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Rainwater harvesting in the Wake of Climate Change: A Case Study from Shimla city, Himachal Pradesh

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Abstract:
Shimla city depends mainly on surface water, available in the form of springs, streams and piped rivulets to fulfill its water demand. With rapid development of the city along with the ever increasing tourist inflow, there is a change in the trend of urbanization, which is highly water intensive. Earlier, the water supply system was meant to support a small population, but the population has now increased many folds. The city faces water shortage in every summer leading to huge demand and supply gap. The sources of water are located quite far from the city and mainly tapped from five main sources namely, Dhalli catchment area, Cherot Nallah, Chair Nallah, Nauti Khad (Gumma) and Ashwani Khad. In the face of changing climate, rainwater harvesting (RWH) could be seen as a promising solution to deal with the urban water demand. However, in Shimla city, roof top harvesting is the best way to collect rainwater and then storing it into the reservoirs (either overhead or underground) for further use. From the present study it has been observed that, the city is suitable for rainwater harvesting as it has the required potential for it and receives a good amount of rainfall during rainy season (from June-September), which constitutes almost 70% of the total rainfall in the region. Therefore, RWH can be a viable option to preserve water for the scarce period in the city. It is also necessary now, to educate people and make them aware about the potential and benefits of rainwater harvesting in times of acute scarcity.

Keywords: Climate change; Rainwater harvesting; Shimla

1.0 Introduction:
The Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC, 2007) points out that freshwater availability in Asia is projected to decrease due to effects of climate change. In order to meet our future water needs, we have to work not only towards climate change mitigation strategies but also towards adaptation strategies such as water resource management and conservation of our natural resources. The reasons for the water scarcity are attributed to changing climate due to global warming and the additional burden of non-climatic factors such as population growth and rapid urbanization. Over dependence on secondary sources of water has made us forget that rain is the ultimate source that feeds all these secondary sources and consequently remained oblivious of its importance (CSE, 2010). Following collection, rainwater can be stored for direct use or can be recharged into the groundwater. In urban areas, rainwater can be captured from various surfaces ie., rooftops of the building, paved and unpaved area (i.e, landscapes, parks, open fields, roads etc.) and storm water drains (drains along the roadside). Rain water can be stored in two ways, ie., i) it can either be stored in the containers above the ground or ii) below the ground or it can be charged into the soil as recharged groundwater.

India has a long tradition of rainwater harvesting. Different techniques of rainwater harvesting were earlier developed and practiced in various parts of the country based on the geographical and meteorological conditions of the region. Significant benefits of rainwater harvesting prevail in urban areas as water demand has already exceeded supply in most of the cities in India like Delhi, Mumbai, Bangalore, Chennai, etc. Rainwater harvesting potential of a site is determined mainly by the rainfall and the catchment area characteristics. The need and the design for rainwater harvesting are also influenced by the number of rainy days. The fewer the annual rainy days or longer the dry period, the more the need for rain water collection in a region. For rainwater harvesting, the catchment area of water resources also play an important role. The catchment area characteristics determine the storage conditions. All calculations relating to the performance of rainwater catchment systems involve the use of runoff coefficient to account for losses due to spillage, leakage, infiltration, catchment surface wetting and evaporation, which will together contribute to reducing the amount of runoff. Owing to heavy slope in hills, water harvesting is a very difficult task. Unlike other urban cities in India, Shimla the capital of Himachal Pradesh largely depends on the surface sources like spring or streams for its adequate and safe water demand. In the recent years, the problem of water supply has started increasing rather at a rapid pace, with the growth and expansion of city. In addition, water supply network constructed around 1875 is being still operated although the population has increased many folds (Pubby, 1996).

In this study, Shimla city had been taken as a case study to understand how the available water can be managed well in hill towns by scaling up some best practices, as that can also reduce the pressure on existing resources. This would serve as an example which could be replicated for other hill towns facing similar water shortage situation. Water supply facilities were introduced in Shimla more than 130 years ago during the British rule, by pumping water from nearby spring sources. The first systematic system of water supply was executed in the year 1875 to feed a small population of 16000 people (Pubby, 1996). With the increase in demand, the supply continued to be augmented several times. The system of earlier water supply in Shimla city comprised of tapping of spring water, old baoris and stream sources, treating it and pumping the same to the storage tanks, which was linked with the pipe network and finally carried to the consumer end (Sharma, 2008a). The authorities or the government bodies responsible for water supply in Shimla are the Irrigation and Public Health (IPH) department and the Municipal Corporation Shimla (MCS). The IPH is responsible for operation and maintenance of these systems, while the Shimla Municipal Corporation receives treated bulk water from IPH and distributes it for commercial and domestic connections. The other duties of SMC include, pumping, metering, billing and collection of water charges of potable water (CDP, 2006).

Shimla is a major tourist destination with the state capital attracting, national and international tourists and housing more than 50,000 floating population, comprising of tourists and visitors and a permanent population of nearly 0.2 million people (Joshi, 2008). The city population has grown tremendously in recent years thereby putting lot of pressure on the existing infrastructure of the city. The influx of tourists visiting Shimla increases drastically particularly during summer season leading to increase in water demand. The City requires 42 million litres water in a day (MLD) whereas; it receives only 30 MLD of water (Himvani, 2010) thus facing acute water shortage each year during summer (Table 1). On one side, the influx of tourist increases the business of the hotels and on the other side; it increases the consumption of water in the city by 3 MLD (Susngi, 2010). Hence, there is an urgent need to study the water management framework of Shimla city to address the problem and implement some counter measures or techniques that could be used to deal with the present and future demand of water. Besides, it also requires complete overhauling of the existing water system. Furthermore, there is high subsidy on water in Shimla city, which is putting extra financial pressure on the water institutions. In this regard, rainwater harvesting (RWH) has come out as a viable management adaptation strategy that the water sector in Shimla city could undertake in order to cope with present and future water shortage. The present study therefore, encompasses the following. i) To study various water sources and further augmentation studies. ii) To review and assess various existing steps for water storage. iii) To review practices adopted by Shimla city water supply and distribution systems. iv) Need to undertake rainwater harvesting within municipal limits by people through enforcement.

2.0 Methodology:

2.1 Profile of the Study Area:

Shimla, the capital city of Himachal Pradesh, being a hill town with a very pleasant climate, is a primary tourist destination in the northern part of India. Every summer, this tourist destination faces acute water shortage and the locals are usually the ones to bear the brunt. Over the years, the situation has reached a point where the hotels in the city have to engage private tankers to tap spring water (Sharma, 2008b) and pay a hefty amount to avail their services.

2.2 Geographical Setting:

Shimla is situated in the north of India in the State of Himachal Pradesh. The city is located in the mid hills of the Western Himalayas. It is situated in the Shimla district, which is surrounded by Kinnaur district in the north-east, by Kullu and Mandi districts in the north-west, by Solan and Sirmaur districts in the south-west and by the state of Uttaranchal in the south-east (Figure 1).

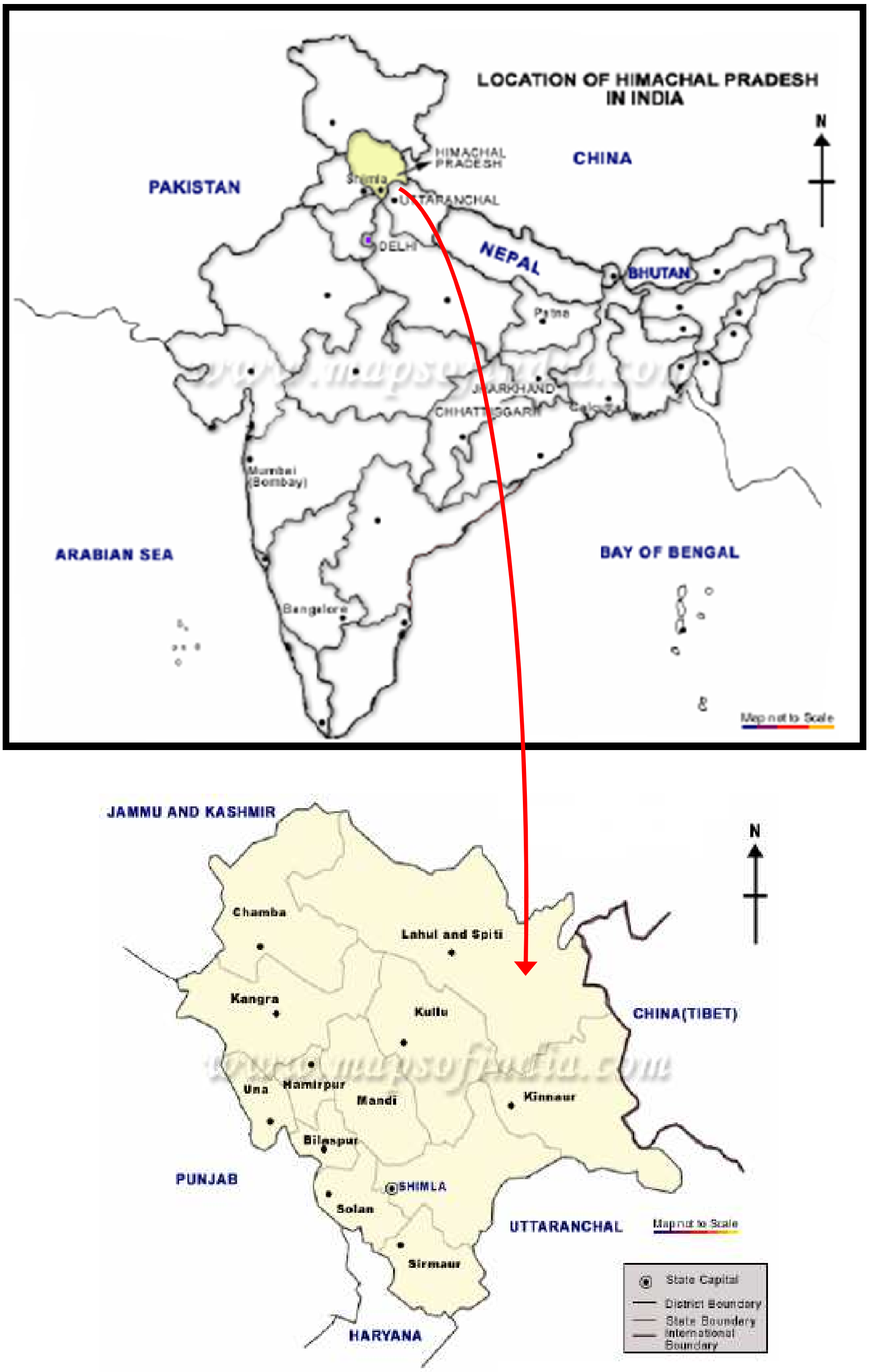


Figure 1.Map of the Study area

2.3 Climate and Rainfall:

The city has a pleasant climate during summer months from April to mid June followed by monsoon up to end of September (Table 2). The city experiences winter from September to March and cold spells between the month of December and February when temperature ranges between -4 to 17 ^{o}C (IMD, 2010). The temperature during summer months varies between 18 and 32 ^{o}C. Average annual rainfall is recorded as 1437.1 mm (IMD, 2010). Most of the rainfall occurs in the month of June, July, August and September, which accounts for 70% of annual rainfall (DPR, 2009) (Figure 2).

2.4 People interviews:

Semi-structured interviews were conducted by targeting the key stakeholders who represent a small population of a particular place. The questions were open-ended and gave the freedom to the interviewees to express their own views. The interview was conducted with different people who are at senior positions at various organizations.

2.5 Strengths & Weaknesses of the Methods Used:

The method used for the study was qualitative in nature; however, it was backed up by the quantitative data. In order to find out the best practices, qualitative research method has been used. Qualitative method generally takes place in a natural setting (Denzin, 1971; Lincoln and Guba, 1985; Marshall and Rossman, 1989) which helps to obtain a more realistic feel of the world that cannot be explained through numerical data and statistical analysis that is used in quantitative research. Therefore, to carry out the analysis for the study, some in-depth interviews were conducted and results were drawn based on the respondent's views. Since, qualitative data is not sufficient to support the interpretations of the study, quantitative data has been used for to avoid any gaps. Quantitative method has its own advantages. Therefore, in order to assess the amount of water, quantitative data was taken into account.

2.6 Secondary Data Collection:

The study was carried out within the Municipal limits of Shimla including the newly added special areas. For data collection and primary surveys, institutions or other relevant sites were informed in advance. Care was taken so as not to disturb the people in odd or non-working hours. Interviews were conducted as per the suitability of the interviewees. The data taken into consideration is from 1980 to year 2005 (Table 1). Parameters like rainfall for last 25 years have been taken into account. The water resources considered for the study is surface water. Information and data is obtained primarily from the official reports, documents and personal communications, which were gathered from the relevant departments.

3.0 Results and Discussion:

3.1 Water Sources and Augmentation Studies:

From the current study, it has been observed that, water for the city is tapped from five main sources namely, Dhalli catchment area, Cherot Nallah, Chair Nallah, Nauti Khad (Gumma) and Ashwani Khad. Department of Irrigation & Public Health have set up pumping stations near all five sources of water with standby tube wells that operate during lean period. At present, the total production of water is about 30.00 MLD which works out an average per capita water supply of 120 litres per capita per day (lpcd) including system loss of about 25% (CDP, 2006). Apart from Dhalli catchments area, the four sources for water supply already developed, are below:

3.2 Dhalli Catchment Area- First supply scheme

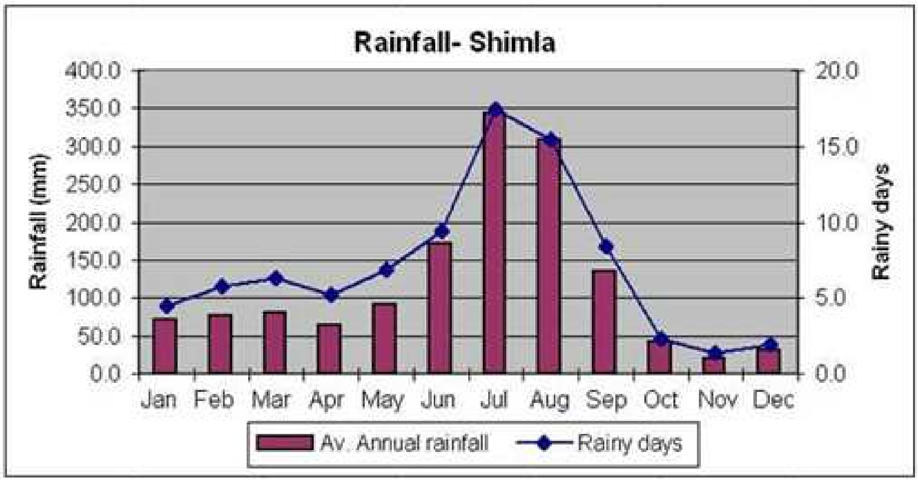
Dhalli catchment area was the first source of water supply based on spring sources of the dense protected forest. An average of 0.45 MLD water is received from this source under gravity condition at Dhalli filter and the source is located at a distance of 12.85 km from Shimla city (MCS, 2010). The water is filtered through slow sand filters and brought to Sanjauli reservoirs for further distribution (DPR, 2009).

3.3 Cherot and Jagroti- First Augmentation:

In 1889, first water supply augmentation was done to cater to the demand of growing population of the city and incoming tourists. Pumps were set near Cherot Nallah having a capacity of 4.8 MLD at source and located at a distance of 8 kms from the main city. The water discharge form Cherot decreases during summer season, therefore another pumping station at Jagroti was established in 1974 to enhance the summer discharge. From this source, an average of 3.5 MLD of water is received which is collected at Dhalli Filter. Part of this water is distributed in the adjoining area of Dhalli Zone and balance is received at Sanjauli reservoir for final distribution through gravity main from Dhalli filter (DPR, 2009).

3.4 Chair Nallah- Second Augmentation:

Chair has a capacity of 2.5 MLD and a direct lift of 885 metres. It is located at a distance of 28 k ms from the city. This source was tapped in the year 1914. From the source, an average of 1.2 MLD water is received which is pumped from Chair source to storage tank at Lambidhar from where water is distributed in Charabra area and the balance water gravitates to the Dhalli filter (MCS, 2010).



Source: CSE (2010a)

Figure 2: Average Rainfall Pattern and the number of rainy days of Shimla

Table 1: Present Water Supply and Demand of Shimla City

S. No.	Description	Amount of water
1.	Total water demand as per city agency (Shimla MC)	42 MLD
2.	Per capita water demand as per city agency (Shimla MC)	135 lpcd
3.	Total available water	30+15=45 MLD
4.	Per capita supply	135 lpcd
5.	15% Leakage loss or unaccounted water	15% of 45 MLD= 6.75 MLD
6.	Total available water after leakage loss	**45-6.75=38.25 MLD**
7.	Actual supply (after deducting leakage losses)	123 lpcd
8.	Demand supply gap (after leakage loss)	**3.75 MLD (approx. 4 MLD)**

Source: Appraisal Report, (2009)

Table 2: Average Rainfall of 25 years of Shimla City (1980-2005)

Months	**Average Annual Rainfall (in mm)**	**Rainy Days**
January	70.9	4.5
February	77.1	5.8
March	81.0	6.3
April	64.6	5.2
May	90.9	6.9
June	171.3	9.4
July	344.1	17.4
August	308.3	15.5
September	135.6	8.4
October	42.5	2.3
November	20.2	1.3
December	31.0	1.9
Total	**1437.1**	**84.8**

Source: CSE (2010a)

Table 3: Storage Reservoirs of water

S.NO	Reservoirs	Capacity in million litres (ML)	Type
1.	Carignano	3.01	Underground (UG)
2.	Sanjaulli	8.78	Underground
3.	Ridge	4.63	Underground
4.	Mans field	3.63	Underground
5.	Kasumpti	2.00	Underground
6.	Kasumpti	0.227	Overhead (OH)
7.	Vice Regal Lodge	0.23	Overhead
8.	Jakhu	0.32	Overhead
9.	Boileaugunj	0.24	Underground
10.	Balancing Reservoir at Mashobra	3.00	Underground
	Total	**26.447**	

Source: DPR, 2009

Table 4: Water zones of Shimla City

S. No.	Name of zone	Area covered
1.	Sanjaulli	Sanjaulli Bazaar, Engine Ghar, Nav Bahar, Snowdown, Jakhoo, Pumping Station, Grand Hotel, Shankli, Scandal, Sangti
2.	Bharari	Bharari, Harvington, Kuftu, Anu, Bermu, etc
3.	Ridge	Telegraph office, Krishna Nagar, Sabzi Mandi, Ripon, Lalpani, Western Command, Ram Bazaar, Middle bazaar
4.	High Court	Lower High Court area, Paradas Garden, Kanlog, Talland
5.	Bishop Cotton School (BCS)	BCS, Khalini, Forest Colony
6.	AG office	Kaithu, Annandale, Kavi, AG Office, Ram nagar Vidhan Sabha, Chaura Maidan, Tuti Kandi, Kumar House, Raj Bhavan, Ava Lodge, Labour Bureau, Kenndy House, Win Gate
7.	Vice Regal lodge	Institute of Advanced Studies, Tilak Nagar, Ghora Chowk, Hanuman Temple
8.	Mansfield	Mansfield to Marina, Secretariat, Chotta Shimla bazaar, Brock Hurst upto Govt. School
9.	Kasumpti	Kasumpti Colony, Lower Brock Hurst, Patti Rehana, Patina Mehli, Pantha Ghati, Patelog
10.	University	University Complex, Summer Hill, Govt. Quarters, Shiv Mandir
11.	Kamna Devi	Hill Spur of Kamna Devi, Forest Colony
12.	Chakkar	Sandal Hill, Tara Devi, Shoghi
13.	Tutu	Tutu Bazaar, Jutogh, Dhamida, Fatenchi
14.	Dhalli	Dhingu Devi Mandir, Dhalli Bazar, Indira Nagar

Source: DPR, 2009

Table 5: Water Cost and Water Charges

S.NO	Description	Cost (Rs, per 1000 litres)
1.	Production cost of water assessed by I&PH department	22.50
2.	Supply of bulk water to Municipal Corporation Shimla	10.64
3.	Subsidy rate for bulk water supply (1-2)	22.50-10.64 = 11.86
4.	Operation and maintenance cost incurred by SMC	6.50
5.	Water distribution cost of Municipal Corporation Shimla	17.14
6.	Water charges for domestic supply	4.25
7.	Cost incurred by SMC (2+4)	10.64+6.50= 17.14
8.	Subsidy rate for domestic water supply (7-6)	17.14-4.25 = 12.89
9.	Total cost of production of water (1+4)	22.50+6.50 = 29.0
10.	Total Subsidy (3+8)	11.86+12.89= 24.75
	% Subsidy	**24.75×100/29= 85.34%**

Source: CDP (2006) & Municipal Corporation Shimla (2010)

Table 6: Projected Water Demand for year 2039

S.No.	Description	Total Population	Per Capita supply (ltrs/day)	Water requirement (ltrs/day)
1.	Permanent population	4, 23,884	135	5,72,24,340
2.	Floating population	16,7111	135	22, 55,985
3.	Fire fighting requirement			20,59,000
			Total	**6,15,39,325 (approx. 61.5M LD)**
4.	Average water available from existing resources			30 MLD
5.	15% Transportation & Distribution losses			4.5 MLD
6.	Total available water			25.5 MLD
7.	Balance water requirement for year 2039			**36.00 MLD**

Source: Adapted from DPR, 2009

3.5 Nauti Khad (Gumma Pumping Station)-Third Augmentation:

Nauti Khad was harnessed in 1924 and is the main source of water supply which provides approximately 16.75 MLD of water. This quantity of water is pumped from Gumma & received at Carignano reservoir from where it is gravitated to the Sanjuli reservoir. From Sanjauli this water is further gravitated to the Ridge reservoir and to Mans field reservoir (DPR, 2009).

3.6 Ashwani Khad- Fourth Augmentation:

From this source, about 7.6 MLD of water is pumped through two stages and received at Kasumpti reservoir. The balance water is again pumped from this reservoir to Mans field tank. From Mans field tank the water is distributed in the adjoining areas (DPR, 2009).

4. Study on Steps for Water Storage:

Water from the above mentioned sources are treated and pumped barring Dhalli catchment source, which operates under gravity conditions. Water thus pumped or gravitated are stored in 10 service reservoirs located at suitable sites covering the MCS (Table 3). The reservoirs located at Sanjaulli is the largest one having a capacity of 8.78ML and the smallest one is situated at Kasumpti having a capacity of 0.227 ML. Newly developed areas of BCS, Chakkar, Totu etc. do not have separate service reservoirs instead they are fed from existing ones causing considerable loss in pressure at the tail end of the network. The city has been divided into fourteen delineated water zones based on topography and location of feeder reservoirs (Table 3).

5. Practices Adopted for Strengthing Water Supply Distribution System:

The current water requirement of the Shimla city is 42 MLD and the available water is 45 MLD, which contains added water supply from Giri River scheme (Table 4). However, due to leakage and losses during transportation, the water available for supply is 38.25 MLD, which shows a gap of 3.75 MLD (DPR,2009). This gap in the demand and supply of water gets widened during summers, when the demand rises up to 45 MLD and supply get reduced. The floating population has assumed to be constant and per capita supply is anticipated to be 135 lpcd (DPR, 2009). The water demand for 2024 is estimated to be 45.3 MLD and 61.5 MLD for year 2039. These figures suggest that the demand for water will continue to increase for next 30 years.

6. Value of Assets and Subsidy on Water:

The production cost of water as assessed by the IPH. Department is Rs. 22.50 per thousand litres and the IPH (Table 5). Department supplies bulk quantity of water to Shimla Municipal Corporation at rate of Rs. 10.64 per thousand litres. The operations and maintenance cost incurred on it is Rs. 6.50 per thousand litres. Thus, the total distribution cost of Shimla Municipal Corporation comes to Rs. 17.14 per thousand litres and the SMC is distributing water to the consumers of Shimla town at the rate of Rs. 4.25 per thousand litres (Table 5). According to the Municipal Engineer of Shimla City, the source of water for Shimla is located very far from the city and in future, the IPH and the Municipal Corporation will not be able to bear the cost of production and distribution. This is because the cost of production and supply has already crossed the limits and SMC does not have any extra resources for further funding. The corporation is charging only Rs 4-5 for domestic supplies whereas, the total cost of production and supply is more than 6 times to this cost (Table 5). In future, this may go out of hand it would be difficult for the departments, the supplier and the distributor to bear such high cost from their own resources.

7. Importance of Rainwater Harvesting by the People:

In recent years a variety of rainwater harvesting structures have been designed to meet various household needs. People living in the city municipal limits need to go for concrete structure of different size depending upon the plot size. Such structures can be either underground or above ground. To meet their water requirement, people have been making underground tanks on slide of building or above ground. These tanks are fed by plastic/PVC (3-4') pipes collecting water collecting from roof tops. The water in the tanks is pumped up with a SHP motor to overhead tanks to meet daily water requirements. For meeting storage requirement plastic syntax tanks are also being used to good effect which require less space and reduce establishing operational costs.

Water requirement in Shimla is growing due to the pressure for developmental activities that anticipates an approximate doubling of the area under urban land use (CDP, 2006). The population of the city is growing rapidly as a result of rural to urban migration and tourist's pressure (Susngi, 2010). Presently the system is not sustainable as it is more than 100 years old and lacks sufficient funds for complete overhauling. Furthermore, climate change too is adding up to the problems in the form of erratic weather patterns which is observed in the form of high temperatures and irregular rainfall patterns resulting in drying of the spring sources during summers (Makhaik, 2010). The town continues to attract tourists and people on official visits from far off places. All these factors are putting tremendous pressure on the existing water resources of the city. As per the future projections (Table 6), the demand of water will get almost doubled in the coming years (DPR, 2009). Even after abstraction of water from downstream River Giri, the city is likely to face a shortage of around 19 MLD by 2024, which would require more expenditure on abstracting water from sources several kilometers away from Shimla city (Tandon, 2008). The sources of water are located quite far from Shimla city and during summers, the flow of water from these sources is reduced. Currently, an additional supply of water has been sourced from Giri River, which is under testing phase, and it provides 15 MLD of water (Kashyup, 2010). Despite improvements carried out so far, the scarcity of water prevails in many pockets of the City. At present, the city receives approximately 38 MLD of water supply (including supply from Giri River) against a current demand of 42.00 MLD, which increases, to 45.00 MLD during summer season. The condition has further deteriorated with the recent merger of special areas of Dhalli, New Shimla, and Tutu. To meet the challenge, municipal corporation supplies water on alternate days and deploys tankers in scarcity-hit pockets of Shimla (CDP, 2006).

The depletion of water sources due to global warming or decreasing forest cover too is responsible for the widening gap between the demand and the supply (MCS, 2010). Due to high temperatures, the natural springs get dried up or reduce their flow during summers. In addition, the century old system of water supply is now wearing out, with increased distribution losses, due to leakages in old and worn out pipes. It was meant to support a small population, but the population has increased many folds. Therefore, the current supply system needs complete overhauling. Furthermore, there is high subsidy on water in Shimla City, which is putting extra financial pressure on the water institutions. The financial health of the water institutions is not comfortable and therefore, if the situation continues, the supply and maintenance cost of the system in the future will become difficult. In view of the present condition of water resources and increasing demands of water for meeting the needs of the rising population as well as likely future problems due to change in climate, a holistic, well-planned strategy with a long term focus is needed for sustainable management of water resources in India (Kumar *et al*., 2005). The unprecedented change in the monsoon related rainfall is expected to have severe impact on the hydrological cycle, thus, changing the pattern, frequency, and intensity of extreme rainfall events (Mall and Kumar, 2009). As estimated earlier by the scientists, the water resources may come under increasing pressure in the Indian subcontinent due to the changing climate (Mall *et al*., 2006). In order to cope with the impacts of climate change which is going to create severe water scarcity, it is high time to plan for adaptation measures and RWH needs to be considered as a 'time-honored' approach for efficient water use in this regard (Rahman *et al*., 2010).

Rainwater-harvesting schemes should therefore be implemented to minimize this run-off loss based on present rainfall scenarios (Burjia and Romani, 2003). It has been observed that the city receives a good amount of rainfall from June- September (IMD, 2010) which constitutes almost 70 % of the total rainfall in the region. Therefore, RWH can be a viable option to preserve water for the lean period. Rainwater harvesting should, therefore be encouraged and enforced as an alternative to provide a solution to water scarcity in the region (Srivastava and Khurana, 2009). Besides harvesting, rainwater has a long-term impact on the local water resources by reducing demands for surface and groundwater withdrawals (UN-Habitat, 2005). According to Samuel and Satapathy (2008), apart from being a useful technology, rainwater harvesting essentially means harvesting and storing rainwater in days of abundance, for use during the lean days. Depending on the plot different types of rainwater harvesting can be undertaken for which augment plans need to be in the place to help people honour the programme.

8.0 Conclusions:

From the current study, it is concluded that, Shimla City depends mainly on surface water available in the form of springs and streams to fulfill its water demand. However, during summers, the discharge from these sources is reduced leading to shortage of water supply. Water is sourced from long distances, which involves high cost and wastage due to leakage during transportation and distribution from source to the consumer end. The demand of water increases from 42 MLD to 45 MLD during peak summer season due to additional pressure from the incoming tourists while the supply ranges between 24 to 27 MLD (DPR, 2009). This shows a huge water demand and supply gap. Rainwater harvesting can be an ideal solution for water problem of Shimla city as the region has the required potential for it and the techniques is already in use at some places within the city. Rainwater harvesting is a necessity due to the possible implications of climate change. There is growing evidence that the changing climate has implications with studies projecting future possible reductions in monsoon related rainfall. Presently, more than 45% of the average annual rainfall, including snowfall in the country, is wasted by natural runoff to the sea. This could result in less availability of potable water in times to come leading to a chaotic situation.

8.1 Recommendations:

Based on the findings from the foregoing discussions, the following recommendations are made:

Increase awareness: There is an acute need to create awareness among people about rainwater harvesting. People should also be trained through government run training programmes conducted by representatives of NGOs, interested individuals at household levels etc. The Rainwater Centre should also be responsible for organizing regular awareness campaigns among people that propagate the need of water conservation and also suggest ways of doing it. The Rainwater Centre should also prepare and maintain a database of implementers, best practices, information on techniques and costs etc.

Explore more options: Groundwater recharge options should be explored to save the maximum rainwater and to avoid its wastage by runoff. This can be done by making recharge pits as the surface of Shimla city is hilly and therefore it doesn't allow natural percolation of rainwater into the ground. In addition to this, recycle and reuse of wastewater should be done by using decentralised systems that treat the wastewater to a stage that can be used for non-potable purposes. Decentralized wastewater treatment meant to treat the wastewater at the same place where it has been generated. It saves the cost of taking wastewater for treatment to far places and then sourcing back the treated water.

Tariffs on water resources: This is one of the key instruments, which can help to ensure that consumers use water carefully. Incentives such as awards, discount on water bills, tax rebate on property. This will also create an obvious pressure on consumers to use the available water judiciously without its wastage.

Adequate infrastructure development for tourism industry:

In order to meet the financial requirements the local bodies can think on generating income by Additional cess on tourist arriving in hotels. Water demand of tourism industry is usually not met by the authorities. This results in purchase of water from private tankers. This puts unaccounted pressure on water resources in Shimla. Tourism industry can be included in infrastructural development in tourist residential complexes.

Inclusion of tourism industry will ensure the satisfaction of industry as well as decrease the pressure on other water resources.

Additional water cess can be charged from hotel industry by the MCS to meet its expense. Construction of small water storage tanks in newly constructed house in MCS be made mandatory. Besides, Subsides for buying collection tanks upto 1000-liter capacity for households needs to be in place.

8.2 Community Participation:
Participation of city residents should be an essential feature of climate change adaptation programmes. Local, civil bodies can make more innovative educational plans for people of surrounding areas to understand the need to conserve water in natural water bodies and maintain them and go in for additional water storage structure.

8.2 Proposed Plans to Address Demand-Supply Gap:
Shimla is covered under the Jawaharlal Nehru National Urban Renewal Mission (JNNURM), which was launched by the Indian Government in 2005 for developing basic infrastructure in over 60 cities in India. Under the JNNURM program of the Government of India, Shimla has been recognized as one of the 63 urban centres eligible for fast growing track development (MCS, 2010). According to the Municipal Engineer of SMC (2010), despite having two rivers, namely Pabbar and Giri flowing near Shimla, the city depends heavily on spring water sources for its drinking water, which is partly responsible for the water shortage the city faces during the lean period from February to May every year. This is because to tap water from these rivers, there is a need of new water supply network and the Municipal Corporation doesn't have sufficient funds to carry out the process. However, there are proposed plans, which are under consideration to supplement Shimla water supply. One of the plans of taking water from Giri River is already in its testing phase and provides 15 MLD of water for the City. Other plans for improving the performance of the existing system through rehabilitation & up gradation need to be geared up for augmentation of water supply through exploration of Pabbar River to meet long-term requirements.

Need policies for effective water management:
- Adequate policies should be framed and implemented for effective allocation of the water resources among competent users. While the prospect of climate change adds an element of uncertainty to the challenge of matching future supplies with demands within the city, it does not alter what needs to be done to ensure that water is managed and apportioned wisely.
- Approved small and big designs of water storage structure should be suggested be MCS for new construction along with the detail cost.
- Local water bodies should be protected from encroachment and animal pollution and fenced.

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