Availability, Accessibility, and Disparities of Water Service in Shimla City: A Study in Sustainability

Dr. Rajesh Kumar[1] and Dr. Madan Lal[2]

[1]*Assistant Professor, Department of Geography, Govt. College Theog, Shimla, Himachal Pradesh, India, 171220*

[2] *Principal, Govt. Degree College, Kandaghat, Solan, Himachal Pradesh, India*

Abstract- **The present paper examines the availability, accessibility, and disparities of water supply in Shimla city, the capital of Himachal Pradesh, located in north-western Himalayas. The study is entirely based on primary and secondary data collected at ward level for the period 2011 and 2020. The study reveals that total water demand (2014) is 58.46 million litres per day (MLD) against system carrying capacity of 54.54 MLD. The gap between demand and supply further increases with system inefficiencies, as a result there are consumers who are getting water supply only for about 45 minutes in a day. The present deficit of 3.92 MLD (2014) may amplify demand 51.01 MLD in 2041 and 72 MLD in 2071. Resource assessment in the related watersheds namely, Dhalli Catchment, Cherot Nallah, Chair Nallah, Nauti Khad, Ashwani Khad, and Giri River accomplished using remote sensing techniques and geographic information system (Arc-GIS 10.3). To fulfil the growing water demand of study area, with gravitating water from upper reach of River Pabbar, lifting water from River Satluj, and rainwater harvesting and reuse of waste water coupled with balance additional water from River Satluj or Giri. The total running water connection of city are increased from 27765 in 2013 to 30995in 2020. Finally, study suggested that the sustained strategy shall take into account the identification of source of supply, collection, transmission, distribution and other related aspects in Shimla city.**

Key words: Arc- GIS 10.3, Availability, Accessibility, Water demand & deficit, Disparity, Sustainability, Shimla city

I. INTRODUCTION

Water is one of the basic necessities of life. It is very important as it is the major constituent of both plants and animals (Chakhaiyar, 2010). The demand for portable water supply and distribution increases with urbanization which is rapid in most of developing countries. In recent times, the rate and dimension of urbanization has increased, which resulted to having more than 50% of the world population living in urban areas within which 64% of them are in developing countries (UNDP, 2012). The increasing rate of population and water demand has compounded the issue of water sources depletion in many parts of the world. Towns and cities in developing countries are currently facing serious challenges of efficiently managing the scarce water resources, urbanization, and infrastructural decay, as well as the issue of sustainability of conventional water management (Zeraebruk *et al.,* 2014).

To signify the importance of water, the year 2005 marked the beginning of the "International Decade for Action: Water for Life" and renewed effort to achieve the Millennium Development Goal (MDG) to reduce by half the proportion of the world's population without sustainable access to safe drinking water and sanitation by 2015 by World Health Organization (WHO) (NIHR, 2013).

Of the total water available on the Earth's surface, 97.3 % is found in the oceans, 2.1 % makes up the glaciers and polar ice, and 0.6 % accounts for groundwater. The rivers, lakes, and streams contain only 0.02 % of the total, which is immediately available for use (Snoeyink and Jenkins, 1980).

The present scale of water to rural or urban population is generally inadequate all over the country hence the MC, Shimla is no exception. Increasing demand of rising population, non-availability of potential source, inadequacy of infrastructure etc. all lead to scarcity of drinking water in the study area. Beginning as a feeder of insignificant population of 16000 souls in year 1875 AD, Shimla city water supply grew to larger proportion augmented and improved over the years. Despite the improvements carried out so far as aforesaid, scarcity of water prevails in many Pockets of the city particularly in special areas amalgamated within the municipal boundary and the areas that are likely to be amalgamated.

The sustained strategy shall take into account the identification of source of supply, collection, transmission, distribution and other related aspects.

The sustainability should be so framed that it would not only integrate the existing system of water supply but would also envisage a strategic plan consistent with future overall development of the city area. The American Water Works Association (AWWA) defines sustainability as ''providing an adequate and reliable water supply of desired quality – now and for future generations – in a manner that integrates economic growth, environmental protection, and social development'' (AWWA, 2009).

II. GEOGRAPHICAL PERSONALITY OF THE STUDY AREA

Shimla is situated in the Central Himalayas at 31o4' to 31o10' north latitude and 77o5' to 77o15' east longitude, its mean elevation is 2130 m above mean sea level. The topography of Shimla is characterised by rugged mountains, steep slopes and deep valleys.

It experiences cold winters during December – February, with temperatures ranging from 0-13oC. Shimla receives snowfall around Christmas or the last week of December. The summers (May – June) are mild with temperatures varying from 20-30oC. The monsoon period extends from June to September and records moderate rainfall. The average rainfall recorded for the last 25 years (1980 – 2005) in Shimla is 1437 mm. Shimla region consists of a thin soil layer (0.15m on ridges to 7m deep in valleys), an intervening layer of detritus (mix of soil and fragments of weathered bedrock) and hard bedrock (Tandon, 2008). Shimla city discovered in 1819 by the British, Shimla has evolved from a small hill settlement to one of the popular tourist destinations in India. Part of Himachal Pradesh was carved out of erstwhile the Punjab state in 1966 and Shimla became the capital of newly formed state of Himachal Pradesh in 1971.
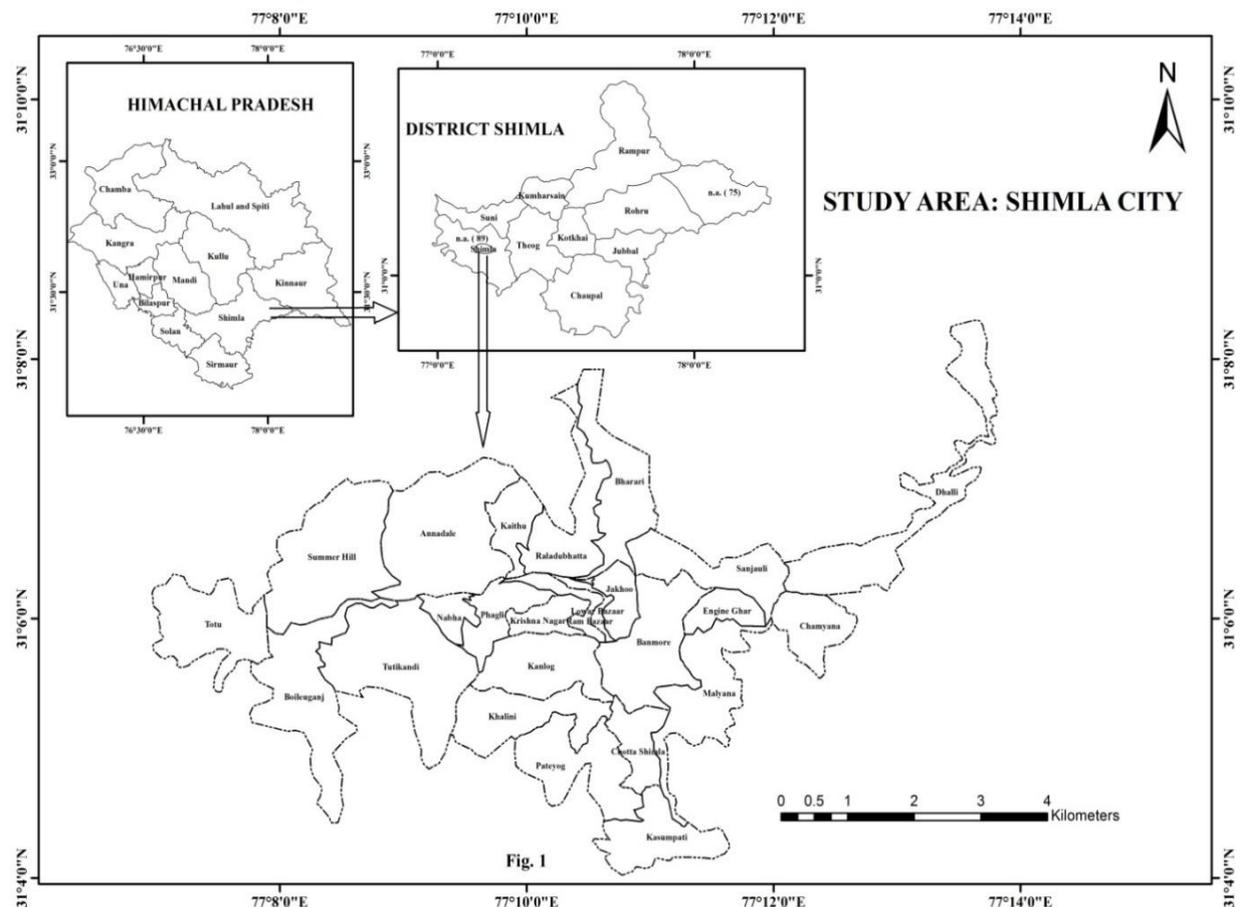

Fig. 1

As per Census (2011), Shimla is the only Class I City in the State of Himachal Pradesh with total population of 1,69, 758 persons. Consequently population of the city has grown by 12 time (from 14,000 in 1901 to 1,69,758 in 2011) during the century. The total area under the jurisdiction of MC Shimla also has increased after merger of New Shimla, Totu (including some parts of Jutog) and Dhalli areas to 35.00 sq km. According to 2011, Municipal Corporation of Shimla (Shimla city) is divided into 25 wards, covering urban core and urban fringes (Fig. 1).

III. RESEARCH AIM AND OBJECTIVES

The aim of this research is to assess availability, accessibility, and disparities of water supply in Shimla city. This aim can be achieved through the following objectives;

➤ To analyze the availability of water supply in the Shimla City.
➤ To trace the ward wise accessibility study area.
➤ To determine the disparity of water supply in Shimla city.
➤ To study optimal level of distribution to achieve sustainability

DATA SOURCE AND METHODOLOGY

The research design comprises of four sections namely; data collection, data input, data analysis and the results and findings.

Data collected for this study are both primary and secondary data. Primary data were gathered from a field survey by developing schedule. For gathering the information related to water service in city, were selected 1% of household form each ward i.e. (467 respondent). Secondary data; include water source, existing water distribution network, and water connection, storage reservoirs obtained from SMC Shimla and relating to population and household data have been collected from the census of India publications, viz Primary Census Abstracts of 2011 census years for Himachal Pradesh.

At the data input stage, the data collected were incorporated into the Arc GIS 10.3 software for processing.

Z-score technique

The Z-score statistical technique was used to analyse the primary data obtained to ascertain the water supply facilities in different wards through field surveys. This method was applied to transform the raw data of each variable into a standard score.

The Z-score method uses an equation to measure how far apart each observation is from the mean:

$$Z_i = (X_i - X)/\alpha$$

Where
Z_i = is the standard score of ith variable,
X_i = is the original value of the individual observation;
X = is the mean of variables, and
α denotes the standard deviation.
Values of the Z-score are added up and averaged to compute the composite mean Z-score, which indicates an index of development. This can be expressed as:

$$CS = \Sigma Z_{ij}/N$$

Where
CS = is the composite mean Z-score
Z_{ij} = is the sum of the Z-score of variables
J = is the in an observation I
N denotes the number of variables.

RESULTS AND DISCUSSION
IV. AVAILABILITY OF WATER SUPPLY

Water supply facilities were introduced in Shimla more than 130 years ago by pumping water from nearby spring sources. The city grew over the years increasing its boundary as well as population with subsequent augmentation of water supply to match the needs of the growing population. With the commissioning of the last augmentation scheme of water supply in the year 1992 the total installed capacity of the system rose to 56.62 MLD.

The detail and distribution of water source for Shimla city is provided in (Table 1).

Table. 1 Source of Water for Shimla city

Sr. No.	Name of source	Transmission Type	Year of Start	Quantities drawn in MLD (Average)	Installed Capacity in (MLD)	Supply to SMC	
						None Lean Period	Lean Period
1	Dhalli Catchment	Gravity	1875	1.80	4.54	0.23	0.20
2	Churat Nallah	Pumping	1914	3.86	4.80	3.86	2.65
3	Chair Nallah	Pumping	1914	3.00	2.50	2.50	1.42
4	Nauti Khad	Pumping	1924& 1982	19.75	24.06	24.06	16.80
5	Ashwani Khad	Pumping	1992	10.80	10.06	10.80	6.30
6	Giri Khad	Pumping	2008	20	20	15	15
	Tube Wells						2.63
	Total			53.55	56.62	52.36	42.15

Source: MC Shimla

V. ACCESSIBILITY AND DISTRIBUTION SYSTEM OF WATER SUPPLY IN SHIMLA CITY

The city has five major water supply zone and fifteen delineated water zones based on topography and location of feeder reservoirs as shown in the (Fig. 2). The supply of drinking water is not fairly in Shimla city. The water is drawn from five different gravity and pumping stations. The study reveals that water is not evenly distributed with the same quantity to all the wards in the city.

Fig. 2 shows that Chaura Maidan Zone covered the western part i.e. ward no. 3, 4, 5, 6, 7, 8, 9 and 10 of city, has gets once in three days supply of drinking water. Under this zone most of feeder reservoirs are A G Office, Vice Regal Lodge, University, Totu and Chakkar. Whereas, in Central zone around 5 wards namely, ward No. 2, 11, 12, 13 and 25 has gets water supply every third day. Ridge and High Court are the two most feeder reservoirs found under this zone. Thirdly, the Lakkar Bazar Zone covered around 3 wards namely Bharari, Banmore and Jakhoo in northern and central part of the city. In southern part of Shimla city, Chotta Shimla Zone covered the 4 wards i.e. ward no. 21, 22, 23 and 24, under the feeder reservoirs Mansfield, Kasumpti and BCS has also get water supply every third day. The fifth, water distributional Sanjauli Zone, mostly covered the eastern part of the city. Around 5 wards of the city have come under this zone namely ward no. 16, 17, 18, 19 and 20. Sanjauli and Dhalli are the main feeder reservoirs of this zone. In this zone, four wards 16, 17, 18 and 19 has get the water supply every third days and ward no. 20 has get weakly in peak season. There are about 12 reservoirs under the five water distributional zone which covered the different area of the Shimla city.
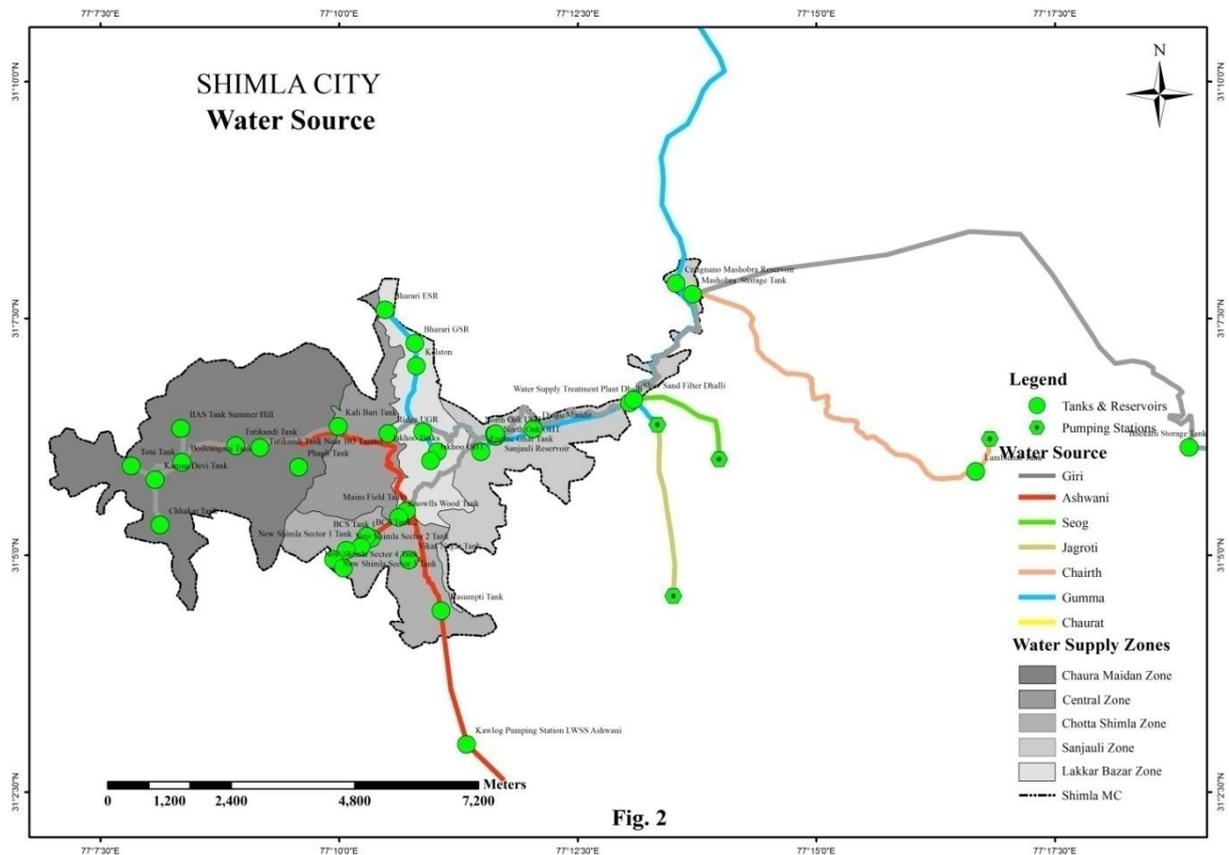

Fig. 2

The study reveals that the water supply situation needs to be improved considerably. Due to inadequate and unplanned distribution network, the water distribution is not uniform with some areas getting excess water and many areas receiving very less quantity of water. At many places the feeder mains have been tapped directly and used as distribution mains.

VI. POPULATION PROJECTION, WATER DEMAND AND DEFICITS

Graph 1 provides details of the population of city and the per capita water availability. At present the per capita surface water availability is about 32 MLD. Rise in population may require the per capita

water availability to 72 MLD by 2071. As the availability of water has wide spatial and temporal variations (including inter-annual variations), the general availability situation is more alarming than

that depicted by the averages. The population projection (Graph 1) shows that the permanent and floating population of Shimla city to be at the level of 493632 by 2071.

Graph 1
Population Projection

Graph 2
Water Crisis
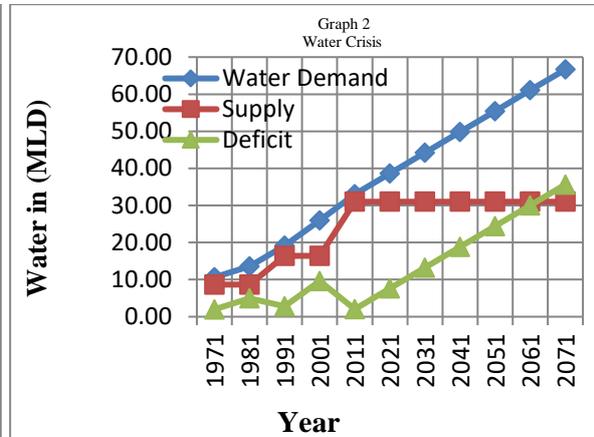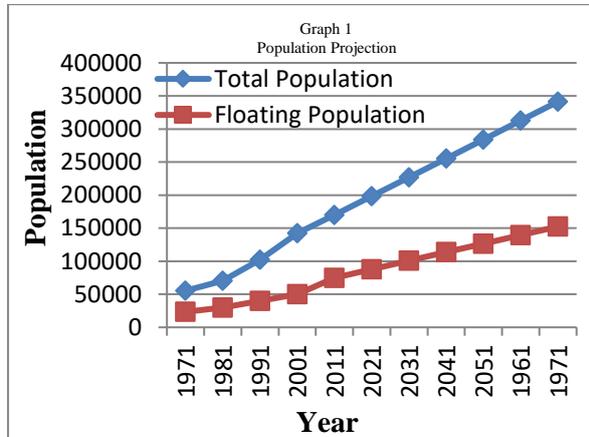
It also assumed that population of Shimla city continuously grow from 1971. The total ultimate water demand is 72 MLD by the year 2071and the intermediate demand by the year 2041 is 51.11 MLD. The deficits between water supply and demand continuously increase. If the population of city continuously increase at the present growth rate, the future requirement of water will be 72 MLD in 2071 (Graph 2).

VII. PEOPLE PERCEPTION AND DISPARITY IN WATER SERVICES

The city gets its water supply from six sources located in three watersheds, have been fully tapped, but the Girl watershed is partly tapped. All the sections of residents perceived the water quality and supply as inadequate. The vast majority (94.2 percent) of respondents have corporation water in their homes, (4.7 percent) have IPH, and (1.1 percent) have other sources (hand pump, well, etc.).

When they were asked about the source of drinking water, the vast majority (91.6 percent) of them said they have tanks as their main source of water, (6.6 percent) of respondents get it directly from the tap, and (1.7 percent) of them have groundwater. Furthermore, when asked how frequently they get water, the majority (89.9 percent) get it once every three days, 6.4 percent get it daily, 2.4 percent get it weekly, and 1.3 percent get it once every two days. It is noted from the perception that more than three-fourths of the respondents are not satisfied with the water supply. With regards to the respondents' "water connection," it is inferred that most of the respondents (88 percent of them) had a water connection in their homes, and 22 percent of them had no water connection in their homes.

Table 6 shows that the highest value of 2.42 for water status is scored by the Bharari ward, whereas the lowest value of 0.27 is scored by the Kasumpti ward. Eight levels of water status are computed based on the composite Z-score.

Table 2 Water facility in Shimla city

Level of Development	Composite Mean z-score	No. of Wards	Name of Wards
Very High	Above 1.84	5	Bharari, Pateyog, Ram Bazar, Lower Bazar and Jakhu
High	1.31 to 1.84	3	Krishna Nagar, Chotta Shimla, Kanlog
Medium	0.80 to 1.31	6	Benmore, Engine Ghar, Sanjauli, Malyana, RulduBhatta, Tuttikandi
Low	0.27 to 0.80	6	Kaithu, Annadale, Boileauganj, Tuttikandi, Khalini, Chamyana
Very Low	Below 0.27	5	Nabha, Phalli, Kasumpti, Summer Hill, Dhalli

Source: Data computed from the primary information collected through field surveys, 2018

Table, reveals that five wards includes in very high level of water facility (z-score values greater than 1.84). The Bharari ward ranks at the top and is situated in the northern part of the city. The other two wards, Ram Bazar, Lower Bazar and Jakhu,

have central parts of the city that lie under the Lower Bazar water supply zone, and the remaining ward, Pateyog, also lies in these categories of z-score value. With the composite z-score values ranging from 1.31 to 1.84, there is three of city. Two wards

are in the central part of the city, which lies in the central water supply zone, and the remaining administrative hub, Chotta Shimla ward, lies in the Chotta Shimla water supply zone.

A medium level of facility is seen in six wards. All these wards have high population concentration. The remaining two wards are in the north and western parts of the city (fig. 3).
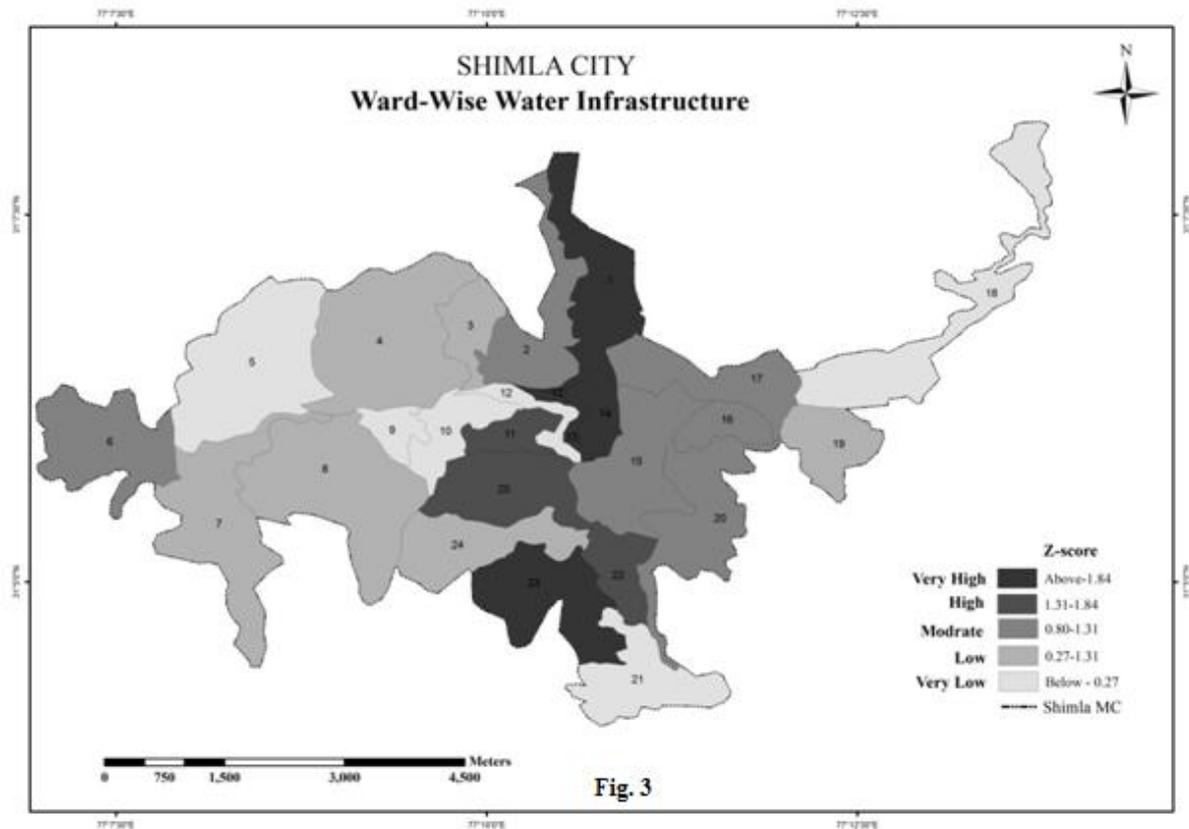

Fig. 3

Table 2 shows that six wards that are represented by low levels of water facilities (0.27 to 0.80 z-score values). Most of them belong to the Chaura Maidan water supply zone, i.e., Kaithu, Annadale, Boileauganj, Tutikandi, and Khalini wards of the city (fig.3). The third ward, Chamyana, is another eastern ward that falls into this category.

Very low level of water facility (Below 0.27 z-score values also includes six wards, most of them lying in the core areas. The number of people living in the Nabha, and Phagli wards of the city made the demand for water rise. The remaining three wards, Summer Hill, Dhalli, and Kasumpti, also had very low levels of water facilities (Fig.3).

VIII. SUSTAINABLE WATER SUPPLY

The sustainable water requirement by Shimla city will be met-out from newly proposed water supply scheme from Pabbar River, the DPR for which already stands submitted for external funding to the Government of India. In Shimla city more newly proposed water supply schemes should be established by the government. The government should be so framed that sustainability would not

only integrate the existing system of water supply but would also envisage a strategic plan consistent with future overall development of the city area. The strategies of sustainable development shall take into account the identification of source of supply, collection, transmission, distribution and other related aspects. It should also be streamlined to fit into the regional development plans, long-term sector plan, land use plan and other open space planning. This scenario may also include the supporting activities like health, education, staff training and infrastructural improvements etc.

IX. CONCLUSION

The study explores that inadequate and unplanned distribution network; the water distribution is not uniform with some areas getting excess water and many areas receiving very less quantity of water. At many places the feeder mains have been tapped directly and used as distribution mains.   At present, the Shimla water system is a non-storage type and has been designed only on the basis of lean period stream flow. Inadequacy of sources is

responsible for water scarcity, hampering developmental and tourists' activities.

The study observed that main reasons for the sub-optimal functioning of the existing water supply system in Shimla city is inappropriate augmentation of source, inadequate storage facility, aged and leaking pipeline network, illegal tapping of transmission water supply pipelines, unauthorized house connections, faulty metering, lack of operation & maintenance of system components, adoption of inappropriate design methodology etc. Certain parts of the city are experiencing severe water supply crisis and level of services offered by service providers has reduced drastically.

Study highlights that per capita availability of water is well below the required norms. The water supply system is under tremendous pressure and water losses due to poor maintenance have made the situation more serious. There is a great disparity between demand and supply of water in Shimla which is around 32 MLD for the city as against the present requirement of 38.4 MLD, considering as a government norms 135 LPCD. In 2071, the number of people who are expected to live there will add up to 72 MLD. Hence, there will be a total deficit of 40.77 MLD in 2071. The inadequate quantity and poor quality of water are always an issue in Shimla. Based on data analysis on water Infrastructure, the city scenario in Shimla is not pleasant. It calls for reorientation in development programmes and a rethink of present policies. Water is a critical concern in the city. Most of the respondents (89.9 percent) are getting water on alternative days and 43.7 percent opined that water quality is good in the city, but most water crises are faced in the summer season.

The founds that sustainable water requirement by Shimla city will be met-out from newly proposed water supply scheme from Pabbar River, the DPR for which already stands submitted for external funding to the Government of India.

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