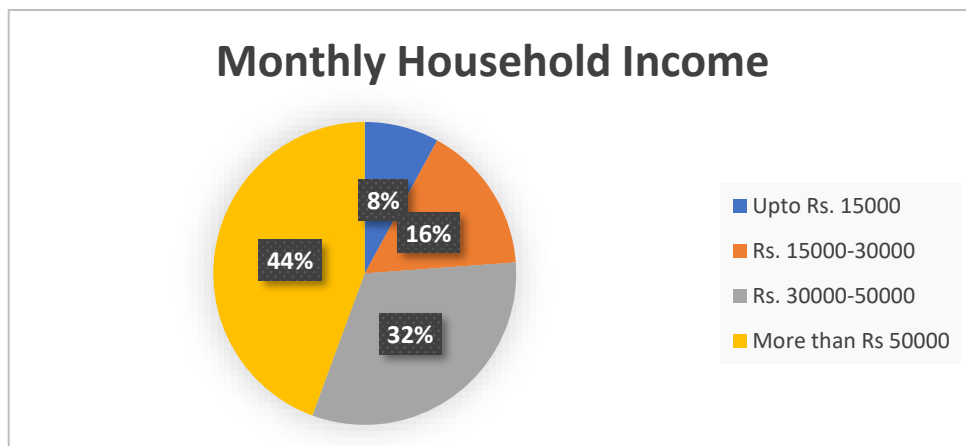


Figure 30 Monthly Household income of Survey 1

The Survey on monthly household income, 44% were found with more than Rs. 50000 and 8% with upto Rs. 15000 only.

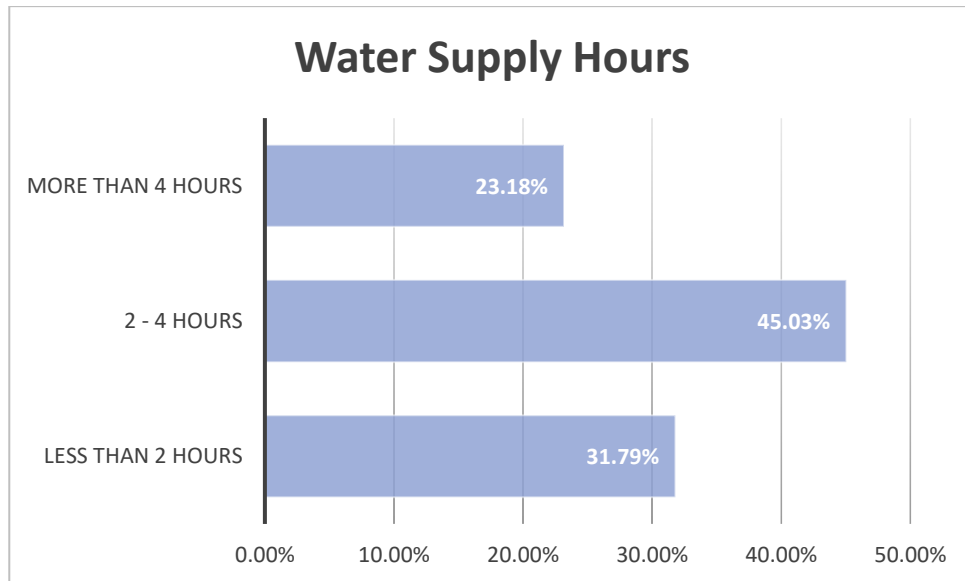


Figure 31 Daily supply hours from Survey 1

The Survey respondents, on water supply hours revealed 45.01% household of Dharan received water ranging 2-4 hours daily, with 31.79% households receiving water for more than 4 hours daily.

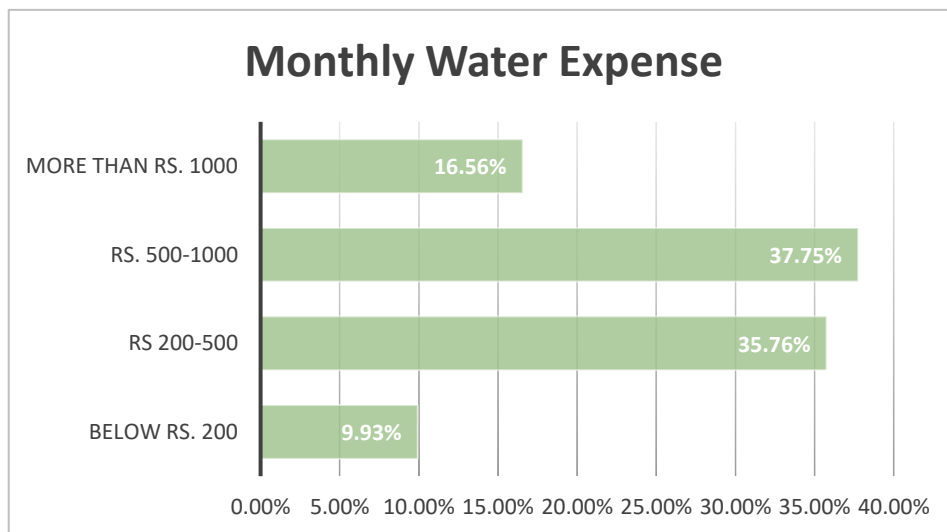


Figure 32 Monthly household water expense from Survey 1

The data on **monthly water expenses** highlights significant variations in household spending, reflecting disparities in access and affordability. Only **9.93%** of households spend **below Rs. 200**, likely relying on subsidized or shared water sources. A substantial **35.76%** fall within the **Rs. 200-500 range**, suggesting moderate costs, possibly from municipal or community water services. The largest group, **37.75%**, spends **Rs. 500-1000**, indicating higher costs due to irregular supply, storage needs, or reliance on private

sources. Additionally, **16.56%** of households spend **over Rs. 1000**, reflecting a heavy financial burden, likely from tanker or bottled water dependency. With over **54% of households spending more than Rs. 500 per month**, affordability remains a challenge, pointing to gaps in the public water supply system. Addressing these through better infrastructure, improved distribution, and community-based water governance is essential for sustainable and equitable access.

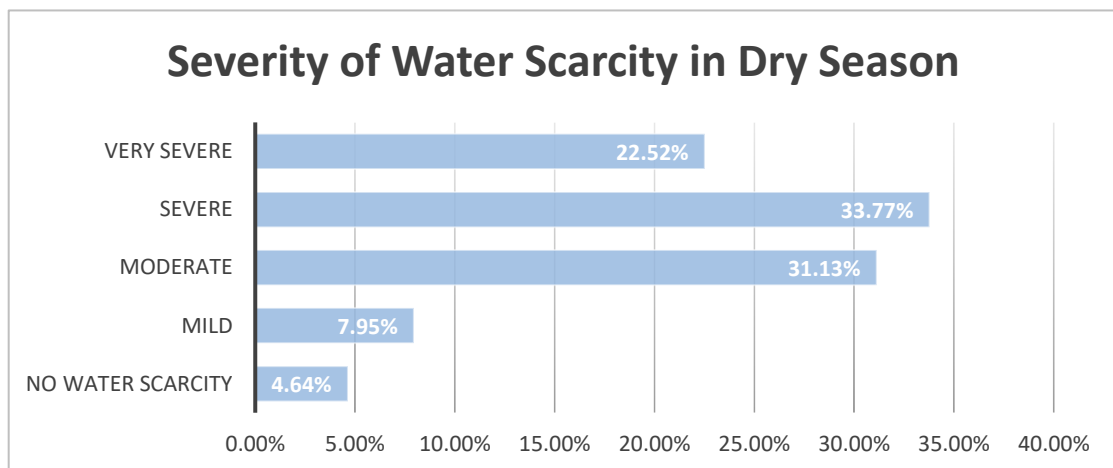


Figure 33 Severity of Water Scarcity from Survey 1

The data shows that water scarcity is a major issue during the dry season, with only 4.64% facing no scarcity and 7.95% experiencing mild shortages. 31.13% report moderate scarcity, requiring occasional rationing. The crisis worsens for 33.77% facing severe shortages and 22.52% experiencing very severe scarcity, indicating extreme struggles to meet basic water needs. With over 56% of households facing severe to very severe water scarcity, urgent action is needed to improve water management, infrastructure, and alternative supply sources.

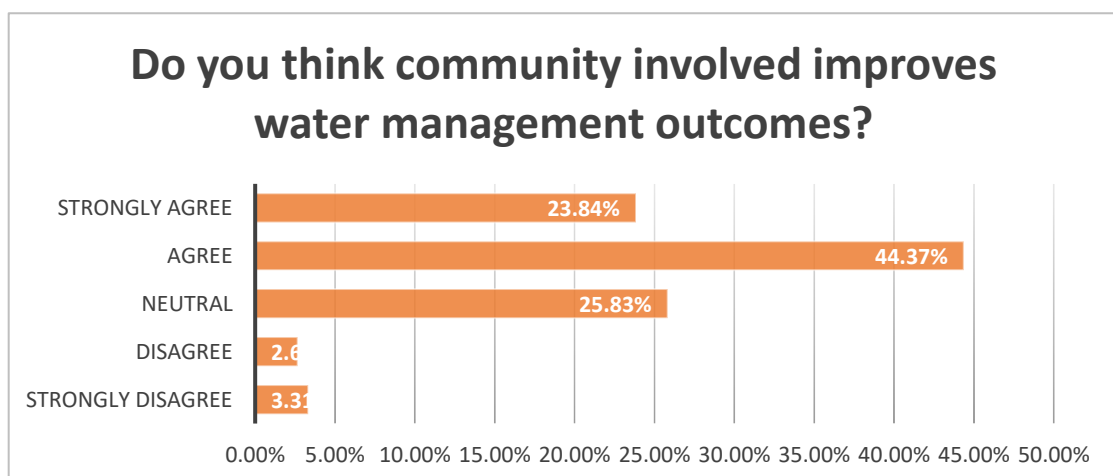


Figure 34 Opinion on community involvement for water management outcome from Survey 1

The survey reveals strong support for community involvement in water management, with 44.37% agreeing and 23.84% strongly agreeing on its benefits. Only 5.96% disagree, while 25.83% remain neutral. This suggests a widespread belief that community participation improves efficiency and sustainability, emphasizing the need for greater engagement in water governance.

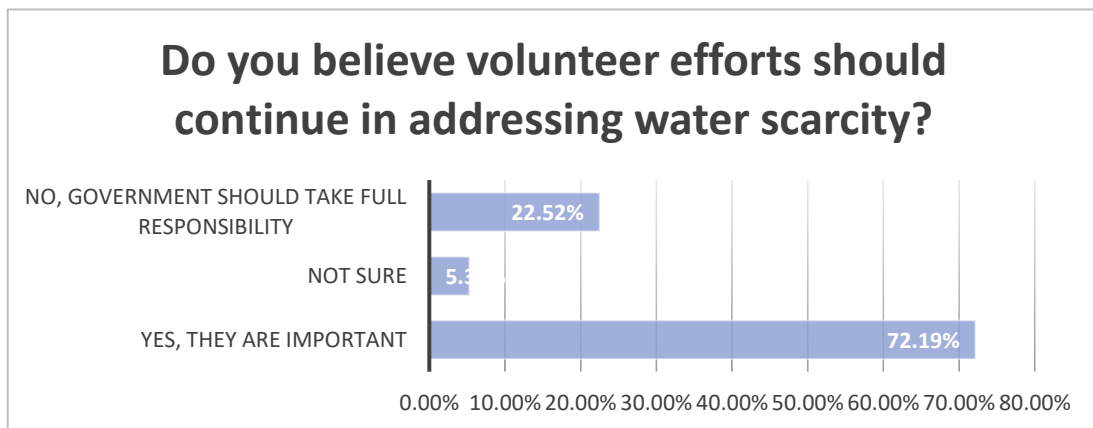


Figure 35 Opinion on Volunteer efforts for water scarcity from Survey 1

The survey shows strong support for continued volunteer efforts in addressing water scarcity, with 72.19% believing they are important. Only 5.30% are unsure, while 22.52% think the government should take full responsibility. This suggests that while most residents value community participation, a significant portion still sees the government as the primary solution provider. Balancing both approaches could enhance water management effectiveness.

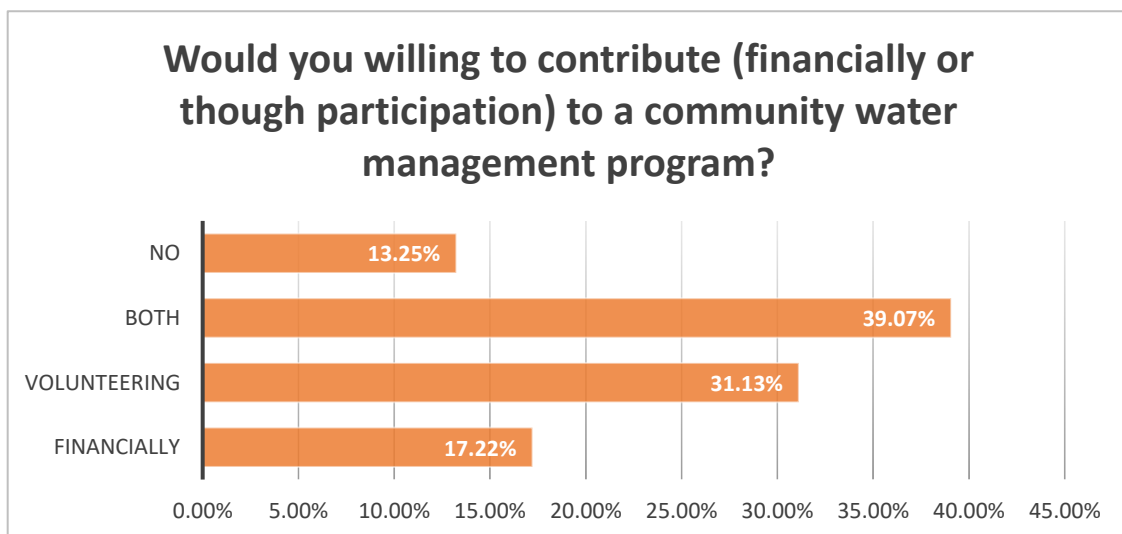


Figure 36 Willingness to participate from Survey 1

The survey data indicates strong community willingness to support water management programs, with 39.07% willing to contribute both financially and through volunteering. Additionally, 31.13% prefer volunteering, while 17.22% are open to financial contributions. However, 13.25% are unwilling to participate, suggesting some resistance. Overall, the findings highlight a high level of community engagement, which can be leveraged for sustainable water management initiatives.

5.4.2 Community Perception and Concerns of Ward 6

A pilot survey involving 45 respondents from various localities was conducted to assess the community's perceptions and concerns regarding the Panbari Khanepani Upavokta tatha Sarsafai Samiti. In addition to evaluating satisfaction with existing water supply and sanitation services, the survey examined residents' awareness of ongoing improvement initiatives and their willingness to participate in volunteer campaigns aimed at enhancing both service delivery and community cleanliness. Although the calculated sample size—using a standard formula for a 95% confidence level and a 10% margin of error—was lower, the survey was extended to 45 participants to ensure comprehensive coverage and data saturation. Random sampling techniques were employed, with participants selected based on key criteria such as age, gender, socioeconomic status, residential area (Tole), and household income. Data were collected through household questionnaires, structured surveys, and face-to-face interviews. This approach provided in-depth insights into community involvement, highlighted the challenges residents face with the current water and sanitation system, and their perceptions regarding community participation initiatives and readiness to engage in community-led efforts for a more reliable and sustainable service network.

Table 13 Demographics from Pilot Survey

Category	Value	Number	Percentage (%)
Gender	Male	26	57.78%
	Female	19	42.22%
	Others	0	0
Age	≤20	4	8.89%
	21-40	26	57.78%
	>40	45	33.33%
Profession	Student	16	35.56%

	Homemaker	9	20%
	Civil Servant	2	4.44%
	Private Sectors	5	11.11%
	Others	13	28.89%
Education Level	Under SLC	16	35.56%
	SLC	5	11.11%
	+2	7	15.56%
	Bachelors	14	31.11%
	Masters and above	4	8.89%
Household Members	1-2	4	8.89%
	3-5	21	46.67%
	6-8	12	26.67%
	>8	8	17.78%

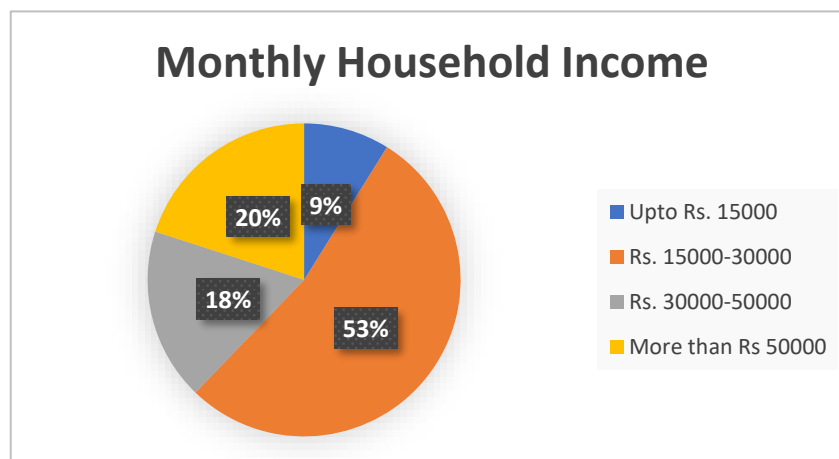


Figure 37 Monthly household income from Pilot Survey

The Survey on monthly household income, 20% were found with more than Rs. 50000 and 9% with upto Rs. 15000, 53% respondents with household income ranging between Rs. 15000-30000.

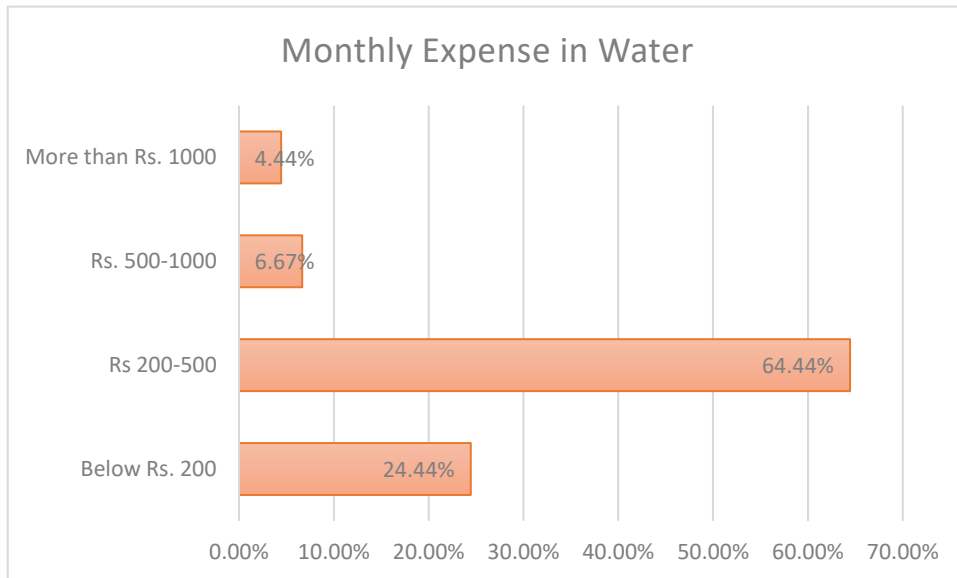


Figure 38 Monthly household expense in water from Pilot Survey

The pilot survey data shows that most households (64.44%) spend between Rs. 200 and 500 on water each month, while about one-quarter (24.44%) pay under Rs. 200. A small fraction (6.67%) spend Rs. 500–1000, and an even smaller group (4.44%) exceed Rs. 1000 in monthly water expenses. Overall, the majority of households incur moderate costs, with only a few facing significantly higher bills

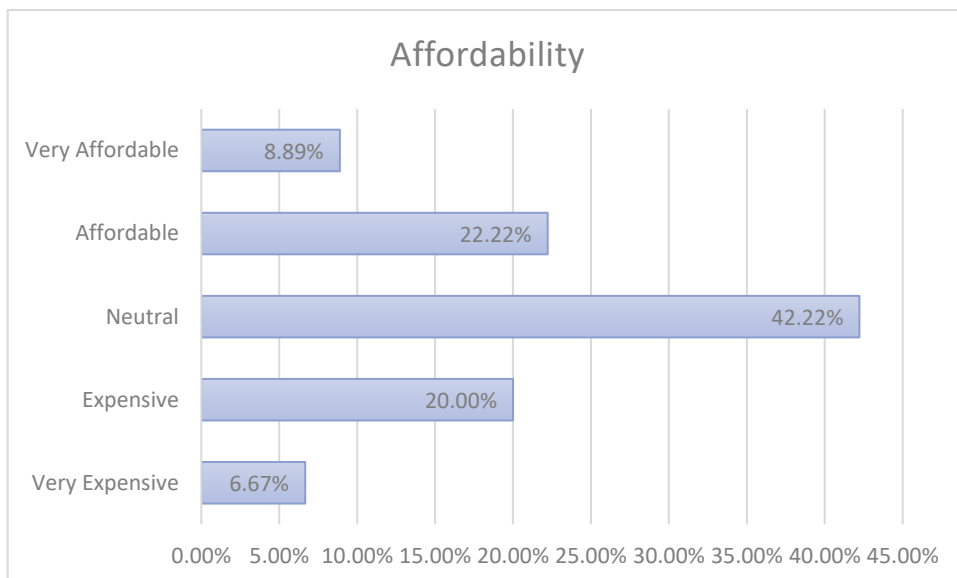


Figure 39 Affordability of Water from Pilot Survey

A majority of households (42.22%) view water costs as neither cheap nor expensive (“Neutral”), while about one in four (26.67%) consider it expensive or very expensive, and roughly one in three (31.11%) find it affordable or very affordable

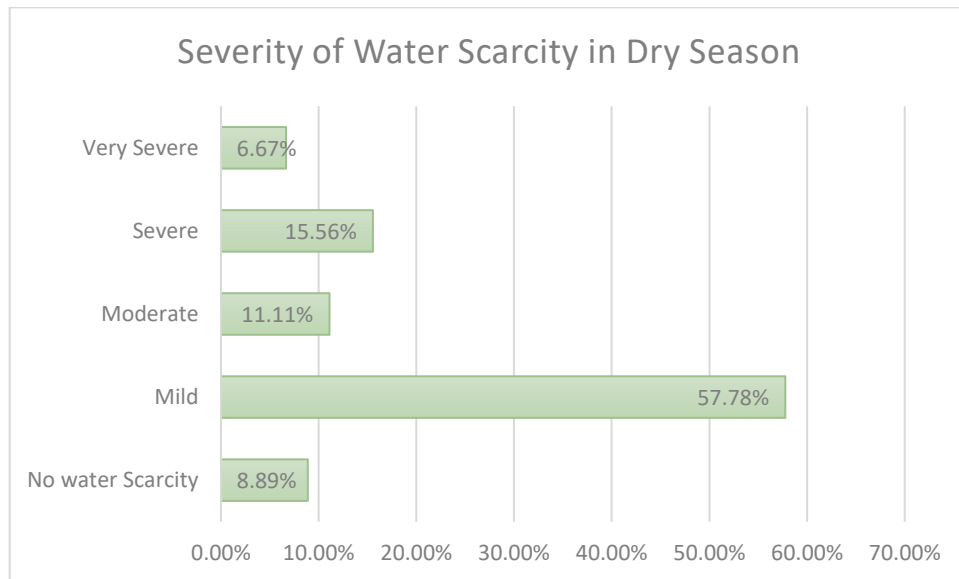


Figure 40 Severity of Water scarcity in dry season from Pilot Survey

The data illustrates that the majority of households (57.78%) experience mild water scarcity during the dry season, while only 6.67% face very severe scarcity. Additionally, 15.56% report severe scarcity, while 11.11% experience moderate scarcity. Only a small group (8.89%) finds there is no water scarcity.

A majority of respondents (57.78%) experience mild water scarcity during the dry season, while 11.11% face moderate shortages. About 15.56% endure severe scarcity, and 6.67% suffer from very severe conditions. Only 8.89% report no water scarcity, indicating that most households encounter at least some level of shortage in the dry month.

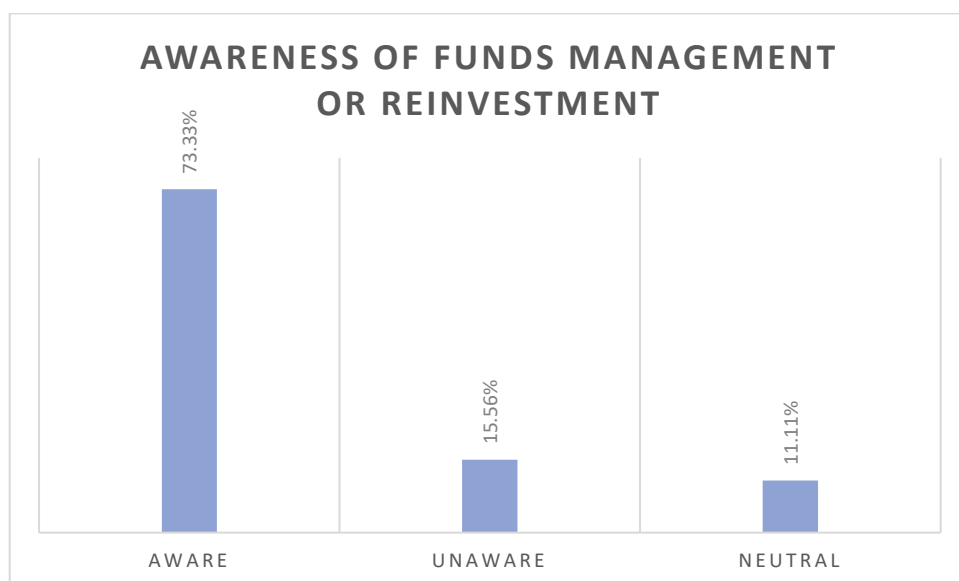


Figure 41 Awareness of funds management

A large majority (73.33%) of respondents are aware of how funds are managed or reinvested, while 15.56% remain unaware, and 11.11% are neutral. This suggests that most community members have at least some knowledge about financial processes and reinvestment of funds.

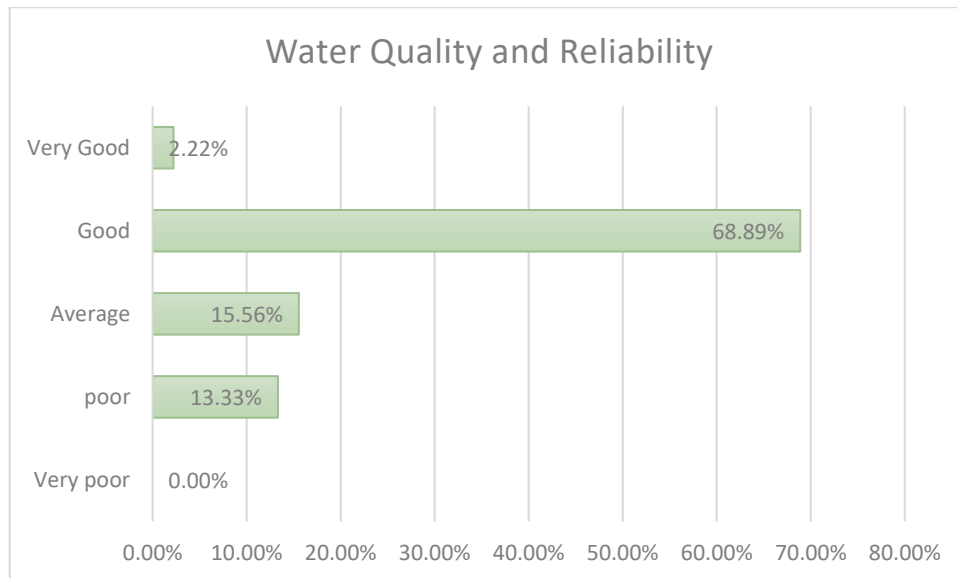


Figure 42 Water Quality and reliability from Pilot Survey

The majority of respondents (68.89%) rate the water quality as good, with 15.56% viewing it as average. A smaller proportion find it poor (13.33%), and none consider it to be very poor. Only 2.22% report the water as being very good, indicating general satisfaction with water quality, though there is room for improvement. for a few seconds No respondents rate the water quality and reliability as very poor, and a strong majority (68.89%) consider it good, with 2.22% finding it very good. Meanwhile, 15.56% see it as average, and 13.33% view it as poor, indicating that most households are satisfied, but a small minority still have concerns.

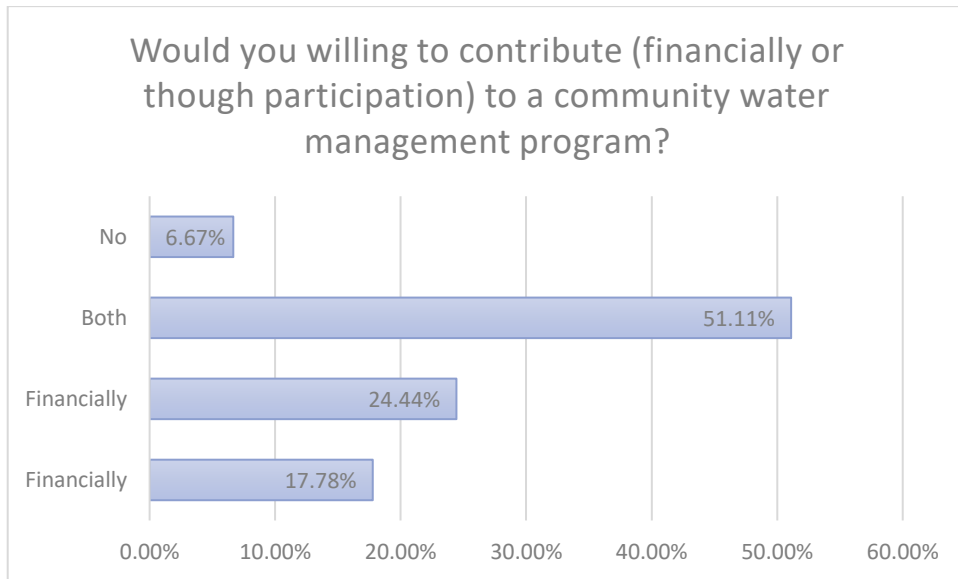


Figure 43 Willingness on contribution from Pilot Survey

Most respondents (51.11%) are willing to contribute both financially and through volunteering. 24.44% prefer volunteering, while 17.78% would contribute financially. Only 6.67% are unwilling to participate

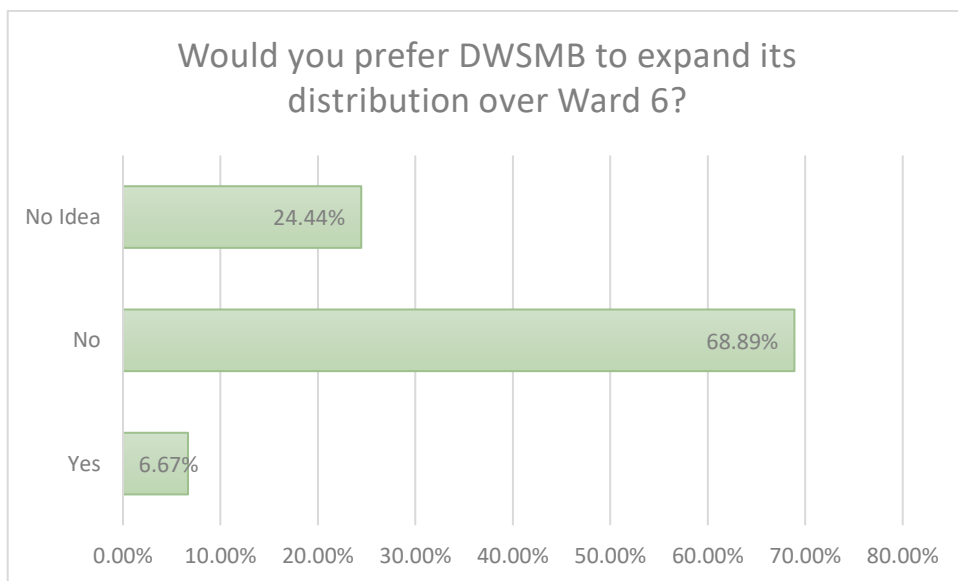


Figure 44 Preference of Water supply from Pilot Survey

The majority (68.89%) do not prefer DWSMB to expand its distribution over Ward 6, while 24.44% have no opinion, and only 6.67% support the expansion

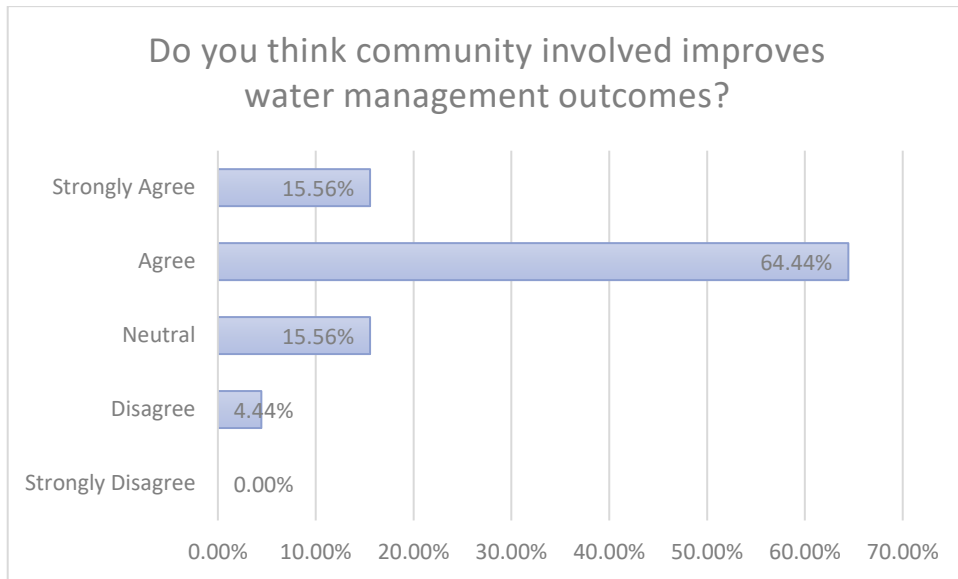


Figure 45 Opinion on Community Involvement from Pilot Survey

The majority (82.22%) believe volunteer efforts are crucial in addressing water scarcity, while 11.11% think the government should take full responsibility. A small portion (6.67%) is unsure.

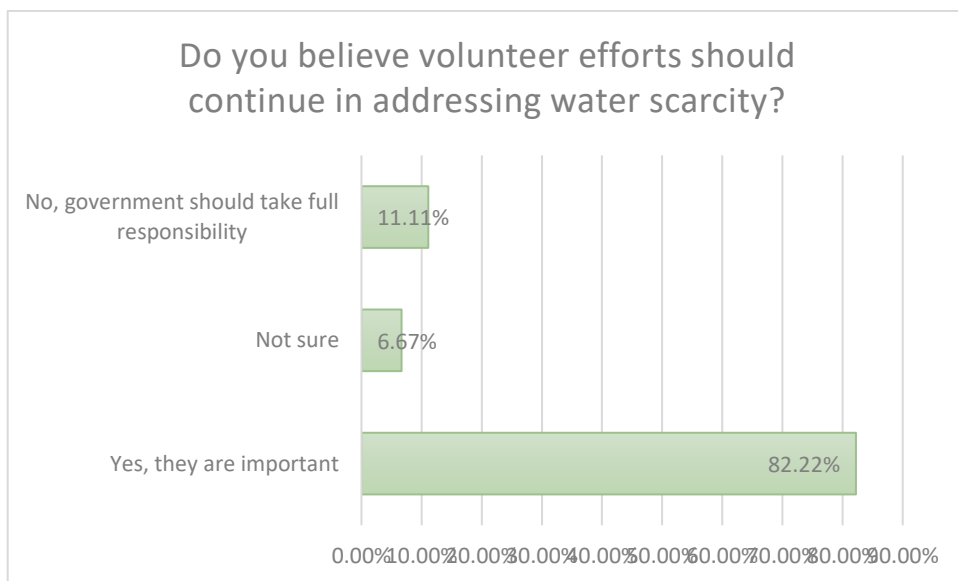


Figure 46 Opinion in Volunteer efforts from Pilot Survey

The majority (82.22%) believe volunteer efforts are important in addressing water scarcity, while 11.11% think the government should take full responsibility, and 6.67% are unsure.

5.5 Institutional Framework and Policy

5.5.1 Policy Support for Decentralized Water Management

Nepal's National Water Plan (2005), Water Supply and Sanitation Act (2079), and Local Governance Act (2017), Water and Sanitations Regulations (2081) encourage decentralization. Institutions like Panbari Upavokta Samiti require increased budget allocations at the local, provincial, and federal levels to sustain operations.

5.5.2 Role of Central, Province and Local Government under Water and Sanitation Regulations, 2081

5.5.2.1 Central Government:

According to Section 8, Sub-section (2), Clause (a) of the Act, the Nepal Government holds specific responsibilities in managing large-scale water supply and sanitation projects. These responsibilities include:

1. **National Pride Projects:** The Nepal Government is responsible for executing water supply and sanitation projects classified as national pride projects, emphasizing their strategic importance for national development.
2. **Public-Private Partnership (PPP) Projects:** Large-scale water supply and sanitation projects operated under the Public-Private Partnership and Investment Act, 2075, fall under the federal government's mandate.
3. **Reservoir-Based Projects with High Dams:** Projects involving reservoirs with a dam height exceeding 10 meters are managed by the central government, highlighting the complexity and risk management required.
4. **Long Tunnel Water Supply Projects:** The government oversees water supply projects with tunnels longer than 1 kilometer, reflecting the technical challenges involved.
5. **Bulk Distribution Systems with Large Pipelines:** Projects involving pipelines with a diameter exceeding 500 millimeters are managed centrally, given their extensive scale and infrastructure needs.
6. **High-Capacity Multi-Stage Pumping Projects:** The federal government manages multi-stage pumping projects with a capacity greater than 25 liters per second and a vertical distance exceeding 1,000 meters
7. **Extensive Transmission and Distribution Pipelines:** Water supply projects with transmission and distribution pipelines exceeding 200 kilometers are

managed by the central government, reflecting the scale and technical requirements

8. **High-Capacity Sewer Collection and Treatment Systems:** The government oversees sewer collection and treatment projects with a capacity greater than 2 million liters per day (2 MLD).
9. **High-Cost and Large Population Beneficiary Projects:** Projects with a cost exceeding NPR 500 million or benefiting more than 15,000 people in Terai, 5,000 in Hill, or 1,000 in Mountain regions are managed centrally.
10. **Multi-Purpose Sanitation Projects with Advanced Technology:** The government manages multi-purpose sanitation projects or those using innovative technologies.
11. **Projects Requested by Provincial Governments:** Projects requested by provincial governments under Section 8, Sub-section (6) of the Act are also handled by the federal government.

5.5.2.2 Role of Province Government

According to Section 8, Sub-section (2), Clause (b) of the Act, the Provincial Government holds responsibility for managing water supply and sanitation projects with a cost between NPR 150 million and NPR 500 million or benefiting a population range of 8,000 to 15,000 in Terai, 2,000 to 5,000 in Hill, or 500 to 1,000 in Mountain regions. Additionally, the Provincial Government oversees reservoir-based projects with dam heights up to 10 meters

5.5.2.3 Role of Local Government

According to Section 8, Sub-section (2), Clause (c) of the Act, the Local Government is responsible for managing water supply and sanitation projects with a cost up to NPR 150 million or benefiting up to 8,000 people in Terai, 2,000 in Hill, and 500 in Mountain regions. Additionally, the Local Government is responsible for managing the disposal of treated solid and liquid waste from wastewater management systems.

5.5.2.4 Gaps on Regulation

- **Overlapping Responsibilities:** The Act defines responsibilities based on project cost and beneficiary population. However, some projects may fall within overlapping thresholds. For example, Projects costing exactly NPR 500 million or serving exactly 15,000 people in Terai could be interpreted as responsibilities

of both the central and provincial governments. Similarly, projects costing exactly NPR 150 million or benefiting exactly 8,000 people in Terai could fall under either the provincial or local government.

- **Unclear Criteria for Advance Technology:** The central government is responsible for projects using "innovative technologies," but the Act does not define what qualifies as "innovative", this might create inconsistent interpretations if a provincial or local government claims a project as innovative to seek federal support.

5.5.3 Policy Review on Water User and Sanitation Committee

According to Section 8, Sub-section (2), Clause (c) of the Act, the policy framework for consumer institutions is designed to ensure inclusive, accountable, and efficient water supply and sanitation services. The regulation mandates the formation, registration, and management of consumer institutions while safeguarding the interests of beneficiaries.

Key provisions include:

1. **Formation and Registration (Section 8, Sub-section (2), Clause (c), Sub-Clause (1)):** Individuals benefiting from water supply and sanitation projects must establish a consumer institution based on inclusive principles and register it under the relevant local government laws. Community institutions or consumer groups registered before the regulation's commencement must be listed with the local government within six months, submitting:
 - (a) A certificate of registration as per prevailing laws.
 - (b) The institution's *Bidhaan*.
 - (c) Service delivery details, including the names and addresses of current executive committee members.
2. **Status and Rights of Registered Institutions (Section 8, Sub-section (2), Clause (c), Sub-Clauses (4) to (7)):** Consumer institutions listed with the local government hold the same legal standing as newly registered institutions. However, registration of multiple institutions providing duplicate services in the

same area is prohibited to avoid redundancy and overuse of water resources. Multiple institutions can collaborate for integrated services and service improvement programs.

3. Water Source Priority and Usage Rights (Section 8, Sub-section (2), Clause (c), Sub-Clause (7)): Consumer institutions have priority rights to use water resources up to the allocated limit, ensuring equitable access. This clause ensures efficient water management while preventing conflicts over resource allocation.
4. Evaluation and Dissolution of Institutions (Section 8, Sub-section (2), Clause (c), Sub-Clauses (8) to (10)): The Ministry-designated authority can evaluate consumer institutions based on performance indicators listed in Schedule-7. If found unsuitable for management or service delivery, the institution may be recommended for dissolution. Before dissolution, institutions must be given a chance to justify their performance. Upon dissolution, local governments are responsible for providing alternative service arrangements.
5. Continuity of Services Post-Dissolution (Section 8, Sub-section (2), Clause (c), Sub-Clause (10)): If an institution is dissolved, the local government must ensure uninterrupted water supply and sanitation services until a new service provider is established.

5.5.4 Licensing Requirement

Requirements for Consumer Institutions (Section 74, Clause 9): According to Section 74, Clause 9 of the Act, any organized institution seeking a license must submit:

- (a) Documents proving financial management capacity.
- (b) Evidence of a minimum of 25% of the project cost as working capital.
- (c) Experience in water supply, sanitation infrastructure, and service management.

For foreign-organized institutions, a minimum of 20% investment in water supply and sanitation projects and at least 10% investment in sewage treatment projects must be from Nepali citizens. Additionally, foreign institutions must provide proof of successful projects in at least one other country.

5.5.5 Funds for Water User and Sanitation Committees in Dharan by Province and Central Government

5.5.5.1 Funds for Projects under Koshi Province

The Koshi Province Government has allocated funding for multiple drinking water projects aimed at improving access to clean water across various municipalities and rural areas. The primary focus of these projects is to enhance water supply infrastructure, rehabilitate existing systems, and construct new facilities to meet the growing demand.

Key Aspects of the Projects:

- **Infrastructure Development:** The projects include the construction of drinking water reservoirs, pipelines, filtration plants, and water distribution networks.
- **Water Quality Improvement:** Some projects aim to enhance water treatment facilities to provide safe drinking water.
- **Urban and Rural Water Supply:** The projects target both urban centers and remote rural areas, ensuring equitable access.
- **Community Participation:** Emphasis is placed on community engagement and participation in water resource management.
- **Budget Allocation:** Different municipalities and wards have received varied funding based on the scale and urgency of their water supply needs.

Funding has been allocated for pumping stations, filtration plants, pipeline extensions, and groundwater recharge programs in districts like Sunsari, Morang, and Dhankuta.

Specific initiatives include renovation of existing water supply systems, expansion of reservoirs, and technical upgrades to prevent water loss.

Dharan Sub metropolitan city, has 14 projects funded by Water Supply and Sanitation Division, Koshi province, where 1 project of Deep boring is for DWSMB and other 13 projects are for Water user and Sanitation committees of Dharan.



प्रदेश सरकार
खानेपानी तथा सरसफाइ तर्फा उर्जा मन्त्रालय
खानेपानी तथा सरसफाइ डिभिजन कार्यालय
इटहरी, सुनसरी
कोशी प्रदेश, नेपाल

फोन:-०२५-५८३३९५, फ्याक्स:-०२५-५८००४२, इमेल:- wssdo.sunsari@gmail.com

२०८१/०६/१०

प.सं. :- २०८१/०५२

च.नं. :- १०२

बिषय :- साइट तोकिएको बारे ।

इन्जिनियर छैठौं भोजराज पोखरेल

- स्वीकृत वार्षिक कार्यक्रम अनुसारका क्रियाकलापहरू सञ्चालन गर्न तपाईंलाई तपसिलमा उल्लेख भए बमोजिम साइट तोकिएको छ । निम्न कुराहरूमा विशेष ध्यान राखी आफ्नो पदीय दायित्वमा समर्पित रहनु हुनेछ भन्ने आशा राखिएको छ ।
१. तोकिएको साइटको नियमित र पर्याप्त सुपरभिजनमा रहि आफ्नो प्रत्यक्ष निगरानीमा गराउनु पर्नेछ ।
 २. निर्माण कार्यहरूको गुणस्तर कायम गर्न सचेत रहि गुणस्तरको जिम्मेवारी वहन गर्नु पर्नेछ ।
 ३. तोकिएको लक्ष्य अनुसारको प्रगति जिम्मेवारीपूर्वक हासिल गरि समयमै प्रगति विवरण पेश गर्नु पर्नेछ ।
 ४. काम सुरु गर्न आवश्यक पुर्व तयारीहरू जस्तै ल.इ तयारी र स्वीकृत, प्रक्रियाहरू पुन्याई नियन्त्रणको सम्झौताहरू गराउने व्यवस्था मिलाउन सचेत रहनु पर्नेछ । यथासमय
 ५. आफूसँग सम्बन्धित योजनाको सामग्रीहरूको विवरण आफूसँगै राख्नु पर्नेछ र योजनाको लागि चाहिने सामग्रीहरू माँग समय अगाडिने गर्नु पर्ने तर्फ प्रयत्नशील रहनु पर्नेछ । पर्याप्त
 ६. आफूसँग सम्बन्धित योजनाको विशेषताहरू लगायतका महत्वपूर्ण जानकारीहरू आफूसँगै राख्नुका साथै सोको प्रयोग गरि तयारी, कार्यक्रम संशोधन, आवश्यक बजेटको यथासमय माँग जस्ता कार्यहरू समयमै गर्न सचेत रहनु पर्नेछ । कार्यक्रम
 ७. काम गराउदा स्वीकृत कार्यक्रम र बजेटलाई ध्यानमा राख्नु पर्नेछ र कार्यालयको आदेश लिइ सम्पन्न गुणस्तरीय कार्यको यथार्थ नापीको आधारमा यथासमय नियमानुसारको बिल तयार गरि पेश गर्नु पर्नेछ ।
 ८. आवश्यकतानुसारको मौखिक जानकारी र लिखित प्रतिवेदनहरू पेश गरी कार्यालयलाई सुसुचित राख्नु पर्नेछ ।
 ९. सुरुवा हुँदा वा योजनाहरूको साइट हेरफेर हुदा आफ्नो जिम्माका कागजातहरू लगायत योजना सम्बन्धि सामान्य जानकारीहरूको लिखित बरबुझारय आफ्नो ठाँउमा खटि आउने वा तोकिएको कर्मचारीलाई गर्नु पर्नेछ ।
 १०. यो साइट विभाजन जे जसरी भए पनि कार्यालयले आवश्यक ठानेमा जोसुकैले जुनसुकै योजनाको आवश्यकतानुसारको कार्य गर्नुपर्नेछ ।

आयोजनाको नाम	कुल बजेट	आयोजनाको नाम	कुल बजेट
झुम्का डुमरियाटोल खानेपानी तथा सरसफाइ आयोजना, रामधुनी भा.सि.नपा १	३२००	खापाटार खा.पा.आ केरावारी ३	१०००
डुम्राहा खानेपानी तथा सरसफाइ आयोजना	३५५०	जलकन्या खा.पा.आ	५००
शिवनगर खानेपानी तथा सरसफाइ आयोजना भा.सी.न.पा.५	२३४८	कालिखोप खा.पा.आ केरावारी ४	१०००
बकलौरी खानेपानी तथा सरसफाइ आयोजना	५००	गोपेनि खा.पा.आ	१५००

Project Description	Amount	Project Description	Amount
डाडे तेलनपुर खानेपानी मुहान संरक्षण तथा पानीटपांकी निर्माण, धरान ४	५००	विराटनगर बृहत खानेपानी उपभोक्ता तथा सरसफाई आयोजनाको अधुरो विकास निर्माण तथा मर्मत कार्य, विराटनगर १४, जतुवा	५००
ढिगाबारी, साउने, देउराली, खैरेनी संयुक्त फिल्टर टपांकी निर्माण, धरान ५	५००	मुसल कोइराला फाउण्डेशन खानेपानी आयोजना, विराटनगर	५००
साविक विष्णुपादुका खैरेखोला बाक्लीटोलमा खानेपानी व्यवस्था, सुनसरी	१५००	विराटनगर बृहत खानेपानी उपभोक्ता तथा सरसफाई आयोजनाको अधुरो विकास निर्माण तथा मर्मत कार्य, विराटनगर १२, बखरी	७००
साविक विष्णुपादुका ४ पटनालिमा खानेपानी आयोजनाको व्यवस्था, सुनसरी	३५००	पोखरिया माध्यमिक विद्यालयलाई खानेपानी आयोजना, विराटनगर ३	५००
पुर्वावारी खानेपानी टपांकी निर्माण, धरान ४, सुनसरी	१०००	युग अबतार पुरुषोत्तम सेवा समाजको शौचालय निर्माण कार्य, विराटनगर १३	७००
सुमनटार मनुवाटा र खानेपानी धरान उ न पा सुनसरी	२०००	सम्पन्न बस्ति खानेपानी योजना, विराटनगर -१२	१०००
धाने खा.पा.यो.व्यवस्थापन, धरान न.पा.२०	५००	मुनालपथ खानेपानी विराटनगर ५ नहर देखि पश्चिम पृथ्वीचोक हुँदै गोमुखी मार्ग खानेपानी पाइपलाइन विस्तार	५००
निशान डाँडा खा.पा.यो.ट्याङ्की निर्माण, धरान ५	५००	जामुनगाछी खानेपानी विस्तार तथा पुनःनिर्माण आयोजना, विराटनगर -४, मोरङ	१५००
बुढासुब्बा खानेपानी तथा सरसफाई उपभोक्ता समिति धरान १४ को पानीटंकी निर्माण र पानी मुहानको टंकी संरक्षण कार्य	१०००	टंकिसिनवारी खानेपानी उपभोक्ता तथा सरसफाई समितिको खानेपानी आयोजना गुणस्तर सुधार कार्यक्रम, बुढीगंगा ३	१०००
देविगाउँ खा. पा. आ. सुनसरी	५००	सिसबनिबडरा खा.पा.आ	५००
हर्दिया दानावारी श्रीगाउ खानेपानीको पाइप लाइन विस्तार धरान ४ हर्दिया दानावारी, सुनसरी	१०००	डग्राहा खानेपानी आयोजना, बुढीगंगा- ७, मोरङ	१५००
गैरी गाँउको फेदबाट खाकर डाँडा जुवाने खानेपानी धरान ४, सुनसरी	१०००	डाँगीहाटी खानेपानी आयोजना वेलवारी ११ लक्ष्मीमार्ग मोरङ	५००
देउराली खानेपानी योजनाको स्तर उन्नती, धरान ५, सुनसरी	२०००	बाहुनी १-७ डिप बोरिङ खा.पा.आ मोरङ	२१४५
धरान उपमहानगरपालिका खानेपानी आयोजना डिपबोरिङ निर्माण, धरान सुनसरी	३३०००	बाहुनी खा.पा. तथा स.आ	३०००
बैजनाथपुर खा.पा.आ	३०००	कसेनी खा.पा.आ. मोरङ	२५००
भोडाहा खा.पा.आ	३२००	रतुवामाई ना.पा.मा ओभरहेड टयाङ्कि निर्माण	१०००
महेरापुर जमकेटि खा.पा.आ कटहरी २,३	३२००	कादुपाडा खा.पा.आ	१०००
खानेपानी टपाङ्की निर्माण, कटहरी ७, मोरङ	५००	उल्लुपट्टु खा.पा.आ	३४००
कटहरी खा.पा.तथा सरसफाई, कटहरी ३, मोरङ	५००	सौठा खा.पा.आ	५००
कटहरी खा.पा.आ. सु.वि. मोरङ	८००	रतुवामाई खानेपानी ठ्याङ्की निर्माण, छालगाछी, मोरङ	१००
कुइकुन्डा खा.पा.आ लेटाङ भोक्टेनि ना.पा	२४००	इटहरा खानेपानी आयोजना, मोरङ	८००
तेतरिया खा.पा.आ	५००	इटहरा खानेपानी आयोजना, रतुवामाई ८, मोरङ	१००

Figure 47 Projects by Water Supply and Sanitation Division office of Koshi Province of DWSMB and Khanepani Upavokta Samitis of Dharan

5.5.5.2 Funds for Project under Central Government

The Drinking Water Quality Improvement Program is focused on ensuring that communities receive water that meets stringent safety standards. Under this program, the

government has invested approximately NPR 20,000 to fund pilot projects that introduce advanced treatment technologies such as arsenic, ammonia, and hardness removal systems, upgrading existing water treatment facilities and establishing modern monitoring systems. In parallel, the Climate Adaptive Integrated Drinking Water Supply Program is designed to bolster the resilience of water infrastructure against climate change, with an allocation of around NPR 15,000 to modernize water storage, distribution, and treatment facilities while incorporating climate risk assessments into the planning and design processes.

The Water Supply and Sanitation Cofinancing Program brings together resources from governmental and local bodies to support integrated development initiatives, with an investment of roughly NPR 10,000 ensuring that enhancements in water supply are complemented by upgrades in sanitation infrastructure. Additionally, the Water Supply Addition and Rehabilitation Program addresses the dual need to expand water service coverage and rehabilitate aging infrastructure by earmarking an estimated NPR 25,000 for modernizing pipelines, storage facilities, and treatment plants, thereby reducing water losses and enhancing distribution efficiency.

5.5.6 Role of Local Government and Water User Committees

Local government plays a pivotal role in ensuring effective water supply management in Dharan. As the primary administrative body, the local government formulates policies, oversees implementation, and monitors the performance of water supply systems. It facilitates a decentralized approach by delegating certain responsibilities to local entities, thereby promoting community participation in decision-making processes.

Water User Committees (WUCs), established under the local government, serve as the operational arm in this decentralized framework. These committees are composed of local residents who manage water distribution, maintenance, and basic quality checks. By providing a direct communication channel between the community and municipal authorities, they help address local concerns more effectively, ensuring that water management practices are transparent, responsive, and aligned with community needs.


Despite these structural roles, **Dharan Sub-Metropolitan City** has not been able to provide significant funding to the WUCs. In practice, it largely confines its support to **annual renewals**, which involve **water quality checks** and **reviewing audit reports** from the committees. Furthermore, the **Urban Planning Division** and the **Dharan Water**

Supply Management Board (DWSMB) have not actively supervised or collaborated with the committees. This limited involvement from municipal authorities constrains the WUCs' capacity to improve and expand water supply services. Consequently, while the decentralized model promotes community ownership, insufficient funding and oversight hamper the long-term sustainability and efficiency of Dharan's urban water supply system.

5.6 Key Informant Interview

<p>1. Dharan Sub Metropolitan City, Urban Planning Division</p>	
<ul style="list-style-type: none"> • Dharan SMC has made recharge pit mandatory during Plans approval, and Byelaws flexible for Buildings incorporating Rainwater harvesting • New Risk Sensitive Land Use plan on process to cater planned urbanization • Water supply responsibility has been given to DWSMB, so no budgets are allocated for water supply programs • There isn't any coordination among DWSMB and Urban Planning section of Dharan SMC 	<p style="text-align: center;">Er. Suraj Shrestha (Head of Urban Planning Division, Dharan SMC)</p>
<p>2. Dharan Sub Metropolitan City, Environmental Division</p>	
<ul style="list-style-type: none"> • The committee operates under the guidance of the Environmental Division, ensuring adherence to water quality standards • New committees are established following clearly defined criteria and renewals are based primarily on the review of water quality reports. • Occasional site inspections are conducted to assess on-ground conditions and ensure compliance with environmental guidelines 	<p style="text-align: center;">Er. Babu Ram Dahal (Environment Division, Dharan SMC)</p>

<ul style="list-style-type: none"> Afforestation program was once done in Sardu-Watershed area, no works for rainwater harvesting and retention Ponds done 	
<p>3. Dharan Water Supply Management Board (DWSMB)</p>	
<ul style="list-style-type: none"> DWSMB has taken responsibility over distribution of water handed over by Nepal Water Supply Corporation Due to old pipeline distribution network, topography and high NRW (40%), inefficiency in water distribution DWSMB is not able to performing at its natural pace due to incomplete administrative board, lacking planned decision, rules. DWSMB has installed 4 new sources to its central distribution system in collaboration with volunteer campaign, where DWSMB leads the project Partnership with Gurkha Welfare Trust to conduct preliminary survey in Kokah 2 project, and other volunteer campaign projects No any official process of handover or takeover of volunteer donations and construction with DWMSB, rather with mayor only DWSMB aiming to supply over khanepani Upavokta Samitis of Dharan and mix the sources with its centralized distribution system in future. It has plans to connect the samitis with Central pipeline distribution with Koshi Project in future. DPR process for Koshi water project has been done by central 	<div data-bbox="954 474 1299 1075" data-label="Image"> <p>The image shows two men standing in front of a large, blue, rectangular board. The board is covered with text and organized into a grid-like structure, likely a schedule or a list of items. The man on the left is wearing a dark jacket and the man on the right is wearing a light-colored jacket. They are standing on a paved area outdoors.</p> </div> <p data-bbox="995 1104 1262 1137">Er. Susan Shrestha</p> <p data-bbox="995 1167 1262 1200">Engineer, DWSMB,</p> <p data-bbox="1015 1292 1246 1326">Er Raju Pokhrel</p> <p data-bbox="890 1355 1369 1388">Project Manager, Secretary DWSMB</p> <p data-bbox="1038 1480 1222 1514">Mr. Ram Rai</p> <p data-bbox="906 1543 1353 1576">Chief Executive Officer, DWSMB</p>

<p>government, where it aims to supply water at production rate of 524 lps, and has planned for 2050 B.S.</p> <ul style="list-style-type: none"> • Efforts of afforestation on Sardu Watershed Conservation area, and guards are kept at water source intake for conservation • No any efforts holistically sustainable water management has been done for rainwater harvesting, waste water reuse, retention pond, etc. <p>What must be done?</p> <ol style="list-style-type: none"> a. Full administrative board formation, to make plans and decisions effectively to run DWSMB b. To cater future demand, new source from Koshi project must be ensured 	
<p>4. Water Supply and Sanitation Division Office, Itahari (Koshi Province)</p>	
<ul style="list-style-type: none"> • Division office has been providing technical and financial helps to both DWSMB and Khanepani Upavokta Samitis • All cost of building infrastructure from source to RVT is financed and necessary procurement and survey is provided by Divion Office for Khanepani Upavokta Samitis • It has identified 16 projects in this fiscal year for Dharan Water Supply improvement, 1 project for DWSMB and 15 projects for Khanepani Upavokta Samitis of Dharan • Khanepani Upavokta Samiti is effectively managing water supply 	 <p style="text-align: center;">Er. Narendra Chaudhary Engineer, Water Supply and Sanitation Division Office, Koshi Province</p>

<p>over areas where DWSMB is lacking, they must collaborate together in future plans to ensure water supply efficiently</p>	<p>Itahari</p>
<p>5. Desh Premi Shramdata, Swatantra Nagarik Samaj</p>	
<ul style="list-style-type: none"> • They have been actively conducting volunteer campaign for water supply project led by DWSMB • No any official agreement has been done for volunteering campaigns; they are helping on their own • Petition on court has been filed to conserve Sardu-Watershed Area, and afforestation campaigns on watershed area was conducted • During Volunteer campaign of water supply, new pipeline to help local Upavokta Samitis at Kokah was done to reduce water scarcity. 	<p>Mr. Prem Kumar Shrestha Activist, Desh Premi Shramdata</p> <p>Mr. Samir Tamang Activist, Swatantra Nagarik Samaj</p>

5.7 DISCUSSION

5.7.1 Existing Water Supply Condition of Dharan

- Dharan suffering from seasonal variability in water sources particularly during dry seasons
- DWMSB supplies 68.03% households and Water User and Sanitation Committees supplies 25.96%
- Old distribution pipelines and high NRW affecting in meeting demands by DWSMB
- Availability of Water is excess in Water User and Sanitation Committees
- Out of 81 only 35 Water User and Sanitation Committees listed under Dharan SMC.

5.7.2 Review of role of community participation in addressing water security in decentralized water management in Dharan

- Community Driven initiatives crucial in water scarcity relief
- Affordability ensured with minimum base rate just to sustain operations
- Volunteer campaigns led by Mayor Harka Sampang, sourcing water supply to DWSMB
- Committees lack technical expertise on daily basis operations
- Commendable community resilience but lacking in Technical aspects of sustainable approach of Water Supply
- These systems rely on community participation, transparent governance, and diversified funding (e.g., tariffs, government support).
- Survey reveals, availability of water is ensured
- Survey reveals, people are positive attitude towards the decentralized water management
- Communities value ownership and accountability in water management but face barriers like affordability and technical expertise.

5.7.3 Review of policy and institutional frameworks in supporting community-driven and decentralized approaches for sustainable water resource management in Dharan

- Support from Provincial and Central Government
- Local Government still not cleared on its role for decentralized water supply management
- Overlapping responsibilities between federal, provincial, and local governments create coordination gaps.
- Lacking of Integrated Urban Water Management approach in Dharan

CHAPTER 6 CONCLUSION AND RECOMMENDATION

6.1 Conclusion

The research highlights the critical challenges and dynamics of water scarcity in Dharan, revealing the complexities of urban water management in the face of increasing demand, outdated infrastructure, and governance inefficiencies. The seasonal variability of water sources, particularly during dry seasons, exacerbates the problem, making a reliable water supply a persistent issue. The study finds that while the Dharan Water Supply Management Board (DWSMB) serves a majority of households (68.03%), significant inefficiencies due to aging distribution pipelines and high non-revenue water (NRW) levels hinder its ability to meet demand effectively. In contrast, Water User and Sanitation Committees (WUSCs) supply a smaller but substantial portion (25.96%) of the population, with some committees managing an excess water supply. However, of the 81 registered WUSCs, only 35 are officially listed under the Dharan Sub-Metropolitan City (SMC), indicating gaps in institutional recognition and regulation.

The findings show strong evidence that issues such as high non-revenue water levels and gaps in supply are linked to these challenges, as many studies also report. For example, while the literature highlights successful cases like the Pani Panchayat model in India and water user associations in Kenya—where organized community management improves

water quality and efficiency—the situation in Dharan is more mixed. Here, local water systems often do not benefit from strong, organized community participation.

A key example is Mayor Harka Sampang's volunteer campaign at the DWSMB. This initiative blends physical science and social science by addressing both technical fixes and community involvement. However, the volunteer efforts were carried out without proper planning at the beginning. This lack of planning led to disputes during the identification of water sources, as the campaign initially targeted areas that were not aligned with the more sustainable water sources identified in decentralized water supply projects in Dharan. Despite these early challenges, the volunteer campaign has helped keep water available on households. Yet, it falls short in legal clarity and comprehensive support, leaving the community's role at a "Tokenism" level on Arnstein's Ladder of Citizen Participation.

In contrast, the decentralized community water supply programs-managed by groups like the Khanepani tatha Sarsafai Upavokta Samiti-demonstrate a higher level of participation. These programs allow community members to share power more equally through active decision-making, planning, and maintenance, placing them at the "Partnership" level on Arnstein's Ladder. Community-driven initiatives have played a crucial role in mitigating Dharan's water crisis, showcasing the resilience and adaptability of local communities. The survey findings suggest a generally positive public attitude toward decentralized water management, with communities valuing ownership and accountability in local water governance. However, these initiatives face limitations, particularly in technical expertise required for sustainable and efficient water management.

While community participation, transparent governance, and diversified funding mechanisms have supported localized water security efforts, the lack of technical capacity raises concerns about the long-term sustainability of these decentralized approaches. The current infrastructure design-where water is extracted from sources linked directly to river systems, is highly vulnerable to natural hazards such as floods and landslides. These events frequently wash away critical components of the system, leading to supply disruptions and increased maintenance expenses. Beyond afforestation efforts, there is also a notable deficiency in sustainable practices like the implementation of groundwater recharge retention ponds, permeable pavements, and rainwater harvesting systems.

From a policy and institutional perspective, Dharan's water governance remains fragmented, with unclear roles for local authorities in managing decentralized water systems. While there is support from provincial and central governments, the overlapping responsibilities across federal, provincial, and local levels have created coordination challenges, limiting effective policy implementation. The absence of an Integrated Urban Water Management (IUWM) framework further hampers efforts to create a cohesive and sustainable water supply strategy for Dharan. These structural gaps underline the need for improved institutional clarity and better integration of decentralized and centralized approaches to water management.

While decentralized water management and community-driven initiatives have significantly contributed to mitigating Dharan's water crisis, their sustainability remains in question due to technical, financial, and governance constraints. Addressing these challenges will require a more structured institutional framework, enhanced technical capacity, and a balanced approach between centralized infrastructure improvements and localized management systems.

6.2 Recommendations

The findings suggest that decentralized water management has the potential to complement traditional supply-side strategies by addressing localized needs and conditions. A shift toward models that empower community stakeholders not only enhances short-term operational outcomes but also promotes long-term water security. However, for these systems to thrive, there must be a robust institutional framework that facilitates ongoing technical support, continuous monitoring, and effective coordination with municipal water authorities. Such measures would help mitigate issues like leakage and resource mismanagement, thereby transforming community-driven initiatives into lasting, sustainable solutions.

There is an urgent need for an *Integrated urban water supply management plan* in Dharan, one that fosters effective collaboration between the Dharan Water Supply Management Board (DWSMB) and various Water User Committees (Upavokta Samiti). Currently, water extraction practices in Dharan are fragmented and uncoordinated, leading to resource conflicts and operational inefficiencies. For example, the DWSMB, without a comprehensive plan, once attempted to extract water from a source already in

use by a Water User Committee, which resulted in disputes that were only resolved after the DWSMB assumed control of that source.

Moreover, within a 100-meter radius, multiple Water User Committees independently extract water, further fragmenting the resource management framework. During the dry season, the Panabari Khanepani Upavokta Tatha Sarsafai Samiti is compelled to rely on borehole water extraction to meet local demand, highlighting the absence of a coordinated strategy. This lack of integration not only intensifies conflicts over water allocation but also hampers the ability to scientifically manage water resources in the context of rapid urbanization.

A *Water Resource Coordination Unit* can be established under Dharan Sub-Metropolitan City (DSMC) to regulate, monitor, and standardize decentralized water supply operations. A shared water reservoir system can be developed to store and redistribute excess water from decentralized sources, ensuring a balanced supply throughout the year. Technical capacity building is also essential, and a *Technical Assistance Program* should be introduced to train Water User Committees on water treatment, distribution efficiency, and leak detection. Additionally, a *Mobile Water Management* Taskforce composed of skilled technicians can be deployed to provide on-the-ground support and address operational challenges in decentralized systems.

The integration of sustainable infrastructural elements is essential to reinforce the water cycle, optimize resource use, and ensure long-term resilience.

Community participation should be encouraged through innovative financial models. A *Water Credit System* can be introduced, rewarding households and businesses that invest in water-saving measures such as rainwater harvesting with lower tariffs. Additionally, *Community-Based Water Bonds* can provide residents an opportunity to invest in local water infrastructure projects with guaranteed returns. These mechanisms will enhance financial sustainability while ensuring that local communities actively participate in water management.

Institutional and policy reforms are necessary to streamline governance and improve water management. Clearly defining the roles of **local, provincial, and federal governments** in decentralized water supply management will help minimize conflicts and enhance coordination. Moreover, Dharan should adopt an *Integrated Urban Water Management (IUWM) Policy*, ensuring that water supply planning is aligned with land-use strategies, climate resilience efforts, and urban expansion plans.

Way Forward

There is further need for research to explore how volunteer participation models-like Mayor Harka Sampang's, can be effectively scaled up to support other urban infrastructure projects by integrating proper planning, technical support, legal clarity, and genuine public involvement.

REFERENCES

- Aboelnga, H. T., Ribbe, L., Frechen, F.-B., & Saghir, J. (2019). Urban Water Security: Definition and Assessment Framework. *Resources*, 8(4), Article 4. <https://doi.org/10.3390/resources8040178>
- Asuman, K. (n.d.). *COMMUNITY PARTICIPATION IN WATER SUPPLY AND SANITATION SERVICES IN WESTERN UGANDA*.
- Bajracharya, R. M., Dahal, N., Neupane, K. R., Singh, V., & Habeeb, R. (2019). Urban Water Security Challenges in the Nepal and Indian Himalaya in the Context of Climate Change. *Resources and Environment*, 9(1), 9–18. <http://article.sapub.org/South Asia>
- Boretti, A., & Rosa, L. (2019). Reassessing the projections of the World Water Development Report. *Npj Clean Water*, 2. <https://doi.org/10.1038/s41545-019-0039-9>
- Coombes, P., Kuczera, G., Kalma, J., & Argue, J. (2002). An Evaluation of the Benefits of Source Control Measures at the Regional Scale. *Urban Water*, 4, 307–320. [https://doi.org/10.1016/S1462-0758\(02\)00028-6](https://doi.org/10.1016/S1462-0758(02)00028-6)
- Dhimal, M., & Dhakal, P. (2012). (PDF) Environmental Burden of Diarrhoeal Diseases due to Unsafe Water Supply and Poor Sanitation Coverage in Nepal. *Journal of Nepal Health Research Council*. <https://doi.org/10.33314/jnhrc.v0i0.307>
- Dwivedi, A., Mohanty, R., & Bharti. (2022). *Compendium on Community Participation in Urban Water and Sanitation*. <https://doi.org/10.13140/RG.2.2.23952.28168>
- Eigenbrod, F., Bell, V. A., Davies, H. N., Heinemeyer, A., Armsworth, P. R., & Gaston, K. J. (2011). The impact of projected increases in urbanization on ecosystem services. *Proceedings of the Royal Society B: Biological Sciences*, 278(1722), 3201–3208. <https://doi.org/10.1098/rspb.2010.2754>
- Environment, U. N. (2017, September 22). *What is Integrated Water Resources Management? | UNEP - UN Environment Programme*. <https://www.unep.org/explore-topics/disasters-conflicts/where-we-work/sudan/what-integrated-water-resources-management>
- Fam, D., Mitchell, C., Abeysuriya, K., & Mellick Lopes, A. (2014). Emergence of decentralised water and sanitation systems in Melbourne, Australia. *International Journal of Water*, X, xxxx. <https://doi.org/10.1504/IJW.2014.060962>
- Ghosh, P., Hossain, M., & Sarkar, S. (2022). Inequality Among Social Groups in Accessing Improved Drinking Water and Sanitation in India: A District-Level Spatial Analysis. *The Professional Geographer*, 1–22. <https://doi.org/10.1080/00330124.2022.2124181>
- Gleick, P. (2000). The Changing Water Paradigm—A Look at Twenty-First Century Water Resources Development. *Water International - WATER INT*, 25, 127–138. <https://doi.org/10.1080/02508060008686804>
- Guba, E. G. (1994). Competing paradigms in qualitative research. *Handbook of Qualitative Research/Sage*. http://miguelangelmartinez.net/IMG/pdf/1994_Guba_Lincoln_Paradigms_Qualitative_Research_chapter.pdf
- Hoekstra, A., Buurman, J., & Ginkel, K. C. H. (2018). Urban water security: A review. *Environmental Research Letters*, 13. <https://doi.org/10.1088/1748-9326/aaba52>

- IUDP. (n.d.). *Final IUDP Dharan 2017 | PDF | Economic Development | Urban Planning*. Scribd. Retrieved November 21, 2024, from <https://www.scribd.com/document/409275148/1-Final-IUDP-Dharan-2017-docx>
- Kallis, G., & Coccossis, H. (2003). Managing Water for Athens: From the Hydraulic to the Rational Growth Paradigm. *European Planning Studies*, 11(3), 245–261. <https://ideas.repec.org//a/taf/eurpls/v11y2003i3p245-261.html>
- Mishra, A. K., Karna, A. K., & abd, sa. (2019). (PDF) ASSESSMENT OF MANAGEMENT TRANSFER PROCESS OF WATER SUPPLY SYSTEMS IN SUNSARI DISTRICT OF NEPAL. *International Journal of Research Granthalaya*, 7(1). <https://doi.org/10.5281/zenodo.2550077>
- Municipality Dashboard—NWASH*. (n.d.). Retrieved March 28, 2025, from <https://nwash.gov.np/municipality-dashboard>
- Ogata, R., Oniki, S., & Karki, K. B. (2024). Sustainable management of small-town water supply in Nepal: Improvement through the multi-stage training mechanism. *Journal of Water, Sanitation and Hygiene for Development*, 14(6), 466–472. <https://doi.org/10.2166/washdev.2024.034>
- Pandey, C. L., Maskey, G., Devkota, K., & Ojha, H. (2019). Investigating the Institutional Landscape for Urban Water Security in Nepal. *Sustainability: The Journal of Record*, 12(3), 173–181. <https://doi.org/10.1089/sus.2019.0007>
- Piratla, K. R., & Goverdhanam, S. (2015). Decentralized Water Systems for Sustainable and Reliable Supply. *Procedia Engineering*, 118, 720–726. <https://doi.org/10.1016/j.proeng.2015.08.506>
- Population | National Population and and Housing Census 2021 Results*. (n.d.). Retrieved February 11, 2025, from <https://censusnepal.cbs.gov.np/results/population?province=1&district=13&municipality=1>
- Sardu watershed area faces existential crisis*. (2024, August 8). <https://newtest.myrepublica.com/news/sardu-watershed-area-faces-existential-crisis>
- Sharma, L., Gupta, N., & Basnayake, S. (2023, September). *IWRM Implementation in Nepal: Harmonizing Water Demand and Supply Dynamics*. <https://www.adpc.net/igo/contents/Publications/publications-Details.asp?pid=1903#sthash.5G14Dwb2.dpbs>
- Sharma, L., Gupta, N., & Seneka, B. (2021, May). *Nepal Policies-Water Sector Policies and Guidelines of Nepal.pdf*. https://www.adpc.net/igo/category/ID1811/doc/2022-otj7NA-ADPC-Water_Sector_Policies_and_Guidelines_of_Nepal.pdf
- Ulz, J. (2023, March 20). *What is a Research Paradigm? Types and Examples | Researcher.Life*. <https://researcher.life/blog/article/what-is-a-research-paradigm-types-examples/>
- United Nations, D. of E. and S. A. (2018). *World Urbanization Prospects The 2018 Revision*.
- Yadav, J. P., Sah, K. P., Karki, K. R., Jha, M. N., & Mishra, A. (2023). Dharan Water Supply System—Alarming Issues and Future. *Zenodo (CERN European Organization for Nuclear Research)*, 10(1), 1–11. <http://dx.doi.org/10.5281/zenodo.7692635>

संक्षिप्त परिचय | *Dharan Sub-Metropolitan*. (n.d.). Retrieved February 11, 2025, from <https://www.dharan.gov.np/en/content/%E0%A4%B8%E0%A4%82%E0%A4%95%E0%A5%8D%E0%A4%B7%E0%A4%BF%E0%A4%AA%E0%A5%8D%E0%A4%A4-%E0%A4%AA%E0%A4%B0%E0%A4%BF%E0%A4%9A%E0%A4%AF>

APPENDICES

Appendix A: List of Key Informant

- Er. Suraj Shrestha, Urban Planning Section Head, Dharan SMC
- Er. Babu Ram Dahal, Environment Division, Dharan SMC
- Er. Raju Pokhrel, Project Manager, DWSMB
- Er. Susan Shrestha, Engineer, DWSMB
- Mr. Ram Rai, CEO, DWSMB
- Er. Narendra Chaudhary, Engineer, Water Supply and Sanitation Division Office, Koshi Province
- Man Bahadur Tamang, Operator, DWMSB

Appendix B: Questionnaires for Water User Committee

1. **Name of the Committee**
2. **Date of Establishment**
3. **Number of Members in Terms of Sex**
4. **Methods Used to Choose Committee Members**
 - Through democratic elections
 - Nominated and/or appointed
 - Other (specify)
5. **Responsibilities of the Community Water Project Committee**
6. **Source of Water Supply**
7. **Supply of Water in Liters per Day**
8. **Number of Households Involved or Water Supplied**
9. **Is Water Treated Before Distribution?**
 - Yes
 - No
10. **How Were Funds Collected for the Water Supply Project?**
11. **Initial Cost for the Water Supply Project**
12. **Is the Quantity of Water the Same as When the Project Started?**
 - Depleted
 - Neutral
 - Added

13. Any Measures for Water Recharge Undertaken?

14. Who Were Responsible for Handling Project Resources (Money, Materials, etc.)?

- Donor
- Community
- Water Committee
- Local Government
- Other (specify)

15. Where Was the Project Money Kept?

- Bank
- Within the Committee
- Home of the Leader
- Other (specify)

16. Any Dispute Related to Management That Affected the Project?

- Yes
- No

17. Any Standard Procurement Process Followed?

- Yes
- No
- Maybe

18. Who is Monitoring the Project After the Donor Phase-Out?

- Committee
- Local Government
- Other (specify)

19. Does the Committee Contribute Any User Fees to Cover Operations and Maintenance Services?

- Yes
- No
- Maybe

20. Willingness to Pay Fees by the Community

- Yes
- No

21. If Yes, What Measure is Used for Fee Calculation?

22. Is the Amount Collected Enough to Cover the Operations and Maintenance Services?

- Yes
- No

23. If Not, Where Do You Get Extra Money to Cover the Operations and Maintenance of the System?

24. Do You Think Community Participation in Planning, Implementation, and Management of Water Projects Leads to Effective and Sustainable Water and Sanitation Services?

- Yes
- No
- Maybe

Appendix C: Questionnaires for KII

Basic Information:

- a. Name of Interviewee:
- b. Designation/Role:
- c. Organization Name:
- d. Year of Establishment:
- e. Geographic Area/Scope of Operation:
- f. Population Served:

Water Supply System:

- a. How is the water supply system structured in this area (centralized, decentralized, mixed)?
- b. What is the source of the water supply (river, well, reservoir, etc.)?
- c. What is the average daily water supply per household?
- d. How is water distributed to the community (pipelines, tanker, community taps, etc.)?
- e. Are there any challenges in maintaining the water infrastructure (leakages, contamination, etc.)?

Community Participation:

- a. What role do the local communities play in the water supply system (management, maintenance, decision-making)?
- b. How do community members participate in the planning and implementation of water supply projects?
- c. Are there community-based organizations or committees involved in water management?
- d. How effective are the communication channels between the water authority and community members?
- e. What are the mechanisms in place for community feedback and addressing grievances?

Decentralized Water Management:

- a. How is decentralized water supply different from centralized systems in your area?
- b. What are the benefits of a decentralized approach for local communities?
- c. How does the local government support decentralized water systems?
- d. Are there any training or capacity-building programs for communities to manage their water resources?
- e. How is the operation and maintenance of decentralized water systems ensured?

Awareness and Education:

- a. How aware are the community members about water conservation and management practices?
- b. Are there any educational programs aimed at promoting efficient water use?
- c. How do you assess the success of awareness programs at the community level?

Challenges and Opportunities:

- a. What are the main challenges in implementing and managing decentralized water supply systems?
- b. How does the community address issues of water quality or scarcity?
- c. What challenges are faced in ensuring equitable access to water for all community members?

d. How do you engage marginalized or vulnerable groups in water management decisions?

Sustainability and Future Plans:

- a. How sustainable do you think the decentralized water systems are in the long term?
- b. What improvements would you like to see in the current water supply system?
- c. Are there any future plans for expanding or improving the water supply system in this area?

Appendix D: Questionnaires for Survey

Section: General Information

What is your gender?

Male

Female

Others

What is your age group?

≤20

21-40

>40

Education Level

Under SLC -1

SLC -2

+2 -3

Bachelors -4

Master and above

What is your ward No. in Dharan

(Drop down menu from 1-20)

What is your profession?

Student

Civil servant

Private sector employee

Homemaker

Others

How many members live in your household?

1-2

3-5

6-8

>8

What is the main source of Drinking water in your household?

DWSMB

Community managed water system

Water Tanker Supply

Others

How frequently do you experience interruptions in your water supply?

Daily

Weekly

Monthly

Rarely

How much water supply does your household receive daily?

Less than 2 hours

2-4 hours

More than 4 hours

How do you store for household water use?

Underground Tank

Overhead Tank

Drums/Containers

Others

How much do you spend monthly in water?

Below Rs. 200

Rs. 200-500

Rs.500 – 1000

More than Rs. 1000

During dry season, How severe is the water scarcity issue in your area?

Very Severe

Severe

Moderate

Mild

No Water Scarcity

What impact does water scarcity have on your daily activities? (Multiple selections)

Increased household expenses

Increased workload to fetch water

Reduced hygiene and sanitation

Health issues due to unsafe water

How do you cope with water shortages? (Multiple selections)

Buying from private water suppliers

Using water efficiently and reducing waste

Depend on water tanks by DWSMB

Are you aware of any volunteer campaigns in Dharan aimed at improving water supply?

Yes, I have Participated

Yes, but haven't participated

No, I'm not aware

If yes, how many working days have you contributed?

Once

2-5

Active participant

How have you contributed water-related community programs?

Physical Labor

Fundraising or Financial Support

Awareness Campaigns

Facilitating campaigns

Others

What type of support do you think is most effective in addressing water issues?

Financial contribution

Active participation in projects

Raising awareness in the community

Government intervention

How much Cash have you contributed for the water related programs?

Upto Rs. 10,000

Rs. 10-30,000

Rs. 30-50,000

More than Rs.50,000

Monthly Household Income

Upto Rs. 15,000

Rs. 15-30,000

Rs. 30-50,000

More than Rs.50,000

Have you been involved in planning process of water-related community programs?

Never

Rarely

Occasionally

Frequently

What prevents you from actively participating in community-led water projects?

Lack of time

Lack of trust in effectiveness

Financial constraints

Government should handle it

What Motivated you to engage in community water projects?

Personal benefit

Community well-being

Environmental sustainability

Social Trend

Do you think community involved improves water management outcomes?

Strongly disagree

Disagree

Neutral

Agree

Strongly Agree

Do you feel your input is valued in community water decisions?

Strongly disagree

Disagree

Neutral

Agree

Strongly Agree

What do you think, prevents more community participation in water management?

Lack of Awareness

Time Constraints

Budget Constraints

Technical Constraints

How satisfied are you with the quality of water you receive?

Very Dissatisfied

Dissatisfied

Neutral

Satisfied

Very Satisfied

What challenges do community-led water supply initiatives face in Dharan?

(Multiple)

Lack of Funding

Technical Difficulties

Lack of government support

Poor Coordination among stakeholders

Limited public awareness

Do you believe volunteer efforts should continue in addressing water scarcity?

Yes, they are important

No, government should take full responsibility

Not Sure

Would you willing to contribute (financially or through participation) to a community water management program?

Financially

Volunteering

Both

No

Do you believe the local government is doing enough to address water scarcity?

Yes, they are making good progress

Some efforts have been made, but not enough

No

Not Sure

What should the government prioritize to solve water problems?

Expanding centralized water supply infrastructure

Promoting Decentralized and community-led water management

Improving water conservation policies

Increasing investment in rainwater harvesting and storage

Regulating private water suppliers and tanker services

Are you aware of any policies or plans related to water security in Dharan?

Yes, I am well informed

Yes, I have heard but don't know the details

No, I'm not aware

Should the government involve local communities more in water management decision-making?

Yes, Community participation is essential

Yes, but only in a limited role

No, it should be fully managed by government institutions

How satisfied are you with the coordination between volunteer groups and government agencies in managing water resources in Dharan?

Very Satisfied

Satisfied

Neutral

Dissatisfied

Very Dissatisfied

Would you support a water tax increase if it guaranteed 24/7 water supply?

Yes

No

Depends on the amount

How would you rate the effectiveness of current water policies in Dharan?

Highly effective

Somewhat effective

Not effective

Not aware

Appendix E: Questionnaire for Survey at Ward 6

Section : General Information

What is your gender?

Male

Female

Others

What is your age group?

≤20

21-40

>40

Education Level

Under SLC

SLC

+2

Bachelors

Master and above

What is your profession?

Student

Civil servant

Private sector employee

Homemaker

Others

How many members live in your household?

1-2

3-5

6-8

>8

Monthly Household Income

Upto Rs. 15000

Rs. 15000-30000

Rs. 30000-50000

More than Rs 50000

Water Supply hours

Less than 2 hours

2 - 4 hours

More than 4 hours

Monthly Expense in Water

Below Rs. 200

Rs 200-500

Rs. 500-1000

More than Rs. 1000

Severity of Water Scarcity in Dry Season

No water Scarcity

Mild

Moderate

Severe

Very Severe

Do you think community involved improves water management outcomes?

Strongly Disagree

Disagree

Neutral

Agree

Strongly Agree

Do you believe volunteer efforts should continue in addressing water scarcity?

Yes, they are important

Not sure

No, government should take full responsibility

Would you willing to contribute (financially or through participation) to a community water management program?

Financially

Financially

Both

No

Water Quality and Reliability

Very poor

poor

Average

Good

Very Good

Affordability

Very Expensive

Expensive

Neutral

Affordable

Very Affordable

Awareness of Funds management or Reinvestment

Aware

Unaware

Neutral

Willingness to Participate on volunteering works

Yes

No

Do you think community involved improves water management outcomes?

Strongly Disagree

Disagree

Neutral

Agree

Strongly Agree

Would you prefer DWSMB to expand its distribution over Ward 6?

Yes

No

No idea

Do you believe volunteer efforts should continue in addressing water scarcity?

Yes, they are important

Not sure

No, government should take full responsibility

Appendix F: IOE GC Paper Presentation Certificate



त्रिभुवन विश्वविद्यालय
Tribhuvan University
इन्जिनियरिङ्ग अध्ययन संस्थान
Institute of Engineering
थापाथली क्याम्पस
THAPATHALI CAMPUS
Accredited By University Grants Commission (UGC) Nepal, 2024

GPO Box- 280, Thapathali, Kathmandu
Tel: 01-5339766
E-mail: info@tcioe.edu.np
Website: www.tcioe.edu.np
गोश्वारा पो. नं. २८०, थापाथली, काठमाडौं
फोन: ०१-५३३९७६६

Date: April 21, 2025

To Whom It May Concern:

This is to certify that the paper titled “**Addressing Urban Water Scarcity through Community Engagement and Decentralized Solutions: A Case of Dharan**” (Submission# 133) submitted by **Siddhartha Bhujel** as the first author, which had been accepted for presentation after the peer-review process, has successfully been presented at the 16th IOE Graduate Conference held during April 18 - 20, 2025. Kindly note that the final revision of the papers and publication process of the conference proceedings is still underway and hence inclusion of the accepted manuscript in the conference proceedings is contingent upon timely response to further edits during the publication process.



Dr. Raj Kumar Chaulagain,
Convener,
16th IOE Graduate Conference



Appendix G: IOE GC

IOE Graduate Conference
[Placeholder for
Publication
Information]

Addressing Urban Water Scarcity through Community Engagement and Decentralized Solutions: A Case of Dharan

Siddhartha Bhujel^a, Sangeeta Singh^b

^{a, b} Department of Architecture, Pulchowk Campus, IOE, Tribhuvan University, Nepal
✉ ^a 079msurp020.siddhartha@pcampus.edu.np, ^b sangeeta@ioe.edu.np

Abstract

Dharan, a rapidly urbanizing sub-metropolitan city in eastern Nepal, faces acute water scarcity exacerbated by population growth, aging infrastructure, and climate variability. This study explores the role of community-led decentralized water management systems, such as Water User and Sanitation Committees (Upabhokta tatha Sarsafai Samitis), in mitigating water insecurity. Using a mixed-methods approach: qualitative insights from household surveys, key informant interviews, and field observations with quantitative data to evaluate the current water supply scenario, community participation, and the effectiveness of supporting policy frameworks

The findings reveal that community-led initiatives, particularly through Water User Committees, have significantly contributed to identifying local water sources, managing distribution, and fostering a sense of ownership among residents. However, challenges such as limited technical capacity, financial constraints, and inadequate governmental support impede sustainable progress. The study emphasizes the need for integrated strategies that combine technical expertise, robust governance, and enhanced community involvement to secure long-term water security in Dharan.

Keywords

Urban Water Scarcity, Community engagement, Decentralized water management, Sustainable water solutions

1. Introduction

Urban water scarcity is emerging as one of the most pressing challenges of the 21st century, particularly in rapidly urbanizing regions where aging infrastructure and climate change compound supply issues (United Nations, 2018). In Dharan, a sub-metropolitan city in eastern Nepal, these challenges are acute. Despite access to multiple water sources, the existing water supply system suffers from infrastructural inefficiencies, high non-revenue water losses, and intermittent service delivery, which together pose serious risks to public health and sustainable urban development [1].

Historically, Dharan's water supply system was established in the mid-20th century to serve a much smaller population. Over time, rapid urban expansion and population growth have outpaced the capabilities of these centralized systems, resulting in overexploitation of water resources and operational challenges that include outdated technology, inadequate maintenance, and a lack of localized management [2], [3]. These issues are further exacerbated by the absence of effective community involvement, which has traditionally been a key factor in managing localized resources efficiently [4].

Recent studies suggest that decentralizing water management and fostering active community engagement can significantly enhance system resilience and efficiency [5]. By involving local stakeholders in decision-making, monitoring, and maintenance processes, decentralized approaches are better suited to adapt to the evolving needs of the urban population. This integration of local knowledge with technical expertise offers a promising pathway to address the persistent water scarcity in Dharan and can potentially serve as a replicable model for other urban centers facing similar challenges [6].

Problem Statement and Objective Dharan, a sub-metropolitan city in eastern Nepal, faces persistent water scarcity despite its access to multiple water sources. The current centralized water management system is burdened by aging infrastructure, high non-revenue water losses, and intermittent service delivery, which adversely affect public health and urban development [7], [1]. Moreover, the lack of effective community participation has hindered the timely maintenance and localized decision-making necessary to address these challenges [4]. This study aims to investigate these critical issues by exploring how integrating community engagement with decentralized water management strategies can provide a more sustainable and resilient solution to Dharan's water crisis.

Research Objective: The major aim of this research is to explore the role of community engagement in decentralized water management solutions in addressing urban water scarcity, focusing on Dharan as a case study, to identify sustainable studies for improving water security and resilience

The specific objectives are:

- To explore the existing water supply scenario of Dharan
- To explore the role of community participation in addressing water security in decentralized water management in Dharan.
- To analyze the role of policy and institutional frameworks in supporting community-driven and decentralized approaches for sustainable water resource management in Dharan.

Addressing Urban Water Scarcity through Community Engagement and Decentralized Solutions: A Case of Dharan

Limitations: The limitations of the research can be listed as follows:

- **Social Desirability Bias:** Some respondents may not have been truthful while answering survey questions or may have provided socially desirable responses.
- **Generalizability:** The findings from this study on Dharan may not be directly applicable to other Nepali cities, such as Kathmandu, Pokhara, or Biratnagar, which have different water management infrastructures, institutional frameworks, and community engagement dynamics.
- **Sampling Bias:** Convenience sampling size was used, which may limit the diversity of perspectives, excluding households and community members with differing water access challenges and water usage patterns in Dharan.
- **Time Constraints:** Limited timeframe for data collection and analysis prevented deeper explorations limiting my case studies to only 12 Water user and Sanitation committees in Dharan, which might affect the comprehensiveness of the study.

2. Literature Review

2.1 Urban Water Management Challenge

Urban water scarcity is increasingly recognized as a global crisis, driven by rapid urbanization, population growth, industrialization, and climate change [8]. Many cities in developing countries, including Nepal, face the compounded challenge of aging infrastructure that was originally designed for much smaller populations. In Dharan, for example, the legacy centralized water supply system now struggles under the pressure of rapid urban expansion, leading to high levels of non-revenue water, infrastructural decay, and sporadic service delivery [7], [1]. In addition to these systemic issues, climate change has introduced greater variability in precipitation, resulting in seasonal shortages and the disruption of traditional water sources. This multifaceted challenge not only undermines water availability but also poses severe public health risks and deepens socio-economic inequities as marginalized communities suffer disproportionately from inadequate access to safe water [4]. Furthermore, unplanned urban sprawl often encroaches on vital water catchment areas, further degrading water quality and exacerbating supply challenges.

2.2 Role of Community Engagement

Community engagement is integral to sustainable water management, fostering inclusivity, ownership, and resource efficiency [9]. Ladder of Citizen Participation provides a framework for understanding the levels of public involvement, from tokenism to true empowerment. Successful examples of community engagement include the Pani Panchayat model in India, where communities collectively manage local water

resources, and Kenya's water user associations that address equitable access [10]. However, challenges such as lack of representation, conflicting interests, and limited capacity building hinder effective participation [11]. In Nepal, traditional systems like *Guthi* (community-based irrigation governance) demonstrate the potential of collective action in managing shared resources, though they require modernization to meet contemporary challenges [10]. For instance, the Community Empowerment Initiative (CEI) in Western Uganda demonstrates that local involvement leads to better maintenance of water sources and improved health outcomes, such as a reduction in water-related diseases from 60% to 4% [12]. The compendium on community community-driven initiatives have enhanced access to clean water. These initiatives often involve local organizations working alongside civil society to empower communities, particularly marginalized groups, to take control of their water resources [3].

2.3 Decentralized Water Supply System

Decentralized water management systems have emerged as a promising alternative to traditional centralized approaches. By devolving authority to local communities, these systems allow for more tailored and responsive management of water resources (Sharma et al., 2021). Decentralized models enable localized decision-making, which can rapidly address infrastructure failures, water quality issues, and supply disruptions. For instance, several case studies have documented the success of decentralized water systems in reducing non-revenue water losses and enhancing the overall maintenance of infrastructure [3]. Despite these benefits, decentralized systems also face challenges. These include the need for robust financial models to support operational costs, capacity building among community members, and the technical expertise required to manage modern water systems effectively.

2.4 Sustainable Urban Water Management

Sustainable urban water management integrates multiple strategies to address both the technical and social challenges posed by rapid urbanization. Low Impact Development (LID) techniques aim to mitigate the negative effects of impervious surfaces—which accelerate runoff and transport pollutants by promoting natural infiltration and evaporation. Urban water supply management traditionally focuses on supply-side methods—such as building dams, reservoirs, and tapping alternative water sources—to increase available water. However, in rapidly growing cities like Dharan, these conventional approaches often fall short due to challenges like groundwater depletion, infrastructural limitations, and increased urban runoff [13], [1]. As a complementary approach, demand-side management promotes water efficiency through pricing strategies, public awareness, and regulatory measures, aiming to reduce consumption and wastage [4], [13].

2.5 Urban Water Security

Urban water security refers to the ability of urban areas to sustainably manage water resources to meet the needs of their

populations while addressing risks such as shortages, flooding, pollution, and external dependencies. It is a subset of the broader concept of water security, which encompasses welfare, equity, sustainability, and risk reduction at various levels (household, state, or global)[14]. Urban water security is shaped by complex governance structures, requiring integrated approaches to balance competing priorities such as flood protection, wastewater treatment, and equitable access[15]. It aligns with the principles of the United Nations Sustainable Development Goal 6 and the human right to water, emphasizing not just supply but also quality, accessibility, and overall well-being [14]. The DECS model defines urban water security across four dimensions: Drinking Water and Human Well-being, ensuring reliable access to safe and affordable drinking water, Ecosystems, highlighting the role of natural water systems in sustaining water quality and availability, Climate Change and Water-Related Hazards, addressing risks such as floods and droughts and the need for resilient infrastructure and Socio-Economic Factors, which include affordability, financial sustainability, and governance mechanisms ensuring equitable access[14, 10, 15].

2.6 Integrated Water Resource Management

Integrated Water Resources Management (IWRM) is a cross-sectoral approach that promotes the coordinated development and management of water, land, and related resources to maximize economic and social welfare equitably while ensuring the sustainability of vital ecosystems[16]. Integrated Water Resources Management (IWRM) is not an end goal but a process designed to address the specific ecological, social, and economic contexts of different regions. Its primary aim is to balance and negotiate trade-offs between three key objectives: economic efficiency in water use, social equity, and environmental sustainability. These aspects are interconnected and require stakeholder engagement to ensure effective decision-making[17].

2.7 National Water Policies and Guidelines

National frameworks in Nepal have progressively recognized the importance of integrating community-based and decentralized approaches into water management. Key legislative instruments such as the Water Resources Act (1992) and the National Water Resources Policy (2020) provide a regulatory foundation for promoting integrated water resource management (IWRM)[18, 6]. These policies advocate for decentralized governance structures that empower local bodies and emphasize the need for transparency, equitable distribution, and community participation. Regional adaptation plans further refine these guidelines to address local challenges, encouraging a bottom-up approach that leverages community insights for effective policy implementation. Despite these progressive policy frameworks, challenges remain in translating high-level mandates into tangible improvements at the local level. Issues such as inadequate funding, limited institutional capacity, and low public awareness continue to hinder the effective execution of these policies, underscoring the need for continuous evaluation and adaptive management strategies

3. Methodology

The study investigates Dharan's water demand and supply dynamics, community involvement in decentralized water management, and the supporting policy frameworks for urban water security. It adopts a pragmatic, mixed-methods approach, recognizing that urban water management is influenced by diverse social, cultural, economic, and environmental factors.

The research follows a sequential exploratory design. Initially, qualitative methods such as interviews, focus groups, and field observations are used to uncover key themes and contextual insights. These findings then inform a subsequent quantitative phase that includes structured surveys and analysis of municipal records. This integrated approach captures both objective data and the lived experiences of local communities, ensuring a comprehensive analysis that underpins sustainable strategies and policy recommendations.

Table 1: Data Collection Framework

Main objective	Specific Objective	Parameters	Source	
To explore the role of community engagement in decentralized water management solutions in addressing urban water scarcity, focusing on Dharan as a case study, to identify sustainable studies for improving water security and resilience.	To explore the existing water supply condition of Dharan	Water supply capacity, seasonal variability, and daily demand trends.	KII Literature Observation	
		Infrastructure condition and reliability	KII Observation	
		Existing Numbers of Water User Committees	Dharan SMC	
	To explore the role of community participation in addressing water security in decentralized water management in Dharan.	To explore the role of community participation, perceptions, and willingness to engage in water management.	Level of community participation, perceptions, and willingness to engage in water management.	KII Survey Observation
			Community Perceptions and satisfactions	KII Survey
			Willingness to engage	Survey
			Adoption of Decentralization system as a whole	Field Observation Questionnaire Literature KII
	To analyze the role of policy and institutional frameworks in supporting community-driven and decentralized approaches for sustainable water resource management in Dharan.	To analyze the role of policy and institutional frameworks in supporting community-driven and decentralized approaches for sustainable water resource management in Dharan.	Policy alignment with community and decentralized solutions.	Data KII Field Observation
			Funding and resource allocation for decentralized projects	KII Secondary Data
			Clarity and effectiveness roles among institutions	Literature KII Field Observation
Implementation effectiveness of policies			KII Field Observation	

For qualitative data, semi-structured in-depth interviews were conducted with municipal officials, community leaders, and members of water user committees, complemented by key informant interviews with experts from water management entities. Focus group discussions with community members provided additional insights on water accessibility and governance, while field observations helped assess

Addressing Urban Water Scarcity through Community Engagement and Decentralized Solutions: A Case of Dharan

infrastructure conditions and environmental impacts.

Quantitative data collection involved semi-structured interviews with 12 Water User Committees and technical experts, along with a structured questionnaire survey administered to a representative sample of households across Dharan. Data from municipal records and national census databases were also utilized to contextualize water supply infrastructure, population growth, and land use changes. A sampling strategy based on Cochran's formula initially determined a sample size of 97 respondents; however, 151 respondents were ultimately surveyed to ensure comprehensive coverage and data saturation.

4. Study Area

The Study area is focused at Dharan Sub-Metropolitan City, which is located in the Sunsari District of eastern Nepal and serves as an important commercial and administrative hub. Upgraded from a municipality in 2017, Dharan spans an area of approximately 192.32 square kilometers. Its strategic location at the foothills of the Mahabharata Range provides access to several freshwater sources, though these resources are not fully harnessed for municipal use.

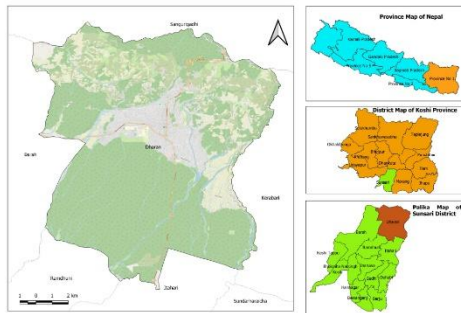


Figure 1: Map of Dharan

Administratively, Dharan has evolved from 11 to 20 wards and now serves as a sub-metropolitan city. The climate is mild and moderate, with average temperatures around 21.6°C and a marked seasonal variation in rainfall, peaking in July and dropping in December. Demographically, the city has a population of 166,531 with a density of 886 people per square kilometer. Land use is varied, encompassing urban areas, agriculture (primarily in the southern plains), and dense forest cover, which makes up over 70% of the area. Overall, despite the lack of perennial rivers, the region's seasonal water bodies play a crucial role in the local water supply.

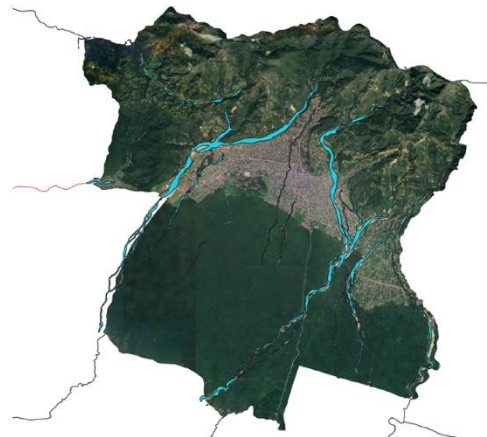


Figure 2: Physical Profile of Dharan

5. Results and Discussion

5.1 Existing Water Supply Scenario of Dharan

The water supply system in Dharan is characterized by a dual approach that merges a centralized network managed by the Dharan Water Supply Management Board (DWSMB) with decentralized, community-driven initiatives.

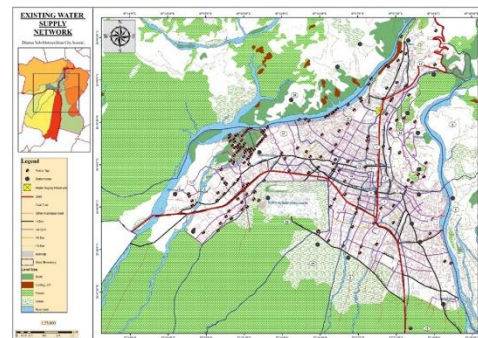


Figure 3: Existing centralized Water Supply in Dharan (Source:[2])

Centralized Water Supply System Initially managed by the Nepal Water Supply Corporation (NWSC) and now overseen by the Dharan Water Supply Management Board (DWSMB), the centralized system covers the core urban areas of Dharan. The DWSMB was established in 2071 B.S. under the Khanepani Byabasthapan Board Act 2063. Historically, water distribution was managed by NWSC; however, due to prolonged legal disputes, the transfer of assets and liabilities from NWSC to DWSMB was delayed until 2077 B.S., which in turn hindered timely pipeline upgrades. Currently, the DWSMB operates with five distribution subsystems (an

increase from the original three) and supplies approximately 28,841 households—constituting 68.03% of the total 42,396 households in Dharan (CBS 2021). Among these, the Sumnima Subsystem (Subsystem C) serves the highest number of households (13,481), while the Phusre Subsystem (Subsystem A) covers the fewest (2,224).

Table 2: Water Supply Distribution Subsystem of DWSMB (Source: [1], Unofficial DWSMB)

Zone (Subsystem)	Area (Ha)	Households (Approx.)	Ward Coverage	Reservoir Capacity (m ³)	Source of Water	Notes
A (Phusre)	114.4	2,224	Wards 1,2, 13, 14	1900	Sardu, Khardu	Core area; infrastructure is relatively established
B (Bijaypur)	220.2	2,640	Wards 14, 3, 7, 13, 15	400	Sardu, Khardu, Deep boring	Reserve tank not built; some areas experience intermittent supply
C (Sumnima)	584.29	13,481	Wards 1, 2, 3, 5, 7, 9, 10, 11, 12, 16, 18, 19	3,000	Sardu, Khardu, Deep boring	Renovated system; covers the main market and dense residential areas
D (Railway)	296.998	3,349	Wards 11, 17	500	3 deep boring wells (Mdaya Community forest)	Newly built subsystem; covers larger areas in wards 11 and 17
E (Pindeswar)	351.5	7,147	Wards 7, 8, 15	1,500	Sardu, Khardu	Newly built subsystem; serves a significant portion of the population

Decentralized Water Supply System In areas where the centralized network is constrained due to geographic limitations or areas newly added to the Dharan Sub Metropolitan City (SMC) such as Panbari and Patnali local bodies have developed decentralized water supply solutions. These systems are operated by local entities, notably the Khanepani Upabhokta Tatha Sarsafai Samitis. According to the NAWASH program, there are 81 such samitis; however, only 35 are officially registered under Dharan SMC, with an additional two in the process of registration. Collectively, these 81 samitis cover a population of 59,245 and supply water to 11,008 households, accounting for 35.58% and 25.96% of the urban population and households, respectively.

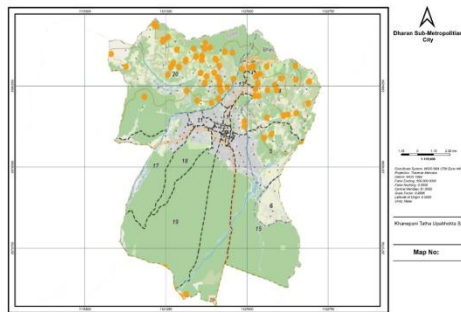


Figure 4: Existing decentralized water supply projects in Dharan

5.2 Community Participation in addressing Water Security in Dharan

5.2.1 Community involved with DWSMB

The community engagement efforts in Dharan play a pivotal role in addressing water security by bridging gaps in

centralized water supply through localized, participatory approaches. The Dharan Water Supply Management Board (DWSMB) has increasingly involved local stakeholders through volunteer campaigns processes, fostering a collaborative environment that enhances operational efficiency and accountability. Concurrently, community driven initiatives are actively working to conserve the Sardu watershed, a vital water source, through reforestation, and protection against encroachments, ensuring long-term water availability is maintained.

5.2.2 Community Management of Decentralized Water Supply System (Water User and Sanitation Committees)

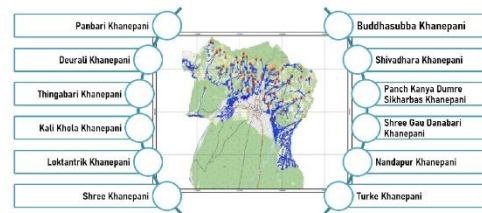


Figure 5: Case Studies of 12 Water User and Sanitation Committees of Dharan

The study shows a dynamic model of **community-led water governance** with a strong emphasis on financial planning, community engagement, and adaptive sustainability strategies. Local committees, varying in size from 7 to 13 members with gender inclusive and established across different years (from 2051 to 2078 B.S.), serve a wide range of households from as few as 6 to over 3,200 and provide daily water supplies ranging from 875 liters to 1,200,000 liters. For instance, Panbari Khanepani (2064 B.S.) serves 2,700+ households with 1,200,000 liters per day, while Deurali Khanepani (2057 B.S.) caters to 3,200+ households with 350,000 liters per day. Collaboration is a key element, with **committees integrating local funds and external contributions**. Examples include Shree Khanepani, which manages a project cost of approximately Rs. 19 lakhs (with Rs. 5 lakhs from UNICEF), and Loktantrik, backed by a Rs. 5-lakh private investment. Innovative financing models are also evident, such as Panch Kanya Dumre Sikharbaas using a 60:40 cost-sharing split between the Gurkha Welfare Trust and the committee.

Monitoring and sustainability efforts are integral to these projects. Many committees **implement water recharge** through annual afforestation, with some adopting collaborative approaches. Monitoring mechanisms range from hiring scheduled personnel (as seen in Panbari, Deurali, and Shree) to unique arrangements like Loktantrik's Rs. 2,000 monthly stipend for oversight. While some water sources remain stable, few face depletion due to competition or landslide effects. Fee collection practices further highlight community engagement. Committees charge specific rates such as Panbari's Rs. 50 for 15 units (with Rs. 7.5 per extra unit) and Deurali's Rs. 100 for 15 units (Rs. 10 per extra unit)

Addressing Urban Water Scarcity through Community Engagement and Decentralized Solutions: A Case of Dharan

and impose fees for new installations that vary significantly across committees. Overall, the funds collected generally meet the needs for operations and maintenance, though some committees occasionally require additional contributions. Despite facing challenges like technical difficulties on slopes and inefficient pipe diameters, these community-led initiatives showcase a proactive, collaborative approach to addressing water supply and sustainability issues.

5.3 Community Perceptions

A two-pronged survey strategy was used to determine how the community felt about water management in Dharan. First, a general survey was conducted utilizing random sampling in every ward of Dharan with the goal of gathering comments on the municipality's water management procedures. Concurrently, another study was carried out in Ward No. 6 with a focus on Panbari Khanepani Upabhokta Tatha Sarsafai Samiti beneficiaries. This survey focused on understanding the detailed perceptions and concerns of those directly served by the community-managed water system.

5.3.1 Community Perception on Volunteer engagement in Water management of Dharan

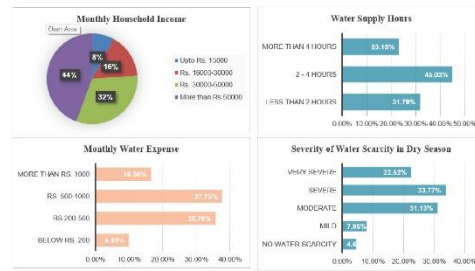


Figure 6: Survey data on Income, Water Supply, Expense and Scarcity

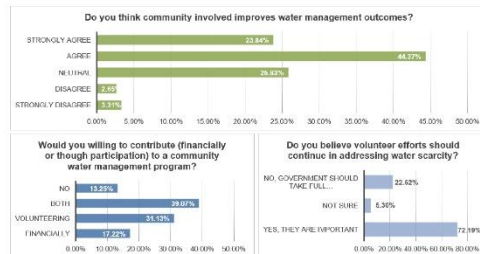


Figure 7: Survey Data on Community Involvement, Contribution and Volunteer efforts in Water Management in Dharan

The survey reveals that a significant portion of households earn more than Rs. 50,000 per month, although a small percentage earn up to Rs. 15,000. In Dharan, nearly half of the households receive water for 2–4 hours daily, while about one-third get

water for more than 4 hours. Monthly water expenses vary widely, with over 54% of households spending more than Rs. 500, highlighting issues of affordability due to irregular supply and reliance on private sources. During the dry season, water scarcity is a serious problem, with only 4.64% of households experiencing no scarcity and more than half facing moderate to very severe shortages. Despite these challenges, there is strong community support for improving water management through both active participation and volunteer efforts, although a notable minority believe that the government should bear full responsibility.

5.3.2 Community Perception and Concerns of Ward 6



Figure 8: Survey Data on Income, Affordability, Expense, Water scarcity, Funds management and Water Quality and reliability

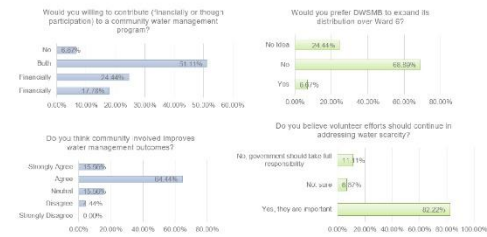


Figure 9: Survey Data on Community Participation, DWSMB expansion and Volunteer Efforts in Water Management

The survey shows that 20% of households earn over Rs. 50,000 monthly, 9% earn up to Rs. 15,000, and the majority (53%) have incomes between Rs. 15,000 and 30,000. Most households (64.44%) spend between Rs. 200 and 500 on water each month, with smaller groups paying less or more, and perceptions of water costs are mixed 42.22% are neutral, 26.67% find them expensive, and 31.11% view them as affordable. During the dry season, 57.78% of households experience mild water scarcity, while 11.11% face moderate, 15.56% severe, and 6.67% very severe scarcity, leaving only 8.89% without any scarcity issues. Additionally, a strong majority (73.33%) are aware of how funds are managed, and most rate water quality as good (68.89%), although a small portion view it as average or poor. In terms of community engagement, over half (51.11%) are willing to contribute both financially and through volunteering, while smaller percentages prefer one form of participation or are unwilling.

Finally, most respondents (82.22%) believe volunteer efforts are crucial in addressing water scarcity, with only 11.11% insisting that the government should take full responsibility, and 68.89% opposing the expansion of water distribution in Ward 6.

5.4 Policy Support for Decentralized Water Management

The institutional framework for water management in Nepal emphasizes decentralization, with policies and regulations designed to distribute responsibilities across central, provincial, and local governments. Key policies such as the National Water Plan (2005), the Water Supply and Sanitation Act (2079), the Local Governance Act (2017), and the Water and Sanitation Regulations (2081) provide the legal foundation for decentralized water management. Institutions like the Panbari Upabhokta Samiti are highlighted as requiring increased budget allocations at various levels to sustain operations, reinforcing the idea that local solutions should be supported by robust policy frameworks.

5.4.1 Roles of Different Levels of Government

Under the Water and Sanitation Regulations (2081), the central government is tasked with managing large-scale projects, including national pride projects, Public-Private Partnership projects, reservoir-based projects with dams over 10 meters, long tunnel projects, and other initiatives with significant technical or financial scope. For example, projects involving pipelines with diameters over 500 millimeters or extensive distribution networks exceeding 200 kilometers are under central oversight. The central government also handles high-capacity pumping and sewer treatment systems, as well as projects with high costs or serving large populations. Meanwhile, the provincial government is responsible for projects with costs between NPR 150 million and NPR 500 million or serving medium-sized populations, while local governments manage smaller projects up to NPR 150 million or serving up to 8,000 people in Terai, with a particular focus on waste disposal from wastewater systems.

5.4.2 Establishment of Water User and Sanitation Committees

The framework establishes clear guidelines for the formation, registration, and management of water user and sanitation committees, ensuring these consumer institutions are inclusive, accountable, and efficient. They must register with local governments, provide requisite documentation, and are granted priority rights to a set water usage limit, promoting equitable resource distribution. The Ministry-designated authority evaluates these institutions on performance, with potential dissolution for underperformance, although local governments ensure continuity of service. Additionally, licensing requirements mandate that these institutions demonstrate strong financial management, maintain at least 25% of the project cost as working capital, and have relevant experience. For foreign-organized institutions, a significant portion of the investment must come from Nepali citizens, underlining the importance of local participation and capacity building.

5.4.3 Funding of different projects for Water User and Sanitation Committees in Dharan

Funding for water projects in Dharan illustrates the multi-tiered nature of resource allocation. Under Koshi Province, the local government has allocated funds for 14 water projects—including one deep boring project for the Dharan Water Supply Management Board (DWSMB) and 13 projects for water user and sanitation committees—aimed at enhancing infrastructure, improving water quality, and expanding access in both urban and rural areas. At the central level, programs such as the Drinking Water Quality Improvement Program (with an investment of approximately NPR 20,000), the Climate Adaptive Integrated Drinking Water Supply Program (around NPR 15,000), the Water Supply and Sanitation Cofinancing Program (roughly NPR 10,000), and the Water Supply Addition and Rehabilitation Program (about NPR 25,000) support pilot projects, technological upgrades, and infrastructural modernization.

5.4.4 Gaps on Policies and Implementations

A review of the policy reveals significant regulatory gaps. Overlapping responsibilities can occur when projects meet exact threshold limits, such as those costing NPR 500 million or serving 15,000 people in Terai, leading to jurisdictional ambiguities between central, provincial, and local governments. Moreover, the Act's vague definition of "innovative technologies" creates inconsistent interpretations, complicating decisions on federal support.

Water User Committees (WUCs) operate as the local arm of this decentralized framework, managing water distribution, maintenance, and quality checks. However, despite their crucial role in connecting the community with municipal authorities, Dharan Sub-Metropolitan City has provided minimal funding—mostly limited to annual renewals—and insufficient oversight. This lack of active supervision from both the Urban Planning Division and the Dharan Water Supply Management Board hampers the committees' ability to improve and expand water supply services, undermining the long-term sustainability and efficiency of the urban water management system.

6. Conclusion and Recommendations

The research highlights Dharan's complex water scarcity challenges amid rising demand, outdated infrastructure, and governance inefficiencies. Seasonal variability exacerbates supply issues, with the Dharan Water Supply Management Board (serving 68.03% of households) hampered by aging pipelines and high non-revenue water, while Water User and Sanitation Committees cover 25.96% of the population despite institutional gaps. Community initiatives, led by volunteers and decentralized water management supported by policies, have provided affordable water access and fostered positive attitudes toward decentralized management. Survey data shows that many residents value these community efforts and feel a sense of ownership in managing local water resources. However, technical challenges persist, and overlapping responsibilities among federal, provincial, and local authorities—combined with the absence of a unified urban

Addressing Urban Water Scarcity through Community Engagement and Decentralized Solutions: A Case of Dharan

water management framework—create additional hurdles

A comprehensive approach to sustainable urban water management in Dharan should integrate decentralized water systems with traditional supply-side methods. Strengthening institutional frameworks is paramount. Establishing a **dedicated Water Resource Coordination Unit** under Dharan Sub-Metropolitan City (DSMC) would facilitate seamless regulation, monitoring, and standardization of decentralized operations. This unit could enhance coordination between the Dharan Water Supply Management Board (DWSMB) and various Water User Committees, reducing conflicts and operational inefficiencies.

Improving infrastructure and technical capacity is equally critical. Developing shared water reservoir systems would help balance supply during peak and off-peak seasons. Additionally, implementing a **Technical Assistance Program** alongside a **Mobile Water Management Taskforce** would empower local committees with essential skills in water treatment, leak detection, and distribution efficiency. Upgrading vulnerable systems by integrating sustainable elements such as groundwater recharge retention ponds, permeable pavements, and rainwater harvesting will also contribute to long-term resilience against natural hazards.

To ensure effective management, adopting an **Integrated Urban Water Management (IUWM) Policy** is recommended. This policy should align water supply planning with land-use strategies, urban expansion, and climate resilience initiatives while clearly delineating roles across local, provincial, and federal levels. Complementing these efforts, innovative financial models like a Water Credit System and Community-Based Water Bonds can incentivize community participation and investment in local water infrastructure. Collectively, these measures would transform fragmented water extraction practices into a cohesive, efficient, and sustainable management system for Dharan.

Acknowledgments

This research extends heartfelt thanks to thesis supervisor for expert guidance, and to the MSUrP Program Coordinator and Pulchowk Campus faculty for their insightful support. Gratitude is also due to the local stakeholders, including municipal bodies, water management teams, volunteer groups, and affected community members, whose contributions enriched the study. Special appreciation is given to colleagues and family for their unwavering encouragement throughout this journey.

References

- [1] J. P. Yadav, K. P. Sah, K. R. Karki, M. N. Jha, and A. Mishra. Dharan water supply system—alarming issues and future. *Zenodo*, 10(1):1–11, 2023.
- [2] IUDP. Final iudp dharan 2017 | economic development | urban planning. Scribd, n.d. Retrieved November 21, 2024, from <https://www.scribd.com/document/409275148/1-Final-IUDP-Dharan-2017-docx>.
- [3] A. Dwivedi, R. Mohanty, and Bharti. Compendium on community participation in urban water and sanitation, 2022. DOI: <https://doi.org/10.13140/RG.2.2.23952.28168>.
- [4] C. L. Pandey, G. Maskey, K. Devkota, and H. Ojha. Investigating the institutional landscape for urban water security in nepal. *Sustainability: The Journal of Record*, 12(3):173–181, 2019.
- [5] P. Ghosh, M. Hossain, and S. Sarkar. Inequality among social groups in accessing improved drinking water and sanitation in india: A district-level spatial analysis. *The Professional Geographer*, pages 1–22, 2022.
- [6] L. Sharma, N. Gupta, and B. Seneka. Nepal policies - water sector policies and guidelines of nepal. PDF, May 2021. Retrieved from https://www.adpc.net/igo/category/ID1811/doc/2022-otj7NA-ADPC-Water_Sector_Policies_and_Guidelines_of_Nepal.pdf.
- [7] A. K. Mishra, A. K. Karna, and sa. abd. Assessment of management transfer process of water supply systems in sunsari district of nepal. *International Journal of Research Granthalaya*, 7(1), 2019.
- [8] United Nations, Department of Economic and Social Affairs. World urbanization prospects: The 2018 revision, 2018. Retrieved from United Nations website.
- [9] Sherry R. Arnstein. A ladder of citizen participation. *Journal of the American Institute of Planners*, 35(4):216–224, 1969.
- [10] R. M. Bajracharya, N. Dahal, K. R. Neupane, V. Singh, and R. Habeeb. Urban water security challenges in the nepal and indian himalaya in the context of climate change. *Resources and Environment*, 9(1):9–18, 2019.
- [11] P. Coombes, G. Kuczera, J. Kalma, and J. Argue. An evaluation of the benefits of source control measures at the regional scale. *Urban Water*, 4:307–320, 2002.
- [12] R. Ogata, S. Oniki, and K. B. Karki. Sustainable management of small-town water supply in nepal: Improvement through the multi-stage training mechanism. *Journal of Water, Sanitation and Hygiene for Development*, 14(6):466–472, 2024.
- [13] H. Kopka and PW Daly. A guide to $\{\LaTeX\}$ -document. 1995.
- [14] H. T. Aboelnga, L. Ribbe, F.-B. Frechen, and J. Saghir. Urban water security: Definition and assessment framework. *Resources*, 8(4), 2019.
- [15] A. Hoekstra, J. Buurman, and K. C. H. Ginkel. Urban water security: A review. *Environmental Research Letters*, 13, 2018.
- [16] United Nations Environment Programme. What is integrated water resources management?, September 22 2017. UN Environment Programme.
- [17] L. Sharma, N. Gupta, and S. Basnayake. Iwrm implementation in nepal: Harmonizing water demand and supply dynamics, September 2023.
- [18] Government of Nepal, Ministry of Physical Planning and Works. Urban_wsspolicy [policy document]: National urban water supply and sanitation sector policy (final draft, 2009), 2009. Retrieved from <https://www.opmcm.gov.np/wp-...>

Appendix H: Plagiarism Test Report

 Page 1 of 144 - Cover Page

Submission ID trn:oid::3117:449309133

079Msurp020_Siddhartha Bhujel.pdf

 Tribhuvan University

Document Details

Submission ID
trn:oid::3117:449309133

Submission Date
Apr 15, 2025, 11:05 AM GMT+5:45

Download Date
Apr 15, 2025, 11:19 AM GMT+5:45

File Name
079Msurp020_Siddhartha Bhujel.pdf

File Size
5.3 MB

138 Pages
32,759 Words
194,059 Characters

 Page 1 of 144 - Cover Page

Submission ID trn:oid::3117:449309133





6% Overall Similarity

The combined total of all matches, including overlapping sources, for each database.




Filtered from the Report

- ▶ Bibliography
- ▶ Quoted Text
- ▶ Small Matches (less than 10 words)

Match Groups

-  **44 Not Cited or Quoted 5%**
Matches with neither in-text citation nor quotation marks
-  **22 Missing Quotations 1%**
Matches that are still very similar to source material
-  **0 Missing Citation 0%**
Matches that have quotation marks, but no in-text citation
-  **0 Cited and Quoted 0%**
Matches with in-text citation present, but no quotation marks

Top Sources

- 6%  Internet sources
- 2%  Publications
- 0%  Submitted works (Student Papers)

Integrity Flags

1 Integrity Flag for Review

-  **Hidden Text**
224 suspect characters on 7 pages
Text is altered to blend into the white background of the document.

Our system's algorithms look deeply at a document for any inconsistencies that would set it apart from a normal submission. If we notice something strange, we flag it for you to review.

A Flag is not necessarily an indicator of a problem. However, we'd recommend you focus your attention there for further review.

Match Groups

- **44 Not Cited or Quoted 5%**
Matches with neither in-text citation nor quotation marks
- **22 Missing Quotations 1%**
Matches that are still very similar to source material
- **0 Missing Citation 0%**
Matches that have quotation marks, but no in-text citation
- **0 Cited and Quoted 0%**
Matches with in-text citation present, but no quotation marks

Top Sources

- 6% Internet sources
- 2% Publications
- 0% Submitted works (Student Papers)

Top Sources

The sources with the highest number of matches within the submission. Overlapping sources will not be displayed.

1	Internet	1%
<hr/>		
2	Internet	<1%
<hr/>		
3	Internet	<1%
<hr/>		
4	Internet	<1%
<hr/>		
5	Internet	<1%
<hr/>		
6	Internet	<1%
<hr/>		
7	Internet	<1%
<hr/>		
8	Internet	<1%
<hr/>		
9	Internet	<1%
<hr/>		
10	Internet	<1%

11	Publication	Subas Subedi, Ramesh Basnstola, Sandip Duwadi. "Comparative Performance Eva...	<1%
12	Internet	www.coursehero.com	<1%
13	Publication	Gongutri Borah. "Urban Water Stress: Climate Change Implications for Water Sup...	<1%
14	Internet	brightideas.houstontx.gov	<1%
15	Publication	Ramesh Durbarry. "Research Methods for Tourism Students", Routledge, 2017	<1%
16	Internet	www.giz.de	<1%
17	Internet	www.nepalpolicy.net	<1%
18	Internet	mafiadoc.com	<1%
19	Internet	stm.eurekajournals.com	<1%
20	Publication	Banda Nsamwa, Kingsley Namangala, Ikabongo Mwiya. "Effect of Digitisation of ...	<1%
21	Publication	Chandra Lal Pandey, Gyanu Maskey, Kamal Devkota, Hemant Ojha. "Investigatin...	<1%
22	Internet	erams.com	<1%
23	Internet	article.sapub.org	<1%
24	Internet	wiredspace.wits.ac.za	<1%

25	Internet	meral.edu.mm	<1%
26	Internet	research.usq.edu.au	<1%
27	Internet	researcher.life	<1%
28	Internet	www.iaset.us	<1%
29	Publication	Innocent Musonda, Erastus Mwanauo, Adetayo Onososen, Retsepile Kalaoane. ...	<1%
30	Internet	oxfamilibrary.openrepository.com	<1%
31	Internet	www.adb.org	<1%
32	Internet	www.dailynewssegypt.com	<1%
33	Publication	"Innovative Approaches in Environmental Health Management", Springer Science...	<1%
34	Publication	Alberto Garrido, Helen Ingram. "Water for Food in a Changing World", Routledge,...	<1%
35	Publication	Bishnu Shau Rauniyar. "E-waste Management Practices: A Case of Itahari Sub-Me...	<1%
36	Publication	Nalaka Geekiyanage, M.H.J.P. Gunarathna, Manjula Ranagalage, Guttilla Yuganth...	<1%
37	Internet	proceeding.conferenceworld.in	<1%
38	Internet	waterpartnership.org.au	<1%

39	Internet	www.sias-southasia.org	<1%
40	Publication	"Integrated Management of Water Resources in India: A Computational Approac...	<1%
41	Publication	Jangbahadur Prasad Yadav, Birendra Giri, Kaji Ram Karki, Bishal K. C.. "Assessing ...	<1%
42	Publication	Nigon, Tyler John. "Uncertainty in Economic Optimum Nitrogen Rate and Accurac...	<1%
43	Internet	canvas.instructure.com	<1%
44	Internet	dl.icdst.org	<1%
45	Internet	www.nema.go.ke	<1%