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An analysis of water supply system in Jaipur city: Problems and prospects

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Abstract

Water is the elixir of life as there cannot be any sustenance without water. With the increasing population, urbanization and industrialization, the dependence on the water resources has increased manifold. Jaipur is the 10th most populated district in India. There is no perennial river in the region and the ancient surface water resources have fast depleted. The traditional water supply sources of the city are in a degraded situation due to lack of attention. The single source of water supply to the city is Bisalpur dam which was commissioned in 2009 depends on the vagaries of rainfall. Due to absence of sufficient surface water resources, the ground water resources are heavily exploited. The total annual ground water recharge of the district has been assessed to be 77.71 mcm and total extractable ground water has been estimated to be 699.43 mcm. Gross annual ground water draft for all uses has been estimated to be 1617.21 mcm with the stage of ground water recharge at 231.21%. (Central Ground Water Board Report, 2020) The highest exploitation is in the Jhotwara block. This poses a serious threat to the question of water sustainability. Due to the increasing concretization and cementing of the pavements we have prevented the percolation of rainwater into the ground as a result of which the recharge of aquifers is not taking place. Drinking water crisis is emerging as one of the biggest problems in the city as many localities are receiving very little water for few hours or dirty water. The lakes located in the district are heavily polluted and industries and commercial sectors are discharging their waste effluents in them. So, there is a problem of not only rapid falling of the water table but also of the quality of water resources. In Sanganer, the water is heavily contaminated with fluoride. Similarly, the walled ancient city of Jaipur is having high salinity in the water. There is a need of not only preserving the water resources but also ensuring their quality.

Keywords: Ground water, over exploited, sustainability, effluents, concretization

Introduction

We cannot imagine the world without water. But we do not take steps to preserve it and ensure its quality. The whole issue of sustainability revolves around getting fresh environment which includes getting fresh air, water and land. The Sustainable development goal 6 declares the importance of achieving “clean water and sanitation for all”. The primary source of water on the planet Earth is rain water which recharges all the aquifers, fills the rivers, lakes, ponds, dams and oceans. If we do not allow the rain water to be locally stored it will vanish as surface run off and there will be no raising of the water table. The study is based in Jaipur which is the capital of the state of Rajasthan and supports a population of 3258299 according to 2011 census.

Initially the capital of the Kachawahas ruler who ruled over Jaipur was Amber which is 11 kilometers away from Jaipur. The capital was designed in such a manner that the state does not face any shortage of water. There was provision of water resources for both the residents and the military personnel. The Maota lake located beneath the Amber fort used to supply water to the royalty and the people living there. Similarly, there is a grand Tanka (ground water Tank) in the Jaigarh fort which used to supply water to the army personnel. It is an example of extraordinary water harvesting technique. There were more than a dozen bawaris in the Amber region which used to supply water to the city but today these sweet water reserves are in a dilapidated condition. When Jaipur was established by Sawai Man Singh II in 1727 the city was designed in such a manner that the residents do not face any water crisis. For this purpose, kunds were constructed in all the corners of the city, the Badi Chaupar, Choti Chaupar had underground kunds which were all filled with water. But today all the resources have depleted due to negligence. Once a lifeline of Jaipur the Ramgarh dam is completely dried since 2000 which once provided water to the city and was also used for

the irrigation purpose in the nearby villages. Now the single source of water supply in the Jaipur region is the Bisalpur dam which is located in the Bisalpur village in the Todaraisingh tehsil of Tonk district. It started supplying water to Jaipur district, Ajmer and Tonk districts since 2009. It is the biggest masonry concrete dam of Rajasthan. However, the dam is located 120 kilometers away from Jaipur and there are various issues like water leakage through the pipes, low pressure of water supply at the consumer's end, and all the tehsils are not connected with the Bisalpur pipeline. The villages not covered with the Bisalpur pipelines face acute shortage of water resources and the problem gets compounded during the summer season. The issue of sustainability of water resources is a major concern here.

Study Region

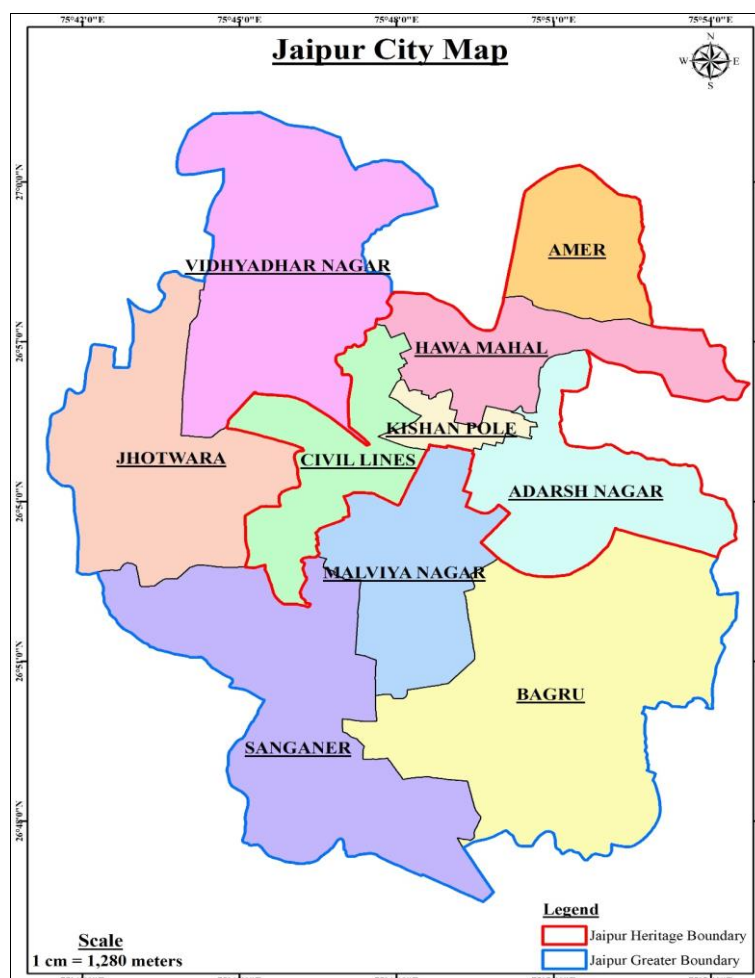
The city of Jaipur was established on 18 November 1727 by Sawai Jai Singh II, who was patron of mathematics and astronomy. The city is one of the planned cities of medieval India having a latitude of 26°9'N and a longitude of 75°8'E with an average altitude of 431 meters. The city is built on the grid pattern which shows the acumen of the ruler in geometry and architecture.

The city is surrounded by Nahargarh hills in the North and Jhalana hills in the East. In the south, it opens into a plain. The city is densely populated with a population of 4.008 million in 2021. It is situated in the eastern part of the state and is one of the fastest growing cities of India.

Climate: The city experiences semi-arid climatic conditions. The summer season commences from April and the temperature rises to a peak of 45 ° Celsius in summer in May -June. Summers are followed by monsoon which begins from first week of July and downpour is received till mid-September. The city receives its maximum rainfall in the monsoon. This rainfall is useful for recharging the aquifers and serve as a store house for use in agricultural and allied activities. Monsoon is succeeded by the winter season when the temperature dips and the lowest temperature is 10° celsius in January. Mawath, a local rainfall occurs in the winter season due to western cyclonic disturbances and it is good for wheat, a rabi crop.

Drainage

The overall slope of the city is from hills in the north to plains in the south and then to the east. There are some seasonal streams in the region. The Dravyawati river rises from the Nahargarh hills in the North of the city. The dhund river rises from the east and flows from North to south at a short distance. Bandi flows in the north west of Jaipur city about 20 kilometers away from Jaipur. Pre independence all these rivers carried fresh water in them which was used by people for their consumption. But today due to increased anthropogenic interference the rivers look like a dirty nallah. Ramgarh dam once the major source of water supply in Jaipur city was constructed on Banganaga river, 30 kilometers away from Jaipur. The current water supply system is from the Bisalpur dam located 120 kilometers from Jaipur city built on the Banas River.



Map 1: Map of Jaipur City

Objectives

1. To study about the traditional water supply systems in the Jaipur city.
2. The paper will explore the water supply systems of Jaipur district post-independence and their present situation.
3. To analyze how the water management issue has become a big concern in the study region and how can the problem be minimized.

Data Base and Methodology

Both primary data and secondary data has been used to analyze the situation. Primary data has been collected through field visits to some selected sites like the ancient bawaris, old wells, Man Sagar Lake, Mawatha lake, Sagar Lake, Galtaji, Ramgarh dam, Bisalpur dam to get an insight to know about their present situation and how they were functioning before. Secondary data has been compiled from the government reports like reports of Public Health and Engineering Department, Reports of Central Ground Water Board, Report on the Aquifer Mapping and Management of Ground water Resources 2020, NGO reports etc. Both the primary and the secondary data has helped to analyze the situation of ground water reserve sin the study region.

Hypothesis

- Increasing urban population has an adverse effect on both the quality and quantity of both surface and ground water resources in Jaipur city.
- There is a demand deficit of water supply in the city due to institutional failure.

Results and Discussion

The city of Jaipur was established in such a way that the topography was utilized in the best possible manner to preserve water. The city is surrounded by the Nahargarh hills in the North, and Jhalana in the East, which is a part of the Aravalli hill ranges, there are isolated and discontinuous hillocks in the west and the south of the city and towards the south there is open plain. So, the city being surrounded by the hills allowed for the natural recharge of the water. When the city of Jaipur was established, there was an increased focus on the canals, ponds, reservoirs, dams, tanks, kunds, wells, step wells, channels and aqueducts. This system was helpful in conserving the rain water and its distribution for catering the various human needs within and outside the city. The ruler of Jaipur was very much concerned with the water supply system that he had given enough attention on the problem of water resources since beginning.

There was an integrated system of water management in the city like kunds existing in the centre of Bari Chaupar and Choti Chaupar which were further linked to the wells and the stepwells. Several bawaris were constructed in and around the region which provided sweet water to the residents and also helped in recharging the aquifers. Some prominent bawaris include Pana Meena ki bawari, Kale Hanuman ji ki Bawari, Jagga Bawari, etc. The ancient capital Amber has a large number of water bodies like lakes, Kunds or tanks, Baolis or step wells. The most prominent being the Maota lake located below the Amber palace. Another is the Sagar Lake situated to the north west of Jaigarh fort. There are two bawaris named as Khasa bawari and the Panna Meena ka kund which are located in the Amber. Similarly, there is an elaborate arrangement of

water supply in the Nahargarh and Jaigarh fort which throws light on the fact that water was central to the planning of the city. Wells and open wells were once the important source of water supply like in 1700. The early water supply of Jaipur district initially relied upon the ground water but the topography of Jaipur was considered and the drainage pattern allowed for recharge of the ground water. The Dravayawati river was also dammed to utilize the water. However, this water system was able to meet the demand of the city until the first quarter of the 20th century.

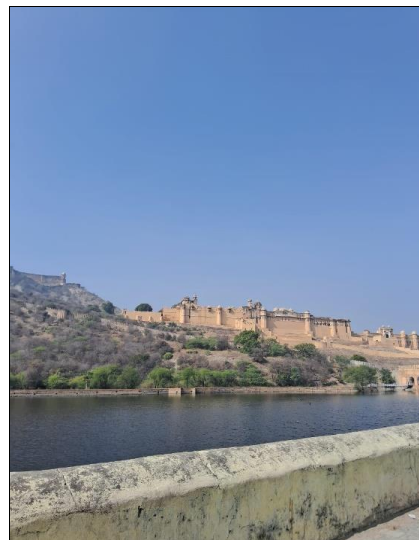


Fig 1: Maota lake, Amber



Fig 2: Tanka in Jaigarh Fort

In 1903, a large reservoir and dam named Ramgarh dam was constructed 30 kilometers northeast of Jaipur district. It used to receive water inflow from the Banganga river. Initially the water of the Ramgarh dam was used for the irrigation purposes in the nearby villages. From 1925 onwards with the generation of the power system the water was brought to the Jaipur district. By 1931, water was reaching the Jaipur city through Amanishah Nallah system and the Ramgarh dam system. In 1953 the capacity of Ramgarh dam was increased from 9 million liters per day to 27 million liters per day. In 1963 the capacity of the dam was further increased from 27 million liters to 53 million

liters. In 1976 the capacity was increased to 129 million liters per day. In the 1980's the Ramgarh dam started showing the downfall. After 1983-84, the water level in the Ramgarh dam never went above 54 feet. By 1999 there was no water recharging the dam. The dam was silted up to 14 feet which led to the reduction in its storage capacity. There was illegal encroachment in the catchment area of the lake which intercepted the flow of water into the dam. Agricultural activities rose in the area. Thus, the failure of the Ramgarh dam to supply water led to over dependence on the ground water resources.

Due to the drying up of the Ramgarh dam, emergency measure was sanctioned in 1989-90 which led to the installation of 202 handpumps and 31 tubewells, later these handpumps became abandoned or dried up. Thus, there was a need for a new water supply system for Jaipur. The Bisalpur project came up in 1990 after other investigated sources were found to be inefficient. The Bisalpur dam is located in the Tonk district about 150 kilometers from Jaipur and supplies water to Jaipur, Tonk and Ajmer district. It started supplying water to Jaipur since 2009. The capacity of Bisalpur dam is 1095 million cubic meters. The Bisalpur system consists of two parts: a transmission system and transfer system. The Bisalpur project is conceptualized in

such a manner to meet the water needs of a fast-growing city and to reduce its over dependence on the ground water reserves. Phase 1 of the Bisalpur project was designed in such a manner to supply 400 MLD with 360 MLD for Jaipur city and 40 MLD for the rural areas. The Phase 11 expansion program is designed in such a manner to provide a total of 540 MLD of treated water to Jaipur city and 60 MLD to the rural areas.

Rainwater which recharges the aquifer is still the significant source of water supply and is used in the agriculture, industrial and domestic sector. Public Health and Engineering department is responsible for supplying potable water to the people here. According to the PHED report (2012), there are a total of 390,893 water connections with 352,393 working connections, 384,058 metered connections, 6835 flat rate connections, 329,093 domestic connections, 51246 non domestic 1 connection, 3719 industrial connections and 1170 public stand post. Another common source of water supply to the areas where PHED does not supply water is through tanker transportation.

Urbanization in Jaipur has contributed to the increased demand for all the resources like water supply, change in the land use/ land cover pattern.

Table 1: The population data for a specific region from 1871 to 2011, along with the annual percentage growth rate for each decade

Years	Population	Variation	Percentage Growth per Annum
1871	137,887	-	-
1881	142,578	+4690	0.34
1891	158,905	+16,327	1.14
1901	160,167	+1262	0.79
1911	137,098	+23,069	-1.44
1921	120,207	+16,891	-1.23
1931	144,179	+23,972	+1.99
1941	175,810	+31,631	+2.19
1951	291,130	+115,320	+6.55
1961	403,444	+112,314	+3.85
1971	636,768	+233,324	+5.78
1981	1,015,160	+378,392	+5.94
1991	1,518,235	+503,075	+4.95
2001	2,324,319	+806,084	+5.30
2011	3,471,847	+1,147,528	+4.94

Source: District Census Handbook, Jaipur (1881-2011)

Since post-independence there has been rapid population growth in the Jaipur city in 1911 and 1921 the population rate was in negative due to epidemics throughout the country. Since 1951 the population has been growing rapidly. During 1951-61 the population growth rate slowed down due to change in the definition of the urban areas but since then it has been increasing.

This urbanization has posed serious impacts in the following ways:

Urban Impacts on Hydrology

In the initial stages of the expansion of the city, the expansion took place in the foothills and thus it could not distort the surface drainage patterns. When the expansion took place, people began to fill, block and divert the streams of Jaipur. There were around 518 rivulets originating from the Aravallis. 398 1st order stream, 92 2nd order stream and 25 3rd order stream and 3 4th order streams. Many streams were used for dumping garbage and many streams have been blocked or have been filled for the construction

purposes.

Urban Impacts on the Surface water

Degradation in the Quality of water

Industries around the prominent water sites have greatly degraded the quality of surface water. The Amanishah Nallah has become so foul smelling that it is difficult to stand by the side of it. Chandlai lake located in the Chaksu block is heavily polluted. These polluted water resources not only become the breeding ground of mosquitoes but also pollute the ground water by direct seepage to the aquifers.

Depletion of surface water: A look at the land use change in the Ramgarh dam area

Indicates that the agricultural activities which greatly increased in the region led to a reduction in the water capacity of the dam.

Urban Impact on Ground water

Jaipur's ground water resources exhibited high water table

and good quality originally. Today the ground water reserves have depleted beyond a critical limit. Urbanization and industrialization have led to the overexploitation of the water resources.

Destruction of Ground water Recharge System

Anthropogenic activities like deforestation, destruction of local water systems, stoppage of river flows and paving/concretization has led to the destruction of the natural recharge systems.

Deforestation results in the loss of the top most soil and thus reduces infiltration. As the built-up land increases the

recharge to the ground water is reduced. Thus, the land use change greatly affects the recharge potential of an area. The alluvium areas contribute to the recharge and are now considerably reduced.

Depletion of ground water

The loss of forest lands, agricultural fields, pasturelands and open waste lands due to urbanization, building of roads, houses or commercial complexes has reduced the open areas in Jaipur. As the open areas have shrunk there is a fall in the water table.

Table 2: Status of Ground water extraction in Jaipur

Assessment Unit Name	Total Annual GW recharge (in Ham)	Stage of GW extraction (%)	Categorization
Amber	4181	224.04	Over exploited
Bassi	5602.07	230.86	Over Exploited
Chaksu	6076.9	238.47	Over Exploited
Dudu	1003.26	115.31	Over Exploited
Govindgarh	5329.25	332.59	Over Exploited
Jalsu	4316.62	214.59	Over Exploited
Jamwa Ramgarh	7774.81	153.76	Over Exploited
Jhotwara	4882.87	474.95	Over Exploited
Kotputli	2750	282.62	Over Exploited
Paota	3268.73	260.65	Over Exploited
Phagi	5402.76	118.70	Over Exploited
Sambhar	5958.32	280.37	Over Exploited
Sanganer	4387.4	272.48	Over Exploited
Shahpura	2999.1	316.67	Over Exploited
Viratnagar	4776	174.97	Over Exploited
District	77715.17	231.21	Over Exploited

Source: Central Ground Water Board, Jaipur, 2020

From the above table it can be seen that all the blocks in Jaipur district are in the over exploited category and Jhotwara block shows the maximum extraction of ground water reserves. Nearly all the blocks are overexploited.

Degradation in Ground water Quality

Fluoride Pollution

Fluoride pollution is heavily seen in Sanganer village. There are many small scales dyeing industry in Sanganer which discharge their effluents in the Amnaishah nallah which seeps underground. Another reason is excessive ground water withdrawal which results in magnifying the inherent fluoride ions from the fluoride bearing rocks.

1. Nitrate pollution
2. Salinity
3. Heavy Metals

Urban Impact on Natural gradient and Flood area

Local flooding has increased as there is fast urbanization in the Jaipur city and we have lost open spaces which are necessary for recharge of the ground water.

An Overview of the Water Supply system in Jaipur

There is no single government entity that controls or manages the urban water supply. The PHED is mainly responsible for supplying water however Jaipur Municipal Corporation, Rajasthan water resources Department, the State Water resource Planning Department and others are also involved in water planning schemes in Jaipur.

Jaipur's water supply system is mainly dependent on tubewells. Many of the tube wells are fitted with power pumps which supply water to clean water reservoirs and five

elevated storage reservoirs. According to a study by the PHED, there are 1340 tubewells scattered throughout the city and 1845 handpumps. There are estimates that there are 20,000-30,000 unaccounted for tube wells in Jaipur. The situation in Jaipur is critical as there are several places receiving erratic water supply for 30-40 minutes per day. Overall, the water quality in Jaipur is found to be acceptable however at some places there are issues of high fluoride and nitrate concentration. According to PHED, Jaipur has 100 online chlorination plants on direct supply tube wells and 12 electro chlorinators are pump stations to purify water from Bisalpur.



Fig 3: Bisalpur Pipe line

Future water Supply Scheme

When the city of Jaipur was established, enough attention was made to ensure water availability throughout the region. We had several water harvesting structures like step wells, wells, kunds, lakes, reservoirs etc. But with the increase in the population the pressure on water resources increased and the dependence on the traditional water resources dwindled and these water harvesting structures fell into disuse. Today there is complete dependence on the ground water resources and no attention is made to recharge the aquifers. Thus, there is an immense need for switching over to the rain water harvesting systems. Roof top rain water harvesting should be given importance. The wells in the study region have become abandoned. Some new techniques like recharging wells through rain water harvesting is a new concept that was observed in the Chaksu block. Water conservation through rain water harvesting should be made as a mass awareness program and campaign. It is important to educate people in this regard. However, our city is facing the immense problem as it inhabits the maximum population. There are certain blocks like Jhotwara, Sanganer, Khatipura which are heavily occupied with the industries like Sanganer has traditional printing mills. The tie and dye industry of Sanganer is contributing to the maximum discharge into a feeder of the Dravyavati river. The entire block of Sanganer has degraded ground water quality due to the discharge of the effluents from the industry. The old city of Jaipur is also no more an exception as it has immense urban population to support and houses several karkhanas or industries. The entire city receives water from the Bisalpur supply system but the supply is highly erratic and at several times it is supplied for a very less time. The crisis accentuates in the summer season when some places receive water after 2 days or more. The electric motors have tremendously increased the problem as the water is extracted with a very high pressure.

Recommendations

1. The water conservation can be made possible by bringing mass awareness and educating the public about conserving the water.
2. There should be emphasis on developing open spaces in the city like open spaces like gardens be built and there should not be concretization and cementing everywhere.
3. Roof top Rain water harvesting should be made a prerogative. Its implementation must be ensured. Rajasthan Government has made it compulsory for houses of 300 square feet or more to have a compulsory water harvesting structure and the industries having 500 square feet or more must have compulsory water harvesting structure. It should be strictly enforced.
4. There should be a sewage treatment plant at Sanganer as the tie and dye industry dumps all its effluents in a feeder of Dravyavati which is polluting the surface source water and ground water.
5. Stringent measures be adopted for drilling of tubewells as they are even drilled where there is no water availability.
6. When the city of Jaipur was established by Sawai Jai Singh II, he paid enough attention on the water supply system of the city that the city faces no water crisis. But today due to lack of attention the traditional water bodies have been discarded and they no longer serve

the purpose. So, a comprehensive planning be made to revive the traditional water supply systems.

7. Several NGOs are working in the direction of water conservation like Jal Bhagirathi Organization, Tarun Bharat Sangh, Gram Navayuvak Mandal of Lapodiya. The Government should work in close cooperation with them and they should also provide training to the youth to conserve water.
8. Industrial and sewage waste water be treated so that it can be reused in the industrial, irrigation sector. Reuse and recycling of waste water be promoted.
9. As the city is expanding fast it is not possible to keep open areas for recharging the water so artificial recharge sites be made to promote percolation of water.
10. To promote optimum utilization of water drip irrigation and sprinkler irrigation be there.
11. Consumer metering is an important to do. As it will curb the misuse of water and will keep a check on the irregular use of water

Conclusion

Arid to semi-arid conditions prevail over Rajasthan. The state also faces uncertainty and unevenness of rainfall. The city of Jaipur is facing increasing water scarcity as the surface water sources have diminished and the ground water resources are getting fast exhausted. There is demand deficit in water supply. Several colonies report irregular and erratic water supply. So, there is a need to adopt integrated water resource management, research new ground water resources availability, rain water harvesting, water audit for domestic uses, treatment of industrial and domestic water through sewage treatment plants. Higher tariffs prevent excessive consumption pattern. In turn it will change the practice of water consumption. So proper measures be taken by the concerned authorities to prevent misuse of water.

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