Dharan Water Supply System–Alarming Issues and Future

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Research Article

Dharan Water Supply System - Alarming Issues and Future

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A B S T R A C T

This study examines the critical issue of water scarcity in the Dharan Sub-metropolitan city, analyzing the various factors that are driving factors driving water demand and proposing strategies and ensuring water security. This study finds that factors replace with the rapid expansion of residential areas, increasing population, steeper slopes, changing lifestyles, natural hazards, technical and management leakage are major contributors to the growing water shortages in the area, leading to a situation of water instability. However, the study also identifies that factor such as precipitation, geology, soil types, potential water sources in the area offer opportunities for stabilizing the water supply in Dharan Sub-metropolitan. This study highlights the combined effect of these various active factors that led to an increase in per capita demand of water from 71 to 100 lpcd. This increasing water demand and shrinking of surface water led to Interrupted Water pumping and overexploitation. Additionally, the study indicates that due to high level of Non-Revenue Water (NRW) up-to 40%, certain parts of the city's residents are facing major difficulties in accessing clean drinking water. The study also finds that positive changes in precipitation, supportive soil types and geology in the city of Dharan increases the potential for water recharge and harvesting. In order to achieve a sustainable and climate-resilient water supply, the study recommends implementing Water management tools likewise protective measures for critical water zones, stabilizing stream banks and gullies for surface water source improvement, artificial recharge of the city through Climate Adaptive Recharge Pits (CARP) and slope interception methods, as well as community-based water harvesting for groundwater source improvement. Furthermore, the study suggests establishing R&D unit involving national and local level experts and stakeholders for better planning and management.

Keywords: Interrupted Water Pumping, Overexploitation, Recharge Zoning, CARP, NWR, Technical leakage, management leakage, Per Capita Water Use, Water Sector Management

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Introduction

In 21st century, urban water supply has become one of the most pressing issue, driven by various factors such as increasing population, changing lifestyle, economic growth and development.[1] The United Nations World Water Development Report from 2018 reported that by 2050, almost 6 billion people will experience a shortage of clean water. This is due to the rising demand for water, declining water resources, and growing water pollution, which are all driven by rapid population growth and economic expansion.[2] In many nations, the population israpidly growing day by day, which has significant consequences for energy production, and management of urban water supply. this is also posing a major threat to existing water resources and supply system 3. According to World urbanization prospects only 220 million (13%) people lived in urban areas in 1900, which increased to 3.2 billion (49%) by 2005 and it is expected to increase 4.9 billion (60 percent) by 2030 4. According to the World Meter data of 2019, Asia is the largest continent in terms of both land area and population, with 59.76% of the world's total population. Of this population, 46.3% live in urban areas.Nepal having the lowest urbanization rate in South Asia at 14%5. However, the situation is rapidly changing, in between 1991 and 2001, population growth in urban areas was three times that of the country as a whole, results highest in South Asia, as shown in Table 1. Urbanization has brought significant stress to major cities of India, Nepal, Bangladesh, Pakistan, and other South Asian nations, as they currently rely on seasonal water supply. Over the past few decades, water stress has led to hundreds of millions of people receiving only irregular water supplies or spending hours waiting in line to get access to drinking water. (Dizikies, 2016; Surie, 2015; Mishra AK, 2019; Mishra AK, Aithal PS. and Hamid Saremi, 2020: Mishra AK and Shah SK. (2018; Shah SK, and Mishra AK (2018).

Table 1.Urbanization in South Asia 2005

Country	Annual Urban Growth Rate	Level of Urbanization
Nepal	6.4%	14%
Cambodia	6.3%	20%
Bangladesh	5.3%	18%
Philippines	4.2%	53%
Pakistan	4.4%	34%
Source: Portnov, B., Adhikari, M. and Schwartz, M., 2007		

Water shortages are becoming more prevalent in both rural and urban areas of the Nepal. The functionality and performance of different water supply system and search of alternative sources of water like rain water harvesting of different location of Nepal assures the water issue of Nepal as of different studies conducted by Mishra and his associates from 2018 to 2022. (Mishra AK, Karna AK, and Dhakal N, 2019: Mishra AK, Karna AK, 2019: Mishra AK, Acharya SR, 2018: Mishra AK, 2019: Mishra AK, 2018: Mishra, AK, Sudarsan JS, Suribabu CR et al. 2022: Anjay Kumar Mishra, Er. Gokul Dev Joshi. 2021). (This research investigates the causes of water stress in Dharan city which is very well-known due to Water insufficiency in every Feb.-March.Urban water security is a critical issue in today's changing world, particularly in light of recent changes in population and socioeconomic factors. To fully understand and address this issue, we must consider a range of factors including the water distribution pattern, the quality and quantity of source water, the management and technical leakage, the optimization of water usage, cultural dimensions, the relationship between population and climate trends in the study area. Comprehensive analysis of these components is necessary to develop strategies for alleviating water shortages and achieving a sustainable water supply for the urban communities.[7] The overall objective of the research is to analyze the Dharan Water Supply System- Alarming Issues and possible future prospects.

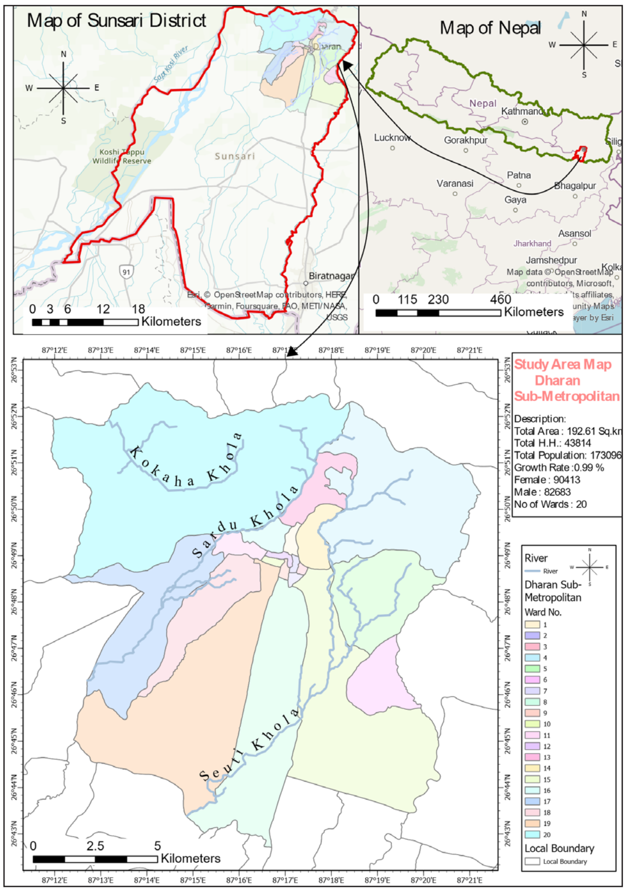

Figure 1.Location Map

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Study Area

Dharan Sub-metropolitan City, most well-known and alluring city of eastern Nepal, which was converted into Dharan Municipality in 2014 A. D. by merging two nearby V.D. Cs, Panchkanya and Bishnupaduka. Dharan was established as a municipality and then upgraded to become a sub-metropolitan city in 2017 This city covers 192.32 Sq.km area with latitude of 26° 42′ 41″ – 26° 52′ 42″ and Longitude of 87° 12′ 04″ – 87° 21′ 23″ as Shown in Figure 1. Settlements of Dharan were built along the main highway that leads to Dhankuta. Along the roadway, there were significant commercial and financial operations, a well-adjusted region had been set aside for industry, education, healthcare. Dharan has made an effort to have a planned development, however the focus has largely been on the city's Centre, which is being built as a hub for trade and business. Due to its rapid development, the area of residency in Dharan is expanding day by day. This growth in population also increases the demand for sewer and road systems, as well as water supply distribution pipelines in these expanding areas. It is important for the city to address these demands and ensure a sustainable and efficient infrastructure to support the growing population.

Brief Description of water Supply in Dharan

Nepal Water Supply Corporation (NWSC), Dharan

The first piped water supply system in Dharan was built by British Army Engineers in 1961. The main source of water for this system was the Sardu and Khardu streams, it was operated by the Dharan Sub Metropolitan. This system marked the beginning of the formal water supply system in the city and paved the way for further development and improvement of the water supply infrastructure. It was handed over to NWSC in 1980's. After that, NWSCextended their water system in 1980's by including groundwater of char-koshe jungle, with funding from IDA (International Development Association). The main sources of surface water for the system are Khardu Kholaand Sardu Khola. Khardukhola system was built in 1961 and Sardukhola system was built in 1971, both have undergone rehabilitation by the NWSC over the years. Flow of rivers decreases significantly during the dry season, which leads to a significant difference in the amount of water produced during the dry and wet seasons. Nepal Water Supply Corporation (NWSC) Dharan Branch which was established in 1980 and working under the Nepal Water Corporation Act, began extracting groundwater in Dharan, from 1988 through the construction of three tube wells funded by the IDA[8]. These wells are located on the southern side of the town along the highway. The water from the wells is pumped to a High Service Pumping Station (HSPS1) and then to HSPS2, before being delivered to town reservoirs. Later on, more tube wells were added in the southern part of the highway in Dharan as a supplement to the existing water supply. Of these new wells, two were specifically created to supply water to the BP Koirala hospital. Any surplus water from these wells is then added to the NWSC systemwhich is responsible for providing public drinking water of 125 liters per person per day of Nepal Drinking Water Quality Standard (NDWQS) to older wards 1-19 of Dharan municipality. Description of Sources of NWSC of Dharan in Table 2, Table 3.

Table 2.Description of Surface Source

Parameter	Units	Surface water sources	
		Sardu	Khardu
Intake		Damaged	Damaged
Transmission Main	Dia.(mm)	50 CI and 200 DI	50 CI and 200 DI
	Length (km)	1.8	3
Yield (Dry Season)	MLD	1.6	1.8
Yield (Wet Season) MLD 5			6
Source: integrated urban development project. August			

Table 3.Description of Ground water Source

Funded By	Well No.	Depth (m)	Size (mm)	Yield (MLD)	
				Dry Season	Wet Season
IDA	1	30	-	-	-
	2	152	300/200	1.5	Damaged
	3	225	300/200	3	1
	4	170	300/200	3	1
BPKH	5	160	300/200	2	1
	6	170	300/20	1.75	1
MWSC	7	165	300/200	1.5	1
Source: Integrated Urban Development Project August					

As shown in Table 2. There two main sources named as Sardu and Khardu Stream used for NWSC water source. They used to collect 3.4 MLD on an average in dry season while this value reached up to 11 MLD in wet season. For collection of water from Khardu and Sardu Stream they had a pipeline of 1.8 km and 3 km respectively.

There was an average supply of 14.41 MLD of water to cover an area of wards 1,2,3,9,10, 12 and partially to wards 8, 11,13,14,15, 16,17,18, 19. To maintain average supply of 14.41MLD, groundwater sources from five wells located in jungle with a capacity ranging from 10.01 to 3.41 MLD were used. They used to collect water in reserve tank from

Surface and ground water sources though the transmission lines description of that explained in Table 4. This average water is supplied through 16000 taps with supply hour of 4-8 hrs. in wet season and 2-1.5 hrs. in dry season.

Table 4.Description of Existing Storage Reservoir

Location	Size (Cum. m)
Phusre	1350
NWSC compound	3000
HSPS1	500
HSPS2	500
Narayanchaur	60
Laxmi chok	70
Chhata chok	300
Source: Integrated Urban Development Project. August	

Table 5.Description of Existing Storage Transmission Pipelines

Location		Size (mm)	Length (km)
From	To		
Sardu	Phusre	150 CI	3
		200 DI	3
Khardu	Phusre	150 CI	1.8
		200 DI	1.8
NWSC Well	HSPS1	300 DI	4.6
HSPS1	HSPS2	400 DI	7.41
HSPS1 NWSC Tank		300 DI	1.2
BPKH Well	HSPS1	250/300 DI	5.5
HSPS1	BPKH Tank	250	5
Source: Integrated Urban Development Project. August			

There are six reserve tanks. The first one, HSPS1, has a capacity of 500 cubic meters and acts as a first stage pumping station to collect water from wells and distribute it to the other tanks. The remaining five tanks with different sizes as mentioned in Table 4, served as distribution tanks. They used pipelines of different materials and sizes for transmission of raw water from the sources to reserve tank. Description of transmission pipelines are in below Table 5.

As mentioned in above Table 5, there are 6 km of CI and DI pipelines of size 150 mm and 200 mm each of length 3 km from Sardu to Phusre. Another pipeline of 3.6 km pipelines is used for Khardu to Phusre. Similarly, total of 4.6 km pipelines is used to collect water from IDA wells and NWSC well to HSPS1 and 5.5 km pipeline to collect water from BPKH wells. There is a 7.41 km pipeline used for flowing water from HSPS1 to HSPS2.

Collected water at different reservoir are distributed using different sizes of pipelines. They use about 78 km of CI, DI, GI and HDPE distribution pipelines of varying sizes from 25 mm to 400 mm as mentioned in below Table 6.

Table 6.Description of Existing Distribution Pipelines

Pipe Materials	Size (mm)	Length (km)
CI	150-300	1.4
DI	80-400	52.30 +
GI	20-150	19+
HDPE	25-150	6 +
Source: Integrated Urban Development Project. August		

All these facilities are still not enough for supply of water to the whole area of Dharan because of which people are forced to look for other sources likes Kali-khola, Tirke, Teendhare, Devi khola. But these sources are unreliable and completely dried up during dry season. The percentage of total population served from these sources is not significant. Private tankers based at Itahari occasionally supply water to the consumers during dry season. These are the regular problem of residents of Dharan and hence they requested the authorities for the alternative solutions such as tapping into larger water sources or storing water, in order to ensure a reliable and sustainable supply of clean water for that community. In spite of these frequent request, NWSC did not pay any heed to those requests because the organizational and financial setting of NWSC was highly centralized. The headquarters of the Nepal Water Supply Corporation (NWSC) in Kathmandu is where the programs, policies, budget for the water supply in Dharan are decided. Such approach widely limited the capacity of the branch office to manage the system and take own initiatives to improve the service. Participation of local community, consumers local and stakeholders such as municipality in the decision-making was neglected in NWSC system and financial constraints to improve existing water supply system and carry out new projects [9] So there were always delayed in solving problems.

Dharan Water Supply Management Board, Dharan

In an effort to tackle the water supply challenges in Dharan, the municipality, local stakeholders, community representatives have collaborated with the Nepal Water Supply Corporation (NWSC) and initiated a new project with the assistance of an Asian Development Bank (ADB) grant and loan. This project is known as the Integrated Urban Development Project (IUDP). The Integrated Urban Development Project, led by Project Manager Er. Raju Pokharel, was launched in May 2012 with the support of the

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Water Management Board of the Dharan Sub-Metropolitan. The aim of the project was to improve the water supply by conserving surface water sources, enhancing water intake and incorporating additional ground water sources, as well as modernizing the transmission and distribution pipelines. For achievement of this goal, the entire area of Dharan Sub-Metropolitan was classified in five sub-distribution systems:

1. Phusre subsystems (A).
2. Bijaypur subsystems (B)
3. Sumnima subsystems (C).
4. Railway subsystems (D).
5. Pindeswor subsystems (E).

First three sub-distribution systems were classified based on existing infrastructure, natural topography, settlement patterns which underwent renovation. Pindeswor and the railway sub-distribution area were freshly built and shown in Figure 2.

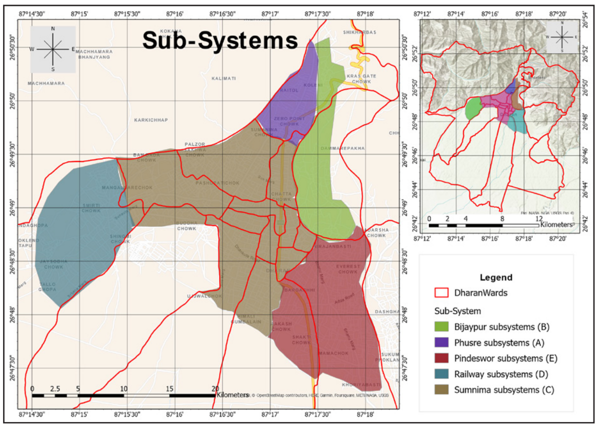

Figure 2.Sub-Distribution Area

Salient feature of all Sub-distribution system and IUDP in Dharan Sub-Metropolitan is shown in following tables.

Table 7.Summary of Surface Source

Surface Source	yield (MLD)	
	Winter Season	Dry Season
Sardu Stream	11.4	2.5
Khardu Stream	6	2
Unofficial Source: Dharan Water Supply Management Board		

As mentioned in Table 7. IUDP project improved the surface Source which increased the capacity from 3.4 MLD to 4.5 MLD in dry season while that value reached up to 17.4 MLD from 11 MLD wet season. They also worked for improvement of ground water sources and added seven new wells out of which two were test well and five were pumping well as mentioned in below Table 8.

Table 8.Summary of Ground Water Source

Wells	No.of Well	Yields (MLD)	
		Wet season	Dry season
NWSC	3		6
Test Tube	2		2
New well	5	2.72 (Railway system only)	7.2
Unofficial Source: Dharan Water Supply Management Board			

From Table 7 and Table 8, it is evident that an average of 19 MLD water were collected from both surface and ground water sources for each season, after the completion of water supply project under the title of IUDP, Dharan.

Table 9.Pipe Lines Extension

Types of Pipes	Transmission Main (km)	Distribution Pipes (km)
DI	34.43	-
HDPE	-	391.33
GI	-	7.877
Unofficial source: Dharan sub-metropolitan		

As Table 9, about 34.43 km of DI transmission pipes were used for transmission of water from new and old source and about 398.91 km of distribution lines were extended to cover Sub-metropolitan.

Table 10.Description of Sub-Distribution System

Zone	Area (Ha)	H.H (no)	Ward Coverage		Reservoir Size (Cu.m)
			Full	Partial	
A	114.4	2224		1,4,13, 16	500
B	220.2	2640	14	3,7,13,15	600
C	584.29	13481	2,4,5, 6,9, 10,12, 18,19	1,3,4, 7,8,11, 15,16,17	3,000
D	296.998	3349		11,17	500
E	351.5	7147	15	7,8,15	1600
Unofficial Source: Dharan Water Supply Management Board					

Newly built Railway sub-system (D) covered grander area of ward no. 11 and 17 with a total number of Household (HH)

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as 3349. Similarly, newly built Pindeshwar sub-system (E) covered second huge no. of population of 7147 in ward 7,8 and 15 with an area of 351.5 ha. While the oldest Sumnima Sub-system (C) which is heart of this water supply system covered the main market area and dense residential area. This sub-system is renovated sub-system and has a total house connected to 13481 households. As the infrastructure in this system is very old, wear and tear of the valve has led the problem of leakage at many extents of the pipeline which increase Non-Returnable Water (NRW) value and creates problems in operation system. This sub-system is also extended in new areas where new connection is increasing every day. Though the policy of DWSM state that, water is to be distributed through new pipelines only, this is not yet achieved, because most of the house are connected to existing pipelines. Hence, DWSM have the compulsion to distribute water through both existing and new pipelines which in turn creates lower head in pipelines. Some parts of this system are running well while some areas are still deprived of water connection. Bijaypur Sub-system (B) reserve tank is not built due to some social and religious issues and hence, some part of this area is not getting water supply during dry periods.

Table 10.Summary of Infrastructures of the Project

Parameters	Quantity	Size (Cu.m)	Remarks
Rapid Mix Tank	2		Sardu Khardu
Sedimentation Tank	1		Sardu
Rapid SandFilter	1		Phusre
Water RVT	1	900	Pindeswor System
	2	500	Phusre and Railway
OHT	1	200	Phusre
Deep Tube Well	3		Railway
	4		Central System
BPT	1		Pindeswor System
Valve chambers	1584		Pipe type valve
	15		Brick wall Chamber
Fire Hydrants	1		Railway Chowk
	1		Sadan School Chowk
	1		Lekhnath Chowk
	1		Shyam Chowk
Boosting Station	3		Submersible booster pump
	5		Submersible booster pump
	3		Submersible booster pump

Phusre sub-system (A) has also undergone renovation, it currently has a lengthy process for a new house connection in addition to an outdated, leaky infra structure. The distribution of water in the Phusre Sub-System (A) is not uniform since it has a steeper slope in that location. Under this IUDP project some other features are also developed in this system which is listed in Table 11.

All other facilities as mentioned in Table 11, are also installed in system for smooth running of water supply system. After the completion all work under IUDP project, all assets and liabilities of NWSC are transferred to Dharan water supply management board on 1 March, 2021.According to the IUDP, there will be approximately thirty thousand house connections by 2030. The number of new house connections is continuously rising, reaching approximately twenty-eight thousand in 2022. The current expected demand is around 25 MLD, but only an average of 19 MLD production has resulted insecurity in water supply in this region.

Key Causes of Water Insecurity in Dharan Sub-Metropolitan

Water insecurity is a complex issue for Dharan community and individuals, including negative impact on public health, Economy and Environmental growth. Population growth, climate change, natural disasters, tourist influx, overuse and mismanagement of water resources, unscientific construction, inadequate infrastructure for water storage, treatment, distribution are some major Water security factors. To address water security, it is crucial to implement sustainable water management practices, make investments in water infrastructure, seek to safeguard and conserve water sources. The following is a list of some crucial elements that affect water security greatly.

Climate Change

According to[10]climate change will hasten and intensify the hydrological cycle and create a challenging environment for managing water sources. Dharan is located in the humid subtropics of the Cwa climate. Figure 6 illustrates the variation in annual total precipitation and average annual precipitation in the Dharan Sub-metropolitan area, which ranges from 873.23 mm to around 1191.97 mm. According to the Figure-5, the amount of precipitation is below average in the western section and above average in the southern part of the char koshe rainforest area.

Growing Residence

Population growth can have a significant impact on water insecurity, as a larger population requires more water for drinking, cookingand other purposes. Growth of Dharan Sub-Metropolitan is rapid change from 2014 to 2022. Dharan city has evolved into a center for higher education, housing several +2 institutions, secondary schools, engineering and medical campuses.Similarly, it has a significant religious presence (Sunny Mandir, Pindeshwar Temple, Budhha-Subbha Temple, Dantkali Temple, Panchkanya), which has boosted religious travel. People from hilly areas move to this metropolis because it offers superior transportation, educational, healthcare facilities. Residential area population change from 2000 B.S. to 2019 B.S. is shown in Figure 3.

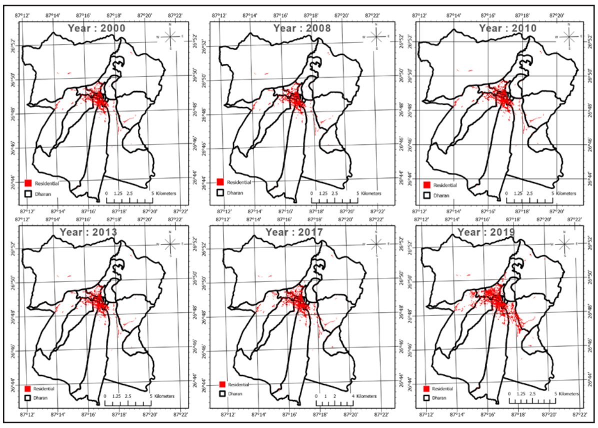

Figure 3.Change in Residential Area (from 2000 B.S. to 2019 B.S.)

Wards 1, 2, 3, 7, 8, 9, 10, 12, 18, 19 are shown in the figure to be the primary residential areas in 2000 B.S., but wards 11, 13, 14, 15, 16 have seen an increase in residential area from 2000 to 2019. Wards 11, 13, 14, 15, 16, 17 are still experiencing an increase in this upward trend. As seen in Figure 5, the population of the city of Dharan is likewise growing. The Dharan Sub-Metropolitan area's daily water demand is rising as a result of this trend.

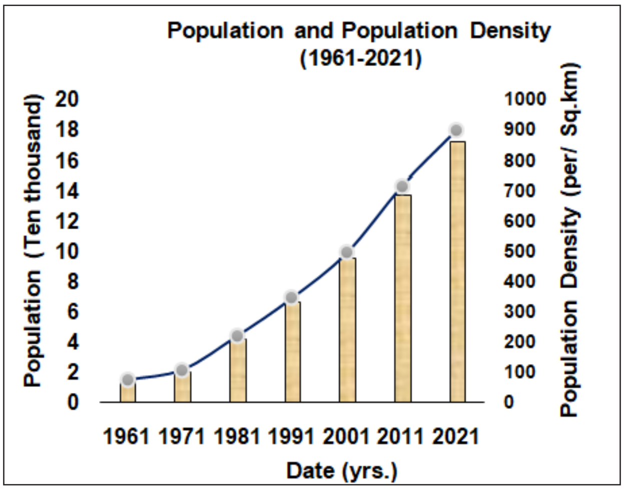

Figure 4.Population and Population Density in Dharan from
Source: UNFPA (2017)

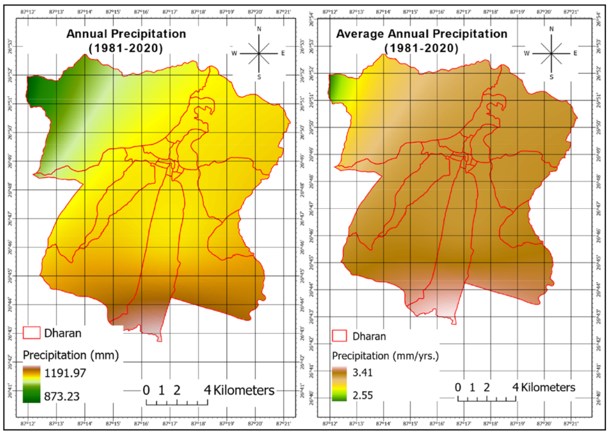

Figure 5.Annual Precipitation and Average Annual Precipitation

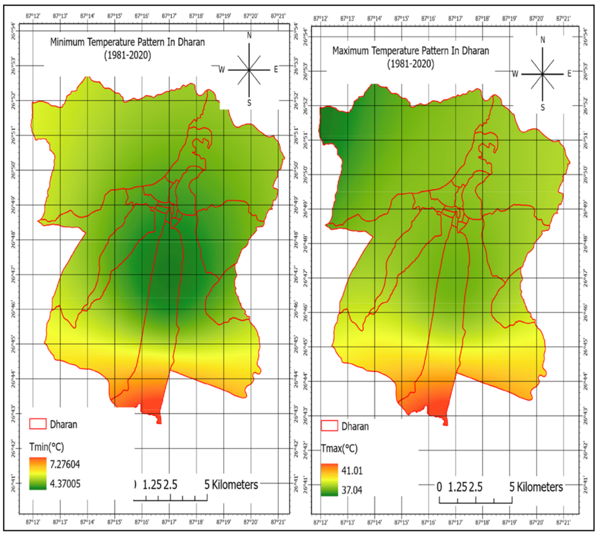

Figure 6.Maximum Minimum Temperature of Dharan

Likewise, as shown in Figure 7, the minimum temperature ranges from 4.37 °C to 7.27 °C and the maximum temperature ranges from 37.04 °C to 41.01 °C. This shows that distribution of maximum and minimum temperature in this area is directly affected by the char koshe jungle of the southern part, while the distribution is uniform in the other areas. The distribution of temperature also affects the precipitation in this region.

Analysis of data shows precipitation and temperature trend is in increasing trend. It is found that winter, Monsoon Post-Monsoon precipitation and Minimum temperature is slightly increasing where both slightly decreasing in Pre-monsoon. Maximum Temperature slightly increase in Pre-Monsoon and decreased in all other seasons as shown in Table 12.

Table 12.Temperature and precipitation trends for Dharan

Season	Temperature Trend (°C/yr.)		Precipitation Trend (mm/yr.)
	T Max	T min	
Winter	-0.0113	0.0007	4.8943
Pre-Monsoon	0.0718	-0.0220	-0.1108
Monsoon	-0.0199	0.0181	0.8658
Post -Monsoon	-0.0063	0.0506	1.8248
Average	0.0085	0.0119	1.8685
Source: Calculation of DHM data (1981-2020)			

This table indicates their inverse relationship with Maximum Temperature and Precipitation. So, there is positive sign in the annual precipitation of Dharan which amenities for water recharge.

Limited Source excess

Sardukhola and Khardukhola area major surface source and char koshe jungle in the southern part of the city is only ground water source. There are also some other sources will be used at the rainy season but it will bedry in dry season[11] Major tributaries of Dharan city are listed below in Table 13.

Table 13.Water availability (IUCN, 2011)

Major tributaries	Dry season (lps)	Wet season (lps)
Sardu and Khardu	280	860
Pakuwakhola	0.63	7.2
Nishane khola	195	278
kalimatikhola	0.61	1.02
Source: IUCN 2011		

Discharge in theses tributaries varies very much as shown in above table. Variation Surface source creates condition for excessive pumping in the dry season to fulfill city demand. There is also some major river of Nepal like Sapta Koshi and Tamor but it is far away from Dharan which will require a huge amount to excess it.

Topography of Dharan

Slope

Dharan is located at the base of a hill with flat ground, some steep places are included in its limit. Figure 8, illustrates the difference between the moderate slope of the flat land region and the steep slope of the mountainous sides. The distribution and availability of water are both impacted by this slope. A steeper slope slows down infiltration, reducing ground water recharge, it also increases gravitational pull-on pipes, disrupting the distribution system for water supply.

Geology and Soil Types

Figure 8, illustrates the geology of the study region, which is made up of sedimentary rocks from the Mesozoic Era, including sandstones and shales. This region's geology is a significant component that influences both the quantity and quality of water. While the western and southern portions of the Sub-metropolitan have aquifers of small depths, the middle and northern parts of the city have aquifers that are relatively deep. Water supply management boards and individuals have trouble pumping water due to the city's center's hard surface and deep aquifer.

Sandy loams soils are the most prevalent types of soilsin this area. These soils have a high ability for infiltration but a very poor capacity for retaining water.

According to a study, the average infiltration rate of the soil in Dharan is 124 mm/hr and ranges from 9 to 400 mm/hr[12]. The geology and soil types support recharging of ground water, although steeper slopes speed up surface runoff, which interferes with recharging.

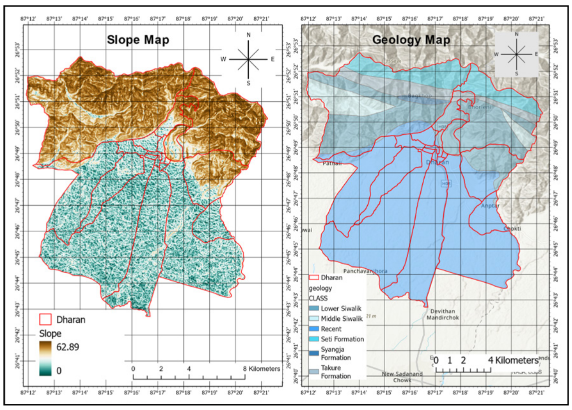

Figure 7.Slope and Geology map of Dharan

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Slum Area of Dharan

Because of the inadequate infrastructure and dense population in slum areas, these communities negatively impact both the quantity and quality of water supply. Slum areas lack modern pipelines, have leaky tanks, suffer from faulty sanitary systems, both of which cause water loss and source pollution. According to a study by.[10] Slum population growth has a greater impact on water supply than rapid urbanization. The population of slum areas is encroaching on various patches of land and endangering the area's water supply. There are significant slum areas in Wards 7, 8, 10, 11, 12, 15, 17.

Natural Hazard

Dharan is prone to natural disasters like Landslides, earthquakes, floods, soil erosion. The quantity, quality, distribution of the water delivery system are all directly impacted by these kinds of natural disasters. The intake and transmission pipelines of the Sardu and Khardukhola stream source are always destroyed by floods. This has a direct impact on water quantity, whereas soil erosion, landslides, seepage have a direct impact on water quality. Such a natural hazard can occasionally disrupt power, which disrupts the pumping and distribution of ground water.

Over-Abstraction

As mentioned above most of water demand is met from the extraction of ground water of the Charkoshe jungle which cannot naturally replenished. This over-abstraction is increasing water depth so yield of well is also decreasing day by day which creates difficulties in running of pumping and Pump damages[13].

Life style of Dharan Population

Dharan is Educational and Technical hub and also famous for introducing new fashion and styles in Nepal. This city has advanced due to settlement of retired British Gurkha Army which uplift the living style of the Dharan people. They use various innovative equipment's, such as washing machines, flushing toilets, summing pools, to preserve the vogue. They also request a variety of water-intensive goods, including dairy and animal items. This lifestyle uses between 71 and 100 Lpcd of water per person per day.[9]

Technical Leakage

Transmission and distribution pipes, infrastructure, the pumping system are all quite ancient. The valves and other control mechanisms in this older infrastructure have been physically harmed by corrosion and wear and tear. Since some current pipelines lack maps, it is difficult to build roads, drainage, other infrastructure that won't harm existing pipelines. They lack a systematic plan for distributing water. A pipeline and valve leak leads in a 30–40% reduction in water production. Such Technical leaks that result in water loss reduce water accessibility, raise maintenance and repair costs, disrupt the entire system by forcing a temporary closure while repairs are being made.

Management Leakage

The elected mayor of the Dharan Sub-Metropolitan serves as the president of the DWSMB Dharan management board. The hectic schedules of the presidents and other board members will cause delays in the selection of labor, technical training, the development of new sauces, financial decisions. This delay in decision-making also delays maintenance work, training, other essential tasks in the source or distribution system, increasing water leakage and allowing pipeline waste. This results in both direct losses and water efficiency losses via lowering water quality. Due to the lack of a skilled personality in the team, maintenance of damaged pipelines, pumps, mechanical operations can occasionally take longer time than expected.

Members of the working team must receive frequent training in order for the system to be managed properly.

Water Quality

Pull-out drain water and other types of pollution are caused by outdated pipelines, worn-out infrastructure, vales, other structural issues. Water quality is reduced as a result of this leaking pipe and aging infrastructure. Low water quality has a direct impact on the system's water efficiency, which has a direct impact on water trafficking and pricing.

Politics

Political statements will directly affect the management and development efforts of the DWSM Board, Dharan. The DWSM Board, Dharan, shall be presided over by the elected mayor of the sub-Sub-metropolitan of Dharan. Political parties therefore have a crucial role in allocating funds, establishing rules and regulations, allocating other resources for the Dharan water supply system. Where to carry out transboundary work in the system requires a lot of politics. Therefore, the political landscape of Dharan has a direct impact on the creation and administration of the system.

Significances of Study

The sustainability of a water supply system depends on both surface and groundwater, which is crucial in light of rapid urbanization, steeper slopes, increasing slum areas, technical and management leakage, natural hazards, politics. This study shows that the per capita demand for water has increased from 71 liters per day to 100 liters per day due to rapid urbanization, changes in lifestyle, loss of water use efficiency. Additionally, technical and management leakage results in non-return water (NRW) accounting for up to 40% of total production. However, the study also indicates that there is a positive change in precipitation and the geology of the study area is conducive to groundwater recharge. However, the steeper slopes impede groundwater recharge by increasing surface runoff

Effective Action and Policy Initiatives to Meet Future Challenges

Dharan is facing a water crisis that is expected to worsen in the future due to the combined effects of rapid urbanization, changes in lifestyle, increasing slum areas, steeper slopes, natural hazards, technical and managerial leakage. To address this issue, effective action and policy initiatives for both surface and ground water sources must be taken in a timely manner. The study highlights that Dharan, located at the foot of a hill, is heavily dependent on an upstream surface water source which is vulnerable to natural hazards such as heavy rainfall, flash floods, soil erosion, landslides. To mitigate these hazards, water conservation bio-engineering practices such as trenching and stream restoration must be implemented. Groundwater is also a crucial source in the dry season in this sub-metropolitan area, but it is steadily decreasing. Therefore, it is vital to take action on groundwater recharge through artificial means such as Climate Adaptive Recharge Pits (CARP) and water harvesting methods, as well as intercepting steeper slopes to decrease surface runoff velocity. Additionally, technical and managerial leakage is a significant issue that must be addressed by increasing staff capacity, implementing appropriate tariffs, reforming water utilities, reducing and eliminating Non-Revenue Water (NRW).[14] In addition to the aforementioned factors, there are other issues such as the presence of squatter settlements in slum areas, changing lifestyles, an increasing floating population that further complicate the situation and pose challenges to ensuring proper water security. These challenges can be addressed by increasing the availability of water sources, improving artificial recharge methods, implementing community-based water harvesting. Effective implementation of these measures and strategies requires suitable policy formulation and adoption at the Dharan Sub-metropolitan, Province-1, national levels.It is clear that the demand for water will continue to grow in the rapidly expanding Dharan Sub-metropolitan city. To effectively manage the water supply system, it is important to have a good understanding of the water demand from different sectors and segments of the local population. This includes projecting water demand for different economic sectors and considering the water use and needs of different ethnic populations. To ensure the security of Dharan's water supply system, several mitigation strategies can be considered, including:

- Improving and protecting surface water sources
- Recharging groundwater
- Intercepting steeper slopes to decrease surface runoff velocity
- Implementing water conservation measures
- Implementing rainwater harvesting
- Controlling and improving technical and management leakage
- Setting up a research panel to continuously monitor and improve the water supply system

Conclusion and Recommendation

The growing population and changing lifestyles in Dharan Sub-metropolitan have led to an increase in water demand. However, the city also faces challenges such as steep slopes, natural hazards, technical problems, management leakage which have resulted in inadequate and unreliable water supply, a lack of security in the water supply system.[15].To improve the water supply system in Dharan, a number of measures can be taken in the near future for both surface and groundwater sources. This includes implementing water conservation structures, stream bank work, gully stability work, natural hazard protection work for surface water sources. For groundwater sources, artificial recharging methods such as CARP, steeper slope intercepted ponds methods, community-based water harvesting methods can be used. Additionally, technical and management improvements can be made to reduce Non-Revenue Water (NRW). To ensure that these measures are effective, it is important to establish a policy research panel to study, identify and share critical gaps in the fields of water resource monitoring, environmental and social analysis, technical design. The panel will collect evidence, scientific findings, sources that can assist local city planners and stakeholders in promoting an evidence-based planning and water security culture.This study provides an overview of the current status of surface water and groundwater sources, as well as the infrastructure of the water supply system in Dharan Sub-metropolitan city. The results show that the city has undergone rapid changes in terms of population growth and lifestyle since 2000-2021. The combined effects of these factors have led to an increase in water demand, which in turn has led to insecurity in the region's water supply. Additionally, technical leakage, management leakage, natural hazards, pollution in upstream, illegal water tapping, old infrastructure, social factors, economic factors are major contributing factors to the water insecurity. The findings of this study indicate that it will become increasingly challenging to secure an adequate supply of water for Dharan Sub-metropolitan in the future. Therefore, sustainable management of the water supply system in Dharan requires exploring alternative surface water sources as well as implementing structural measures for water conservation such as protection against soil erosion, stream bank stabilization, landslides prevention and gully stabilization for surface water sources. Artificial groundwater recharge through CARP and artificial recharge ponds should also be considered. Efforts should also be made to reduce technical and management leakage in order to decrease Non-Revenue Water (NRW) and implement appropriate water pricing. It is also recommended that expert panels be mobilized to study potential surface water and ground water sources, artificial recharging methods, leakage control methods and management improvement methods for the local and national government. This approach will enable the compilation of data from scientific studies and knowledge repositories that will assist city-level planners and stakeholders in promoting a culture of evidence-based planning and water security.

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