Water Resources Management in Arid and Semi-Arid Regions of Rajasthan; A Case Study

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Abstract—*In this paper an effort has been made to examines the existing water resources of Rajasthan state in order to assess the efficacy of water resources of Rajasthan in fulfilling the water requirement for different purposes. Rajasthan state is chosen in present study because it is nearest available arid and semi –arid region and detailed data were available for this region. Rajasthan is situated about 200 km from Aligarh city. It was easier to approach the area under study for verification of the available data.To accomplish this task various published reliable well established geographical and hydrological data of the state and the district-wise present and future population of people and livestock were collected. It includes.*

Keywords*: Fresh, water, scarcity. pollution, life styles, population.*

1. INTRODUCTION

Water is a precious resource which is essential for the survival of life. It is used in various sectors like irrigation, hydropower generation, industries and institutions, domestic purposes, navigation, wildlife etc on which country's economy depends. However, this resource is limited and also not properly managed. The quality of surface and ground water is also degrading due to improper disposal of the waste in rivers**.** In the developing countries, about 80% of diseases are water borne and nearly 1 out of every 5 deaths under the age of 5 worldwide is due to a water-related disease. These water scarcity and degraded quality constrains have jolted the whole world to take the right steps toward managing and improving this most valuable resource for the sustainable health. Exponential growth in population and rapidly changing life styles of people are worsening the problem of water scarcity. Water scarcity problem becomes further complex in arid and semiarid regions. Therefore, the available surface water and ground water resource has to be properly managed by using water optimally in every sector of water use. Under these circumstances it is essential to understand and find new ways and techniques to preserve and augment the good quality water resource. Present study is concerned with the water resources management in arid and semi-arid regions of Rajasthan. Rajasthan state is chosen in present study because the detailed reliable data are available for this state.

2. REVIEW OF LITERATURE

Rainwater harvesting in general and domestic rooftop water harvesting in particular, spatial and temporal trends of domestic water use, water legislation, climate change challenges, increase in water productivity, poverty levels, hydrology, agricultural production systems, institutional, legal and regulatory arrangements in place to address the challenges, pollution control, water use efficiency, protection of vital ecosystem, provision of water in the water scarce regions through IBWT programme, adaptation of strategy of extensive utilization of recovered water by improving the treatment plant and quality of effluents, social life of the people, economy of the country, fresh water resources and their quantity , quality, demands and the management related problems in India, ill effects of saline water on the crops and the method to use this saline water for irrigation, surface water resources potential, various water conservation options, use of crop residue mulches, occasional shallow cultivation especially after each rainfall and large scale adoption of the drip (trickle) irrigation system, access to safe drinking water, sanitation , food and energy at reasonable cost. Scarce, population growth, agricultural, pollution, water quality and ecology; culture, myths, perceptions and public understanding, are the issues addressed by several investigators including Donato et al (2014), Goutam Sadhu et. al. (2014)), Bin Guo et. al. (2013), Marcella Nanni (2012), Sami Abdul-Rahman et. al. (2011), Seleshi Awulachew et. al. (2010), Bin Liu & Robert Speed (2009), Pieter S. V. H. Heyns et. al. (2008), C. D. Thatte (2007), Gangyan Zhou (2006), Commission on Sustainable Development (2005), Sharad K Jain et. al. (2004), Ayaman F. Abou-Hadid (2003), Christos A. Karavitis & Petros Kerkides (2002), S. Ethan & A. Umar (2001).

3. DATA COLLECTION

3.1 Area of Rajasthan

The north-western state of Rajasthan is the largest Indian state with an area of **3, 42,239 sq.km** comprising of the **10.41%** of the total geographical area of the country. This state stretches

lengthwise **869 km** from west to east and **826 km** from north to south.

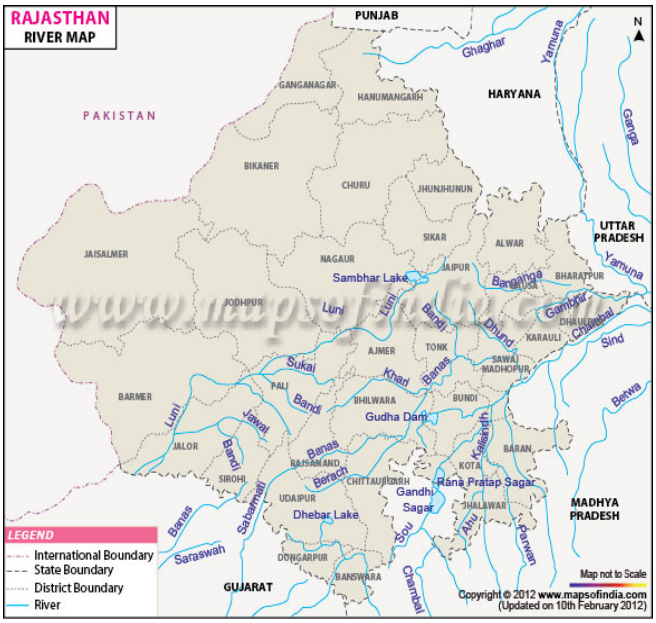

Fig. 1: Rivers in Rajasthan

Fig. 2: River Basins in Rajasthan

3.2 Water Availability in Rajasthan

Basin-wise annual surface water and ground water yield and the water transported from neighboring state like Haryana, Punjab, Madhya Pradesh and Gujarat are collected from Water Resources Department , Government of Rajasthan. Latest data regarding water quality of major rivers, minor rivers, canals, lakes and ponds and ground water are collected from Central Pollution Control Board (CPCB).

3.3 Profile of Rajasthan (given in tables 1 to 6 and figures 1. And 2.)

Table 1: Physical details of Rajathan

Particulars	Contents
Location	Western state of India bordering with Pakistan
Latitude	26.5727° N
Longitude	73.8390° E
Area	342239 km2
Human	68548437
Literacy rate	66.11% (less than avg. Indian literacy rate
Occupation of	Agriculture(mainly), trade and business
Cattle population	61192840

Table 2.Sources of surface water

Rivers	Chambal, Ghaggar-Bhakra, Sabarmati, Luni, Banas, kali sindh, Jawai, Ahar, Gambhir, West banas, Arvari,
Lakes	RaJasama and lake, Fateh Sagar lake and Pichola lake in Udaipur, Ana sagar lake in Ajmer, Pushkar lake, and
Canals	Agra canal, Indira Gandhi canal, Narmada canal,
Dams	Jawai dam, kota barrage, hemawas, Rana Pratap sagar dam, ummed sagar bandh, Bisalpur dam project, Gambhiri dam, Jawahar sagar dam, Kot (Sikar) dam,
Tube	1205267 (total in India 19124383) as on 30/04/

Table3. Land use distributions

Total land	342239 km2
Agricultural land	45415.12 km2 (13.27 % of the total area)
Non-agricultural land	296823.88 km2 (including forest cover)
Forest cover	15229.95 km2 (4.45 % of the total land of

Table4. Hydrologic characteristics

Average annual rainfall	Avg. annual rainfall 574 mm (Low and erratic rainfall deviates from as low as 100 mm in Jaisalmer (Lowest in the state) to 550 mm in Ajmer and highest (1638 mm) in Mount Abu (Sirohi district) situated on southeast region of
Duration of rainfall (monsoon period)	The southwest monsoon which has its beginning in the last week of June in the eastern parts, may last till mid-September.
Droughts	1 in every 2.13 years
Estimated total revenue receipts for 2015-16	111361.66 crore

Table 5. Important Crops

Crop	Kharif	Rabi
Part of	Pearlmille, Mothbean,Sesamum	Wheat, Mustard,
Ganganagar	Cotton,Clusterbean	Wheat, Mustard,
Bikaner,	Pearlmillet, Mothbean,,	Wheat,Mustard,Gra
Nagaur,	Pearlmillet, Clusterbean,Pulses	Wheat,Mustard,
Jalore, Pali,	Pearlmillet,Clusterbean,Sesamu	Wheat, Mustard

Ajmer,	Pearlmillet,Clusterbean,Sorghu	Wheat,Mustard,Gra
Alwar, Bharatpur,	Pearlmillet,Clusterbea, Groundnut	Wheat, Barley, Mustard, Gram
Bhilwara, Chittaurgarh,	Maize,Pulses, Sorghum	Wheat, Mustard, Gram
Dungarpur,	Maize,Paddy, Sorghum, Black	Wheat, Mustard
Baran,	Sorghum, Soyabean	Wheat, Mustard

Table 6. Industries in Rajasthan

Ordinary	Textile Rugs ,Woolen goods, Vegetable oil ,
Heavy Industries	copper and zinc smelting, manufacture of

Table 5.3: District Wise Availability of Water from All Sources

Sr. No.	District	Basins	Mean Surface Wate	Imported Water	Dynamic fresh ground		Total Available Water
					Fresh	Saline	
1	Ajmer	**Shekha**	809.4	79.491	445.6	67.90	**1402.4**
2	Alwar	**Ruprail,**	656.3	15.323	454.2	55.16	**1181.0**
3	Banswara	**Mahi**	930.0	174.90	151.2	0	**1256.1**
4	Baran	**Chamba**	966.9	376.33	222.1	2.925	**1568.3**
5	Barmer	**Luni,**	351.2	1499.9	310.5	282.4	**2444.3**
6	Bharatpur	**Ruprail,**	621.7	15.323	345.7	56.51	**1039.3**
7	Bhilwara	**Banas ,**	1430.	376.33	429.6	12.71	**2249.0**
8	Bikaner	**Outside**	99.06	1420.5	144.6	228.1	**1892.3**
9	Bundi	**Chamba**	966.9	376.33	222.1	2.925	**1568.3**
10	Chittaurg	**Banas**	463.3	0	207.5	9.786	**680.69**
11	Churu	**Outside**	99.06	1420.5	144.6	228.1	**1892.3**
12	Dausa	**Bangan**	764.4	5.628	402.2	41.76	**1214.0**
13	Dhaulpur	**Parbati ,**	1284.	376.33	372.0	10.37	**2043.2**
14	Dungarpu	**Mahi ,**	1113.	174.90	166.9	2.733	**1457.7**
15	Gangana	**Outside**	108.8	1420.5	264.3	451.4	**2245.2**
16	Hanuman	**Outside**	108.8	1420.5	264.3	451.4	**2245.2**
17	Jaipur	**Sabi,**	799.0	5.628	510.6	40.41	**1355.7**
18	Jaisalmer	**Outside,**	351.2	1499.9	310.5	282.4	**2444.3**
19	Jalore	**Luni,**	277.9	165.36	223.1	54.33	**720.80**
20	Jhalawar	**Chamba**	966.9	376.33	222.1	2.925	**1568.3**
21	Jhunjhun	**Shekha**	192.8	1420.5	216.8	231.9	**2062.1**
22	Jodhpur	**Luni,**	351.2	1499.9	310.5	282.4	**2444.3**
23	Karauli	**Gambhi**	1873.	381.95	667.2	44.68	**2967.5**
24	Kota	**Chamba**	966.9	376.33	222.1	2.925	**1568.3**
25	Nagaur	**Outside,**	445.0	1499.9	382.7	286.2	**2614.1**
26	Pali	**Luni**	252.2	79.491	165.9	54.33	**551.94**
27	Pratapgar	**Banas,**	2360.	551.23	580.9	12.71	**3505.2**
28	Rajsaman	**Banas,**	715.6	79.491	373.4	64.11	**1232.6**
29	Sawai	**Banas,**	731.5	5.628	337.9	34.31	**1109.5**
30	Sikar	**Shekha**	308.9	1420.5	360.1	234.2	**2323.8**
31	Sirohi	Luni,	637.6	165.36	344.4	58.59	**1206.1**
32	Tonk	Banas,	1430.	376.33	429.6	12.71	**2249.0**
33	Udaipur	**Mahi,**	1828.	254.39	540.3	66.85	**2690.4**
	State Total		**25264**	**19311.**	**10747**	**3670.**	**58994.**

Table 5.4: District-Wise Water Requirement In Different Sectors (Mm3/Yr.) For 2011

District	Domestic water	Agriculture water demand	Industrial water demand	Wild life water dema	Water for power stat	Institutional water (5% of	*Firefighting water demand	Livestock water	Total water requirement (Mm3/yr.)
Ajmer	103.	1618.	5.32	0.0	-	5.175	1.855	19.7	1754.
Alwar	95.3	2571.	25.2	0.4	-	4.767	2.212	29.2	2729.
Bansw	35.5	1150.	7.87	0.2	12.	1.779	1.547	19.2	1228.
Baran	32.8	1805.	0.36	0.5	37.	1.640	1.276	14.1	1894.
Barme	81.3	4690.	11.2	0.0	10.	4.067	1.862	28.5	4827.
Bharat	67.3	1665.	1.14	14.	-	3.367	1.842	14.3	1767.
Bhilwa	65.4	1647.	8.56	0.1	0.0	3.274	1.791	24.4	1751.
Bikane	97.9	3897.	5.92	0.0	23.	4.897	1.774	22.8	4054.
Bundi	29.3	1552.	0.41	0.2	-	1.466	1.216	13.8	1599.
Chittau	40.0	1428.	26.9	0.2	62.	2.000	1.434	22.1	1583.
Churu	81.5	3423.	1.97	0.1	-	4.075	1.648	14.5	3527.
Dausa	37.2	1040.	0.88	0.0	-	1.861	1.475	13.7	1095.
Dhaulp	32.6	635.8	4.55	0.1	17.	1.632	1.267	10.2	704.1
Dunga	27.1	676.0	2.13	0.1	-	1.355	1.360	16.3	724.5
Ganga	58.7	3207.	6.62	0.0	107	2.937	1.619	23.7	3408.
Hanum	54.0	3797.	1.32	0.0	0.1	2.702	1.537	20.1	3877.
Jaipur	298.	3022.	90.8	0.1	-	14.92	2.971	39.9	3469.
Jaisal	22.7	1631.	0.48	0.0	4.8	1.138	0.944	15.0	1677.
Jalore	54.6	2498.	0.78	0.0	-	2.734	1.560	19.1	2577.
Jhalaw	34.2	2100.	1.37	0.3	0.0	1.714	1.371	17.6	2157.
Jhunjh	78.7	1498.	8.47	0.1	-	3.936	1.687	16.4	1607.
Jodhpu	155.	4064.	6.70	0.0	1.4	7.778	2.216	26.7	4264.
Karaul	35.3	988.6	0.65	0.3	-	1.768	1.393	13.0	1041.
Kota	94.2	1539.	32.9	0.1	88.	4.710	1.612	11.1	1773.
Nagaur	119.	4100.	2.75	0.0	-	5.954	2.099	25.4	4255.
Pali	75.8	2187.	4.67	0.1	-	3.790	1.647	19.0	2292.
Pratap	17.4	876.8	0.10	0.4	-	0.872	1.075	15.8	912.6
Rajsa	30.3	369.4	9.00	0.1	-	1.519	1.241	13.3	424.9
Sawai	35.6	1294.	0.85	0.2	-	1.782	1.333	9.69	1343.
Sikar	101.	1896.	2.41	0.0	-	5.077	1.888	22.7	2030.
Sirohi	28.8	610.1	6.27	0.2	-	1.441	1.175	9.90	658.0
Tonk	39.6	1735.	1.52	0.0	-	1.984	1.376	13.8	1793.
Udaipu	82.8	973.9	16.8	1.2	-	4.141	2.021	28.3	1109.
	2245	6619	297.	20.	367	112.2	53.33	624.	69917

*Firefighting demand is calculated by using formula: Volume of water (kl/day) = 100 x √ p (for p> 50000) p= population in thousands.

Result

Using domestic waste water reclamation, industrial waste water utilization, desalination of salty water, adoption of micro irrigation system in agriculture, controlling conveyance losses total amount of water can be managed as under and shown in Fig.3.

Total water available in the state as per the data available (Mm3/yr) = **58994.44**

Total water requirement in different sectors as calculated (Mm3/yr) = **69917.76**

Deficit quantity of water (Mm3/yr) = **10923.30**

Total water managed by adopting present strategies (Mm3/yr) = **5008.00**

Water deficit regions of the state are managed by employing the proposed techniques: use of domestic waste water in irrigated fields, use of grey water in flushing of W.Cs, recirculation of water in industries adopting the concept of zero effluent discharge, desalination of saline water, micro irrigation technique, crop rotation, less water consuming crop cultivation, Cultivation medicinal plants, minimizing water conveyance losses. Using these techniques 5008.00 Mm3/yr. water can be managed. as compared to total deficit of 10923.30 Mm3/yr.

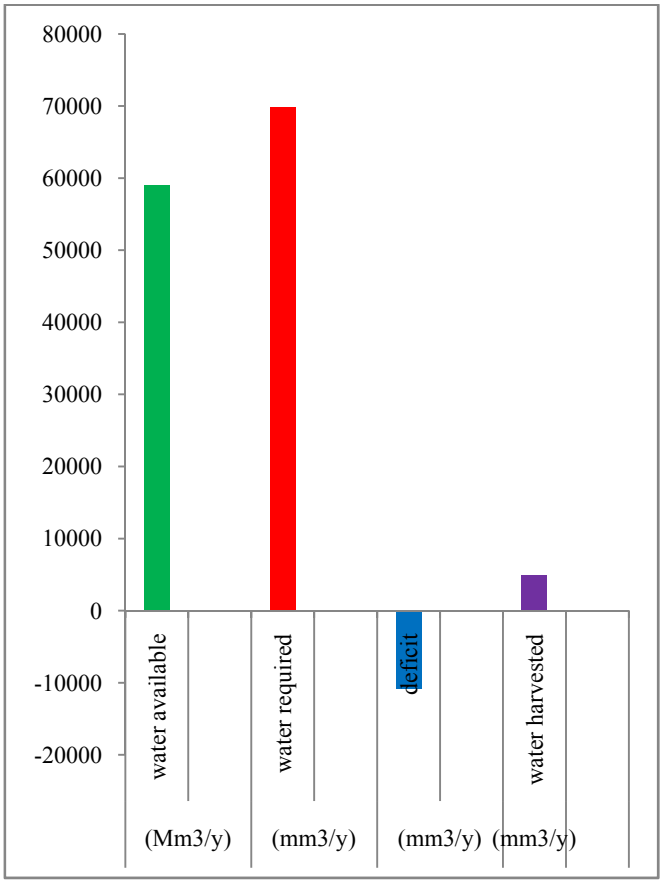

Fig. 3 Water availability, requirement, deficit and water managed by present water management strategies

4. CONCLUSIONS AND SUGGESTIONS

From present study following conclusions have been drawn-

1. Change in climate, rapid growth in population, change in life style of people, urban development, industrial development and environmental degradation are severely affecting the water resources of the country in general and arid and semi arid regions in particular.
2. Comparision of water availability with water requirement indicates that Out of 33 district of Rajasthan water availability in existing water resources is found quite satisfactory in seven districts. However, in other seven districts the water availability is found just above the margin and in four districts just below the margin. In the remaining 15 districts the water availability is unsatisfactory.
3. Together with water scarcity, the quality of water also degraded in the state which creates an unhygienic condition in the region, therefore, by adopting best suited method of waste water treatment and best suitable use of treated waste water can reduce the unhygienic and mismanagement condition of the water resources.
4. Except Jodhpur the pH value of ground water is within the permissible range.
5. Except jodhpur, Bhiwadi, Ajmer, Udaipur and Bharatpur the B.O.D of the ground water lies within limit i.e. less than 3. It can be reduced by proper treatment of waste water before discharging it into the ground surface.
6. Except Jaipur, Udaipur, Ajmer, Pali, Bhiwadi, Jhunjhunu the fluoride content in ground water lies within the permissible limit. The fluoride content may be brought under permissible limit by water recharge through rainwater harvesting to ground water aquifers.
7. Except Ajmer, Jodhpur, Bhiwadi, Pali, Udaipur, Alwar and Bharatpur, conductivity of ground water lies within permissible limit.
8. In case of major rivers of the state, except B.O.D at Jaipur, all the other parameters i.e., pH, D.O. and conductivity lie within permissible limits. Excess in B.O.D. at Jaipur may be due to discharging of waste water without treatment into the rivers.
9. In case of lakes and ponds, values of conductivity and pH are within permissible range but D.O. and B.O.D values in Jaipur and Pushkar Lake are violated.
10. Water deficit regions of the state are managed by employing the proposed techniques: use of domestic waste water in irrigated fields, use of grey water in flushing of W.Cs, recirculation of water in industries adopting the concept of zero effluent discharge, desalination of saline water, micro irrigation technique, crop rotation, less water consuming crop cultivation, Cultivation medicinal plants, minimizing water conveyance losses. Using these techniques 5008.00 Mm3/yr. water can be managed. as compared to total deficit of 10923.30 Mm3/yr.

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