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Impact of Drought on Urban Water Supply: A Case Study of Jaipur City

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Abstract -Ground water level in Rajasthan is depleting in last few years. The state is facing water scarcity problems as a drought like situation. The population of Jaipur city has been increased exponentially in the past few years, leading to acute shortage of drinking water. The water demand has been found to be 419.70 mld and the water supply for domestic purposes as 340 mld, thus, the deficiency in water demand as 79.70 mld. Unfortunately, with diminishing resources of drinking water, the human behavior towards water conservation is not changing. It directly impacts on scarcity of drinking water in droughts as well as in future. The objective of the study is to assess the present status of water balance for the city including all resources and demand of water by the population of the city. It was observed that due to little awareness of people and participation with Government agencies the impacts of drinking water problems during drought can be positively minimized. The outcome of the study would benefit the urban development authorities in optimizing the existing water resources through proper water harvesting.

***Index Terms*— Drought, Water Balance, Demand and Service level.**

I. INTRODUCTION

The drought is just not the scarcity of rainfall but is more related to water resource management. Thus, the conventional attitude to a drought as a phenomenon of arid and semi-arid areas is changing because even areas with high average rainfall often face acute water scarcity (Narain et. al., 2005). Jaipur is the first planned city of India, located in the semi-desert lands of Rajasthan. The city, which once had been the capital of the royalty, now is the capital city of Rajasthan. At present, Jaipur is a major business centre with all requisites of a metropolitan city.

The City with a population of approximately 3.11 million and a growth rate of about 4% per annum, depends almost entirely (97%) on ground water resources for its potable water supply. The current rate of ground water abstraction is not sustainable. The water table throughout the entire city area has fallen dramatically over the past three decades and continues to decline at an alarming rate, accompanied by increasing concentration of nitrates in the ground water supply; the nitrate concentration in the Jaipur urban area have increased from an average of less than 50 mg/l in the early 1970s up to an average of about 250 mg/l (with a peak of over 400 mg/l in some areas) in 2001. The Jaipur water supply problems are well known and the State Government has made long term plans to augment the Jaipur water supplies by developing sustainable surface water resources in the region. The Bisalpur Dam and reservoir, which is located on the Banas River about 120 km south west of Jaipur City, was constructed in the mid-1990s by the Department of Irrigation Govt of Rajasthan, for the purpose of providing potable water supplies to Ajmer City, Jaipur City and other towns in the region, and to provide supplemental irrigation for agricultural lands downstream of the dam site (BWSP Resettlement Plan Vol-2 Report).

The major rivers passing through the Jaipur district are Banas and Banganga. Ground water resources to the extent of about 28.65 million cubic meters are available in the district. Although serious drought is rare, poor water management and exploitation of groundwater with extensive tube-well systems threatens agriculture in some areas. Jaipur has a hot semi-arid climate receiving over 650 millimeters (26 inches) of rainfall annually but major patch of rains occur in the monsoon months between June and September. Temperature remains relatively high throughout the year, with the summer month of April to early July having average daily temperatures of around 30 °C (86 °F). During the monsoon there are frequent heavy rains and thunderstorms but flooding is not common (the only flood which Jaipur faced was in 1980). The winter months of November to February are mild and pleasant, with average temperatures ranging from 15–18°C (59–64 °F) and with little or no humidity. There are however occasional cold waves that lead to temperatures near freezing (City Development plan).

II. JAIPUR WATER SUPPLY

A. Present Status of Demand and Production

The population within the Jaipur Urban Agglomeration was 23.74 Lakhs according to 2001 census. This has been estimated to have risen to about 27.70 lakhs in 2005. Out of this, population within the walled city is estimated to be about 6.50 lakhs, the rest about 22.24 lakhs residing in the colonies outside the walled city (CDP, 2006).

TABLE I: Present scenario of water demand in Jaipur

1	Population of city as per 2001	23.74 Lakhs
2	Present population (2011)	31.12 Lakhs
3	Population connected	27.98 Lakhs
4	Water demand	4197 Lakhs Liters
5	Water supply	3400 Lakhs Liters
6	Deficit	797 Lakhs Liters

(Source: S.E PHED City office, 2011)

B. Extent of Coverage and Service levels

In 2005, the entire population was not dependent upon PHED water supply. According to PHED estimates, about 23.80 lakhs population was being served by PHED water supply system, the rest 3.72 lakhs population was served through other systems developed and maintained by housing cooperative societies or from own sources. Thus in 2005, about 86.50 % populations were under PHED supply system. Production in Jaipur water supply system in that year from all sources was an average 348 million liters a day (mld). This worked out to a per capita supply of 146.20 liters per day for the population under the PHED supply system and for the total population; it worked out to be 126.50 lpcd. Judging by prevalent national standards and compared to water supply systems in most of the large urban cities including metros, water supply system of Jaipur in 2005 and currently, could be termed as satisfactory. These figures however, represent only the production from all sources. Actual quantity reaching the consumers is lower due to high Unaccounted for Water losses (UFWL). A study entitled "Assessment of UFWL and reduction of losses in Jaipur water supply system" was conducted by PHED between 1997 and 1999, which showed that UFWL was as high as 44 % on account of different reasons. This means that against 348 mld productions, the quantity reaching consumer ends was only about 195 mld. In per capita terms, availability at consumer ends is only about 82 liters' per capita a day. This perhaps is the major cause why the general population feels that supply is inadequate against the requirement. Other causes include substantial drops in supply pressures due to large quantities released in short durations (CDP, 2006; JMC).

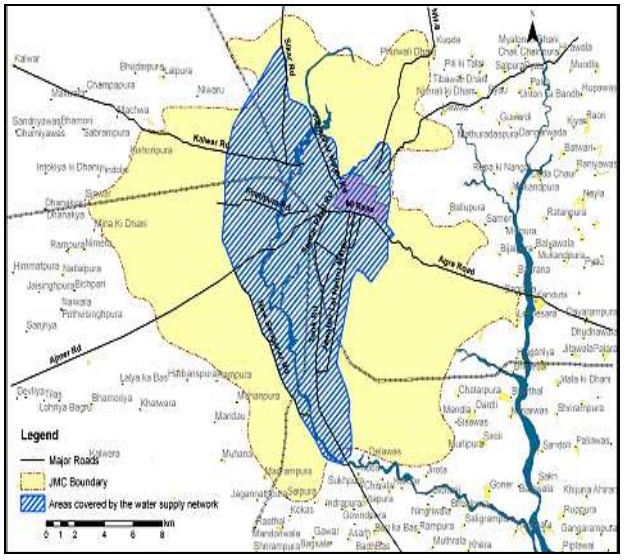

Fig.1: Jaipur Water Supply Network Coverage

C. Existing System Sources:

The corporation operates the majority of the tankers and approximately 1,640 trips per day are required to meet the city's supply-demand gap (PHED 2011) during summer. There are also large numbers of private tankers operating in the city, which has led to the development of parallel, informal water markets. There are several towns and villages in the vicinity of Jaipur. Six of these towns and settlements within a 25-35 km radius have been recognized as satellite settlements and are considered to be within the Jaipur Development Authority's (JDA) planning area (JDA 1995). The Master Plan recognizes these settlements as "appropriate locations for physical growth (of Jaipur city)" and expansion of the peri-urban areas. While RIICO (Rajasthan State Industrial Development and Investment Corporation) has developed industrial areas in the vicinity of a couple of these settlements, most of these settlements rely on agriculture or allied activities as their main occupation (MS Rathore, 2011)

D. Water Supply Situation in Jaipur

Jaipur's water supply system production in 2010 from all sources was an average 401 MLD. Of this, approximately 368.32 MLD came from tube wells, while Bisalpur Dam provided 32.64 MLD (PHED 2011). The current supply is about 148 lpcd for the population under the PHED supply system. This is on par with average public water supply standards in a number of cities in the country, including mega cities like Mumbai or New Delhi. However, only about 90% of the population in the city is covered under the water supply scheme of PHED (LEA & CEPT 2005).The scheme includes mix of supplies from both tube wells, as well as water from Bisalpur Dam. (MS Rathore, 2011)

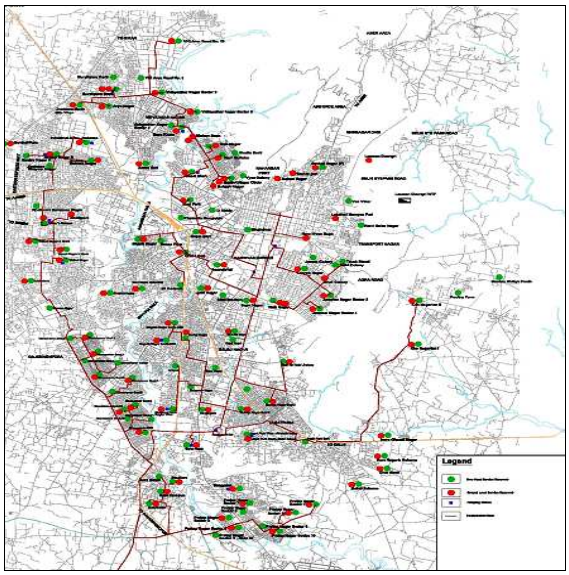

Fig.2: Existing Water Supply System Proposals under Bisalpur Project

Jaipur's water supply system is predominantly dependant on groundwater, with nearly 92% of the population relying on it to meet their needs, even though Bisalpur began serving the city in 2010. There are 1,658 government-owned and operated tube wells scattered throughout the city, which are responsible for the bulk of total production. In addition, there are approximately 2,477 private hand pumps installed at various locations, which help to meet the demand of weaker sections of society (PHED 2011). Local

groundwater extraction rates exceed that of the recharge rate, decreasing water tables at an average rate of 1 meter per year. During the summer months of March-May, the additional demand for water is met by tankers, providing relief to the city's population, especially for those living in areas not supplied by the PHED piped system. The Municipal Corporation operates the majority of tankers and approximately 1,640 trips per day are required to meet the city's supply-demand gap (PHED2011). There is also large number of private tankers operating in the city, which has led to the development of parallel informal markets (Nexus M.S. Rathore, July2011)

The only surface source namely Ramgarh Lake, which used to be the main source of supply more than 30 years back, produces insignificant quantity. After the monsoon of 2005, not enough quantity was received in the lake and the present level is only about 29'. No water is being drawn from the lake at present and the current storage is being kept in reserve to meet the contingency situation during summer season. About 1 MLD is being however drawn from the seepage from the dam. The 1340 tube wells scattered over various parts of the city, are responsible for the bulk of the total production (347 mld). In addition, there are about 1845 hand pumps installed at various locations, which help in meeting the demand of the weaker sections of the society. Details relating to locations of a large number of tube wells, Clear Water and Overhead Reservoirs and their capacities, Hand pumps and productions in different zones are enclosed in Efforts have been made to document details of these to the extent it has been possible to collect the information from the Public Health Engineering Department (Narain et. al., 2005; CDP, 2006; JMC, 2011).

TABLE II: Water Production in Jaipur City

1	From tube wells (1897 nos.)	2900 Lakh Liters
2	From Bisalpur system	720 Lakh Liters
3	Single point tube wells (117 nos.)	15 Lakh Liters
	Total	3635 Lakh Liters

TABLE III: Details of Sources in Jaipur City

1	Tube wells	1897 nos.
2	Hand pumps	1983 nos
3	PVC tanks	510 nos
4	Water supply zones	112 nos.
5	Tankers trip per day	1000 nos.
6	Quantity supplied through tankers	40 lakh liters.

TABLE IV: Water Demand and Supply Scenario

S.N	Year	Population Projections	Average Demand in mld	Proposed Production in mld	Peak Demand From Bisalpur in mld		
					For Jaipur	For Rural	Total
1	2006	30,09,000	400.0	200.0	200.0	40.0	250.0
2	2007	31,16,000	415.5	185.0	241.9	40.0	291.9
3	2008	32,25,000	431.0	170.0	283.8	40.0	333.8
4	2009	33,35,000	446.5	155.0	325.6	40.0	375.6
5	2010	34,47,000	462.0	140.0	367.5	40.0	417.5
6	2011	35,60,000	477.5	125.0	409.4	40.0	459.4
7	2012	36,75,000	493.0	110.0	451.3	60.0	526.3
8	2013	37,91,000	508.5	95.0	493.1	60.0	568.1
9	2014	39,09,000	542.0	95.0	535.0	60.0	610.0
10	2015	40,29,000	575.0	95.0	576.3	60.0	651.3
11	2016	41,52,000	609.0	95.0	618.8	60.0	693.8
12	2017	42,77,000	642.5	95.0	660.6	60.0	735.6
13	2018	44,03,000	676.0	95.0	702.5	120.0	852.5
14	2019	45,33,000	709.5	95.0	744.4	120.0	894.4
15	2020	46,64,000	743.0	95.0	786.3	120.0	936.3
16	2021	47,99,094	776.5	95.0	828.1	120.0	978.1
17	2022	49,34,188	810.0	95.0	870.0	120.0	1020.0

E. Water Balance

An understanding of the water balance of the city is essential to account for different components of water input and output and for reliable water resource planning. In this case for tube wells constituents_290 mld, from Bisalpur system 72 mld, from single point tube wells 1.5 mld thus, total 363.5 mld out of which the water supply has been found as 340 mld. The water demand was estimated as 419.7 mld thus, there is a deficiency of 79.7 mld water which affect on ground water table of the city (Table I,II,III).

A study conducted by PHED during 1997-99 indicated that water table was depleting at an alarming rate of more than 1 m per year and it was predicted that by about 2008, water from Jaipur underground aquifer might deplete. They estimated the depletion of water table at present, which was observed as an average 3 m per annum. (JMC, 2011)

F. Water Resource Potential

The water demand for the Jaipur city for domestic use during normal rainfall can be made sufficient in moderate drought. However, further development of the proposed structures like tanks, reservoirs, nadis, tanks, khadins and anicuts at potential sites will increase the net availability of water. About 70 % of the demand for drinking water can be achieved by these structures during severe drought. Additional requirements for drinking water have to be supplemented through ground water resources or out-sourcing from adjoining regions.

III. CONCLUSION

TABLE V: Issues Reasons and Solutions

Issues	Reason	Solutions
Continuous increase in water demand	Urbanization Industrialization and explosion of population	Integrated water resource management, The policy, "Planning for water resources" indicates that the government would adopt an inclusive and multi-sectored approach

		conjunctive' use of ground and surface water resources.
Depleting ground water table	Extraction of ground water through Wells and Tube Wells, decreasing due to (i) urbanization, (ii) coverage through sewerage system and (iii) erratic rainfall. The combined effect of these factors is resulting in fast depletion of ground water table.	**Conservation of water resources:** In order to conserve and enrich groundwater resources, the policy advises the reduction of groundwater withdrawal as much as possible by conserving water. It proposes that an evaluation of recharging potential groundwater resources should be undertaken for better planning. The policy further recommends an aquifer-wise planning of groundwater resources quite similar to the river basin approach for surface water planning. **Augmenting surface water sources:** The policy recommends that traditional water harvesting structures be encouraged, in addition to the re-use of treated waste water along with promoting rain and storm water harvesting.
Deteriorating water quality	Inefficient Sewage network and Sewage treatment	Proper sewage collection, transportation and treatment system to be developed

In the past few years, ground water level in India as a whole and in Rajasthan, in particular is going down. The State is facing a drought like situation. Ninety-nine percent dams of Rajasthan are completely or are at the verge of drying. Major cities like Jaipur is facing tremendous problem of drinking water. The city has adequate water supply with an availability corresponding to 126.5 lpcd covering more than 86.5 % population. However, on account of a high UFW (unaccounted for water) of 44 % the net water supply gets reduced to 82 lpcd. The main source of water is ground water, which is fast depleting as a result of growing population. It has been found that presently there is a deficiency of 79.7 mld in water demand. To overcome this problem it is recommended that there is an urgent need to work on ground water recharge as conjugate use of water; use of ground water and storage function of aquifers to supplement or regulate surface supplies under the simplest form of conjunctive use plan ground water providers would use surface flow when legally available during runoff periods and would rely on wells during periods when surface during periods when surface flow is unavailable. By Integrated water resource plan; in order to suggest integrated management of water resources plan, two basic principles which are to be considered are (a) water should be considered as an economic, social and environmental good, and (b) to promote efficient, equitable and sustainable development through integrated water resource management, rainwater harvesting, water audit for domestic purpose, re utilization of treated waste water.

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