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Traditional Techniques of water conservation in western Rajasthan

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Summary

Water is a prime natural resource, a basic human need and a precious asset of the state. Planning, development, operation and maintenance of all water resources to support the growth of the state economy and the well being of the population, in response to the growing need for drinking water, agricultural products, industrial production and electricity, a general improvement of living conditions and employment is of utmost importance. The state of Rajasthan is one of the driest states of the country and the total surface water resources in the state are only about one percent of the total surface water resources of the country. The rivers of the state are rain fed and identified by 14 major basins divided into 59 sub basins. The surface water resources in the state are mainly confined to south and south-eastern parts of the state.

Introduction

The ground water also plays an important role especially in agriculture and drinking water supply. The situation of ground water exploitation is also not satisfactory as in areas where surface irrigation is provided there is a tendency of not using ground water for agriculture which creates problem of water table rise and even water logging. On the contrary, in large areas of the State, ground water is being over exploited and the water table in some areas is going down even at the rate of 3 meter per year. Our ancestors were very careful about the harvesting of rain-water and conservative use of ground water. But with the expansion of population volume and consequently enhanced use of ground water for drinking, industrial and irrigation purposes, the balance of ground water recharge and exploitation has lost its existence. The result has been reflected in the shape of drying-up of existing resources of ground water.

Water Resources of Rajasthan

Rajasthan is the driest state in India with scarce water resources. In the year 2011, annual per capita availability of water in the state was only 840 m3. With increasing population, the scarcity will increase further and the per capita water availability in the state is expected to be as low as 439 m3 by 2050, against the national average of 1,140 m3 by the year 2050. According to the State Water Plan, the projected nonagricultural demand for water is to increase from 3.29 BCM per year (the 1995 level) to 5.05 BCM per year in the year 2018, and it is estimated to reach 8.07 BCM per year in the year 2045.

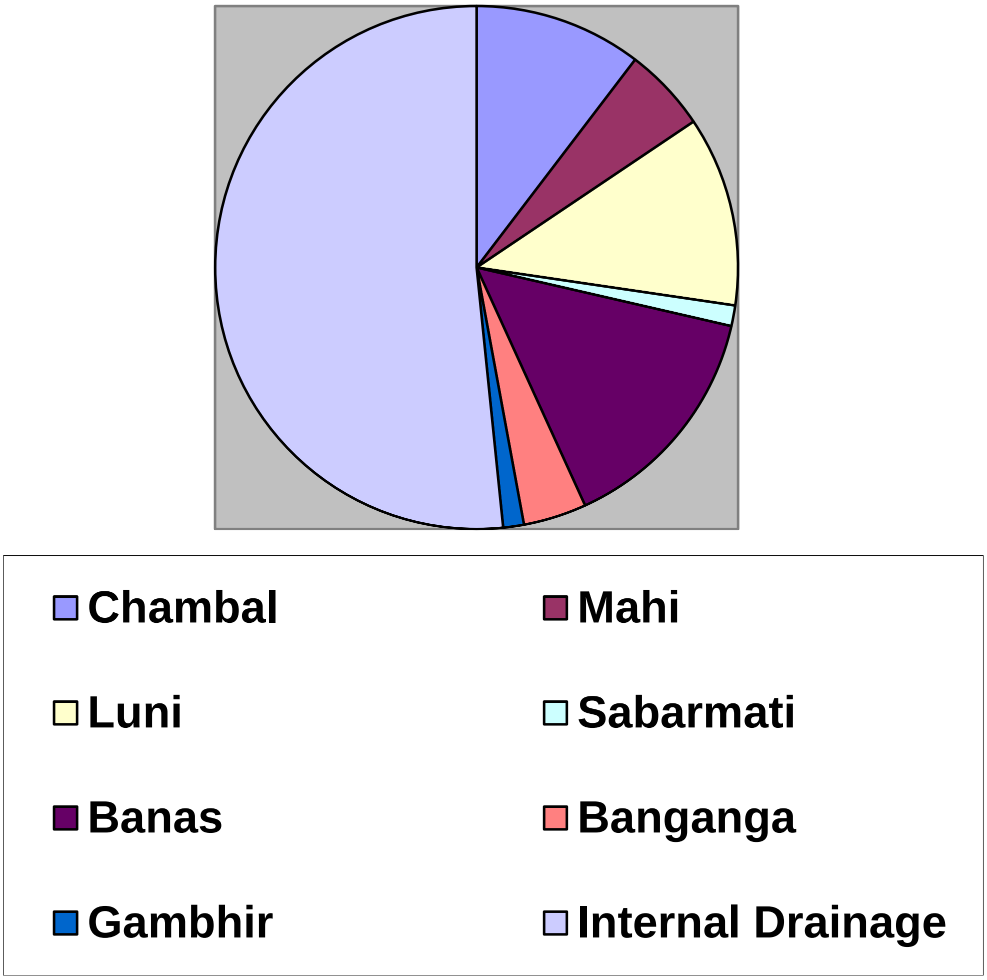
If all the 13.6 million hectares of cultivable land of Rajasthan are used for irrigation, the agricultural water requirement will be nearly 100 BCM per year, which obviously is not available. However, the State Water Plan has been prepared to create the irrigation potential for about 40 percent of the cultivable land of 5.125 million hectares (Vision 2018). There are eight major river basins in the state but Chambal and Mahi are the only perennial rivers that receive water from catchments located outside the state (figure 3). Water resources data simulated for each basin suggest that the internal surface water resources in the state during normal rainfall years amount to 48.01 BCM. However, only 16 BCM of surface water is utilizable (Vision 2018). Besides, inter-basin water transfer from other states amounts to 17.9 BCM annually (Vision 2018).

Basin wise analysis of population and total water availability (table 1) shows that the highest per capita water availability of 1,798 m3 is in the Chambal basin, followed by the Sabarmati (1,729 m3) and the Mahi (1,120 m3), whereas the lowest (190 m3) is in the Banganga basin. The higher per capita water availability in the Chambal basin is mainly due to the perennial nature of the river and inter-basin water input from outside the state. Lower water availability is mainly in ephemeral (monsoonal) river basins, such as Banganga, Gambhir, Luni, etc., receiving flow from high-intensity rainfall during the monsoon. As compared to ephemeral river basins, the per capita water availability in areas located outside of the basin is high due to their low population density. Overall per capita water availability in the state during 2018 was 825 m3. The availability of water resources gets reduced by 40 to 60 percent during moderate and severe drought years causing serious water scarcity in the affected regions.

Table 1 : Basinwise water resources potential, 2018

River basin	Area (km2)	Population (million)	Available water resources (BCM)	Per capita water availability (m3 per year)
Chambal	33,849	7.03	12.64	1,798
Mahi	16,985	4.15	4.65	1,120
Luni	38,310	5.99	3.14	524
Sabarmati	4,164	0.59	1.02	1,729
Banas	47,600	12.87	6.75	525
Banganga	12,763	5.12	0.97	190
Gambhir	4,173	5.17	2.23	431
Internal drainage (outside of the basin)	168,431	17.28	16.61	961
Total	342,239	58.20	48.01	825*

- *Average per capita water availability.*



Groundwater resources potential of Rajasthan, 2018.

District	Net annual Groundwater availability (MCM)	Actual annual groundwater exploitation (MCM)	Present groundwater balance (MCM)	Stage of groundwater development (%)
Ajmer	314.42	348.82	-34.40	110.94
Alwar	912.30	1112.07	-199.77	121.9
Banswara	162.50	39.21	123.30	24.13
Baran	495.31	321.99	173.31	65.01
Barmer	49.80	255.91	-6.10	102.44

Bharatpur	514.	79.66	34.60	93.27
Bhilwara	426.79	450.38	-23.59	105.53
Bikaner	197.61	144.52	53.09	73.13
Bundi	55.70	232.12	123.58	65.26
Chittorgarh	460.11	519.48	-59.37	112.9
Churu	197.69	117.35	80.34	59.36
Dausa	268.01	295.30	-26.29	109.77
Dholpur	237.21	245.80	-8.58	103.62
Dungarpur	92.78	76.53	16.26	82.48
Ganganagar	198.83	133.51	65.28	67.17
Hanumangarh	194.61	166.67	27.94	85.64
Jaipur	684.41	1015.99	-331.58	148.45
Jaisalmer	52.59	39.60	13.00	75.29
Jalor	423.61	827.48	-403.86	195.34
Jhalawar	397.70	381.24	16.46	95.86
Jhunjhunu	243.04	419.68	-176.64	172.68
Jodhpur	393.13	660.87	-267.74	168.1
Karauli	412.66	340.81	71.85	82.59
Kota	404.10	220.80	183.30	54.64
Nagaur	628.16	842.14	-213.98	134.07
Pali	413.39	330.34	83.05	79.91
Rajsamand	154.19	143.62	10.56	93.15
S. Madhopur	384.70	311.54	73.17	80.98
Sikar	324.52	344.70	-20.17	106.22
Sirohi	265.65	247.37	18.28	93.12
Tonk	414.53	270.67	143.86	65.3

Udaipur	283.63	298.58	-14.95	105.27
Total	**11,158.97**	**11,634.78**	**-475.8**	
Average	**104.3**			

Water harvesting and its potential for drought mitigation:

Water harvesting and conservation at basin, area, field or micro level can bring sustainability to the water sector and, consequently, increase water availability in drought years. Water harvesting is the process of concentrating rainfall as runoff from a catchments to be used in a target area. In Rajasthan, and particularly in the low-rainfall western zone, there are several kinds of rainwater harvesting systems such as bawari, jhalara, talab, nadi, tanka, khadin, kund and harvesting of roof water. Out of these, bawari and jhalara depend on groundwater, while talab, nadi, tanka, kund and khadin are based on harnessing surface runoff (Khan 1995; Khan and Narain 2000). With the implementation of government schemes for domestic water supply in many areas, some of these systems were neglected. However, with increasing human population, shortfall in groundwater and recurring droughts, these rainwater harvesting systems are attracting growing attention. Modern technologies of rainwater harvesting and groundwater recharge such as anicut, percolation tank, subsurface barrier and pond with infiltration wells have recently been developed to rejuvenate the depleted freshwater aquifers (Khan 1996a; Khan 1996b; Narain and Khan 2000; Narain and Khan 2002).

Bawari and Jhalara Bawari and jhalara are local names given to step wells. These ancient water harvesting systems were mainly set up in cities and big towns to provide a water supply to the community. They were constructed at exorbitant cost and were often monumental, beautiful mansions with fine embroidery stone works covering large areas and were associated with religion and culture.

Historically, many of these step wells were named after some renowned social or royal personality or a holy site. Groundwater aquifers like bawari and jhalara are essentially sweet water aquifers getting a regular, heavy recharge. At present, 88 jhalaras and bawaris are found in Rajasthan. With the introduction of pipe-borne water supply schemes and the dumping of waste material in these structures, these water sources got relegated and abandoned. However, in recent years, some of these systems have been renovated and the quantity and quality of the drinking water are maintained through the use of low-head electric pumps. The details of some traditional water harvesting structure are as foelow:

Nadi

A *nadi* or dug-out village pond is the oldest and still prevalent storage structure for rainwater harvesting. The water stored in a nadi is generally used for drinking by livestock and human beings. A nadi also acts as a source of groundwater recharge through seepage and deep percolation. It is estimated that the recharge from a nadi covering 2.25 ha and having a storage capacity of 15,000 m3 in an alluvial area may induce a groundwater recharge of 10,000 m3 in one rainy season. A poorly maintained nadi suffers high water losses through evaporation, seepage and biotic interference resulting in rapid siltation and pollution. The Central Arid Zone Research Institute (CAZRI) in Rajasthan has designed nadis of different capacities for varying morpho-climatological conditions (Khan 1989). Trees that take water from the deeper soil profile strata are recommended for planting around the structure in order to reduce evaporation and improve the micro climate. Such an environmentally friendly nadi constructed at a location in the Barmer district was sufficient to serve 500 people throughout the year and was replicated at ten different locations in the region.

Tanka

The *tanka* (underground cistern) is another major source of drinking water in western Rajasthan. It is constructed in a circular or rectangular shape, normally on bare ground where surface runoff can be diverted to the tanka by creating a clean catchment around it. A traditional tanka constructed with lime plaster and thatched with bushes has a life span of 3-4 years. With the decomposition of brush wood, falling of leachate and entry of foreign material with runoff through the open inlet, the quality of stored water in the tanka deteriorates over time making it unhygienic for drinking. CAZRI has developed a tanka of improved design with a capacity ranging from 10,000 to 600,000 liters and provision for three inlets with a wire mesh and a silt trap, to ensure pollutant and silt free inflow (Khan 1996a; Khan 1996b), and an outlet for overflow. The water is generally withdrawn manually from its roof top or sometimes through a pump. A life span of such a structure is more than 20 years. The improved tanka developed by CAZRI has become popular and widely adopted in Rajasthan.

Roof Water Harvesting Harvesting of roof water is an age-old practice to obtain safe drinking water, which is being revived and emphasized now. In ancient times, houses in western Rajasthan were constructed with stone and lime and roof water was diverted to tankas. Harvesting of roof water is being neglected because of pipe-borne water supplies even in rural areas, which is essentially based on groundwater withdrawal locally or in the vicinity. Roof water harvesting is now becoming the order of the day in towns as well as in rural areas due to the alarming rate of groundwater depletion. If harvesting of roof water is revived on a large scale, it will alleviate the scarcity of drinking water and also reduce the rapid depletion of groundwater. The estimated water yield from a 1,500 m2 roof top with an effective rainfall of 250 mm and a 0.8 runoff coefficient is 300 m3, which is enough for a drinking water consumption of 30,000 person days at 10 liters per capita per day (lpcd).

Roof water harvesting for the recharging of groundwater can also be recommended for areas having suitable aquifers. This approach requires harvesting and channelizing roof water to either existing wells, tube wells, bore wells or specially designed wells. It is most suitable for urban housing complexes or institutional buildings located in drought-prone arid and semi-arid regions. Based on CAZRI recommendations, the Government of Rajasthan has made harvesting of roof water mandatory in all new buildings with a covered area of more than 1,500 m2. The runoff efficiency of roofs made up of different material has been evaluated (Khan 1995).

Runoff efficiency is highest (85%) for corrugated iron sheet roofs followed by stone slab roofs (80%), paved surface (68%) and clay tile roofs (56%). The lowest (39%) is for thatched straw roofs. Based on an 80 percent runoff efficiency of cement concrete roofs, the water yield for varying sizes of roof in different rainfall zones has been estimated.

Water yield from rooftops in different rainfall zones.

Rooftop	**Rainfall (mm)**										
area (m2)	**100**	**200**	**300**	**400**	**500**	**600**	**700**	**800**	**900**	**1,000**	**1,200**
	Water yield (m3)										
100	8	16	24	32	40	48	56	64	72	80	96

200	16	32	48	64	80	96	112	128	144	160	192
300	24	48	72	96	120	144	168	192	216	240	288
400	32	64	96	128	160	192	224	256	288	320	384
500	40	80	120	160	200	240	280	320	360	400	480
600	48	96	144	192	240	288	336	384	432	480	576
700	56	112	168	224	280	336	392	448	504	560	672
800	64	128	192	256	320	384	448	512	576	640	768
900	72	144	216	288	360	432	504	576	648	720	864
1,000	80	160	240	320	400	480	560	640	720	800	960
1,500	120	240	360	480	600	720	840	960	1,080	1,200	1,440
2,000	160	320	480	640	800	960	1,120	1,280	1,440	1,600	1,920
2,500	200	400	600	800	1,000	1,200	1,400	1,600	1,800	2,000	2,400
3,000	240	480	720	960	1,200	1,440	1,680	1,920	2,160	2,400	2,880
3,500	280	560	840	1,120	1,400	1,680	1,960	2,240	2,520	2,800	3,360
4,000	320	640	960	1,280	1,600	1,920	2,240	2,560	2,880	3,200	3,840

Khadin

In recent years, nearly 550 khadin farms have been developed in western Rajasthan for an average water harvest of 54,000 m3 per khadin benefiting 6,400 farm families. Potential sites for developing 490 new khadin farms of different sizes in western Rajasthan have been identified and delineated on 1:50,000 scale topographical sheets. When these are developed, the total of 1,040 khadin farms would have a runoff harvesting potential of about 42 MCM water for increasing sustainability of crop production, meeting the drinking water requirement of 12,000 farm families, enhancing groundwater availability through recharging and providing a sound drought mitigation strategy.

Anicuts

An anicut in Rajasthan is a small water harvesting masonry dam constructed across a stream to hold sufficient water and submerge the upstream area during the rainy season. The stored water is used for lift irrigation and for recharging groundwater in adjacent wells used for drinking. If the submerged area is large, bed cultivation is practiced using the stored soil profile moisture like in a khadin. Based on satellite imagery, topographical maps and field surveys, more than 2,100 potential anicut sites, under varying land forms in different districts, have been identified. By constructing anicuts at all these identified locations it is possible to harvest and conserve nearly 25.8 MCM of additional water, from which a population of nearly 470,000 people can benefit by using it both for drinking and limited supplemental irrigation.Percolation Tanks Percolation tanks are recharge structures constructed on small streams with adequate catchment for impounding surface runoff. These tanks are used solely for quick recharging of groundwater. Percolation tanks are more efficient than ponds for recharging and conserving water due to low evaporation losses. Selection of suitable sites for the construction of percolation tanks and subsequent maintenance are crucial for their effective functioning. Under favorable hydrogeological conditions, percolation rates may be increased by constructing recharge (intake) wells within percolation tanks. At the beginning of the first seasonal runoff intake, the rate of percolation is as high as 178 to 166 mm/day, which remains at that level for a day or two, and thereafter the rate of percolation declines drastically due to the deposition of a fine soil matrix on the tank surface. Studies conducted on artificial recharge through percolation tanks constructed in hard rock and alluvium formations in the Pali district of Rajasthan showed a percolation rate of 14 to 52 mm/day. Percolation accounted for 65-89 percent losses whereas the evaporation loss was only 11-35 percent of the stored water. The results also indicate that the tanks in a hard rock area contain water for 3-4 months after the receding of the monsoon.

Subsurface Barriers

Subsurface barrier is the most suitable artificial recharge structure in a sandy bed of an ephemeral desert stream. Since it is constructed below the riverbed on impervious subsurface strata, the structure is secure from floods, does not need elaborate overflow arrangements or periodic desalting and has limited evaporation. The construction needs a concrete or brick masonry wall, 30-60 cm wide, extending down to the impermeable/compact basement. A subsurface barrier may also be constructed with angular rock pieces arranged in the form of a 100 cm wide dry masonry wall or with a 250-micron polyethylene sheeting, properly embedded in the soil. Subsurface barriers within 300 m from the water supply well are enough to store drinking water required for a village with a population of 500 people. As the domestic wells are located in the village, there is a need for constructing these structures close to the villages. One of the structures should be upstream and the other downstream of the village. During the dry season, when the pumping water level in the well is low, the hydraulic gradient is reversed and the water is drawn from the groundwater mound downstream to supply safe drinking water.

Churu district is not an exception of these circumstances where ground water-table is depleting day by day and quality of ground water is deteriorating. The nature has blessed this earth with water, which is an essential requirement for human, cattle, and vegetation to survive, Our ancestors were very careful about the conservative use of water. With the expansion of population volume and enhancement of development activities, use of ground water for various purposes has increased considerably affecting the ground water resources of the district profoundly. Consequently, the philosophy of extraction of ground water in a planned way and its use in a very conservative manner is coming up with a prime status in day to day discussions of the society.

Conclusion

The above picture of the district is extremely miserable and if this trend happen to continue in future than ultimately all the activities related with ground water development will have to be stopped or restricted very tightly. Unluckily, if the above conditions worsen father than what will be the picture of the district, presently it is beyond the range of imagination.

In the present scenario, it has, therefore, become essential that the available resources of ground water are used very conservatively so that these can be used for a considerable long time spell. The people should be made acquainted with the worseness of present/existing situation, adoption of appropriate methods of conservative use, and the future planning of existing resources of ground water.

Poor recharging of aquifers and excessive extraction of ground water are the two main factors, which may be held responsible for such a miserable situation of the district. The first one is beyond the control of human efforts, but the second factor can be minimized by sincere efforts. Certain tips are being given below which, if adopted with firm determination, will make enable to put a couple of steps ahead in the direction of precise ground water management:

(i) Irrigation activities are responsible for the major part of extraction of ground water. It is therefore, desirable that instead of traditional crops some other crops requiring less quantity of water for irrigation should be adopted so that consumption of ground water is reduced.

(ii) Along with sprinkler-system of irrigation, irrigation drip-system should also be adopted on large scale to minimize the requirement of irrigation water.

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