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Sustainable ground water management: A case study of Jaipur district

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Abstract
Jaipur district is the most urbanized and industrialized district in Rajasthan. There is no perennial river in the region. The rivers like Banganaga, Dhundh, Masi, Morel, Sabi are the ephemeral streams which drain the region. There are a few lakes in the region like Mansagar lake, Ramgarh lake, Maota Lake, Sagar Lake etc. which are currently not fit for consumption. As of 2020, all the 15 blocks of Jaipur district are in the overexploited category. (CGWB report, 2020). Agriculture sector is the biggest consumer of water in the region, followed by the industrial and the domestic sector. The changing land use land cover dynamics has also changed the pattern of ground water recharge in the region. With more urban landscapes emerging in the region, there has been reduction in the open areas, and recharge potential of the ground has also been limited. It is very important to construct rain water harvesting structures in the region, where the water table has gone down tremendously. In the urban areas there is a need to adopt roof top rain water harvesting technology. In the agriculture sector less water intensive crops be sown and more emphasis to be laid on precision agriculture for promoting ground water reserves. This paper explores the diminishing ground water reserves in the district and suggest measures for recovering them.

Keywords: Ground water, perennial, over exploited, recharge, diminishing

Introduction
Water is the basis of life on the earth. The earth has limited fresh water resources availability. This limited resource is used in all walks of life. Water is found as surface water and ground water. Surface water is found in rivers, lakes, ponds, dams, etc. whereas the ground water resources are found in the voids or space found in the earth which depends on the local geology of the region. In India, highest reserves of ground water are found in the Ganga Yamuna Doab belt whereas the limited ground water reserves are found in the basaltic belt of Peninsular India. In Rajasthan, the ground water reserves are variable. There is high water table in hadoti belt due to high rainfall and high recharge potential of the land where as it is lowest in the western landscape due to underlying aquifers and very scarce rainfall. Jaipur district has varying aquifers like young alluvium, older alluvium, granite, gneiss, quartzite, schist etc. Younger alluvium and older alluvium constitute the major aquifer here. In the last few decades there has been change in the land use land cover pattern of the district, and rainfall patterns due to which once rich ground water reserves have declined in the district. In the absence of sufficient surface water reserves, the ground water resources are over exploited. There are some zones in the district which have come under the dark zone. This could become a serious calamity in the future if adequate water harvesting structures are not constructed and water conservation measures are not taken on a large scale, the ground water reserves would be completely depleted.

Study Region
Jaipur district is situated in the eastern part of Rajasthan. In the north it is bounded by Sikar district, in the east lies Alwar and Dausa district, in the south lies Tonk district and in the west, it is bounded by Ajmer and Nagaur district. It stretches between 26 °30´ N to 27 ° 15 ´ north latitudes and 75 ° 30 ´E to 76 ° 15 ´ East longitude. The total area of Jaipur district is 11,136.2 square kilometres. It is first planned city of modern India and was initially built to support fewer people but with time the population also expanded and the population also increased. Total population of the district is approximately 66, 26,178 (census 2011).

Physiography
Jaipur district has an undulating topography, the central and the western part of the district is even and hills are observed in the east and the north. The general topographic elevation of the district is between 300-400 m above the mean sea level. Hills are prominent in the north and the north eastern part of Jaipur district, some hillocks are observed in the west and in the south west, while there are low land plains in the south.

Drainage
The slope of the city has a trend from the hills in the North and to the plains in the South, then to the South - east. Nearly all ephemeral streams flow in this direction. The major rivers draining the area include Sabi, Banganga, Bandi, Mendha, Mashi and Sota rivers. Sota and sabi rivers flow in the north easterly direction, Banganga flows in the south western direction and flows through Viratnagar, Shahapura and Jamwa Ramgarh. Mendha flows in the north western part of the district, and it merges with the Sambhar Lake and Mashi river flows in the south western part of the district.

Soil
The major part of the district has alluvial sandy soil which is spread in the eastern half of the district. The western part has desert and seirozem soil. Regosols and Lithosols are spread in the hills and foothills have yellowish brown soil.

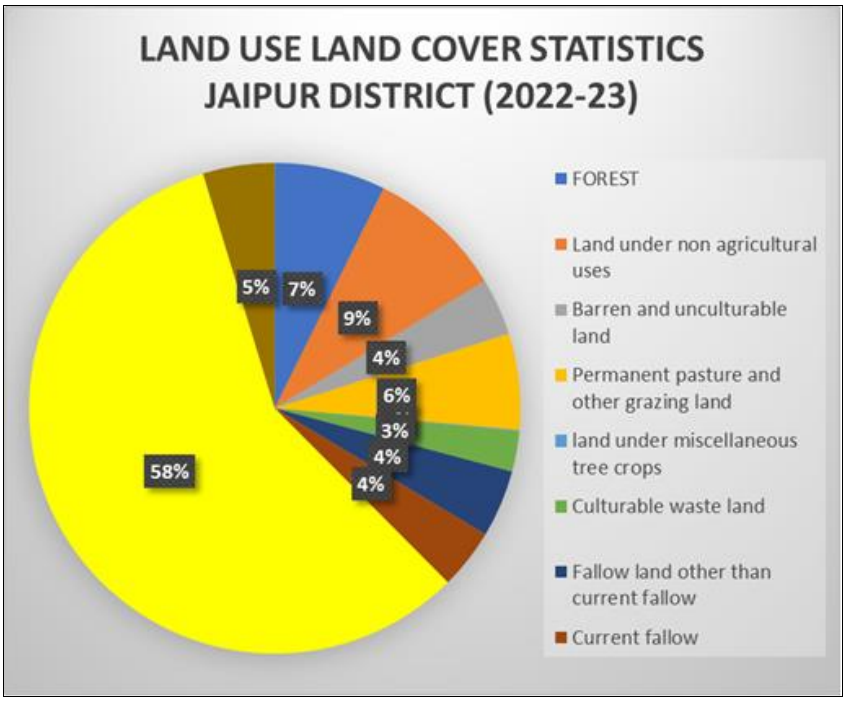
Climate
Jaipur district has semi-arid climate. The summer season commences from the mid of March and the temperature rises to as high as 44 °Celsius in May/June. The summers are then followed by the rainy season. The rainy season commences from the first week of July and lasts till last week of September. There is again rise in the temperatures in the October followed by a dip in the temperature in November. The lowest temperature is observed in January when the temperature falls to as low as 10°celsius. Mawath a local rainfall which originates due to the western disturbances, causes rainfall in the winter season and is good for the growth of wheat.

Land Use
The land use of a region is a complex interplay of social and economic factors of a place. The land use pattern of a place is controlled by the factors like land forms, soil, slope and natural resource of a region.

Table 1: Land Use pattern of Jaipur district

Category	Area in hectare (2022-23)
FOREST	83852
Land under non-agricultural uses	103147
Barren and unculturable land	43229
Permanent pasture and other grazing land	72600
land under miscellaneous tree crops	963
Culturable waste land	30355
Fallow land other than current fallow	50821
Current fallow	45402
Net sown area	661428
Area sown more than once	54050

Source: District Statistical Abstract, Jaipur district, 2023-24.



Source: District Statistical Abstract, Jaipur district, 2023-24

Chart 1: Land Use Pattern of Jaipur district

From the chart it can be seen that 58 percent is occupied by the net sown area, the agriculture sector occupies the largest area whereas the forest occupies only 7 percent area.

Agriculture

Agriculture is largely confined to the traditional kharif crops, which are dominantly dependent on the monsoon, whereas the rabi crops are mainly irrigated. Major crops grown are Bajra, Wheat, jau, gram, rai, mustard, Ground nut, taramira etc.

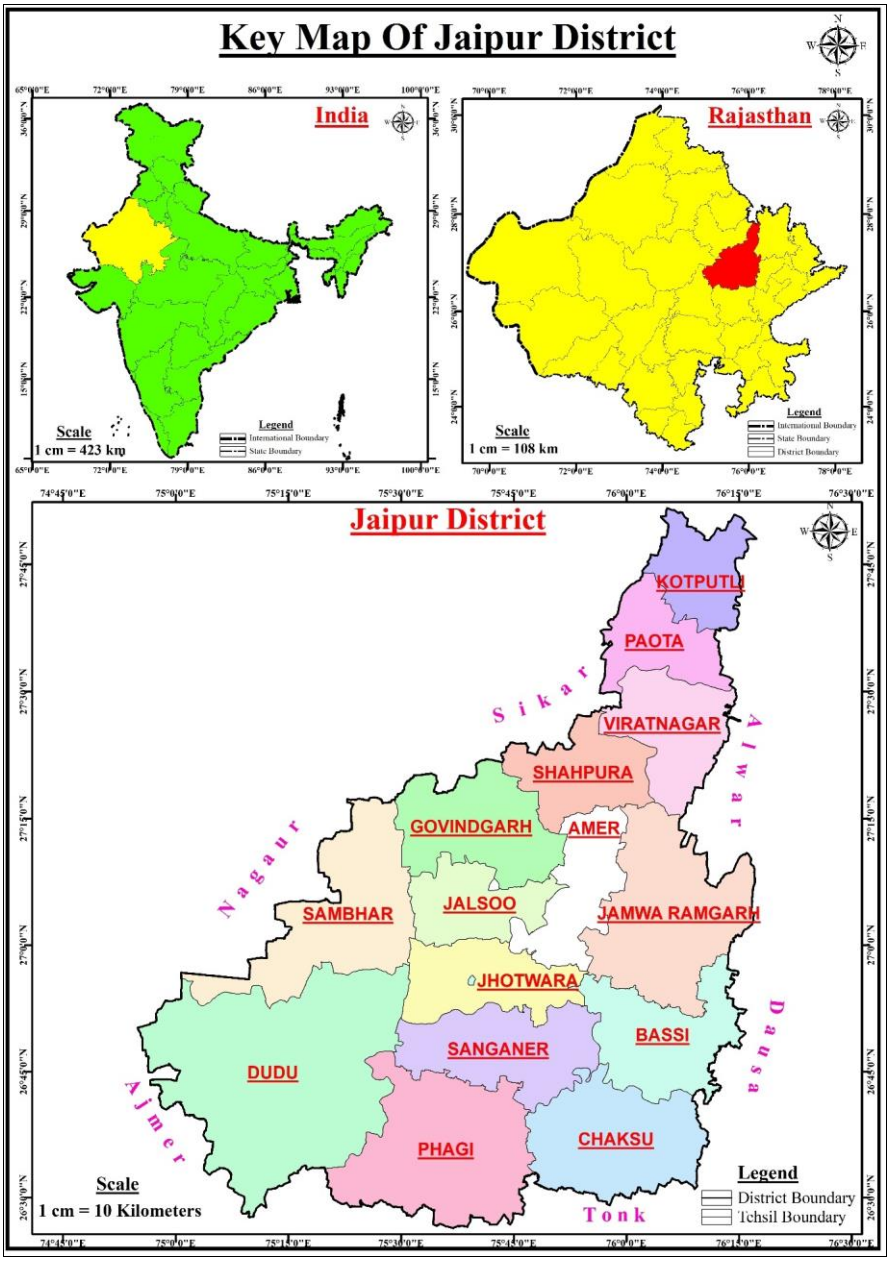
Irrigation

Irrigation is mostly through wells; a very small part is fed through canals also in Phagi. Ground water plays an important part in irrigation and it contributes about 95 percent of the irrigation needs.

Table 2: Area under Irrigation, Jaipur district

Area Type	Area in hectare	Area in Percent
Net Irrigated area	280330	100
Gross irrigated area	342458	
Area irrigated by GW in ha	279044	99.54
Area irrigated by ponds in ha	1286	0.46
Canals	0	
Other sources	0	
No of dug wells	143423	
No of tube wells	57401	

Source: District Statistical abstract, Jaipur district, 2021-22



Source: Survey of India

Map 1: Key Map of Jaipur district

Objectives

1. To assess the ground water resource availability in the district and its usage in agriculture, industrial and domestic sector.
2. To understand the quality of ground water resources in the region.
3. To find out the suggestive measures for promoting ground water reserves in the study region like the need for rain water harvesting and water conservation measures.

Data Base and Methodology

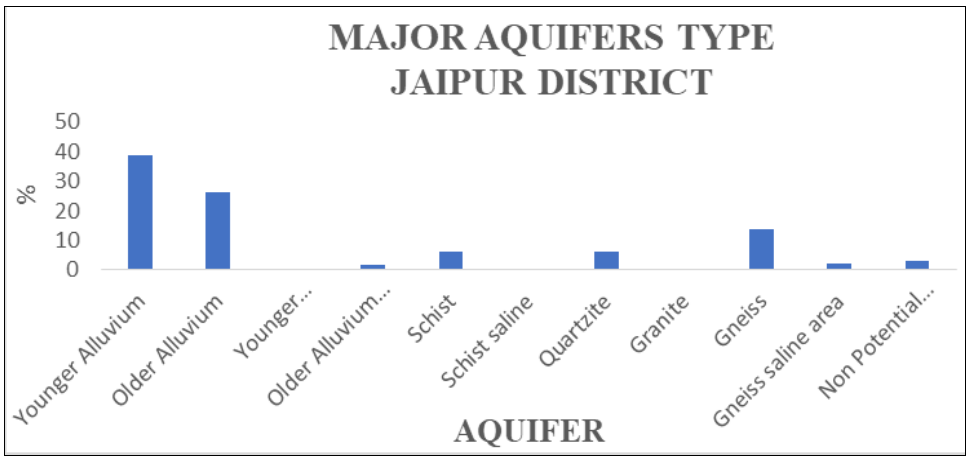
Both primary and secondary data has been used for the study. Primary data has been collected through field surveys and information was collected from the farmers through schedule in some randomly selected blocks of Jamwa Ramgarh, Bassi, Amber, Chasku, Dudu, Chomu to know about the irrigation practices and overburden on the ground water reserves, interviews of the officials at Ground Water Board, Jaipur, hydrologists, NGO's etc. were taken to assess the reality whereas the secondary data has been collected from government reports like NAQUIM reports Central Ground Water Board, District outline report, Agricultural statistics report, PHED reports etc.

Hypothesis

- Increased urbanization and industrialization have put pressure on the ground water resources of the region which has affected both its quality and quantity.
- Appropriate water harvesting structures can play an important role in raising the water table of the region which in turn could bring productivity in the region.

Discussion

Ground water resources of a region are significantly determined by the aquifer composition of a place. Ground water in the district is found in a number of lithogenic units ranging from younger alluvium to old Gneisses. Younger alluvium, older alluvium, granite, gneiss, quartzite, schist forms major aquifer in Jaipur district. Some aquifers are saline also.



Source: Report on Aquifer Mapping and Management of Ground water resources, CGWB, Jaipur

Graph 1: Major Aquifers of Jaipur District

The younger alluvium which comprises the maximum part is composed of consolidated and semi consolidated clay, sand, pebbles, etc. and is spread over the northern part of the district. Older alluvium is also composed of consolidated clay, gravel, sand, silt. Older alluvium is spread in the southern part of alluvial spread between Bassi-Jaipur-Kishangarh Renwal and extends till the beginning of the hard rock aquifers. Schist is found in the south of Sambhar, North east of Jamwa Ramgarh, and North and south of Chaksu, Quartzite which occupies 6.4 % area is found in west of Chaksu, between Bassi and Viratnagar, around Amber, in the west as strip in Kotputli, and Shahpura. Granite which occupies only 0.4 % forms aquifer along the edge of Jamwa Ramgarh block, Gneiss which occupy 13.9 % area forms aquifer in south western part of Jaipur district in Dudu and Phagi.

Ground water resources are classified as static and dynamic resources. Static ground water resource is called as in storage reserves. Static ground water reserves are not replenished every year whereas the dynamic ground water resources are replenishable. Static ground water resources are spread abundantly in the older and younger alluvium. Static water resources are the highest in the younger alluvium but it is lowest in the phyllite and schist aquifers. Quartz and Gneiss also forms aquifers in some places. Govindgarh has the highest potential of static water resources. Good amount of static water resources is also found in Amber, Chaksu, and Phagi. Static water resources are found in less quantity in Jamwa Ramgarh, Kotputli, Jhotwara blocks of district.

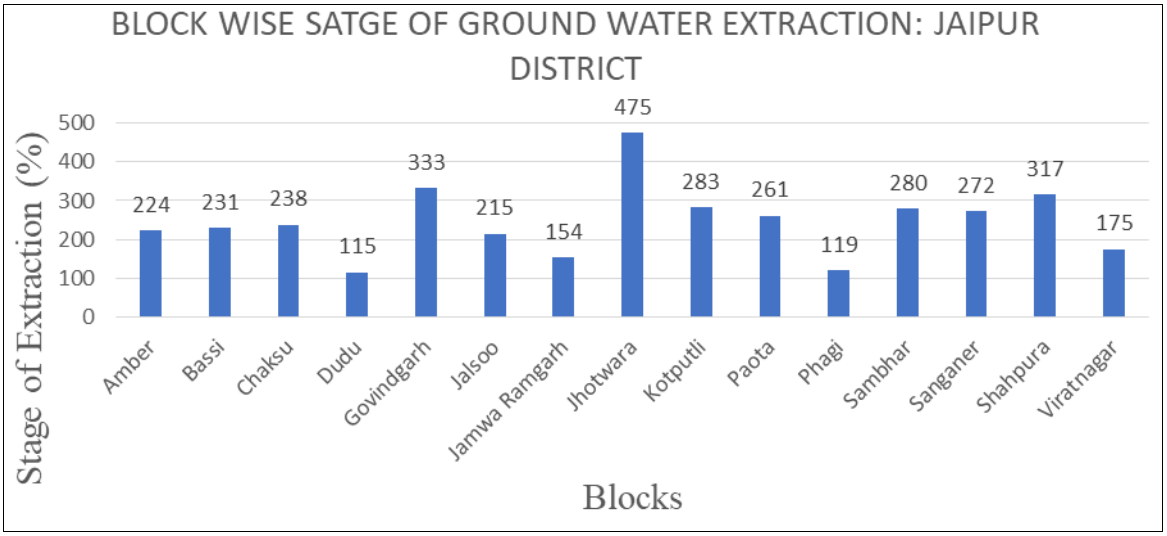
Whereas Dynamic ground water resources are found abundantly in the older alluvium whereas they are found in the least in the quartzite aquifer. Amber, Chaksu and Govindgarh have dynamic ground water resources whereas Shahpura has least.

Increased demand of water in all the sectors has led to overexploitation of ground water reserves in all the blocks of Jaipur district which is represented through the following table.

Table 3: Status of Ground water resources in various blocks in Jaipur district

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

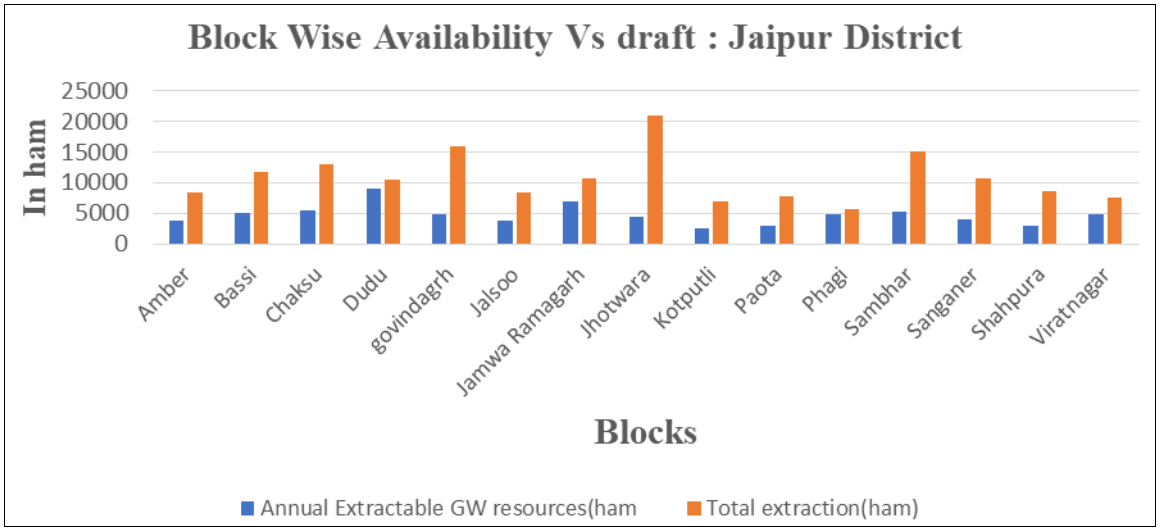
Source: Report on Aquifer Mapping and Management of Ground water resources, Central Ground Water Board, Jaipur, 2020



Source: Report on Aquifer Mapping and Management of Ground water resources, Central Ground Water Board, Jaipur, 2020

Graph 2: Block wise stage of Ground water Extraction in Jaipur district

From the above table and the graph, it can be seen that the ground water reserves are in a distressful situation. The ground water extraction is highest in Jhotwara block, followed by Govindgarh due to high population pressure and industrial activities in the region. Shahpura also has high ground water extraction. The other blocks also have high rate of ground water extraction which is posing a serious problem for the whole district.



Source: Report on Aquifer Mapping and Management of Ground Water Resources, Central Ground water Board, 2020.

Graph 3: Block wise Availability vs. Draft 2020: Jaipur

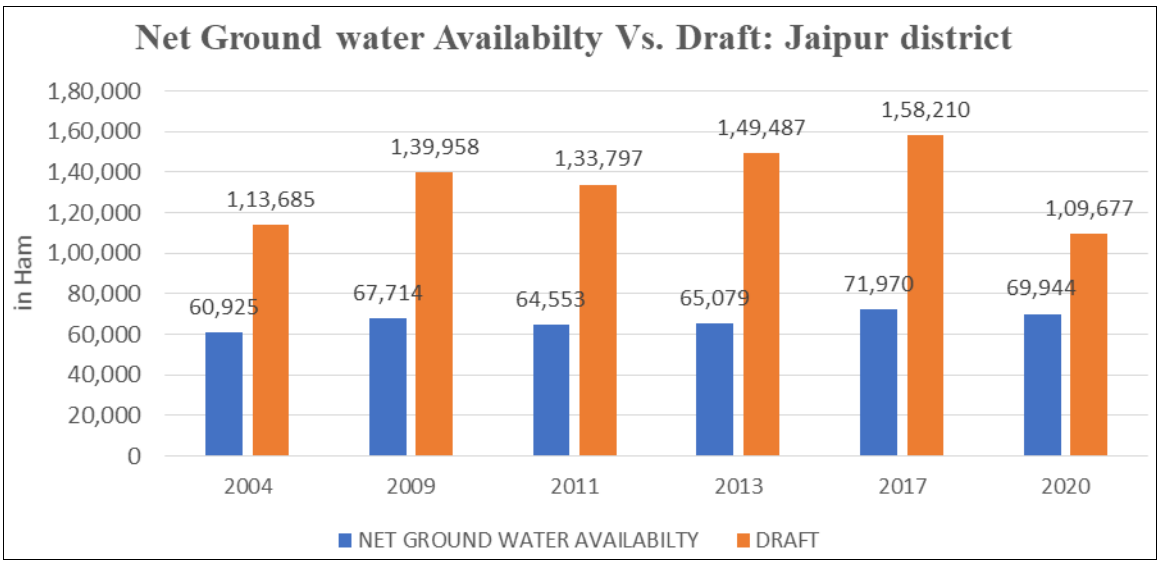
The graph above infers that in all the blocks the ground water draft is much higher than the ground water availability. As per the Ground Water Resource Analysis 2020 the district is deficit of 918 mcm ground water. The maximum extraction of ground water is in the irrigation sector. All the blocks are categorized as Over Exploited and needs necessary actions like water conservation and measures of harvesting rain water

Table 4: Annual net Ground water draft, (ham) 2004, 2008, 2012, 2017 and 2020

Year	Agriculture	Domestic and Industrial	Total
2004	91996	21689	113685
2008	114640	25316	135597
2012	108111	25686	133797
2017	117891	31596	149487
2020	109676.8	52043.72	161720.52

Source: Ground Water Year Book 2004, 2008, 2012, 2017 and 2020

From the above table it can be seen that the net annual ground water draft has increased significantly from 2004 which was 113685 ham to 161720.52 ham in the year 2020.In the agriculture sector the annual net ground water draft was 109676.8 ham in the year 2020 which has increased form 91996 ham in the year 2004. There has been a rapid increase in the ground water demand for industrial and domestic purposes also due to increasing population pressure and the demand of water in the industry. The demand of ground water has increased by 58 % from 21689 ham in the year 2004 to 52043 ham in the year 2020. This shows that the water is extremely exploited by the growing industrial sector.



Source: Aquifer Mapping and Management of Ground Water Resources, Central Ground water Board, 2020.

Graph 4: Net Ground Water Availability vs. Draft in Jaipur district

It can be seen that in all the years the ground water draft is much higher than the ground water availability. However, it could be seen that in the year 2020, ground water draft has reduced considerably over the years and the ground water availability has increased. This is due to the sustainable ground water recharge practices. Thus, there is an immense potential of adopting water harvesting structures for mitigating water crisis.

For understanding the ground reality field survey was conducted in some random villages of Amber, Bassi, Chaksu, Dudu, Chomu, Jamwa Ramgarh blocks. At all the places where the water recharge structures were not there, the water table was very deep in those regions. For e.g. in the Amber block, the villages surveyed were Natata, Naradpura, Saiwar, Labana, all the villages reported declined water table, there was no agricultural activities in these regions, and the villages were dependent on the tanker systems. In Chomu also the falling water table has led to decline in the size of land holdings as the land is unproductive for agricultural operations. Only those villages where there are water harvesting structures like farm ponds, there were agricultural activities. In the areas near to Ramgarh dam the water table was very deep. The tubewells in all these villages were providing water from a depth of 800-900 feet. In the villages where rain water harvesting structures are built on a larger scale, the water table is high there. For example, in Laporiya village, by community consciousness there has been revival of several water harvesting structures and thus the entire region has witnessed productivity and self-sufficiency in agricultural production there. The same model needs to be replicated in other villages also, which are seriously facing water crisis. The deep ground water resources also face other quality issues like:

Declining Ground water level trends (2011-2020)

Water level is declining at an average rate of 0.50 m/year when analyzed for the years (2011-2020). There is decline in the water level trend in both the pre monsoon and post monsoon seasons in the entire district except in Dudu, Phagi and Chaksu blocks

Deeper water levels
There are few shallow aquifers in the Jaipur district due to the overexploitation of ground water resources than its recharge. In a larger part of the district the water tavble lies below 40 meters below the ground level.

Limited Ground water Potential
Due to the depletion of the shallow aquifers, the hard rocks lying below the alluvium has less secondary porosity and permeability and thus this in turn has very less ground water potential.

Ground Water Quality
There are several problems like the issue of inland salinity and anthropogenic constituents like nitrate and other pollutants.

Inland Salinity
The southern block of the district comprising of Dudu, Phagi and Chaksu are afflicted with the problem of inland salinity. The values of electrical conductivity are high in these regions making it unfit for drinking or irrigation purposes.

High Fluoride
There is high fluoride content in the samples collected from throughout the district. The worst affected blocks are Phagi and Chaksu where 67 % and 60 % water samples have been found out with high fluoride concentration. Viratnagar, Dudu and Sanganer also have nearly 35 % samples with high fluoride concentration. Consumption of fluoride rich water may lead to dental or skeletal fluorosis.

High Nitrate
High nitrate concentration is also spotted throughout the district, and about 38.34% samples had nitrate concentration beyond permissible limits of 45 mg/l. The worst affected blocks are Sanganer, Amber, Jhotwara, Chaksu and Kotputli blocks.

The consumption of water which is heavily contaminated can pose serious health issues and thus needs urgent attention. So certain measures are recommended for the restoration of healthy ground water reserve which are as follows:

- For planning for the management of ground water reserves in an area, the government must address factors like low rainfall, limited ground water storage, ground water salinity, excessive fluoride, nitrate concentration, deep water levels etc.
- It is important to put regulation on the extraction of water from deeper aquifers. So that the deep aquifers are protected for future generations.
- In the urban areas, due to paving and cementing the surfaces, infiltration and interception of rain water has become almost impossible. So, roof top rain water harvesting has to be adopted compulsorily. It is mandatory for every household built on 225 sq. meter of plot to have a compulsory rain water harvesting structure whereas commercial building built on a 500 sq. meter of plot must have a compulsory rain water harvesting structure.
- In the year 2024, there was heavy rainfall in the district. The water table rose in some areas also where there were recharge structures, otherwise the rain water flows as surface run off. Thus, a huge amount of water is wasted in the absence of harnessing the water through water harvesting structures. The rain water harvested can be used for other purposes like in irrigation sector, domestic sector etc.
- Traditional water harvesting structures like bawaris or step wells, kunds or step tanks, old talabs, ponds which are in a dilapidated state needs urgent attention for repair, so that they could serve as potential source of water supply and in turn reduce dependence on the ground water.
- In the urban cities more green spaces like parks, gardens be constructed for promoting recharge of ground water.
- In the agriculture sector, less water intensive crops like gram, pulses, bajra, jowar, vegetables like raddish, cauliflower, tomato be grown in place of water intensive crops like rice, sugarcane, cotton, wheat,
- Micro irrigation practices like drip irrigation and sprinkler irrigation be promoted in place of flood water discharge.
- Sewage Treatment plants be built so as to recycle waste water which could be used in non-potable domestic and irrigation sector.
- Stringent rule must be laid for the over exploitation of ground water resources. Farmers must be provided training on adopting efficient crops that are suitable for the region.

Conclusion
Water Conservation must be made focal point of development. The third world war will be fought for water. Over extraction of groundwater reserves have not only degraded its quantity but also its quality. The need of the hour is to sustainably manage it. Remote Sensing and GIS can be effectively used to map aquifers, and to know about its quality, and it's in storage. Local level water harvesting measures play an important role in increasing the ground water recharge of the area, which in turn will raise the water table in the region. Capacity building must be developed among the farmers to promote the judicious usage of the water resources. Stringent laws must be placed that curb industries to dump their effluents in the water resources. Mass awareness on the sustainable usage of ground water reserves can play a massive role in bringing behavioral change in the people to conserve the sacred resources.

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