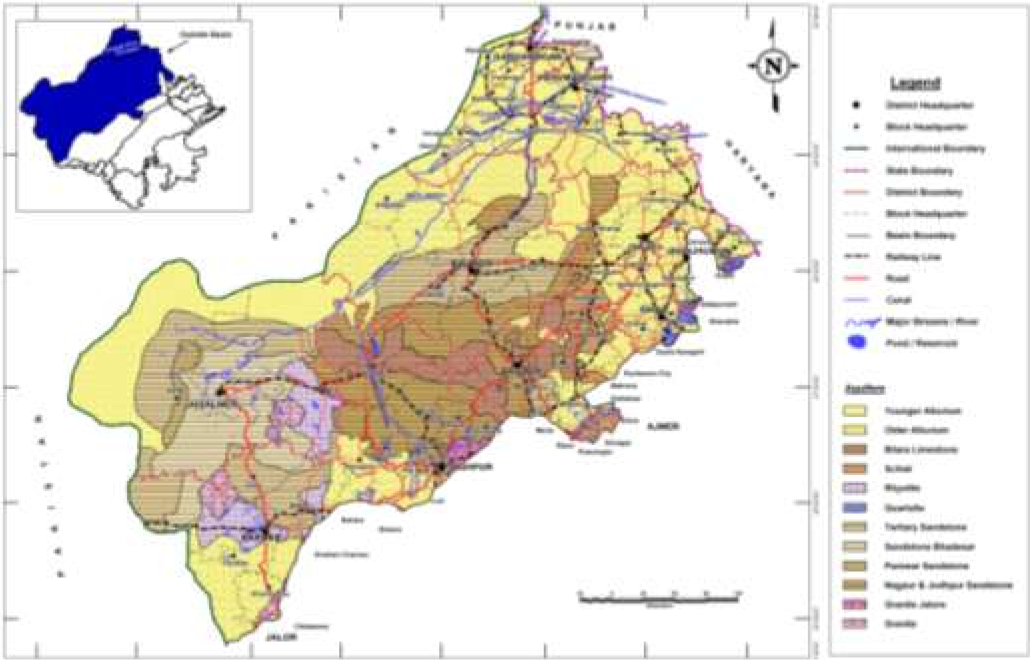
DRINKING WATER SECURITY IN THE ARID RAJASTHAN

Western Region- Rajasthan



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CHAPTER I
INTRODUCTION

1.1 Introduction

Water and Sanitation as basic human rights has been widely recognized nationally and internationally. Supply of safe, hygienic and potable drinking water and improved sanitation and hygiene to both rural and urban population is undoubtedly the top priority of the global organisations as well as national and state governments. As there is established correlation between poverty and lack of drinking and sanitation services these efforts will also be strong step in poverty reduction. The global level concern for safe and sufficient drinking water goes back to the United Nations declaration of the 1981-91 decade as International Drinking Water Supply and Sanitation Decade. The new global initiatives were again raised by the states of the United Nations by unanimously reaffirming their commitment to working toward a world in which sustaining development and eliminating poverty would have the highest priority. The Millennium Declaration was signed by 189 countries, including 147 Heads of State, in September 2000 containing the Millennium Development Goals (MDG's) and targets to be achieved by the year 2015. The MDG's gave enormous importance to poverty alleviation across the globe by listing it as the first goal. The link between improved water supply, sanitation and poverty was centrally placed. The Goal 7 (Ensure environmental sustainability) primarily addressed the water and sanitation issues by targeting 'halving by 2015, the number of people living without safe drinking water or basic sanitation'. Clean water is not enough it has to be accompanied by sanitation and hygiene. Sanitation is necessary to preserve human dignity especially for women to protect themselves against assault. The indicators set for measuring was 'the proportion of people with sustainable access to an improved water source and sanitation'. Indian government also committed to this declaration and the listed goals.

The MDG's were followed by the Sustainable Development Goals (SDG's), as defined in the 'Transforming Our World - the 2030 Agenda for Sustainable Development'. On September 25th 2015, countries adopted a set of goals to end poverty, protect the planet, and ensure prosperity for all as part of a new sustainable development agenda. Each goal has specific targets to be achieved over the next 15 years. Goal 6 is 'Clean Water and Sanitation' – with an objective to ensure availability and sustainable management of water and sanitation for all. The Sustainable Development Goal 6 goes beyond drinking water, sanitation and hygiene to also address the quality and sustainability of water resources, which are critical to the survival of people and the planet. The 2030 Agenda recognizes the centrality of water resources to sustainable development and the vital role that improved drinking water, sanitation and hygiene play in progress in other areas, including health, education and poverty reduction.

India and States' water policy are guided by SDGs and Water and Sanitation has become priority agenda of governments and translated into numerous programs and projects.

The State of Rajasthan falls under the ecological regions of Thar Desert and Central Highlands. The state comprises of six geo-cultural regions namely Thar, Dhundad, Mewar, Marwar, Hadoti and Shekhawati. The western region comprise of Thar, Marwar and part of Shekhawati geo- cultural regions covering the districts namely, Barmer, Jaisalmer, Bikaner, Churu, Jodhpur, Nagaur, Sikar, Jhunjhunu, Pali and Jalore. In the western region Talab, pond/nadi, Tanka and other traditional structures were the source of drinking water earlier, but gradually with time and government interventions the source got shifted to dug wells and eventually to tube wells and canals.

Rajasthan is a deficient state in Indian sub-continent with regard to water availability. Nearly, one percent of the country's surface water is available for the state constituting about 6 percent of the human and 19 percent of livestock population living in 10 percent of the total geographical area of the country. Two-thirds parts of the State is part of the Thar Desert which is larger than most of Indian states except Madhya Pradesh, Uttar Pradesh, Andhra Pradesh and Maharashtra. About 60 percent of the total desert blocks in the country fall in Rajasthan that further aggravated the water crisis. The groundwater condition is quite alarming in the state. During the recent decades, as per the available estimates, it has been deteriorated at the faster rate i.e. around 36 percent during 1984 to 138 percent in the recent years[1]. The rainfall is erratic and there is large variation in regional and temporal distribution of rainfall. The average annual rainfall ranges from 100 mm in western region to 800 mm in southern region of Rajasthan. Such nature of rainfall condition creates imbalances in water availability in the state. Thus, Rajasthan is a most precarious state in Indian continent because three main factors such as (i) frequency of droughts (four out of every five years), (ii) extremely low and erratic rainfall and (iii) limited supply of surface water. Together, these factors put a high pressure on the per capita availability of water, which is less

[1] Report of the Group on the Estimation of Groundwater Resources of Rajasthan prepared by Central Groundwater Board, Government of India and Department of Groundwater, Government of Rajasthan, Jodhpur (Different Issues)

than half (807m^3) of the national average (2,000 m^3), and expected to decline further to 457m^3 by 2045[2] (Government of Rajasthan, 2003). This means that the state will slip from scarcity to an absolute scarcity zone.

The scarcity problem is more revealing if the quality aspects of water are taken into account. Quality of water is also noticeable in Rajasthan. It accounts for more than half i.e. 51 percent of the fluoride and two-fifth as 42 percent of the saline affected areas in the entire country. More than three-fourths of the villages and habitations are affected by poor quality water, affecting 20 million people in the state. As the available estimates, There are 121683 Villages and Habitations (V&H) for drinking water supply (As on April 1, 2015 the total number of villages and habitations are 43264 and 78419 respectively). Of the total V&H in Rajasthan 111148 were covered through different sources under drinking water supply by the PHED which is 91.34 percent of total. The achievement in terms of covered villages and habitation seems to be remarkable in the given condition of prevailing water scarcity in Rajasthan. However, quantity, quality, equity and other aspects are concerned lot has to be achieved.

The regional distribution of the problem villages in the rural Rajasthan reveals that 54 percent of the non covered (problem) villages are located in the Western region, 34 percent in the North-eastern region, and the remaining 12 per cent in the Southern region. In the Western region these villages are located in Barmer, Bikaner, Churu, Jaisalmer, Nagaur and Jodhpur districts.

The Western Region of Rajasthan comprise of 12 districts namely, Barmer, Bikaner, Churu, Jaisalmer, Jalore, Jhunjhunu, Jodhpur, Nagaur, Pali, Sirohi, and Sikar, which is covers around 50 percent of the total geographical area of Rajasthan. The region is defined as out of Basin area as there is no river basin in the area. The average rainfall ranges between 150 mm in Jaisalmer to 350mm Jhunjhunu. Western region accounts for around 35.6 percent of Rajasthan population. In the Western region there are 12715 villages and 35887 habitations, i.e., a total of 48602 V&H. These account for 39.9 percent of total V&H in Rajasthan.

Livestock population in the region is 22795909 which is 39.5 percent of total population of Rajasthan. Livestock is major source of livelihood and their drinking water demand have to be addressed as of humans.

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2 Report of Expert Committee on integrated development and management of water Resources; State Water Policy, 2010, Government of Rajasthan, Jaipur

The status of drinking water coverage in the western region is concerned 97.7 percent of villages and 73 percent of habitations are under covered category. Except the districts; namely Barmer, Jaisalmer, Jodhpur and Churu, all other districts villages are 100 percent covered. In case of Habitations coverage only in Jhunjhunu, Sikar, Jalore and Sirohi district's are 100 percent covered and in rest of the districts it ranges between 54 to 87 percent. The drinking water **coverage of population** in Rajasthan and western region is by ground water, surface water and other sources. Groundwater serves 67 percent, surface water 83 percent and traditional sources 65 percent of total population (as on 2015) in Rajasthan, while the coverage of western region population from these sources is 33, 17, and 35 respectively.

There is big gap in what state claims through published statistics and ground reality because the data only shows of coverage of concentrated settlements against the disperse/scattered settlement and without mentioning the quality of water and duration of supply. Provision of drinking water security requires greater understanding of the Household /population covered, sources of coverage, quality of water supplied and sustainability of source.

Sustainable and safe drinking water supply to the rural population is the major agenda of all the governments in Rajasthan. Historically, being the arid and semi-arid region the problem of water scarcity in general and drinking water specifically was addressed by communities harnessing rainwater in different types of structures and adopting water conservation practices in all types of usages. After independence, investments were made in creation of number of infrastructure to augment and supply water to rural population residing in large number of villages and habitations. The human settlement pattern in western Rajasthan is different and density of population is also lower (126persons per sq.km.) than rest of the areas in the State. A typical desert village is spread in around 15 to 20 km. having small hamlets of single or multiple houses. Drinking water supply to such a scattered population is most challenging task. Despite large are being covered with canal systems (IGNP and Narmada Canal) there is drinking water crisis in the region. The traditional water sources still provide drinking water for at least six months to human and livestock population in the Western Region.

Addressing drinking water problem of human and livestock and providing drinking water security in water scarce western region by use of modern scientific knowledge is the overall objective of the study. The specific objectives are discussed in the following section.

1.2 Objectives

On this backdrop, the present study is proposed in arid and semi-arid areas of Rajasthan with following specific objectives:

I. Review critically the policies and programme relating to rural drinking water supply in the arid and semi-arid areas of Rajasthan.

II. Documentation of existing traditional practices followed in drinking water supply in arid and semi-arid areas.

III. Examine the village institutional arrangement that govern the drinking water management system with a view to understand the participation of communities.

IV. Explore scope for blending the traditional and modern technologies and practices to ensure drinking water security in western Rajasthan.

1.3 Methodology

The present study was conducted in arid and semi arid areas covering the 8 districts of Western Rajasthan.

First a team of multi disciplinary experts was constituted comprising of Social scientist specializing in NRM, Geologist, Hydro-geologist, Community Mobilizer and GIS expert.

Published Secondary data and primary data were collected also field visits were undertaken in all the districts of Western Rajasthan with the experts.

To ensure water security, it is essential to focus on understanding the resources. It is crucial to understand water as a natural resource and its importance for all forms of life. To ensure water security for all, there are bundles of technologies both traditional and modern. The second step was to document traditional technologies, practices and their importance in natural resource management in the region. Examine these technologies in the specific geo-cultural context and suitability in the changed context.

A detailed scientific study was undertaken to understand the existence and role of drinking water structures/water bodies in the western region of Rajasthan by documenting the following features: Topography, geology, geomorphology, geo-hydrology, surface and groundwater availability, demand and quality, also variation in their availability, water bodies and traditional water harnessing structures, etc. to identify sustainable and secure sources and strategy for management of those sources to ensure water security.

1.4 Layout of the Report

In Chapter I the geographical context the nature of drinking water problem in Rajasthan in general and western Rajasthan in particular are described. Objectives and methodology are also discussed. The status of drinking water in the western Rajasthan is discussed in Chapter II. It presents the villages and habitations covered and population covered by source in the region. The next Chapter III highlights the traditional drinking water systems and their contribution in meeting human and livestock drinking water demand. The scientific aspects of these water bodies are analysed at length. The final Chapter IV deals with measures for attaining drinking water security in the western region.

CHAPTER II
STATUS OF DRINKING WATER IN WESTERN RAJASTHAN

2.1 Rajasthan – some features

Rajasthan accounts for 10 percent of the land area, one percent of country's water resources, and 5 percent of the India's population. More than 75 percent of its population resides in rural areas. State also suffers from chronic water scarcity as the quantity and duration of rainfall are uncertain.

The rural and urban population growth in Rajasthan is reported in Table 2.1. It shows that rural population increased from 33.94 million in 1991 to 51.54 million at the rate of 2.11 percent per annum, while the urban population increased faster than rural as it increased from 10.07 million in 1991 to 17.08 million in 2011 at the rate of 2.67 percent per annum. The overall growth rate of human population in Rajasthan was 2.25 percent, which is highest in the country. The urban population is likely to grow faster in the coming decade as most of the facilities are developed in urban areas so rural-urban migration is increasing.

Table 2.1: Rural and urban population growth in Rajasthan

(In million)

Year	**Rural**	**Urban**	**Total**
1991	33.94	10.07	44.01
2001	43.29	13.21	56.50
2011	51.54	17.08	68.62
Growth Rate(%)	**2.11**	**2.67**	**2.25**

Increase in human population in general and urban population in particular will lead to higher demand for domestic water both in rural and urban areas. Rainfall is the ultimate source of water and there is significant variation in regional and temporal distribution of rainfall as evident from the fact that 60 per cent of its area is classified as arid and semi-arid, mainly the Western and North-Eastern parts. The uneven distribution of rainfall creates an imbalance in water availability for drinking, irrigation and other usage, influencing the social and economic development of the regions. The rainfall is highest in the southern region while lowest in the western region. On an average Rajasthan receives 157439 Million Cubic Meters (MCM) of rainfall annually of this 90 percent is received during the monsoon season. The Figure 1, 2 and 3 shows the rainfall pattern in Rajasthan for the period of 1901 to 2016. It shows that there is significant variation in annual rainfall and it is very difficult to plan for drinking water security based on such high variation. Figure 2 & 3 shows the Five and seven year Moving Average Rainfall Pattern in Rajasthan and that gives some idea about the rainfall cycle. This information can be used for planning water supply in normal, below normal and above normal rainfall years. The implication of this distribution of rainfall is in terms of water storage capacity of reservoirs to maintain supply during rest of the year or for next years. Uncertainty in rainfall also results in frequent droughts. The frequency and intensity of droughts i.e. moderate or severe vary across districts/ regions over time significantly[3]. The condition can be understood by the fact that since 1901 i.e. over 115 years there were only 9 years when none of the district and village was affected by drought. These facts indicate the difficult natural conditions prevailing in the state posing serious challenge before the State Government to supply safe drinking water to large number of villages, habitations and scattered rural population. The task becomes more difficult if the growth in population is also higher than rest of the India increasing thereby the demand for water manifold.

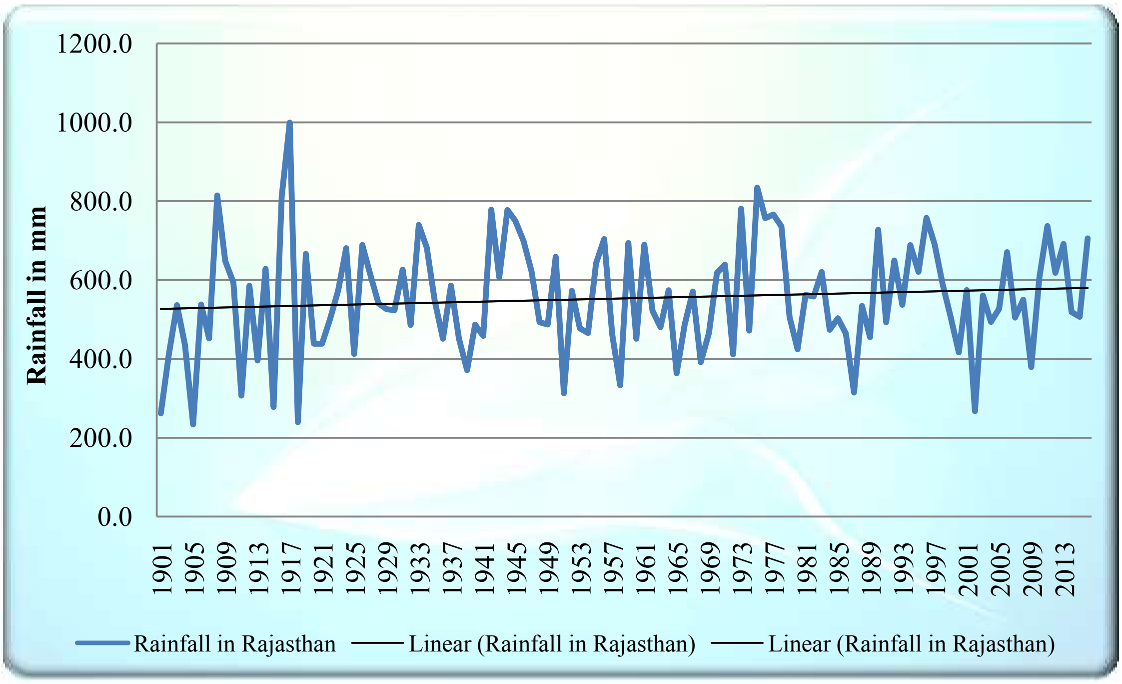


Figure 1 : Rainfall Pattern in Rajasthan 1901-2016

3 For details see Rathore, MS (2003) Adaptive Strategies to Drought in Rajasthan, Institute of Development Studies, Jaipur, 2003, (mimeograph).

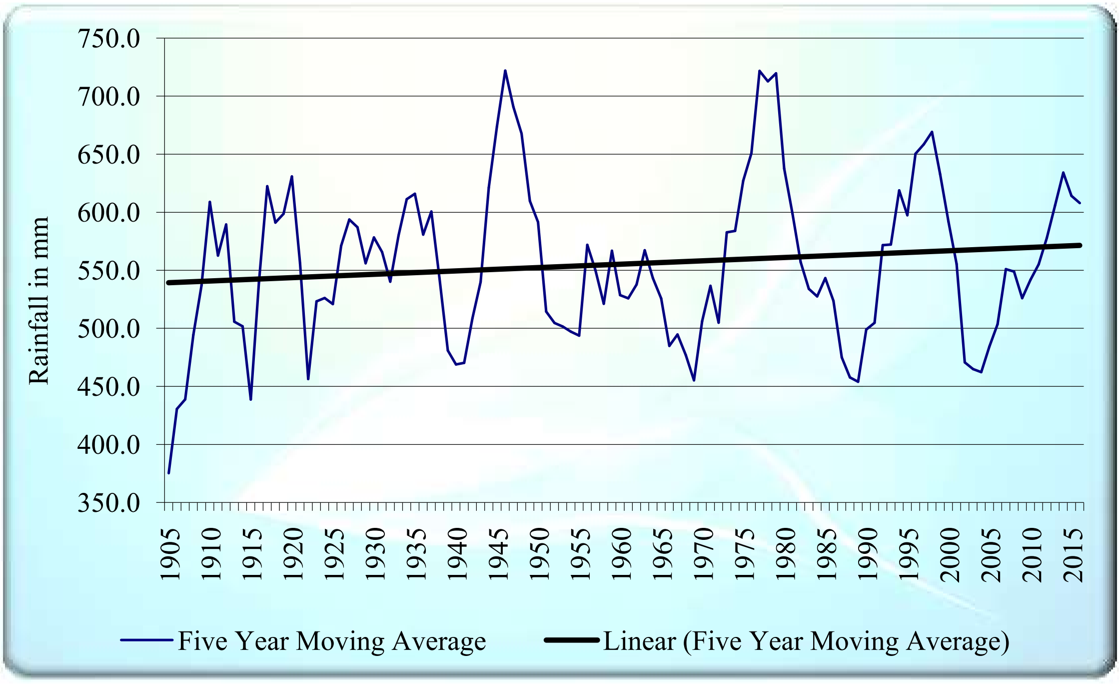


Figure 2: Five year Moving Average Rainfall Pattern in Rajasthan

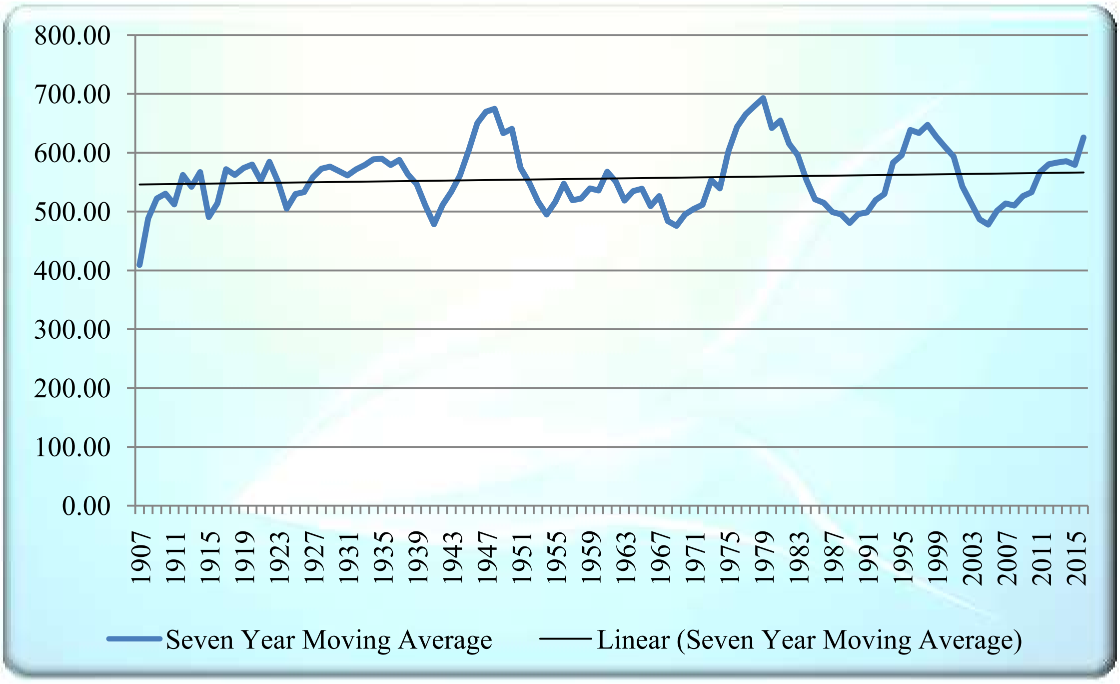


Figure 3: Seven Year Moving Average Rainfall Pattern in Rajasthan

2.2 Drinking Water Coverage- Rajasthan

Drinking water supply coverage in the State of Rajasthan is given in Table 2.2. It shows that there is big jump in drinking water coverage as only 43.7 percent of villages were covered in 1983 and that increased to 91.3 percent in 2015. The coverage was highest in the year 2014 reaching up to 99.4 percent. This progress has to be judged in the light of; first, there has been change in the definition and norms of declaring any village as covered village, bases on the source and distance of source from habitation. Second, the number of villages and habitations has changed over time based on Census definition, or Revenue Department declaring new number of villages or habitation. As on April 1, 2015 the total number of villages and habitations in Rajasthan are 43264 and 78419 respectively.

Table 2.2: Villages covered by drinking water supply in Rajasthan

Year	**Covered**	**Uncovered**	**Total Villages and Habitations**
Jan-83	14550	18755	33305
	(43.69)	**(53.31)**	(100)
Dec-95	37183	705	37889
	(98.14)	(1.16)	(100)
Mar-04	37675	214	37889
	(99.44)	(0.54)	(100)
Dec-09	39739	1745	41484
	(95.79)	(4.21)	(100)
01.04.2015	111148	10535	121683*
	(91.34)	**(8.66)**	(100)

* Total Villages=43264 & Habitations =78419

Source: http://indiawater.gov.in/IMISReports/Rajasthan and PHED Annual Progress Report 2015-16, page 3.

Against this listed target after two decades Rajasthan recorded the significant achievement by covering all the villages and urban cities and towns under their drinking water schemes. However these achievements were partial in nature, as the policies changed, the norms of drinking water also changed and as per the new norms many more villages and habitations were listed as problem village from drinking water supply point of view. It was either because of inadequate supply from the source or the distance of source and quality of water.

The Villages and Habitations severed by different drinking water schemes in Rajasthan are shown in the Table 2.3. The Table shows that Handpump is the major source of drinking water as it severs 57.5 percent of villages and habitations followed by Regional Schemes 24.5 percent, Pipes and Pipes & Tanks 14.5 percent, TSS and Janta jal Scheme 1.9 percent and Traditional sources 1.7 percent respectively. From water security point of view Handpump as a source cannot be considered as sustainable source because of highly variable rainfall pattern in Rajasthan and given the status of groundwater resources where only 25 Groundwater Blocks out 236 Blocks are under safe condition and the water development has reached the stage of 137 percent (see Table 2.5). Also 25 percent of handpumps go dry every year and almost all handpumps require deepening every second year. Therefore, every year state wide special drive to repair handpumps is under taken.

Regional schemes and Pipe & Tank schemes are largely dependent on groundwater except small area where IGNP canal water is the source. In normal, wet and very wet rainfall year the traditional water sources provide drinking water for at least six months to human and livestock population in the Western Region.

Table 2.3: Villages and Habitations severed by different drinking water schemes in Rajasthan.

Years	Village covered under scheme					
	Pipes/ P&T scheme	**Hand pump**	**Regional scheme**	**TSS/ Janta Jal scheme**	**Diggi &others**	**Total Covered village**
1980	5753	8797	-	-	-	14505
	(39.66)	**(60.34)**				(100)
1995	3207	23171	8673	1823	309	37183
	(8.62)	(62.32)	(23.33)	(4.9)	(0.83)	(100)
2004	4804	21639	9826	1127	279	37675
	(12.75)	(57.44)	(26.08)	(2.99)	(0.74)	(100)
2009	5516	20353	10663	1146	2101	39739
	(13.88)	(51.22)	(26.83)	(2.88)	(5.29)	(100)
2015*	16094	63890	27226	2093	1845	111148
	(14.48)	**(57.48)**	**(24.49)**	**(1.89)**	**(1.66)**	**(100)**

* Total Village=43264 & Habitations =78419
Source: http://indiawater.gov.in/IMISReports/Rajasthan

The Table 2.4 shows the status of groundwater development in Rajasthan since 1995 to 2011. It shows that Rajasthan is heading towards groundwater drought unless some serious measures are taken, such as, to change the trend of groundwater draft or special efforts towards groundwater recharge. The stage of groundwater development has changed from 95% in 1995 to 137 percent in 2011 and agricultural (irrigation) draft is solely responsible for this over exploitation of groundwater resources all over Rajasthan. Presently there is severe groundwater imbalance (Table). This situation will directly affect the drinking water supply both in terms of quantity and quality of water availability.

Table 2.4: Status of Groundwater in Rajasthan - 1995- 2011

(Figures in MCM)

Item	Year					
	1995	**1998**	**2001**	**2004**	**2009**	**2011**
Gross/ Net groundwater recharge	13157	12602	11159	10382.58	11862.24	11911.44
Groundwater Draft (1) Irrigation (2) Domestic & Industrial	 9085 696	 11036 983	 10454 1181	 11599.01 1392.19	 12864.89 1654.35	 13133.18 **(88.5%)** 1709.82 **(11.5%)**
Gross draft(1)+(2)	9781	12019	11635	12991.2	14519.24	14843.00 (100.0)
Groundwater balance	3376	3894	**(-)476**	**(-)2608.62**	**(-)2657.0**	**(-)2901.56**
Stage of groundwater Development in percent	**59**	**69**	**104**	**125**	**135**	**137**

Source: Ground Water Department and Central Ground Water Department, Report of the Group on the Estimation of Ground Water Resources of Rajasthan 9as on 1.1.2001), April 2002,2004 2009,2011.

The changing status of groundwater in Rajasthan is reported in Table 2.5. It shows that in 1984 there were 181 blocks (76.7%) were in Safe category and 22 Blocks (9.3%) were in Over Exploited category and in the year 2011 that has changed to 25 Blocks (10.4%) in Safe category and 172 Blocks (71.4%)as Overexploited category. The 10 percent Safe Blocks are mostly in canal command areas or saline groundwater areas. The groundwater condition is at alarming stage particularly when 90 percent of drinking water supply in the State is from groundwater and top of it as the groundwater goes down the water quality is seriously affected.

Table 2.5: Changing Status of groundwater in Rajasthan (1984-2011)

Category	**1984**	**1988**	**2001**	**2004**	**2009**	**2011**
Over Exploited (>100%)	22 **(9.3)**	41 (17.0)	86 (36.0)	140 (59.3)	164 (69.5)	172 **(71.35)**
Critical (90 to 100%)	6 **(2.5)**	26 (11.0)	80 (34.0)	50 (21.2)	34 (14.4)	24 **(9.97)**
Semi critical (70 to 90%)	27 **(11.5)**	34 (14.0)	21 (9.0)	14 (5.9)	8 (3.4)	20 **(8.30)**
Safe (70%)	**181** **(76.7)**	**135** **(57.0)**	**49** **(21.0)**	**32** **(13.6)**	**30** **(12.7)**	**25** **(10.38)**

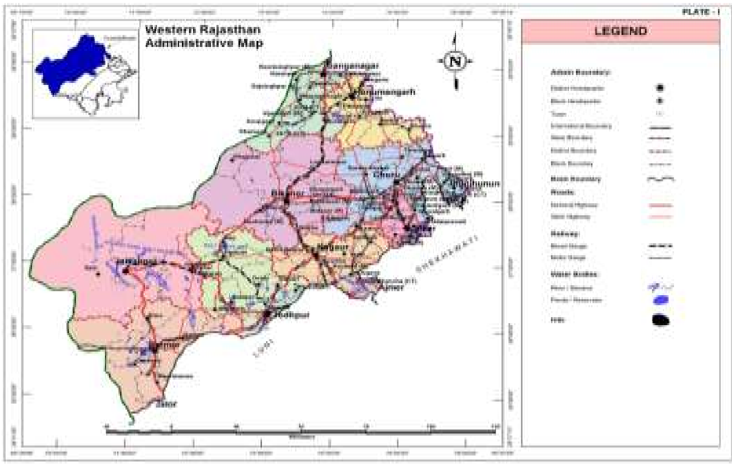
Source: Ground Water Department and Central Ground Water Department, Report of the Group on the Estimation of Ground Water Resources of Rajasthan (as on 1.1.2001), April 2002,2004,2009,2011.

Groundwater which is the major source of drinking water supply accounting for more than 90% in rural areas depleted fast during last two decades. Hence to reduce dependence on groundwater large surface water schemes in the name of 'Rajasthan State Water Grid' are being proposed to take care of future water supply mostly to meet the requirements of urban and rural areas. The water supply under the Grid is likely to cover entire population of the State by creating Bulk Water Transfer Infrastructure. Reviewing the State's sectoral policies and programs it was observed that the State government has taken various other measures in water sector such as, formulation of new water policy followed by legal and institutional reforms and water sector related initiatives in the last few years[4].

The achievement in terms of covered villages and habitation seems to be remarkable in the given condition of prevailing water scarcity in Rajasthan. However, quantity, quality, equity and other aspects are concerned lot has to be achieved. These issues are discussed below in the context of western region of Rajasthan.

2.3 Western Region of Rajasthan

The Western Region of Rajasthan comprise of 12 districts namely, Barmer, Bikaner, Churu, Jaisalmer, Jalore, Jhunjhunu, Jodhpur, Nagaur, Pali, Sirohi, and Sikar (Map 1), which is aroud 50 percent of the total geographical area of Rajasthan. The region is defined as out of Basin area as there is no river basin in the area. The average rainfall ranges between 150 mm in Jaisalmer to 350mm Jhunjhunu.



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4 The new initiatives are; enactment of Rajasthan Water Resources Regulatory Act, 2012; Rajasthan River Basin and Water resources Planning Act, 2015; Rajasthan Lakes (Protection and Development) Authority Act, 2015; Formulation of Comprehensive Water Law and Harmonization of Existing Water sector Acts; Rajasthan Urban Water Policy 2015;State Sewerage & Waste Water Policy 2015; Mukhyamantri Jal Swavlamban Abhiyan; Interlinking of Rivers, etc. Also various GOI initative in water sector in the context of Rajasthan are seriously taken up to ensure water security to people of Rajasthan.

The share of western districts population in the total population of Rajasthan in the census years 1991, 2001 and 2011 is shown in Table 2.6. It shows that western region accounts for around 35.6 percent of Rajasthan population. Among the western districts Jodhpur district has the highest population followed by Nagaur and Sikar. The lowest population district is Jaisalmer. The growth rate of population in the western region was 2.28 percent compared to 2.25 of Rajasthan State. The Jaisalmer, Barmer and Bikaner districts have registered highest rate of population growth in the last two decade crossing the rate over 3 percent. There was decline in the rate of population growth in the decade 2001- 2011 but in the last decade instead of further decline it increased for Rajasthan and the western Districts also.

Table 2.6: Growth of human population (Rural and Urban) and the share of Western Districts in total population of Rajasthan.

(Percentages)

District	**1991**	**2001**	**2011**	**1991-2001 (%)**	**2001-2011 (%)**	**1991-2011 (%)**	**Density**
Barmer	9.24	9.80	10.67	3.19	2.86	3.02	92
Bikaner	7.79	8.35	9.70	3.29	3.53	3.41	78
Churu	9.93	9.59	8.36	2.23	0.59	1.41	148
Jaisalmer	2.22	2.53	2.75	3.96	2.83	3.40	17
Jalore	7.35	7.22	7.50	2.40	2.36	2.38	172
Jhunjhunu	10.18	9.54	8.77	1.92	1.12	1.52	361
Jodhpur	13.86	14.39	15.10	2.97	2.47	2.72	161
Nagaur	13.80	13.84	13.56	2.61	1.78	2.19	187
Pali	9.56	9.08	8.35	2.05	1.13	1.59	164
Sirohi	4.21	4.24	4.25	2.67	1.99	2.33	202
Sikar	11.86	11.41	10.97	2.19	1.58	1.88	346
Western Region	**35.32**	**35.49**	**35.60**	**2.58**	**1.98**	**2.28**	126
Rajasthan	**100.0**	**100.0**	**100.0**	**2.53**	**1.96**	**2.25**	200
	(44005990)	(56507188)	(68548437)				

Note: Figures in parenthesis are numbers of persons.

Access to water in rural areas depends on source, settlement pattern and social aspects, such as caste and cultural practices. The distribution of rural population by caste category is shown in Table 2.7. Around 31.5 percent of the SC and 31.6 percent General population reside in western region and 28 percent of overall Rajasthan's rural population.

Table 2.7: District wise Number of Rural Population (as on 01/04/2015)

(Percentages)

District	SC	ST	General	Total
Barmer	3.99	1.90	5.01	4.31
Bikaner	4.16	0.04	3.58	3.11
Churu	4.03	0.10	3.29	2.91
Jaisalmer	0.94	0.45	1.39	1.15
Jalore	3.33	2.01	3.44	3.18
Jhunjhunu	3.22	0.51	4.30	3.48
Jodhpur	4.15	0.89	4.83	4.06
Nagaur	6.55	0.11	6.21	5.28
Pali	3.35	1.51	3.32	3.03
Sirohi	1.74	3.24	1.27	1.68
Sikar	3.54	0.83	5.05	4.08
Western Region	**31.48**	**8.86**	**31.64**	**27.88**
Rajasthan	**100.0**	**100.0**	**100.0**	**100.0**

Source: http://indiawater.gov.in/IMISReports/Rajasthan

2.4 Water Availability in Western Region

Surface and Ground Water availability in western region of Rajasthan is shown in Table 2.8. It shows that surface water availability sources are; major, medium and minor dams, located in different districts. The three districts namely; Bikaner, Jaisalmer and Jalore, has significant volume of surface water mostly transferred from outside state through Indra Gandhi Canal system (IGNP) and Narmada Canal system. In rest of the districts greater dependence is on ground water, mostly having quality problem.

Table 2.8: District wise total water availability (Surface and Ground water) in Western Region.

District	Major		Medium		Minor		Total		Ground Water (MCM)	Total Water (MCM)
	Live Storage (MCM)	CCA (Ha.)	Live Storage (MCM)	CCA (Ha.)	Live Storage (MCM)	CCA (Ha.)	Live Storage (MCM)	CCA (Ha.)		
Barmer	-	-	-	-	31	5,719	31	5,719	252	283
Bikaner	3,091	534,000	-	-	7	,1,783	3,098	535,783	242	3,340
Churu	162	28,000	-	-	-	-	162	28,000	135	297
Jaisalmer	3,044	526,000	-	-	1	23	3,045	526,023	64	3,108
Jalore	617	246,000	60	11,669	-	-	677	257,669	426	1,104
Jodhpur	353	61,000	53	6,379	177	28,977	582	96,356	396	978
Jhunjhunu	-	-	-	-	21	5,581	21	5,581	251	272
Nagaur	-	-	-	-	57	11,792	57	11,792	519	576
Pali	282	48996	119	20,805	188	37,898	589	107,700	295	883
Sikar	-	-	8	2,207	34	7,861	43	10,068	297	340
Sirohi	-	-	75	16,407	116	23,326	192	39,733	275	467

Source: State Water Grid for Rajasthan, PDCOR Ltd. 2016, page 71-72.

Details on total annual groundwater recharge, natural discharge and net annual groundwater availability in the western region is reported in Table 2.9. Groundwater availability is highest in Nagaur district and lowest in Jaisalmer district and in most cases the water quality is not as per the drinking water norms.

Table 2.9: District wise ground water availability in the western region.

District	Total Annual GW Recharge (MCM)	Natural Discharge during non-monsoon season (MCM)	Net Annual GW Availability (MCM)
Barmer	278	26	252
Bikaner	255	13	242
Churu	142	7	135
Jaisalmer	70	7	64
Jalore	467	40	426
Jodhpur	439	43	396
Jhunjhunu	276	25	251
Nagaur	575	56	519
Pali	327	32	259
Sikar	329	32	297
Sirohi	304	28	275

Source: State Water Grid for Rajasthan, PDCOR Ltd. 2016, page 68-69.

2.5 Drinking Water Coverage in Western Region

2.5.1 *Coverage of Households*: The focus of this study is Western Region of Rajasthan, therefore, the status of drinking water in the districts falling in the region is discussed below. Table 2.10 shows the status of Villages and Habitations (V&H) covered for drinking water as on December 2015. It shows that there are 43264 Villages and 78419 Habitations in Rajasthan. While in the Western region of Rajasthan there are 12715 villages and 35887 habitations, i.e., a total of 48602 V&H. Villages and Habitations account for 39.9 percent of total V&H in Rajasthan. As regards the drinking water coverage in the western region is concerned 97.7 percent of villages and 73 percent of habitations are under covered category. Except the districts; namely Barmer, Jaisalmer, Jodhpur and Churu, all other districts villages are 100 percent covered. In case of Habitations coverage only in Jhunjhunu, Sikar, Jalore and Sirohi district's are 100 percent covered and in rest of the districts it ranges between 54 to 87 percent. Provision of drinking water security requires greater understanding of the sources of coverage, quality of water supplied and sustainability of source.

Table 2.10: Covered & Uncovered Villages and Habitations in Rajasthan - 2015

(Numbers)

District	Covered		Un covered		Overall		
	Villages	Habitations	Villages	Habitations	Villages	Habitations	Total
Barmer	2270 (92.6)	4842 (54.0)	182 (7.4)	4132 (46.0)	2452 (100.0)	8974 (100.0)	11426
Bikaner	857 (100.0)	728 (70.3)	0 (0.0)	307 (29.7)	857 (100.0)	1035 (100.0)	1892
Churu	872 (99.9)	548 (76.9)	1 (0.1)	165 (23.1)	873 (100.0)	713 (100.0)	1586
Jaisalmer	743 (98.3)	1643 (53.3)	13 (1.7)	1441 (46.7)	756 (100.0)	3084 (100.0)	3840
Jalore	791 (100.0)	1988 (75.0)	0 (0.0)	661 (25.0)	791 (100.0)	2649 (100.0)	3440
Jhunjhunu	926 (100.0)	1549 (100.0)	0 (0.0)	0 (0.0)	926 (100.0)	1549 (100.0)	2475
Jodhpur	1741 (94.8)	6531 (72.0)	95 (5.2)	2538 (28.0)	1836 (100.0)	9069 (100.0)	10905
Nagaur	1575 (100.0)	3216 (87.8)	0 (0.0)	447 (12.2)	1575 (100.0)	3663 (100.0)	5238
Pali	1017 (100.0)	1508 (100.0)	0 (0.0)	0 (0.0)	1017 (100.0)	1508 (100.0)	2525
Sirohi	470 (100.0)	522 (100.0)	0 (0.0)	0 (0.0)	470 (100.0)	522 (100.0)	992
Sikar	1162 (100.0)	3121 (100.0)	0 (0.0)	0 (0.0)	1162 (100.0)	3121 (100.0)	4283
Western Region	**12424 (97.7)**	**26196 (73.0)**	**291 (2.3)**	**9691 (27.0)**	**12715 (100.0)**	**35887 (100.0)**	**48602 (39.9)**
Rajasthan	**42864 (99.1)**	**68284 (87.1)**	**400 (0.9)**	**10135 (12.9)**	**43264 (100.0)**	**78419 (100.0)**	**121683 (100.0)**

*Figures in parentheses are percentages.
Source: Pragati Viveranika 2015-16, PHED, Department, Government of Rajasthan, Jaipur

The three main sources of drinking water supply are; Ground Water, Surface Water and Rain Water. There are different delivery sources for drinking water supply, such as Pipe Water Supply (PWS), Open Well, Tube Well, etc. Table 2.11 provides details on Villages and Habitations drinking water coverage by *Groundwater Schemes* in Western Region. It shows that 98.4 percent of V&H in Rajasthan and 76.2 in the Western region are served by different Groundwater Schemes. PWS account for 55.9 percent, Open well 4.5 percent, Handpump 15.2 percent, Tubewell based other sources 23.9 percent and others 0.3 percent. Handpumps are in large numbers in the state and covers 41.5 percent of V&H but are not suitable in the desert region as either the groundwater is brackish (Bikaner, Churu, Jodhpur, Jalore and Nagaur districts) or very deep and it is for this reason mostly PWS are planned for the region. In case of groundwater schemes quality of water is the major concern.

Table 2.11: Villages and Habitations drinking water coverage by Groundwater Schemes In Western Region- 2015.

(Percentages)

District	PWS	Groundwater Schemes				Total V&H (No.)
		Open Well	Tube Well		Infiltration Galary/Well	
			Hand Pump	Others		
Barmer	73.59	2.15	19.27	4.99	0.00	4706
Bikaner	69.75	0.40	5.46	19.77	4.62	2013
Churu	83.21	1.35	2.23	13.20	0.00	1477
Jaisalmer	69.08	0.00	29.75	1.17	0.00	1795
Jalore	69.64	0.32	6.32	23.72	0.00	3798
Jhunjhunu	44.68	7.99	17.42	29.19	0.72	2491
Jodhpur	69.84	0.13	5.10	24.92	0.02	9584
Nagaur	36.02	21.88	8.52	33.55	0.02	4250
Pali	27.38	9.26	43.10	20.26	0.00	2991
Sirohi	28.23	2.26	66.88	2.63	0.00	797
Sikar	11.91	3.61	22.24	62.20	0.03	3156
Western Region(WR)	**55.96**	**4.56**	**15.20**	**23.97**	**0.31**	**37058**
WR share in Rajasthan	**48.37**	**47.39**	**11.33**	**38.32**	**27.78**	**30.94**
Rajasthan	**35.81**	**2.98**	**41.51**	**19.35**	**0.35**	**119742**

Source: http://indiawater.gov.in/IMISReports/Rajasthan

Drinking water coverage of habitations by *Surface Water Schemes* in Western Rajasthan is reported in Table 2.12. The main surface water sources in the region are Ponds, canal, and treated surface water sources. Surface water covers only 1.9 percent of V&H of Rajasthan and only 0.9 percent of V&H of western region. Canals as source of drinking water is mainly in Jalore, Bikaner, Jodhpur and Pali districts and treated surface water as source in Barmer, Churu, Jaisalmer, Pali and Jodhpur Districts. Ponds as a source of drinking water are mostly in Nagaur and Sikar districts. In the case of surface water supply the question of quality of water is an issue to be examined as the quality of IGNP canal raw water was found unfit for drinking (HEDCONE 2005).

Table 2.12: Habitations drinking water coverage by Surface Water Schemes in Western Rajasthan- 2015.

(Percentages)

District	Surface Water Schemes (Percentages)								Total V&H (No.)
	Pond	River	Lake	Stream	Canal	Spring	Treated Surface Water	Rivulet Naula Gadhera	
Barmer	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0	17
Bikaner	4.0	0.0	0.0	0.0	96.0	0.0	0.0	0.0	25
Churu	0.0	0.0	0.0	0.0	3.8	0.0	96.2	0.0	26
Jaisalmer	0.0	0.0	0.0	0.0	3.3	0.0	96.7	0.0	30
Jalore	0.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	23
Jhunjhunu	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
Jodhpur	0.0	0.0	0.0	0.0	79.3	2.7	18.0	0.0	111
Nagaur	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	15
Pali	1.0	0.5	0.0	0.0	72.5	0.0	26.1	0.0	207
Sirohi	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
Sikar	60.0	40.0	0.0	0.0	0.0	0.0	0.0	0.0	5
Western Region (WR)	**4.6**	**0.7**	**0.0**	**0.0**	**62.5**	**0.7**	**31.6**	**0.0**	**459**
WR share in Rajasthan	**51.2**	**3.8**	**0.0**	**0.00**	**34.9**	**100.0**	**10.5**	**0.0**	**1.96%**
Rajasthan	**1.8**	**3.3**	**0.6**	**0.0**	**35.1**	**0.1**	**58.9**	**0.1**	**2341**

Source: http://indiawater.gov.in/IMISReports/Rajasthan

Drinking water coverage of V&H by *Rain Water, Traditional and Other Drinking Water Schemes* in Western Rajasthan is reported in Table 2.13. Traditional sources account for only for 2.9 percent of drinking water coverage in Rajasthan and 4.5 percent in the western region. The number seems to be underestimate as there are large number of single households settled outside the nucleus villages and are scattered in the sand dunes of western region. Also government data only shows their own source and do not report household having their own drinking water supply from traditional water structures. Out of this reported 4.5 percent coverage by traditional sources the Roof top rainwater covers 54.9 percent in all the districts of western region except Sirohi and Jodhpur districts. While rainwater harnessed on ground covers 22.2 percent and is mostly in Jodhpur, Jaisalmer, Jalore, Nagaur and Churu districts. Traditional sources such as Khadin, Nadi, Tanka, Pond, Well, Beri, etc. account for 10.1 percent and are mainly in Bikaner, Nagaur and Sikar districts. The non conventional sources account for 12.8 percent of coverage and are in Jhunjhunu, Pali and Nagaur districts. Despite all these sources cover only 4.5 percent of V&H in western region. Even if we agree to this low coverage figures yet these are the only source of drinking water for households in the area and the possibility that these households likely to be covered in future by government schemes is bleak.

Table 2.13: Villages and Habitations covered by Rain Water, Traditional and Other Drinking Water Schemes in Western Rajasthan- 2015

(Percentages)

District	Rain Water		Traditional	Others	Total V&H (No.)
	Roof Top	Ground	Khadins/ Nadis/ Tankas/ Ponds/ Wells/ Ooranis	Non Conventional	
Barmer	100.0	0.0	0.0	0.0	1
Bikaner	61.9	0.0	38.1	0.0	21
Churu	87.3	11.1	0.0	1.6	63
Jaisalmer	39.4	60.6	0.0	0.0	175
Jalore	66.2	33.8	0.0	0.0	65
Jhunjhunu	65.8	0.0	5.3	28.9	38
Jodhpur	0.0	100.0	0.0	0.0	4
Nagaur	43.5	28.5	13.8	14.2	1172
Pali	74.7	1.0	0.0	24.2	384
Sirohi	0.0	0.0	0.0	0.0	0
Sikar	76.3	2.0	18.9	2.8	249
Western Region(WR)	**54.9**	**22.2**	**10.1**	**12.8**	**2172**
WR share in Rajasthan	**51.3**	**77.6**	**71.1**	**86.3**	**32.5%**
Rajasthan	**65.0**	**17.4**	**8.6**	**9.0**	**3578**

Source: http://indiawater.gov.in/IMISReports/Rajasthan

The general perception about drinking water security is to cover a village or population by piped water supply (PWS) and that to under public water supply. State line departments and PRI institution are all out for planning public piped water supply creating appropriate infrastructure and distribution system yet fail to achieve desired results. Table 2.14 shows the status of habitations covered with PWS. It indicates that of the ongoing and completed PWS schemes western region share is 48.37 percent and at state level the covered V&H is only 35.8 percent (Table 2.11). If we look at the issue of public versus private sector participation in the drinking water supply Table 2.15 shows that public sector dominates by owning more than 90 percent of the source and private sector has very little share less than 10 percent. Despite such a major role of state the drinking water security is not ensured, therefore the big question is can there be a new model of water resources management to address the problem of Rajasthan?

Table 2.14: Habitation Covered with Piped Water Supply in Western Region-2015

(Percentages)

District	Habitation Covered With PWS			
	With Ongoing	With Completed	With New	Total
Barmer	31.12	68.88	0.00	4113
Bikaner	0.64	99.36	0.00	1412
Churu	46.48	53.52	0.00	1648
Jaisalmer	29.14	70.86	0.00	1438
Jalore	14.20	85.80	0.00	2881
Jhunjhunu	77.84	22.16	0.00	1196
Jodhpur	31.32	68.60	0.08	7267
Nagaur	38.16	61.84	0.00	1782
Pali	21.64	78.36	0.00	864
Sirohi	8.26	91.74	0.00	242
Sikar	29.80	70.20	0.00	406
Western Region(WR)	**30.53**	**69.44**	**0.03**	**23249**
WR share in Rajasthan	**54.78**	**48.43**	**100.0**	**48.37%**
Rajasthan	**27.98**	**72.00**	**0.01**	**46301**

Source: http://indiawater.gov.in/IMISReports/Rajasthan

Table 2.15: Sources of Drinking Water supply in Western Region- 2015

Private/Public Sources 2015

District	Private Source	Public Source	Total V&H (No.)
Barmer	9.20	90.80	28334
Bikaner	2.28	97.72	15053
Churu	2.33	97.67	18245
Jaisalmer	8.56	91.44	10691
Jalore	7.18	92.82	7230
Jhunjhunu	16.59	83.41	35863
Jodhpur	18.06	81.94	39715
Nagaur	7.74	92.26	12706
Pali	0.42	99.58	20950
Sirohi	3.60	96.40	15854
Sikar	3.11	96.89	50828
Western Region(WR)	**8.28**	**91.72**	**255469**
WR share in Rajasthan	**29.66**	**30.69**	**30.6%**
Rajasthan	**8.55**	**91.45**	**834699**

Source: http://indiawater.gov.in/IMISReports/Rajasthan.

2.5.2 *Coverage of population*: The other way to look at the drinking water supply is to see how much population is covered rather than households. The drinking water **coverage of population** in Rajasthan and western region by ground water, surface water and other sources is reported in Tables 2.16 to 2.18. Groundwater serves 67 percent, surface water 83 percent and traditional sources 65 percent of total population (as on 2015) in Rajasthan and the coverage of western region population from these sources is 33, 17, and 35 respectively. Table 2.16 shows population covered by Groundwater Schemes in Western Region. The table shows that the different schemes namely, Pipe Water Supply covers 49.4 percent, open well 8.7 percent, Tube well 41.7 percent (Handpump 13.6%+ Others 28.1%), others o.2 percent of population in the western region.

Table 2.16: Population covered by Groundwater Schemes in Western Region-2015

(Percentages)

District	PWS (%)	Groundwater Schemes (Percentages)				Total population (No.)
		Open Well	Tube Well		Infiltration Galary/Well	
			Hand Pump	Others		
Barmer	77.1	1.4	14.9	6.6	0.0	1502039
Bikaner	73.6	0.2	5.1	20.3	0.8	1907725
Churu	76.0	2.4	2.6	19.0	0.0	1747546
Jaisalmer	73.3	0.0	25.0	1.7	0.0	450259
Jalore	61.5	0.4	10.7	27.4	0.0	2228833
Jhunjhunu	31.6	11.3	19.6	36.6	0.9	2747735
Jodhpur	66.1	0.1	3.0	30.7	0.0	2407970
Nagaur	36.1	25.4	10.5	27.9	0.0	4437255
Pali	37.9	14.2	22.5	25.3	0.0	2615101
Sirohi	51.2	4.8	38.2	5.8	0.0	908544
Sikar	23.0	5.2	17.7	54.0	0.0	2925217
Western region	**49.4**	**8.7**	**13.6**	**28.1**	**0.2**	**23878224**
WR Share in Rajasthan	**43.5**	**53.1**	**13.4**	**40.2**	**13.7**	**33.0%**
Rajasthan	**37.5**	**5.4**	**33.6**	**23.1**	**0.5**	**72329351**

Source: http://indiawater.gov.in/IMISReports/Rajasthan

Population covered by Surface Water Schemes in Western Rajasthan is reported in Table 2.17. The major surface water sources are canals, treated surface water and ponds. Canal system account for 52.7 percent and treated surface water 34.2 percent of surface water schemes. It is interesting to note that our field visit revealed that Nadi and Talab as a source of drinking water for human and livestock is very important source in the entire western region and that do not reflect clearly in the government published data. There are Talabs in all the western region districts where government pipe water scheme is in operation and severing large population villages or townships.

Table 2.17: Population covered by Surface Water Schemes in Western Rajasthan- 2015

(Percentages)

District	Surface Water Schemes (Percentages)								Total Population (No.)
	Pond	River	Lake	Stream	Canal	Spring	Treated Surface Water	Rivulet, Nalla, Gadhera	
Barmer	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0	16056
Bikaner	0.8	0.0	0.0	0.0	99.2	0.0	0.0	0.0	30224
Churu	0.0	0.0	0.0	0.0	46.9	0.0	53.1	0.0	4502
Jaisalmer	0.0	0.0	0.0	0.0	0.2	0.0	99.8	0.0	37821
Jalore	0.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	2973
Jhunjhunu	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Jodhpur	0.0	0.0	0.0	0.0	47.5	2.0	50.5	0.0	25205
Nagaur	100	0.0	0.0	0.0	0.0	0.0	0.0	0.0	23767
Pali	4.3	0.8	0.0	0.0	70.1	0.0	24.8	0.0	184652
Sirohi	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sikar	16.0	84.0	0.0	0.0	0.0	0.0	0.0	0.0	9725
Western region	**10.0**	**2.9**	**0.0**	**0.0**	**52.7**	**0.2**	**34.2**	**0.0**	**334925**
WR share in Rajasthan	**78.2**	**8.7**	**0.0**	**0.0**	**59.5**	**100.0**	**7.8**	**0.0**	**17.3%**
Rajasthan	**2.2**	**5.8**	**0.5**	**0.0**	**15.3**	**0.0**	**76.1**	**0.1**	**1934977**

Source: http://indiawater.gov.in/IMISReports/Rajasthan

Population covered by traditional sources is reported in Table 2.18. Even in this modern age with number of alternative sources and facilitating technology still traditional sources meets drinking water requirement of 53.4 percent of population of western Rajasthan. It shows that roof top rain water harnessing covers 63 percent, rainwater harnessed on ground 14.6 percent, traditional sources 10.4 percent and Non conventional sources 11.9 percent of the drinking water needs of population in western region.

Table 2.18: Population covered by Rain Water, Traditional and Other Schemes in Western Rajasthan- 2015

(Percentages)

District	Rain Water		Traditional	Others	Total Population (No.)
	Roof Top	Ground	Khadins/ Nadis/ Tankas/ Ponds/ Wells/ Ooranis	Non Conventional	
Barmer	100.0	0.0	0.0	0.0	1937
Bikaner	56.9	0.0	43.1	0.0	15071
Churu	68.0	7.3	0.0	24.7	10742
Jaisalmer	22.7	77.3	0.0	0.0	16403
Jalore	97.1	2.9	0.0	0.0	102881
Jhunjhunu	60.5	0.0	4.1	35.3	46686
Jodhpur	0.0	100.0	0.0	0.0	616
Nagaur	52.5	22.7	12.3	12.6	1491848
Pali	84.7	0.1	0.0	15.2	503031
Sirohi	0.0	0.0	0.0	0.0	0
Sikar	69.6	3.4	21.6	5.4	327478
Western Region	**63.0**	**14.6**	**10.4**	**11.9**	**2516693**
WR share in Rajasthan	**55.4**	**79.6**	**53.4**	**79.3**	**34.8%**
Rajasthan	**68.2**	**11.0**	**11.7**	**9.0**	**4191976**

Source: http://indiawater.gov.in/IMISReports/Rajasthan

2.6 Drinking Water Quality

Given the scenario of drinking water in Rajasthan where ground water is the major source and it has been over exploited all over Rajasthan, only 25 Blocks are safe consequently the groundwater quality is seriously deteriorated affecting the health of people. At the state level 19.8 percent habitations are suffering from chemical contamination of drinking water but for the western region the percentage is as high as 78 percent. Table 2.19 provides details on the Villages & Habitations (V&H) suffering from chemical problems in drinking water in Western Region of Rajasthan. It shows that 38.3 percent of the total V&H in Rajasthan are in western region and of that 77.7 percent are suffering from chemical problem. District wise analysis of chemically affected V&H in western region shows that Barmer district has the highest number (89.6%) affected by chemical problem followed by Jodhpur (45.9%), Nagaur (20.9%) and Jalore (4.8%), Churu (21.8%), etc.

Table 2.19: Habitations suffering from chemical problems in drinking water in Western Region of Rajasthan- 2014

Districts	Total Habitation	Chemical problem Habitation	Percent of total
Western region	**46338(38.3)**	**18624(77.7)**	**40.2**
Barmer	11390	10203	89.6
Bikaner	1862	302	16.2
Churu	1567	341	21.8
Ganganagar	3689	44	1.2
Hunmangarh	1985	8	0.4
Jaisalmer	3773	436	11.6
Jalore	3429	900	26.2
Jodhpur	10899	4998	45.9
Nagaur	5238	1094	20.9
Pali	2506	298	11.9
Rajasthan	**121133**	**23956**	**19.8**

Source: http://indiawater.gov.in/IMISReports/Rajasthan

The Water quality affected Villages & Habitations by the type of chemicals in Western Region of Rajasthan is shown in Table 2.20. It shows that Fluoride, Salinity and Nitrate are the major chemicals affecting the health of people in Rajasthan. The V&H affected by different chemicals in Rajasthan are; Salinity 62.1 percent, Fluoride 31.7 percent, and Nitrate 6.2 percent. The western region is worst affected. Table shows that 92.1 percent of V&H are affected by Salinity, 64.4 percent Fluoride, and 51.5 percent Nitrate. Within western region V&H affected by Salinity are in all the districts but more severe in Barmer, Jodhpur, Bikaner and Churu districts. While salinity as a problem can be addressed to some extent by under taking various measures but fluoride in groundwater is major problem as evident from the Table 2.20. The percentages of V&H affected from fluoride touches; Jaisalmer 95.2 percent Sirohi 89.3% Sikar 84.2%,Pali 78.9%, etc. This problem can be only addressed by changing the source from groundwater to surface water.

Table 2.20: Water Quality Affected Villages &Habitations in Western Region of Rajasthan

(As On 01/04/2015) (Percentages)

District	Fluoride %	Arsenic %	iron %	Salinity %	Nitrate %	Total Village & Habitations (No.)
Barmer	6.6	0.0	0.0	93.3	0.1	9963
Bikaner	12.9	0.0	0.0	37.4	49.6	278
Churu	57.6	0.0	0.0	21.7	20.7	382
Jaisalmer	95.2	0.0	0.3	0.3	4.3	392
Jalore	77.9	0.0	0.0	19.4	2.8	651
Jhunjhunu	66.8	0.0	0.0	0.4	32.8	232
Jodhpur	30.3	0.0	0.0	66.6	3.1	4470
Nagaur	75.0	0.0	0.0	10.0	15.0	1162
Pali	78.9	0.0	0.0	4.2	16.9	261
Sirohi	89.3	0.0	0.0	10.7	0.0	75
Sikar	84.2	0.0	0.0	2.6	13.2	114
Western Region(WR)	**25.3**	**0.0**	**0.0**	**70.8**	**3.9**	**17980**
WR share in Rajasthan	**64.4**	**0.0**	**7.1**	**92.1**	**51.5**	**80.8**
Rajasthan	**31.7**	**0.0**	**0.1**	**62.1**	**6.2**	**22254**

Source: http://indiawater.gov.in/IMISReports/Rajasthan

Above we discussed Villages and Habitations affected by water quality problem the Table 2.21 provides details on the **population affected by water quality** in the western region. It shows that fluoride and salinity affects 49.6 and 39.1 percent of population respectively. In the districts Bikaner, Jhunjhunu and Churu nitrate is also emerging as threat to the health of people in the region. Serious interventions are required to address the problem at all levels in order to ensure water security in the region.

Table 2.21: Water Quality Affected Population in Western Region of Rajasthan

(As On 01/04/2015) (Percentages)

District	Fluoride %	Arsenic %	Irion %	Salinity %	Nitrate %	Total Population
Barmer	7.4	0.0	0.0	92.5	0.1	1713075
Bikaner	13.3	0.0	0.0	31.7	55.0	406706
Churu	63.3	0.0	0.0	18.1	18.6	560696
Jaisalmer	97.2	0.0	0.0	0.1	2.6	91154
Jalore	76.4	0.0	0.0	19.6	4.1	505233
Jhunjhunu	67.3	0.0	0.0	0.6	32.1	226740
Jodhpur	49.2	0.0	0.0	47.9	2.9	626655
Nagaur	76.0	0.0	0.0	8.9	15.0	1166354
Pali	83.2	0.0	0.0	3.8	13.1	366967
Sirohi	93.5	0.0	0.0	6.5	0.0	230763
Sikar	85.5	0.0	0.0	1.3	13.2	120487
Western Region(WR)	**49.6**	**0.0**	**0.0**	**39.1**	**11.3**	**6014830**
WR share in Rajasthan	**65.5**	**0.0**	**0.3**	**72.4**	**58.7**	**67.0**
Rajasthan	**50.7**	**0.0**	**0.1**	**36.2**	**12.9**	**8975350**

Source: http://indiawater.gov.in/IMISReports/Rajasthan

CHAPTER III
TRADITIONAL DRINKING WATER MANAGEMENT

Over the last one and half century there have been two major paradigm shifts in water resource management. One is that individual and communities have steadily lost their role, almost completely, to the state in the management of water resources. The second is that the reliance and use of the simple technologies of using rainwater has been replaced by complex engineering technologies of ground water extraction or river water storage and use for multiple purposes. However, river water and ground water aquifers are only a small portion of the total rainwater precipitation. This has resulted in growing and, in many cases, unbearable stress on these sources. Dependence on the state has meant that costs have increased and financial sustainability is endangered as cost recovery is poor. Repair and maintenance is poor and people have lost interest in using water carefully or in conserving it. As a result despite all government efforts, including large allocation of resources and launching of a number of new drinking water schemes, the number of 'problem villages', have no access to adequate and/or potable water, remains unchanged as evident from facts discussed above in Chapter II.

The issue is not primarily about the ability of government, non-government organisation or communities to choose one or another technically viable solution of water problems. It is also not really about integration or planning mechanisms for resolving multiple demands on and disputes over a limited water resource base. Both technical solutions and the degree of integration required depend heavily on context and specific nature of the water resources constraint being addressed. Since both natural and social conditions are changing and are subject to substantial uncertainty, one cannot make linear plans that will solve water problems for our lifetimes or for future decades. Instead, we need the capacity (information, forums and processes for decision making, legal and regulatory mechanisms, executive capabilities, and governance with embedded dispute resolution mechanisms) to enable society to respond to constraints that could be local or regional, short or long-term, political, economic or technical. This is the real challenge (Moench et al., 2003).

Scarcity whether absolute or induced, is not, however the only fundamental challenge in the western region of Rajasthan. Water quality and pollution are increasing and are major well known issues contributing to scarcity. Less published, however, are the challenges inherent in the variability and changing nature of water supplies along with the limited nature of scientific information and technical knowledge. Furthermore, the challenges are not confined to water *per se* but are also inherent in the rapidly evolving management of the environment. Water problems and water management options are much a product of the social, economic and institutional context as they are of the technical factors governing local hydrologic conditions. In addition, many of the most important water related challenges have to do with socio-economic distribution of access. Water problems tend to reflect the development paradigm adopted. Traditional wisdom, to some extent, can help in understanding the above listed issues, addressing and suggesting way forward in achieving drinking water security in the western region of Rajasthan.

3.1 Jal Darshan: What we can learn from traditional wisdom

A strategy of water management must be based on a philosophy of how water is to be viewed. What is the nature and value of water? Is it an economic commodity to be managed by the market principles of supply and demand? Or, is it a fundamental human right defined on the criteria established in the UN Declaration of Human Rights that includes protection of the right to livelihood and well being? Water is not just a basic need but it is a gift of nature that needs to be treated with respect. It is an essential component of human ecology and environment. Also, water has deep cultural, symbolic and spiritual significance in many cultures. Indian cultural traditions and ancient religious texts like the Rig Veda provide many examples of the way in which water was to be understood and managed. According to ancient Hindu beliefs, water is one of the five elements of the cosmic world. It is worshipped and the sources of rivers are given importance as holy places of worship.

The concept of dharma is another concept that was central to the tradition. This is important as dharma entails responsibilities – individual as well as collective – towards all aspects of the universal community of living beings. It also provides a code of conduct for the use natural resources, as well as a vision. In short, there is much to learn from the rich ancient wisdom. For sustainable use of water, the message that has to be learnt is human behaviour (greed and exploitation) needs to be self regulated and to accept the responsibility of giving back to nature, at least, same amount of water that we extract from the ground (mother earth). Cleanliness and non-pollution directions are also found in some of the Vedic texts.

3.2 Ancient Indian Methods of Water Conservation and Rainwater Harvesting

Rainwater harvesting structures are a part of a strategy for water conservation. People in all parts of country have a long standing tradition of rainwater harvesting by designing different types of structures and management systems.

The Indus Valley Civilization, that flourished along the banks of the river Indus and other parts of western and northern India about 5,000 years ago, had one of the most sophisticated urban water supply and sewage systems in the world.

The fact that the people were well acquainted with hygiene can be seen from the covered drains running beneath the streets of the ruins at both Mohenjodaro and Harappa. Another very good example is the well-planned city of Dholavira, on Khadir Bet, a low plateau in the Rann in Gujarat.

One of the oldest water harvesting systems is found about 130 km from Pune along Naneghat in the Western Ghats. In ancient times, houses in parts of western Rajasthan were built so that each had a rooftop water harvesting system. Rainwater from these rooftops was directed into underground tanks. This system can be seen even today in all the forts, palaces and houses of the region. Underground baked earthen pipes and tunnels to maintain the flow of water and to transport it to distant places, are still functional at Burhanpur in Madhya Pradesh, Golkunda and Bijapur in Karnataka, and Aurangabad in Maharashtra.

The principle behind rain water harvesting is simple: to hold the drops of rainwater in a very clean space and stock it. Be it in *kund*, *kundi*, tanka (pond, small pond, reservoir), talab, the names and form may change, but the function is the same: to preserve for tomorrow the drops that have fallen today. Ponds are to be found everywhere. Inside the forts constructed atop mountains, in temples, at the foothills of mountains, in the courtyard of houses, on rooftops, in villages, outside the villages, in uninhabited places, in fields; everywhere, at any time, these can be made. There are *kundis*, which are two to three hundred years old and others that have just been made.

In Rajasthan, wherever any space is available, people made a sloping courtyard there. The slope can be from one side to the others but if the courtyard is big enough, it can run from the four sides and converge towards the middle portion. In this portion, a *kund* is made according to the shape and size of the courtyard and according to the amount of rain, which falls. The inside of the *kund* is lined in such a way that not a single drop from the water collected within is lost through seepage, and thought the year the water remains clean and protected. People in different parts of country innovated such structures, with improvisation based on local condition and needs and gave them different names. Such structures are time tested and were the sustainable source of drinking water to all.

3.3 Region specific means and technology of rainwater harvesting/ water conservation

Rainwater, runoff and the floodwaters from rivers were all harvested. The design and structure of each system was decided by the terrain and rainfall pattern of the region. Hence each eco-zone of India had unique techniques for harvesting water[5]. For Rajasthan, **in the arid and semi-arid regions**, where the streams are more seasonal, the diversion channels first led the water to a storage structure like a tank for later use. Storage systems to collect just runoff from the watershed were also built. In regions with good groundwater aquifers, dugwells with innovative methods to lift the water were in use. Deep wells were dug in the beds of tanks and rivers, both to serve as a source of good water when the water recedes and also to recharge the groundwater when they are fully submerged and in areas where rainfall is the only option, people devised methods to literally “catch rainwater where it fell”.

Throughout India, several ingenious ways have been devised to catch and store rainwater for future use. They are known as traditional water harvesting systems. It is the traditional water harvesting systems that have made life possible even in the Thar Desert.

The technology and engineering of the traditional water harvesting systems differed, depending on whether they were to provide drinking water or to be used for irrigation. Those meant for drinking water were generally smaller, sometimes covered and with steps leading down to the water. This ensured that people could only collect water manually in small quantities to meet their individual or family’s needs. Irrigation systems on the other hand spread over large open areas and had a complicated network of pipes and channels for collecting and distributing water.

3.4 Traditional Water Harnessing Systems

Water has been harvested in India since antiquity. Evidence of this tradition can be found in ancient texts, inscriptions, local traditions and archaeological remains. There is some evidence of advanced water harvesting systems even from pre-historic times. The Puranas, Itihasas (Ramayana and Mahabharata) and various Vedic, Buddhist

5 For details on region specific rainwater harvesting systems/technique see Rathore, M. S. Rajendra Singh (2009) “Indigenous Knowledge of the Vulnerable Communities Living in Drought Prone Area of Rajasthan, India”, published in Chakrabarti, PG D. et al. (2009) Indigenous Knowledge for Disater Risk Reduction in South Asia, Macmillan Pub. Ind. Ltd., Delhi (SAARC Diaster Management Centre, New Delhi), pp. 49-73. And Agarwal, A. and Narayan, S. (ed.) Dying Wisdom- State of Environment- A Citizens’ Report- 4, Centre for Science and Environment, New Delhi, 1997.

and Jain texts contain several references to water, its importance in life, livelihood and management systems and structures, namely, canals, tanks, embankments, wells and large number of local names[6]. *Khadins*, tanks, *nadis* and *Johads* in Rajasthan, *bandharas* and *tals* in Maharashtra, *bundhis* in Madhya Pradesh and Uttar Pradesh, *ahass* and *pynes* in Bihar, *kuhls* in Himachal Pradesh, *ponds* in the Kandi belt of Jammu region, and *eris* in Tamil Nadu, *surangams* in Kerala, *kattas* in Karnataka are some of the ancient water harvesting, including, including water conveyance, structures still in use today. Traditional systems are specific response to ecology and culture in which they are evolved and satisfied certain local needs in an environment friendly manner. Traditional systems have benefited from collective human experience since time immemorial and in that lies their biggest strengthen. They are based on the sound principles of ecological conservation in contrast to environmental overuse of modern systems.

Traditional water harnessing systems can be observed even today in different parts of the Rajasthan. Most are based either on harnessing surface rainwater run-off or groundwater extraction. The tankas, *khadeens, baoris*/ step wells, *talabs*, *kunds,* etc. are functioning at least in western part of Rajasthan. People fall back to some of these sources of water when the new State run systems breakdown for one reason or another (power failure, source failure). The main features of these traditional water supply systems that are also their strengths in comparison to the modern modes of management are:

- **Location** specific and suitable to local conditions.
- **Structure**: Well planned, technically correct, low cost, well designed, sustainable, sound engineering (long lasting), low O&M cost, made with local material, people friendly technology, no outside expert required to build or maintain.
- **Management**: Decentralised community/ individual management, practices sustained by codes of established customary practices that were also linked to social, religious and spiritual activities around water bodies that ensured cleanliness, maintenance and community involvement. Additionally, addresses the issue of equity in access to water.

6 For more details, see five books on water and life, religion, culture, etc. published by Tarun Bharat Sangh drawing from Veda and other religious texts.

However, these systems have partially lost their significance due to state-sponsored policies and interventions. Introduction of laws based on the British system emphasized private ownership rights of individuals. In 1863, the Public Works Department (PWD) was created. As a result, local control over *johars* and *talaabs* was withdrawn and placed under the PWD. Similarly in 1865, the right to collect revenue from forests and arable and non-cultivated land was taken over by the Government. These changes mark the end of the commons and as a result of the water bodies as well. The commons were the catchment areas for the water bodies and areas of groundwater recharge. High population growth and systematic encroachments have aggravated the situation to an extent that it often appears beyond repair.

After Independence the State took over the responsibility of supplying drinking water and that too from alternative sources for public health reasons. The State could address the drinking water needs of some but it has failed to provide water to all. Further it has led to deterioration of most traditional structures that came to be seen as inferior sources. Therefore, It becomes necessary now to take a fresh look at not only what we can learn from the traditional sources but also the role that they can play in the system of providing sustainable water security in areas where even today state had partial coverage of drinking water.

3.5 Role of Traditional Systems

People want `modern' systems of drinking water supply because nobody likes to walk long distances to fetch water from a well or a tanka/Talab. Supply at doorstep, by turning a tap is quite naturally the preferred mode. It is only when modern system fails or breakdown (which is quite frequent in rural areas) people think of traditional systems. Also in western Rajasthan desert areas there are large number of villages and habitations where modern systems may never reach because of its unfavourable economics and settlement pattern. People in these areas continue to depend on traditional systems for drinking water. Traditional systems have been severely eroded, thrown into disuse and even eliminated in most parts. This deterioration has worsened over time despite the fact that the present system of centralized supply and management of water has failed to meet the needs of a large number of people. Some of the facts responsible for the decline of traditional systems are; (i) growth in population and water demand which could not be met through traditional technologies and systems and at the same time, availability of modern and more convenient water supply through centralized storage systems, (ii) the government's emphasis and open bias in favour of large, complex, and costly systems with low capital efficiency ensuring that power and authority stays with the bureaucracy and the community remains bonded to it, (iii) the fostering of greater dependence on the state itself for even small matters like maintenance of existing systems; and (iv) state promotion of individual beneficiary oriented schemes leading to decline of active community participation in the maintenance of traditional systems (Agarwal & Narain 1997).

Traditional systems use low cost, user-friendly techniques and were easily kept in good operational condition by local communities. Traditional community-based structures also contributed to social cohesion and self-reliance. On the contrary modern systems harmed the society by fregmenting the community and increase dependence on the government. The problem is compounded by the fact that modern systems, operating on market economy principles, are far from perfect in terms of their distribution impact. A few are favoured at the cost of many. Water supply schemes are taken up in the election years but water is rarely released in them. Government agencies often fail to keep modern systems in good working conditions[7]. Therefore, if drinking water supply in rural Rajasthan has to be sustainable, equitable and community based, then traditional systems have to be rejuvenated and developed along with the modern systems.

3.6 Traditional Water Management Strategies

The principle of traditional water harvesting was to conserve rainwater where it falls according to local needs and geographical conditions. Traditional water harvesting systems have to meet domestic and irrigation needs of the people. Functionally, these systems have sustained communities through dry months and at times even stood the test of prolonged drought periods. But sometimes, when the rains failed for years together, small systems broke down. This created the need for big systems. But the balance between small and big structures was worked out carefully. Traditional systems used low cost, user-friendly techniques and were easily kept in good operational conditions by local communities, i.e. no external support was required or no external dependence was created.

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[7] Rathore, M.S. (1990) "Traditional Water Harnessing Systems in Rajasthan - A Study of Underground Tanks" in Mathur PC and R.K, Gujar, Water and Land Management in Arid Ecology, Rawat Publication, Jaipur

3.6.1 Drinking Water Management

`Water is Life' and its realization takes place only when one come across water scarcity as prevailed in the Thar desert of Rajasthan. It can be understood also by the fact that when a guest arrives in a household in Thar Desert instead of serving water he is offered butter-milk or milk or only one glass of water that too blended with brackish water. Guest's demand for water makes the host uncomfortable, as he has to fetch potable water from long distance at heavy cost. The desert area receives low rainfall varying between 100 mm to 350 mm in a year, and 90 per cent of years some part or other is drought affected, i.e. quantum of rainfall is 25 per cent or more below the average rainfall. People walk miles to fetch drinking water and use each drop of it very carefully. Even in such adverse conditions, human and livestock could survive with the traditional rainwater harvesting technologies. Surface and subsurface water harnessing technology was evolved to quench the thirst. Even after the modern technological interventions, these traditional systems are still the most reliable source of drinking water in the region.

Thar society evolved cultural beliefs that ensured judicious use of the scarce resource of water and, over the centuries enabled it to keep competing pressures on its natural resource base within manageable limits, permitting survival in the desert terrain. The system not only supported the scattered settlement of rural population but also city like Jaisalmer, centre of trade route from Gulf countries to India. Ghadhsisar Lake is a living example of how, with very low rainfall, a lake in the middle of sand dunes could sustain life.

Ghadhsisar Lake in the Thar Desert (Jaisalmer)

The water harnessing structures used for supply of drinking water varies according to geological conditions, rainfall in the area, and type of settlement. In most parts of western Rajasthan, the desert area, there is a layer of gypsum at varying depth starting from Northwest to Southwest districts. Below the gypsum layer, the groundwater is deep and mostly brackish of varying intensity. Therefore, the traditional drinking water sources are designed to overcome these features. Rainwater is harnessed both on the surface and below surface depending upon the topography and demand for water. Rainwater trickling down in the earth is tapped at two places: firstly sub-surface water and secondly the groundwater. To avoid mixing of rainwater to brackish groundwater, small structures, namely *kuin* (shallow wells), about a depth of 45 to 55 feet, are dug to tap the sub-surface water before it percolates to the salty water table, to meet the need of few households or single household. The structure of *kuin* has a small opening at the top and size of cavity gradually increases with depth. It is mostly above the gypsum layer so the water is of good quality and it is named as `*rejani*' water. The desert people have classified water into three categories; first is *palar pani*, i.e. rainwater falls on the surface of the earth and collected in different structures or flows in rivers, etc. The second is called *patal pani*, that is, subterranean water or groundwater. The third type of water is called *rejani pani*, which is the sub-surface water above the gypsum layer, much better than *patal pani* (mostly brackish) and mostly used for drinking purpose. There is special technique to construct a *kuin*, which collects this special *rejani* water. A *kuin* has a circumference of 6 to 8 ft. to a depth of 45 to 100 ft.[8]

Rainwater harnessing by construction of different types of structures is very common across Rajasthan. These are constructed to harness the *palar* water (rain water) for mostly drinking and other domestic use. The common names of these structures are *kund, kundi, tanka*, etc. These are individually and community owned and located within boundary of house, agricultural fields or in village common lands. These structures can meet only partial water demand of a household, but also serve as water storage tank when rainwater is exhausted. People transport water in distress year or period of a year, from distance and fill these structures to use for longer period.

8 For more details see Anupam Mishra, Rajasthan ki Rajat Bunde, Gandhi Shanti Pratishtan, New Delhi, 1995.


Tanka in front courtyard of a house

The designs of these structures are based on their size and amount of rainfall in the area. Inside of these structures is lined in such a way that not a single drop of the water collected within is lost through seepage and throughout the year the water remains clean and protected. The catchment areas around these structures is called *agor,* are made of specific size and are well maintained so that raindrops get collected into the structures free of any pollution. Such structures are also constructed in agricultural fields. Given the large area of agricultural land in the desert region, the distance between village settlement and agricultural fields are quite long. In monsoon season mostly people work on their agricultural fields and they have to protect their crops from animals, hence mostly they temporarily shift on fields. Since to work on field's in hot weather water is needed and this water demand is met by construction of small and big *kundis* made at small intervals. *Kundis* can be both private and collective. Private *kundis* is made in front of houses, in the front courtyard (*angan*) and/or backyards. The collective *kundis* are made on common lands or usually between two villages. *Kundis* are made in sandy regions where the water table is deep and the ground water is salty. These are totally made of local material.

Earthen kund in an agricultural field

In the Desert Region whether a house is small or big, a permanent structure or not, the *kundi* will always be of a permanent structure. The villages are generally far-flung and moreover thinly populated. Therefore, it is not possible to have a centralised arrangement to distribute water to such widely dispersed settlements. That is why the society evolved a totally decentralized system of water work, based on their local needs and available rainfall. They also made *kunds* to collect rainwater, which falls on the roof, courtyard and the plains.

Kundi in agriculture field

The other structures are *tankas* (reservoirs). They are pretty much like *kunds* and *kundis*. The water collected in them comes from the roofs of houses instead of the courtyard. The size of *tanka* is in proportionate to the size of roof and also considering the family water requirement. The *tanka* is usually located in a room, a hall or courtyard and it is properly covered. To ensure its purity, no one goes on the rooftop wearing any footwear. Tanks are even made in uninhabited places, far from localities, villages, and hamlets and are basically for society. These are also meant for herdsmen and cowherds.

Tanka Near House **Tanka in Agricultural Land**

Besides these small structures, meeting the drinking water needs of individual household or few households there are structures to meet the water requirement of a village, large village, or number of villages or a town. Such structures are known as *bandh-bandha, taal-talai, johar-johari, nadi, talab, sarvar, sar, jheel, deibandh-jagah, dahari, khadeen, bhe.* All these water bodies are to harness rainwater. In the region which today's society considers impossible to live ancient society made it possible through designing these different types of water harnessing structures to survive for generations. The forms and names of these structures vary according to the different topographies of the earth. These structures could sustain people in very extreme climatic conditions including consecutive droughts and famines. The number of structures, their design, size and their management systems were well defined based on the water demand. Though these structures are many centuries old, even today they help meet the water demand of people in desert region. The strength of these structures is that even after so many years they are still holding firm in one form or another and upholding the strength of society. Meager rainfall in the desert region/the catchment areas of these structures is capable enough to fill up the structures and meet the drinking water needs of the human and livestock populations. Except in some parts where state intervention, in terms of making alternative water supply systems (canal or groundwater based schemes), the traditional systems went out of use and partially destroyed for their neglect.[9] IGNP canal water is supplied to many villages and government considers it as safe but there is major quality problem[10].

9 For more details on the strength of these traditional structures and society, see Anupam Mishra (2001), "The Radiant Raindrops of Rajasthan", RFSTE, New Delhi.

10 On quality of IGNP water see M. S. Rathore, Deepak Malik and M. Bagoria, (2002), " A Report on Water and Health: A study of IGNP", HEDCON, Jaipur.


Traditional community rainwater harvesting structure in Sikar district, Rajasthan.

As regards total water availability and the management of that accumulated/ stored water, community evolved different marks, symbols etc. that can be understood by common people to assess, after the rainy season, the total amount of water available for rest of the year. Based on the availability of water the use pattern was self-regulated by the society.

The traditional structures were good enough to provide drinking water security to the animal and human population in the desert area. Despite large investments made to bring canals in the region unfortunately the modern state with its technology, manpower and wealth have failed to provide safe drinking water security to desert population. Even today there are many villages where people are totally dependent on traditional water systems and they maintain them and are water secure. While in villages where people have neglected their traditional sources, drying up of the public source or breakdown in pipeline makes them more vulnerable than others who have maintained their traditional sources. In fact recurring droughts had forced the community to remember and maintain their traditional structures. There is something very attractive about modern technology, howsoever irrational, unsustainable, or ecologically destructive it may be on occasions. The conventional development model has eroded the capacities of communities to self-organise, even to the extent of robbing them of self-respect. The outcome is resilience depletion. Resilient livelihoods are those that can first recover (self-organise) after disruption and, following recovery, are capable of learning and adapting. They are strong enough to cope with surprises and change, as condition requires. Therefore, serious efforts are required on the part of state and civil society to bring back the confidence and resilience of communities.

Presently there is no social or institutional mechanism to guide the community to rejuvenate the traditional structures and management system. There is need to identify the need and create platform for community to participate and address the problems. In the next section some of the issues are addressed.

3.7 Technical and Scientific aspects of Traditional Water Harvesting Structures in Western Rajasthan

Rain fall in the western region of the state is very low (350 mm per year) and water evaporation rate is very high i.e. more than 2.75 m/annum. The settlement pattern is also scattered in Dhanies (Hamlets) and villages. Thus for providing drinking water security various type of structures were constructed depending on Hydro-geomorphology, soil, water bearing formation, type and depth of weathering etc. A detail study was made in all the districts of western Rajasthan with geological, geo-hydrological, geo-morphological, topography, and drainage maps and other technical details and a report is produced as Volume II of this main report. The questions asked were; why a specific type of structure in that location/region? Is it because of geographical conditions or other factors?, etc. The learning's from Part II of the report applicable to different type of structures is discussed below.

I. Sagar/Mahsamnd/Samand/Lake/Talab: These are big water bodies and name is also given as per their size. These are constructed mainly in rocky areas where there is defined river/stream/channel. These have proper dam wall and waste weir to release the excess water. The storage capacity of such structures is huge and normally water remains thought the year. At times these have feeder channel also. In some areas even Talab is constructed by digging the depression in genteelly slopping area having good catchment of Kakar and Clay and the earth so excavated was used for dam wall (e.g. Talb of Bap). In areas with large open field, i.e. having good catchment and runoff, such structures were constructed in series so as to harvest excess runoff released from one at upper catchment is harvested and stored in the second structure at downstream side and so forth (in Jodhpur district).

II. **Nadi/ Pond:** Traditional water bodies like village ponds have been catering to local human and livestock population since centuries. These water bodies (ponds/nadi) are best suited in the western region and also show the engineering skill and high degree of community sharing, social awareness to protect and maintain. The basic thinking behind a village pond water was **"WATER FOR ALL"**, that is, free access from common pool resource.




Depending upon the social custom, land use, and topography the catchments of these water bodies they are built in common lands and/or agricultural land. Most of villages with flat topography will have their own pond/nadi. The site selection depends on available natural catchments and its water yield. In general the storage capacity of pond/nadi is very limited with water availability for 6 to 8 months. The larger village ponds having more depth (4-5 M) with large catchments, the water lasts round the year. It is observed that ponds have very large water spread area as compared to total storage due to which, the evaporation losses of total stored volume of water is very high. In general the total evaporation losses accounts around 50-70% of total storage depending upon various factors such as climate, water spread area, wind velocity and direction of blow etc.

Inter dune areas of desert, the surface is generally clayey with little slope are the suitable location for such water bodies. Thus the Nadi's are excavated to store the surface runoff. The clayey and kankar layer at bottom of excavated part do not allow stored water to seep down and it becomes perfect storage structures. One wonders that in spite of known fact that evaporation rate is very high why nadi's have large water spread area with limited depth. The capacity of such structures is decided by runoff from catchment which is normally large. Since impermeable layer of Clay and kanker is up to limited depth i.e. 4-5 m b.g.l, so depth have to be restricted to store the water, failing which water will seep down. Thus by increasing the surface area, the entire water which comes as surface runoff can be stored.

Most of the ancient Nadi's have been constructed by Nomadic tribe (Banjara/ Chrawha) who used to travel with cattle's and other animals like goats, sheep during the summer for grazing adopted a typical migratory system. They have even evolved very scientific way to dispose the excavated soil while constructing the surface water structures. One of the nomadic tribe is known as **"Lakahi Banjaras"** used to make big dump/mound of excavated earth as lead for the same was too much. If this excavated material disposed within the catchment which is by and large circular, the soil will come to water body and the water body will be silted. Their technique is wonderful way for ensuring no silting and cost reduction.

In order to address the problem of high evaporation losses which is about 70% and is between March and June, villagers use to lift water using the Camel/bullock carts or now a day's water tanker and store in private household tanka or community Tanka to ensure water during peak summer period. It has to be appreciated that community not only used scientific aspect to protect the scares resource but is also united to conserve the same.

These ponds/nadies were being maintained without any written code of conduct or rules for many centuries.

III. **Kund:** It is also rain water harvesting structure dug out at suitable location. In the areas having good catchment with clay and kankar with larger thickness, normally a rectangular excavation is done with lining from stones all sides and steps. At times people confuses it with step well (Bawri). The Walls of all the four sides are above the ground level and provided with inlet for surface water to inflow in the Kund. A separate way is given for cattle's to drink water which at places is regulator. In order to ensure that no seepage takes place from the stored water, the bottom of kund is treated with clay and/or lime mortar. The depth of kund ranges from 4 to 5 meters. If the catchment area is not good then even the catchment is treated with lime mortar.

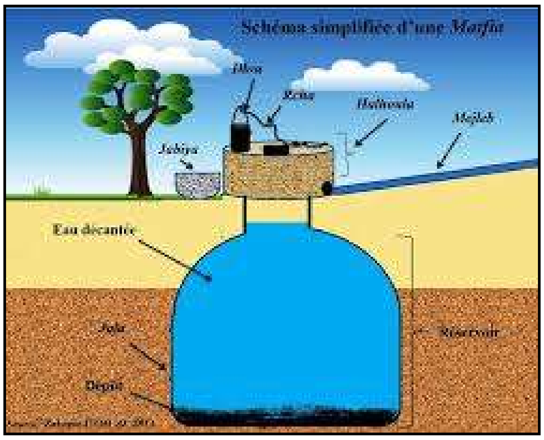
Sethani ki Bawari/Kund- Churu

These are constructed in areas having clay and kankar in catchment which generates more runoff. An excavation to a depth till the impermeable zone and run off is collected in it. To have good quality and volume of water care has to be taken that catchment is not polluted. There should be periodic silt removal from it. The bottom of a Kund should not be scraped as it have impermeable bottom which is necessary failing which all the water will percolate down.

IV **Beri:** Beri is under ground water storage structure. It is constructed in the areas where the thickness of weathered zone is more than 8-10 meters and it comprise of hard clay and knkar. It is very common to harvest runoff from genteelly sloping catchment in agriculture fields for drinking water needs. It is unlined storage structure with narrow top and very large below the narrow neck. Normally the narrow neck is about 1m in diameter up to depth of 2-3 m followed by large diameter excavation of about 8-10 m to a depth of 8-10 m to store the runoff. A desilting chamber with screen is provided at intake point. In Bap area of Jodhpur this type of structure is very common.

It is replica of Tanka but without dedicated catchment and civil work. Here the silt content in water coming will be very high. Therefore, care has to be taken while de-silting as in side is cavity, so while de-silting ensured that it does not collapse. At the inlet proper screen has to be provided to check the grass and leaves. It is advisable to provide a de-silting chamber to check the silt.

Beri in Bap area of Jodhpur



Schematic diagram of Beri

Kui/Beri's are alos constructed in village common lands where the rainwater flows from the agor (catchment) and percolates into the sandy soils. In order to access the percolated water kuis or beris are dug. Kuis or beris are normally 5 to 12 m deep. The structure is constructed through traditional masonry technology. Normally six to ten of them are constructed in a catchment. However, depending on the size of the catchment the numbers of kuis or beris are decided. This is the most predominant form of rainwater harvesting in the Barmer region and are mostly privately owned. Rainwater harvested through this technique is known as Patali paani.

Proper de-silting of water body and Kui is must to ensure proper inflow into the Beri. At times algae growth take place inside walls of beri due to moisture above the water level and reduces the inflow. Annual cleaning the inner walls of beri should be carried out for tapping seepage.

V **Tanka:** Tanka is a traditional rainwater harvesting technique, common to the Thar Desert region of Rajasthan, India. It is meant to provide drinking water for a single or a small group of families and is an important element of water security in these arid regions. Tanka is underground tank constructed for storing the water. The capacity of Tanka varies from few hundred liters to thousands of liters. It is civil structure and its capacity depends on water demand of household, type and size of catchment, rainfall and rain fall periodicity. The catchment for harvesting rain runoff can be roof top, paved area or artificially constructed catchment with clay/mud /cement, locally known as **"Agor".** Tanka's are similar to underground storage tanks in urban areas to store piped water supply, which is for limited period and use by pumping. Water from tanka is lifted by bucket and rope or handpump fitted on the top of the structure**.**

Tanka with artificial catchment is of two types; (i) Traditional Tanka, the catchment area (Agor) prepared with local material i.e. mud. Such types of catchment are age old and common in the western region. The slope of catchment is towards the central part where the tanka is constructed to store rain runoff. Traditionally tanka was lined with stones and top covered so that sun light does not penetrate, mainly to protect from growth of algae. At the inlet normally a screen is provided to catch leaf or other unwanted scrap material, etc. To draw water in some cases a pulley is also provided so that bucket and rope can be used. In most tanka no pulley is provide and directly water is withdrawn by rope and bucket. (ii) Modern Tanks, the artificial catchment area is of cement, to have more runoff, otherwise all other features remain the same.

The Agor is generally above from the ground level so that water carrying silt is checked. In the dune areas where silt comes with the wind, the Agor is so designed that the height is more in the direction from which the wind blows. Further in the areas where clay is more, the construction of tanka is tricky, as the clay swells during the rainy season due to moisture and causes cracks if it is build with cement. Traditionally stones with lime mortar were used for lining of walls of tanka. To avoid siltation in Tanka at times silt trap is provided as shown in Figure.

Tanka with artificial catchment and silt trap

Tanka in Agriculture Field **Tanka in common Land**

In order to get clean un-polluted water it should be ensured that catchment and tanka is properly cleaned before onset of rainy season. Further to prevent algae and bacterial growth sunlight is not allowed to penetrate in the tanka. All these are being practiced. However it is observed that artificial catchment is not properly protected from animals as it is not fenced due to which dogs etc. normally sit in the wet areas when water is drawn. It causes pollution and damages the catchment. In order to prevent this there should be fencing all around such catchment. Further normally water is withdrawn by using bucket and rope, which may cause pollution especially in community Tanka. It is suggested that a hand pump to be installed outside the periphery of catchment to withdraw water which will also help in proper upkeep of catchment.

Khadin: *Khadin* is also called *dhora*, is an ingenious construction designed to harvest surface runoff water for agriculture. Its main feature is; a very long (100-300 m) earthen embankment built across the lower hill slopes lying below gravelly uplands. Sluices and spillways allow excess water to drain off. K*hadin* system is based on the principle of harvesting rainwater on farmland and subsequent use this water-saturated land (soil moisture) for crop production. Khadin's were first designed by the Paliwal Brahmins of Jaisalmer in western Rajasthan in the 15th century. A shallow dug well near the Khadin provides safe drinking water.

It requires less up keep. Only Sluice and spillway should be properly maintained regularly repaired so that excess water timely allowed to go failing which either the entire water will flow out and/or it will be water logged.

Dug wells: In some parts of Western Rajasthan dug wells are also common especially where ground water is not saline. At places dug wells are more than 100m deep with diameter of only 1-1.5 m. It is surprising how these were dug. In parts of Bikaner where ground water is saline, dug well is constructed in depression and all the surface runoff is diverted into this dug well. As the density of fresh water is less it floats over the saline water, which is then withdrawn by bucket and rope. It is a good example of scientific input to store fresh water in saline aquifer. In hard rock areas large diameter dug wells are constructed to harvest more ground water from fractures and at times these are rectangular to tap more fractures or weak zones.

Dug well in hard rock

Anicut: These are constructed across small streams having gentle slope and are feasible both in hard rock as well as alluvial formation after proper scientific survey and sharing it with community to have input based on their traditional wisdom. Basically they are constructed for ground water recharge in the areas having sufficient thickness of permeable bed or weathered formation (identify through geophysical survey). However it is desirable to construct recharge shaft in the submergence area so that recharge is quick and multiple filling can also happen. The excess water is allowed to flow over the wall. In order to avoid scoring from excess run off, water cushion is also provided at downstream side. It should be ensured that no water directly lifted from pumps for irrigation; which is a very common practice. Further if water remains in the Anicut beyond March it will evaporate. Periodic de-silting of shaft and bed of water spread area to be done so that percolation is not restricted. The height of anicut wall has to be restricted to 2m as per the government guidelines.

3.8 Scientific and systematic analysis of Traditional Water Bodies in Western Region

A detailed scientific study was undertaken to understand the existence and role of drinking water structures/water bodies in the western region districts of Rajasthan by documenting the following features: Topography, geology, geomorphology, geo-hydrology, surface and groundwater availability, demand and quality, also variation in their availability, water bodies and traditional water harnessing structures, etc. (for details see Report Vol. II). After analysis of available information summary on traditional water harvesting structures wise information were prepared for each district and reported below.

The tables cover the following aspects:

1. Type of structure
2. Need/Purpose
3. Where located and Why
4. Technology/ Scientific aspects & material used
5. Water quality and health issues
6. Sustainability of structures in changed environment (geographic, economic, social)
7. Management systems
8. Options for drinking water security
9. Social/Economic/equity aspects

Traditional Water Harvesting Structure wise information

Type of structure- Talab

Districts: Barmer, Jaisalmer, Jodhpur, Bikaner, Nagaur, Jalore, Pali

Issues	**Findings – Field survey**
Need/Purpose	Mainly drinking water and domestic use. In case of large structures also used for irrigation. Mainly constructed by ancient rulers for water needs and also to provide employment during drought and famine years.
Where located and Why	Talabs are constructed where there is defined channel for runoff water to carry and slope is more. Jaisalmer: Mainly sandstone areas in eastern parts of the district. Some of the big structures have feeder channel. Bikaner, Jodhpur, Nagaur: Hard rock area with long flat land shallow weathered zone. Some of the big structures have feeder channel.
Technology, Scientific aspects & material used	Talabs' are water impounding structures in some case also serve as groundwater recharge structure (e.g. in Jalore district). Talabs' existed since centuries and are linked to history of human civilization in desert region. All the aspect of modern technology is taken care such as; compact earthen bund or Stone masonry bund. Stone pitching is done to check erosion from waves and ripples, also from human and livestock movement. Weir is provided for over flow. Regular de-silting was done by community and even the catchment is protected from pollution and encroachment. Evaporation losses are minimized by keeping depth more and smaller water spread area. Also to avoid evaporation losses water is lifted by March end and stored in household Tankas'. Local material used.
Water quality and health issues	Water quality good and no health issues if not polluted by sewage and solid waste which was not the case in earlier days. However due to human settlement around these structures at places sewage is directly discharged affecting quality of water. It has happened only in those cases where alternative water supply source was created by government. Since the groundwater in the region is brackish and having high fluoride content, the surface water of Talabs will always a preferred source of water. Animals are also allowed to drink water or swim in water the water quality affected seriously particularly when water level is low.

Issues	Findings – Field survey
Sustainability of structures in changed Environment (geographic, economic, social)	In the absence of any other drinking water source Talabs will always remain a sustainable source, if maintained properly and catchment is kept intact, i.e. free from encroachment and pollution. Small towns and large villages water supply is still dependent on these structures. Even if IGNP linked pipe supply is there the present experience is that the IGNP supply is not regular, quality not good, also distribution problems, therefore, the importance of Talab will remain for both human and livestock population. Presently supply in these structures is affected because of change in land use pattern, and pollution. Lack of periodic de-silting and maintenance of feeder channel and catchment, lack of community participation and greater dependence on government and PRIs. China clay mining in the Bikaner district is affecting catchment area of all the water bodies affecting the sustainability of structures. Mining of minerals, stones, etc. is also very common in all the districts of western region and that is affecting the water bodies and quality of water.
Management systems	Traditionally maintained by Kings, rulers and community. However this culture is declining, especially where the ownership is transferred from community to government or PRIs and provision of alternative sources of water are made available. Change in the ownership of structures has affected community participation. Traditional unwritten/conventional/customary system of management is breaking down because of general decline in community participation in village activities. Government takeover of these sources has created dependency syndrome resulting in almost no community participation. Government always looks for alternative source, engineering based supply side management systems, controlled by them and not interested in retaining traditional systems.
O & M costs	O&M cost was never a major issue as rulers and community were maintaining them in the past, now Panchayat is managing or Water Resource Department is maintaining these with their own budget. However, the cost of management has increased just because government owns it.

Issues	Findings – Field survey
	Decline in social responsibility of O&M of these structures is also because of MGNREGA works. Government treats de-silting work as an employment generation activity rather than a scientific de-silting of Talab to increase the capacity.
Alternative options for drinking water security	Canal Water: In the northern parts of western region the Gang canal was constructed which is unique and first inter -basin transfer of water by Raja Gagna Singh was followed by IGNP which is also flowing and providing water for irrigation, domestic and industrial use. Canal water is good alternative option but water is mostly supplied to nucleus villages/settlements is unsafe because not treated properly. Since in the western region there is scattered settlement pattern hence difficult to provide drinking water within the prescribed limits. Tap water: Through GLR using ground water (GW) but GW is brackish and fluoride affected, therefore, not a good alternative. Rooftop rainwater harvesting: Good, sustainable supplementary sorce for those have pakka houses and finance. Or private and or Community Tanka.
Social/Economic/equity aspects	There is no conflict noticed on the issue of access to water. All caste, class people have equal right and access to Talab water. Rather water body brings people together. Number of social rituals and festivals are performed around water bodies. Fairs are organized and people from distance villages assemble and ogranise social activities. There are set norms of water use lay down by the community, such as, water is not allowed to be lifted by tanker after a certain level of water is attained in the structure. Thefts of water and tanker water market are the two emerging points of water conflict. New practice of introducing nominal water charges to regulate water use and also raise money for O&M expenses. The contribution of these structures is significant in the form of eco-system services to the society and nation. The value of the ecosystem services provided by Talabs is undermined or not accounted anywhere by the state and/or people.

Type of structure- Naadi,

Districts: Barmer, Jaisalmer, Jodhpur, Bikaner, Nagaur, Churu, Jalore, Pali

Issues	**Findings – Field survey**
Need/Purpose	Mainly for meeting domestic and drinking water needs of humans and animals. It is a water impounding structure only in some cases it also acts as groundwater recharging structure.
Where located and Why	Where the catchment area is small Nadi is best suited structure for rainwater harvesting. Naadis are small excavated or embanked village ponds constructed in inter- dunel areas having impervious layer up to 5-6 m bgl. To mitigate the scarcity of drinking water for humans and animals. That is the only land space in sand dunes where rainwater can be harnessed. Nagaur: Mainly in areas having hard rock catchment with defined channel and depression to store runoff. Water can remain in it from 2 to 8 months.
Technology/ Scientific aspects & material used	Harvesting the runoff in areas where catch is good and storing the same. The size of Naadi depends upon rainfall in the area and physiographic conditions. Not much technology but much local knowledge and wisdom is involved in excavation of depression. The excavated earth is used for making wall (Bund) to protect. The depth of Naadi, length, height and direction of bund is location specific keeping in mind the size of catchment, wind direction and sand blowing direction in the summers. A traditional Naadi has the limitation of high evaporation and seepage losses, sedimentation and water pollution. Sedimentation deposition reduces the Naadi water impounding capacity. Modern science and technology can help addressing their issues. Evaporation losses are minimized by keeping depth more and smaller water spread area. Traditionally, to avoid evaporation losses water use to be lifted by the month of March end and stored in household Tankas’.
Water quality and health issues	Water quality good, no health issues till it is not polluted by sewage or human activities; like washing cloths and taking bath, defecation in the catchment area etc. Also if animals are allowed to drink water or swim in water affecting the water quality.

Issues	Findings – Field survey
	Guinea worm problem did exist before 1980s but with increase in awareness now claimed to be eradicated. Groundwater is unfit for drinking as it is brackish and contaminated with fluoride, nitrate etc. therefore only surface water is safe.
Sustainability of structures in changed Environment (geographic, economic, social)	Nadi as a structure is most relevant as on today and likely to be in future also in the western region. The sustainability issue is related to catchment capturing due to increased pressure on land and change in land use pattern affecting water inflow. Neglect of structures is observed where villages are served by government water supply schemes. But it is still a major source of drinking water for animals. Decline in social responsibility of O&M of these structures because of MGNREGA works.
Management systems	Traditionally managed by community and owned by community. However this culture is declining because of neglect, especially where alternative sources of drinking water are made available by the state. The main reason of neglect is increased awareness about the quality of water compared to alternative sources and health issues. Traditional unwritten/conventional/customary system of management based on open access and water as common pool resources. The system is breaking down because of general decline in community participation in village activities.
O & M costs	Annual cost negligible as community was managing and maintaining now Panchayat is managing, also the ownership transferred from community to Panchayat. Every 5 year major de-silting and clearing of feeder channels, etc. is required. That cost might be higher and Panchayat has to arrange it under rural development programs. Community contribution may or may not be there.
Alternative options for drinking water security	*Canal water*: Under the government water supply programs canal water supply in the region is on top priority. But canal water is supplied only to nucleus villages/ settlements. Given the scattered settlement pattern in the region it is difficult to provide water within the prescribed limits of rural drinking water supply. However, canal water quality is also a big issue.

Issues	Findings – Field survey
	Tap water: Provision of tap water supply is attempted through GLR using groundwater (GW), but GW is brackish and of poor quality. RO Plants are attached to GLRS for supply of safe drinking water to humans. There are success and failure cases of ROs. *Rainwater harvesting*: Rooftop or surface rainwater harvesting through construction of tanka is also a safe source of drinking water, known and practiced by people in the region. For livestock drinking water demand traditional structure (Nadi) are the only source.
Social/Economic/equity aspects	Equal access to water as it is managed as common pool resource by the community-No social issue. Water is not allowed to lift by Tanker after water in the structure reach to a certain level. New practice of introducing nominal water charges to regulate water use and also raise money for O&M expenses.

Type of structure- Tanka (Individual and/or community owned)

Districts: Barmer, Jaisalmer, Jodhpur, Bikaner, Nagaur, Churu, Sikar, Jhunjhunu

Issues	Findings – Field survey
Need/Purpose	Domestic water round the year
Where located and Why	A small circular or rectangular underground tank with lime mortar or cement plaster, constructed normally on shallow ground. located anywhere as per the local and individual need, such as, near the house (which is very common), in agricultural fields, schools, hospitals, Panchayat Bhavan, grazing lands, village commons, etc. Tankas are either individually owned or community owned. In the western region villages are scattered and at considerable distance from one another. The density of population is low therefore it is not possible to have a centralized water system. Community evolved a decentralized water management system and even addresses the issue of women drudgery in fetching water.

Issues	Findings – Field survey
Technology/ Scientific aspects & material used	Tanka catchment can be roof top or artificially made. The artificial catchment can be of made of local material such as Mud and clay or more recent with cement. The artificial catchment is generally circular and the slope is towards the centre (tanka) which is underground. Tanka is covered from the top, to block sun light entering in it. Protecting from sunlight ensures no algae and bacteriological contamination. The size of underground storage tank(tanka) depends on rainfall in the area, size of roof, household demand, etc. The walls of tanka are made of stones or bricks. Now a day's even RCC walls are being made. In clayey areas tanka is made of cement, as there are chances of developing crakes due to swelling of clay when saturated during the rain. Tanka is made in such a manner that no water can seep through the base and water remains intact and clean. Traditionally, inner lining of the tanka used to be of local material (limestone) having complete protection from any bacteria in water. In addition use of alum to clean water was very common.
Water quality and health issues	Quality of water is good till it is not polluted. It is observed that catchment prepared using local material, water quality is better as it has more mineral contents compared to cemented catchment. The catchment if not protected from movement of human being and animals the quality becomes un-potable. Water lifted by using bucket and rope create chances of pollution in water especially in community Tanka. Suggestions: It is advisable to fence the catchment and install a hand pump outside the catchment, which will reduce chances of damaging the Agore (catchment) and contamination of water.
Sustainability of structures in changed Environment (geographic, economic, social)	Tankas are most sustainable and useful structures, government is also promoting them. They serve as rain water harvesting and storage structures During drought year if there is a tanker supply, water can be stored in it. Tanka demand will increase as we are going ahead for "Swachh Bharat Abhiyan" with emphasizes on sanitation and restricting open defecation, which may require water availability round the year at nearest point.

Issues	Findings – Field survey
	Where ever government has introduced new schemes and alternative source of drinking water Tankas have fallen into disuse and are not maintained but if the government/alternative sources are unreliable and meets partial household drinking water demand then the Tanka is most useful supplementary source. New Tankas are combination of traditional and modern techniques, as one finds handpumps, use of filters, plastic pipes, etc.
Management systems	The community tanka's are maintained by community /panchayat. Individual tanka's are maintained by owners. The catchment area/rooftop is cleared before rains, tank and filters are cleaned. Since Tanks are life line for community the management system is well developed. Tankas in school and Panchayat Bhawans are maintained by respective organizations
O & M costs	Negligible annual cost, maintained by individuals/community.
Alternative options for drinking water security	Good source for water security both at community and individual level. *Talab and Naadi*: Water availability depends on rainfall, which is highly variable. Evaporation losses are very high from surface water bodies (Talab, Naadi), therefore, water is lifted and stored in Tankas. Tanka is complimentary source rather than substitute. *Canal Water*: Canal supply is for limited period once in 7-10 days so these structures help regular supply. These structures can be used as storage tanks. *Tap water*: Water supply from GLR or tubewell can be other supplementary source feasible only if groundwater is not brackish, which is not the case in western region.
Social/Economic/equity aspects	Equal access to water. Reduces conflict of ownership and equity and improves access to drinking water. In case of community Tanka the management and usage rules are well defined, equal access to all. In order to improve access to poor households unable to afford individual tanka government should support them through easy loans for construction of tanka.

3.9 Management Guide lines for Traditional Water Harvesting Structures

In the western part of the state especially in outer basin areas variety of structures are existing which are time tested. As discussed earlier these are now neglected by both community and government. Following are the brief guidelines to manage and even revive and restore traditional structures, as they have the potential to play major role in providing drinking water security especially in rural areas.

Sagar/lake/Talab: These are mainly constructed in hard rock areas having good runoff and defined channel. These have large capacity of holding the ware and depth is also more. By and large these structures are maintained by government agencies like Water Resources Department. The water is used for water supply and/or for irrigation. At times these are supplemented by canal ware to provide security e.g. Kaylana lake in Jodhpur, Jaisalmer Talab etc. It was observed that in spite of above average rainfall these structures are not filling to their full capacity. The main reason for this is **"Catchment Capturing".** It is observed in the catchment of such structures numerous interventions are made, such as, construction of other water harvesting structures namely, Anicuts, diversion channels, roads, etc; due to which the committed flow is captured or obstructed in upstream, resulting in limited utility or less than the planned use of structures.

Nadi/Pond: These are most common structures distributed throughout the Western region and are used either as water impounding structure or groundwater recharge structure depending on the geology and hydrogeology of the area. The village ponds/Nadies are the prime sources of drinking water but have been neglected both by community and government. The present use of such structures is for allocation of MGNREGA works to generate rural employment. In general following aspects to be looked for their revival & restoration:

I. **Catchment:** It is the feeding source to pond and has numerous problems such as:
   a. Encroachment due to which either the area has reduced and/or used for other activity resulting in less run off.
   b. Human Interference such as disposal of village refuses, sewage etc. cause pollution.
   c. Growth of Plants especially shrubs etc. affects the run off. At times depressions are formed due excavation of soil for various purposes that reduces the run off.

d. New harvesting structure comes up within the same catchment thereby sharing the run off.

2. **Bund:** In general bund is for proper disposal of excavated earth, as normally ponds are constructed on flat terrain. Due to improper maintenance and/or improper construction various problems take place which are:

(a). **Gulley Formation** in the pond is very common problem due to rain as the earth/soil, so deposited is loose. This problem is very common where the soil is sandy or silt. The angle of repose of such soil is very large there by not only the erosion and gully formation takes place due to rain but also as the water level in the pond falls, the angle of repose changes with the change of moisture content in soil and start sliding.

(b). **Tree roots** also damages the bund, along which water channels are formed and slowly erosion takes place there by damaging the bund. Plantation of trees should be avoided on the bund and preferably grass or shrubs to be planted to check the erosion.

(c). **Improper compaction** at the time of construction and de-silting may enhance the erosion & gully formation, especially during rains. It is common if compaction is not proper, then the bund upper part start sliding.

(d). **Ripple action** caused by wind also damages the bund especially in upstream part between the HFL & dead storage level. This phenomenon is very common in the areas where wind velocity is very high e.g. Western Rajasthan.

(f). **Encroachment**, human & animal movement also causes the damage to bund. It is very common that in many places the animals are allowed take water from pond & they start approaching to water body from bund side there by damaging it.

Human & animal movement also causes the damage to bund.

II. **Submergence Area or Water Filled Area**: The submergence area should be protected not only for its capacity but also for any way of pollution. In general following are the reasons for its damages:

(a). **Silting** is very common problem in all the ponds in the submergence area. It not only reduces the storage capacity of pond but especially the pond designed for recharge to ground water; their efficiency reduces many folds. Further it is likely that the water spread area may increase to accommodate the run off thereby causing more loses both from evaporation & seepages.

Silting

(b). **Growth of weeds** is common in ponds especially in the pond in which water remains throughout the year. The weeds may cause the pollution to water & at times adds to losses.

Growth of weeds is common

(c). **Human activity** which is knowingly or unknowingly causes serious damages to all the components of ponds. It is very common in the villages to digging out the clay either from the tank bed or from the catchment. If it is from the tank bed and not limited to the depth of clay bed which acting as barrier and not allowing the water to seep down, then the losses due to seepage will increase many fold, resulting to complete draining of stored water and locally called as "*talab phoot gaya*".

III. **Social Aspects:** Social aspects play vital role in maintenance of any common pool resources including ponds. Aspects which require attention for management of ponds are:

(a). **Awareness** to keep the catchment clean to avoid any pollution and also to ensure that there is no encroachment.

(b). **Protection from pollution** especially directly in the water. It is observed that community is not aware about the harms, which can be caused by allowing the used water, be in the form of village sewage, bathing water etc. to be drained into a pond. At times even the buffaloes are allowed remain in the water. All these activities are being practiced and polluting the pond water.

(c). **Cast based society and settlement pattern,** which still prevailing in villages also affects proper maintenance of ponds. At times different cast people have different approach to fetch water from pond and causing damages to bund and also conflicts in sharing of water.

(d). **Water lifting method** may also cause pollution, especially from the dug well adjoining to pond. It observed that every house hold will have its own bucket and rope to withdraw water from well and may cause pollution. It is better to install hand pump and cover the well so that directly no pollution can take place.


Withdrawal of water through Rope and bucket

(e). **Mosquito breed** is very common especially in shallow water bodies and in the adjoining areas, if slushy.

Mosquito breeding

(g). **Economics** also plays a significant role for community participation and proper maintenance of water bodies. There is no general practice to pay for use of Nadi/Talab water and even for its proper repair and upkeep. Though, traditionally labour contribution in de-silting of water bodies was very common in western region. Payment for water, it may be any amount as decided by the village community was tried by NGOs in the region and is working well. This practice can provide financial sustainability to all water bodies in the region.

3.10 Sequence of operations for Pond/ Nadi/ Tanka/ Anicut/ Kund/ Beri/ etc. rehabilitation.

There are enough evidence to establish that even today traditional water bodies are meeting the drinking water demands of human and livestock population in western region despite their neglect. It is strongly felt that to ensure drinking water security in the region these structures need rehabilitation/rejuvenation to ensure their sustainability. Presently there is lack of institutional, technical, handholding and financial support. If the rehabilitation work has to be undertaken there is need for guidance.

In order to impalement the rehabilitation work in planed way following sequence is suggested

1. Identification of water body/structure based on the selection criteria. All details and maps to be collected for technical and scientific analysis.
   - Proper analysis of water body for Rehabilitation- Taking tour along with community and share all scientific inputs.
   - Rapid Rural Appraisal (RRA) of water body and village.
   - Assessment of rehabilitation and repair works required
   - Identification of community need and willingness including financial aspects

2. Pre observation of the water body components such as;
   - Weed infestation (area and density)
   - Nature of weeds
   - Method proposed for eradication of weeds (uprooting, burning, cutting etc.)
   - Scientific investigation of tank components e.g. bund, feeder channel, waste water wear etc.
3. Formation of water users association
   a. Organising meeting of Gram Sabha/ all people using water from the water body.
   b. Selection of members for Water Users Association and a leader.
   c. Prepare guidelines on roles and responsibilities of water users and managers.
   d. Also identify an organisation/institution to provide handholding support and technical guidance.

4 Obtaining firm commitment from the community for their contribution towards water body rehabilitation works, planning and implementation of work including future maintenance at their own.

5. Preparation of detail plan involving community and estimates for community contribution or funding agencies. This should include following:
   - Removal of weeds and shrubs from catchment area/ water body bed/feeder channel/ bund
   - Demarcation of water body boundary through survey
   - Identification of encroachment in various components of water body
   - De-silting of water body bed and feeder channel
   - Repairs/ modifications of surplus weir
   - Tree plantation and other measures for erosion control

6. Monitoring the actual execution of works:
   - Implementation of rehabilitation work as proposed in the plan and estimate
   - Participatory monitoring of the progress
   - Quality check at each component of work
   - Periodic recording of measurements
   - Periodic verification of work account from community
   - Preparation of completion report and expenditure statement

7. Community involvement for fund and maintenance should be as follows:
   - Arranging matching grant
   - Training on operation, maintenance and management
   - Arranging for proper documentation, record keeping and social auditing

CHAPTER IV
MEASURES FOR DRINKING WATER SECURITY

The Rajasthan government has listed 121683 Villages and Habitations (V&H) for drinking water supply (As on April 1, 2015 the total number of villages and habitations are 43264 and 78419 respectively) and as on 1.4.2015 in 111148 villages and habitations were covered accounting for 91.34 percent of total, though different sources. Analysis of source of drinking water it revealed that Handpump is the major source of drinking water as it severs 57.5 percent of V&H followed by Regional Schemes 24.5 percent, Pipes and Pipes & Tanks 14.5 percent, TSS and Janta jal Scheme 1.9 percent and Traditional sources 1.7 percent respectively.

The regional distribution of the problem villages in the rural Rajasthan reveals that 54 percent of these non covered (problem) villages are located in the Western region, 34 percent in the North-eastern region, and the remaining 12 per cent in the Southern region. In the Western region these villages are located in Barmer, Bikaner, Churu, Jaisalmer, Nagaur and Jodhpur districts.

The Western Region of Rajasthan comprise of 12 districts namely, Barmer, Bikaner, Churu, Jaisalmer, Jalore, Jhunjhunu, Jodhpur, Nagaur, Pali, Sirohi, and Sikar, which is covers around 50 percent of the total geographical area of Rajasthan. The region is defined as out of Basin area as there is no river basin in the area. The average rainfall ranges between 150 mm in Jaisalmer to 350mm Jhunjhunu. Western region accounts for around 35.6 percent of Rajasthan population. In the Western region there are 12715 villages and 35887 habitations, i.e., a total of 48602 V&H. These account for 39.9 percent of total V&H in Rajasthan. As regards the drinking water coverage in the western region is concerned 97.7 percent of villages and 73 percent of habitations are under covered category. Except the districts; namely Barmer, Jaisalmer, Jodhpur and Churu, all other districts villages are 100 percent covered. In case of Habitations coverage only in Jhunjhunu, Sikar, Jalore and Sirohi district's are 100 percent covered and in rest of the districts it ranges between 54 to 87 percent. There is big gap in what state claims through published statistics and ground reality because the data only shows of coverage of concentrated settlements against the disperse/scattered settlement and without mentioning the quality of water. Provision of drinking water security requires greater understanding of the Household /population covered, sources of coverage, quality of water supplied and sustainability of source.

Historically, it has been established that traditional water structures in the western region of Rajasthan are answer to the drinking water supply to disperse settlement of village habitation, particularly for those habitations where centralised system of water supply is uneconomic or technically not feasible. Improvisation of these sources/structures by modern science can further strengthen their utility even in the modern era. The only major limitation of these structures is to match their capacity to ever-increasing water demand. The specialty of these structures is that there is range of options, ranging from individual household, rooftop harvesting to community structures. But they cannot meet all demands, however, can definitely meet the drinking water demand of a household or village community and livestock a major resource of livelihood. It is possible only if we consciously learn from the structures and make understand people at large to their role in future drinking water security.

The introduction of new engineering structures and also modifying the time tested designs and material used in traditional structures without understanding the social, economic and cultural milieu has led to drinking water insecurity in the region and complete demolition of village water management institutions and water culture. Therefore, re-establishing faith in time tested old age traditional structures is needed with input from new modern science and technology to overcome the gaps, particularly the quality of water.

4.1 Tools for providing Drinking water Security.

People living in the arid Region of Rajasthan have developed their own coping strategy in keeping with the environmental and resource specificities, but the operational component of this coping strategy is under severe strain due to rapid demographic, technological and institutional changes. Drought and water scarcity always loom large, minimizing the options for inter-year and intra-regional variability in water availability and livelihood options. People through different coping strategies try to adapt both to good and bad rainfall situations whereas policy-makers and administrators often respond to only drought situation.

Since Independence, the arid areas have benefited from development efforts and public support programmes. The state policies, to some extent, also reduced this vulnerability to severe water scarcity. At the same time, most of the state initiatives leading to these gains have significantly affected the traditional adaptations/adjustment mechanisms making them unfeasible or ineffective. The public relief strategies to help people were designed and pushed to such a level that they have more or less displaced the people's own adjustment mechanism and generated strong dependence on state support.

The public policies and large number of rural development programmes pursued under different National Development Plans adversely affected the collective sustenance arrangements as most of them focused more on individuals rather than on groups of traditional types. The most important factor helped in collective sustenance and induced group participation in resource management were the village common property resources, i.e., water, grazing lands, etc., unfortunately these have been privatised on a large scale, because of state failure to protect them.

Therefore, the tool to evolve a safe, sustainable drinking water security for people living in the western region of Rajasthan should be based on protecting the village commons (the source of water) and State taking serious note of traditional/indigenous knowledge of people and traditional water bodies.

4.2 Strategy for sustainable drinking water security

The strategy for sustainable drinking water security can be establishment only through a decentralised framework of self-reliant independent community managed system. There are enough evidences in Rajasthan to establish that communities are capable of managing their own affairs. Such a strategy needs to be developed on the basis of the following principles:

- The objective should be to provide **safe drinking water security to all**
- Role of state to be transformed from that of providers to that of facilitator (committed by state in its State Water Policy 2010).
- Communities/Panchayat's to be given full responsibility to plan, operate, manage and maintain all rural drinking water schemes as provided by the 73rd & 74th Amendment.
- Ensuring quality and source sustainability through appropriate technological innovations and interventions based on the existing scientific and traditional knowledge and practices including ground water and rainwater harnessing systems.
- Undertake water sector governance reforms to support the above listed aspects.
- Addressing social and gender equity in access to water.

Detailing such a strategy has the following two components viz. (i.) determine technological alternatives and (ii) steps for enabling and empowering village communities to deliver the desired outcomes.

First, Technical alternatives are not merely engineering solutions but they also have to consider specific geo-cultural contexts. Local specificities define and describe the different ways in which local communities have found solutions to the water issues. Solutions include the settlement pattern of the habitation, identification of a suitable source and the management responsibilities of the community. On the basis of extensive study of local water supply systems, Tarun Bharat Sangh (an NGO working mainly in Rajasthan) had worked out a detailed geo-cultural atlas that demarcates about 95 zones in India demarcated on the basis of agro-climatic and geographical conditions and cultural practices of natural resource management[11]. This can be useful starting point for identifying local solutions. Basically, the local systems are rainwater harnessing systems and groundwater recharge systems. *These systems include management of catchment areas and commons for providing adequate flow and recharge. Restoring the hydrological systems is crucial for local level source sustainability. These are described separately in the Volume II of this report.*

Second, Enabling and empowering village communities so that *community can effectively participate* in planned interventions. Community participation is considered as panacea for all rural problems and has been also the main thrust of State Water Policy 2010. Despite it being prescribed in all the programme guidelines, the processes for realizing the objectives are neither clearly defined nor understood. As a result it is rare to find effective community involvement in programmes and their implementation. The situation needs serious analysis.

Community Participation

Community participation refers to involvement of the village households, both men and women population in water resource management by working for rejuvenation of traditional water bodies/structures, building new structures, feeling sense of owning the structures and water resource, work for its conservation and protection, pay some contribution (according to capacity) for use of water, identify problems if any and help finding solutions, take care of sanitation in the village, help reducing drudgery of village women and facilitate equitable access to resources.

[11] M. S. Rathore (2007) Sustainable, Safe Drinking Water security in Rural India: An Alternative Approach, Jal Biradari Publication, Tarun Bharat Sangh, Jaipur.

Community should feel responsibility, authority and should have control over resources. Take initiative to build sustainable drinking water source, share some cost in construction and accept responsibility for operation and maintenance of the system(s).

State has to make special efforts by involving right kind of local NGOs to mobilise community participation.

As the community is the user of improved facility, manager of water source and supply and also has to take measures for its sustainability, therefore, community participation can be ensured only when;

- State gives them enough indication that the resources belong to them (i.e., ownership of water) and state will act as facilitator and will provide all support to harness, augment and protect village water resources.
- Whatever water source and water supply facilities are created when belongs to community and government facilitates in maintenance of assets then people will be motivated to generate their own resources for O&M of systems. State support can then only be in crisis or if some major investment is needed to build a larger system. PRI's/local communities/village water committees should be suitably empowered to generate resources for O&M and other use.
- Communities have to be provided technical input for the new engineering schemes by organising capacity building trainings. Training is also needed for hand-pump repair, O&M of tube-well, construction and rehabilitation of traditional structures, geology and hydrogeology of the area, etc. The trainings should empower/equip them to plan, implement, use, maintain and initiate alternative water supply schemes.

A region wide campaign is necessary to make free commons (the catchments of rainwater harnessing systems) and restore the hydrological system to help attaining sustainable drinking water in rural villages. It is also in line with the Supreme Court judgment to remove all kinds of encroachment from these lands. The second step is empowerment of beneficiaries. This must include a participatory approach as far as decision making is concerned a sense of ownership by the end user fully vested with the rights and duties regarding the restoration and the development of resources and transparency as far as management and benefits are concerned. It has been increasingly realized that an outside NGO or agency cannot play this role.

4.3 Managing Drinking Water

To achieve sustainable development and environmentally sound management of water resources in rural areas of western region of Rajasthan greater attention have to paid to the formulation and implementation of a state drinking water policy with the following general objectives:

(i) Ensure on a sustainable basis adequate water supplies for present and future needs of rural areas based on traditional and modern systems jointly.

(ii) Adopt participatory approach of planning and implementation of water security plans at panchayat level.

(iii) Improve access and efficiency in distribution of water.

(iv) Devise economic incentives and disincentive for managing water demand through appropriate pricing and tariff structures.

(v) Prevent water pollution; and

(vi) Reverse current trends of water resources degradation and depletion through capacity and awareness building of all the stakeholders.

To achieve these rural water development and management policies have to be formulated within the framework of regional water management based on a river basin approach/watershed based approach rather than village, town, or cities. Since the western region has no river basin and watershed and size of villages are also large, up to 20 kilometers it is suggested that gram panchayat should be the unit of planning taking notice of small rivulet flows/drain as part of plan. Rainfall and traditional water bodies are very important component of water planning hence authentic village wise data be generated and used for planning.

The strategy in case of canal water and bulk water supply through large system particularly in towns and cities in the region greater emphasis should be on demand management along with supply management which, in any case, will have to receive due importance because of the deficient water situation in the region. It is high time to recognize pricing of water as an extremely important instrument of demand management and fix tariff accordingly. Water demand reduction methods and strategies should be formulated using economic incentives and legal instruments.

An important aspect where there is lack of clarity both at policy and at technical levels is the alternative models of service delivery such as privatization, contracting, NGO, wholesaling by PHED to user groups, peoples participatory - involving user groups (Sahabhagi Yojana), etc;. Secondly, choice between the supply sources ranging from surface to ground water systems; namely, canal, tubewell, ponds etc., the approach on these issues should be to allow innovative methods of delivery systems in different parts of the region, document them and then try to draw inferences. Also there is strong need to allocate some budget for R & D particularly in the social and economic aspects to guide policy analysts.

For drinking water security it is essential to understand the nature of water and use by different sources according to the conditions that prevail. In general understanding today, water is regarded as an undifferentiated resource to be used for any and all uses that require water. If irrigation is the priority, surface and groundwater are all used. Deep wells, bore wells, tubewells and mining of water for irrigation is being used. This is the primary cause of depletion of groundwater and therefore, drinking water insecurity.

Conservation of water is an essential component of drinking water security. The attitudinal change from conservation to exploitation changed only after state intervention and taking the role of provider and creating a dependency syndrome. People gradually started looking at state line departments for all kinds of services and lost initiative to protect, maintain and manage their water structures and institutional arrangements. Therefore, fresh efforts has to made to reverse the trend and change the mind set of people and make them responsible for ensuring drinking water security.

State Groundwater department assesses the status of groundwater and groundwater withdrawal but there is time leg in release of the report and therefore, cannot be used in annual action plan. As there is tremendous scope for rainwater harnessing and recharging, efforts are needed in a mission mode to enhance ground water by undertaking special programmes using appropriate technical and scientific inputs. Government, panchayat and community should ensure recharge of at least that much quantity of water which is withdrawn annually, where ever feasible, through artificial recharge structures.

All traditional water bodies in the villages should be identified, demarcated and freed from encroachments. Their catchment and inundated area must be recorded and notified on a public signboard displayed at a prominent place. These water bodies need to be rejuvenated with the help of community participation. Many of these water bodies are presently being used as waste disposal grounds. It should be ensured that after cleaning they are not being polluted again. A state level rule, regulation or law be promulgated to check pollution in water bodies and Panchayat's be made responsible for monitoring and reporting the status half yearly.

The present system of centralized, supply side management model of drinking water supply lack in ensuring drinking water security in villages. Therefore, there is a need to adopt new approach, viz. decentralize community driven water management system. This entails transfer of ownership, control and management of village water resources to the village community after building their capacity and providing all kinds of technical support by the line departments. As the quality of surface and groundwater is the major problem, it should be addressed first by measuring the level of pollution, followed by checking pollution by public participation. This may require a water sanitation campaign in each village. Financial and technical support should be made available by the respective departments.

Rooftop harvesting of rainwater should be made mandatory for all the schools, government office buildings and community buildings even private houses in order to recharge aquifers.

4.4 Village Level Interventions

The first step in ensuring village drinking water security is to formulate a village water management committee represented by all sections of the village community. The village committee must be made accountable and transparent in all its activities and ensure use of water resources in an equitable manner. This committee should be made responsible for planning, development, management and water security in a village. This is possible only if there are statutory provisions made with administrative and political commitment to support such a model of water resource management.

Each village/habitation should identify at least one surface and groundwater source, based on their traditional wisdom and scientific input. It might be possible that the identified source was sustainable in the past but presently has dried up due to neglect or because of over-exploitation but can be revived with some community effort and scientific input, may also be considered.

Groundwater Act will remain ineffective unless the management and monitoring of groundwater are vested in the village water committees. Groundwater has to be planned on aquifer or block level and recharge measures are to be suggested based on location specific geo-hydrological conditions. Scientific information on all the groundwater parameters usable by village water committee be prepared and shared with the committee.

Till now the PHED had a supply-side management system. Consequently people had developed a tendency/attitude of exploitation and inefficient use of water resources. People considered water as a free resource and it is the responsibility of democratic state to provide water free for all kinds of uses. The government is seen as provider rather than facilitator. Therefore the traditional wisdom and practices of water conservation and management got eroded. Hence, there is a need to change rolls, i.e. the state should change from provider to facilitator and people should feel their responsibilities to manage the resource sustainably. This is possible only if they learn from their traditional customary practices of water conservation, augmentation and protection. The state and village community should jointly work to ensure recharge of ground water to the extent that matches the exploitation from ground. The natural balance between what one takes from the nature and what gives back to nature should be maintained. It will require special IEC efforts based on specificity of each geo-cultural region.

Presently there is shift in water policy in favour of privatisation of ownership, management, investment and transfer of water resources. This policy will be counter-productive in achieving the goal of sustainable drinking water security. Therefore, it has to be changed to communitisation of the ownership and management of water resources. The village community be made accountable and responsible, should own the village water resources.

4.5 Common measures for Water Security

In the western region Talab, pond/nadi, Tanka and other traditional structures were the source of drinking water earlier, but gradually with time and government interventions the source got shifted to dug wells and eventually to tube wells and canals. Following interventions are required to rejuvenate the traditional sources to ensure sustainability of water supply sources, i.e. providing drinking water security in the **Thar region** of Rajasthan:

- Rejuvenating Talab, nadis, kunds, beri and khadins
- Promote individual kunds for people who can afford.
- Promote public/community kunds for poor people.
- Construction of well inside the nadi or hand pump near it for availability of potable drinking water for three months.
- Promoting rooftop rain water harvesting in all private, public and community structures.
- Promoting ground water recharge by locating appropriate sites.

- Modernization of old tanks and construction of new tanks.
- Construction of kuis near to tanks in order to collect their seepage.
- Protecting traditional systems from encroachment of their catchment's areas.
- Protecting all water bodies from encroachment and pollution of water.
- Revival of village water management systems or institutions by providing them legal, financial and technical support.

All western region districts are facing water shortage therefore, some common measures are suggested, which are as flows:

1. **Evaporation suppression**: As the average temperature in western region is high particularly during summers the evaporation from surface water bodies ranges from about 2m to as high as 3.5m annually. It suggested that measures to be taken to reduce the losses from evaporation. This reduction is possible either by change in the design of the structure or by available new technology. The easier way is that the water bodies should be deep and surface area should be as less as possible. New technologies have come to reduce the evaporation by 50%, are environmental friendly and even wave friendly. The chemical which is in the form of liquid has to be spread over the water surface periodically that reduces the evaporation by 50%.
2. **Use of saline and hard water:** In major parts of western districts the quality of ground water is very poor. New technology such as Hydrosmart is available, which can be used to improve the quality both for irrigation and drinking. It is EMF based technology and the maintenance cost is negligible. The advantage of this technology is not a single drop of water is wasted or rejected compared to ROs where significant amount of water with high concentration is released and there is disposal problem also.
3. **Re-Cycling of sewage:** Huge volume of sewage is generated both in Rural and urban areas, which can be treated and reused for agriculture and even for flushing the toilets. In Rural areas the treated water can be used for irrigation.
4. **Pressure Irrigation:** In order to improve the irrigation efficiency which is about 60-70% in case of Tube Well irrigation and hardly 30% for surface water, it is suggested that pressure irrigation like drip or sprinkler should be promoted. Even if we improve the irrigation efficiency by another 20-30% the present/ future water crises can be resolved and we can provide the water security to future generations.
5. **Solar Power:** Irregular and untimely electricity supply results in over use of water as farmers leave their switch on for irrigation. In order to ensure regular

and demand based supply for irrigation it is desirable to shift on solar pumps. Government is also promoting the same and providing good amount of subsidy.

6. **Disposal of rejected RO water:** Use of RO has become very common and even the Govt. is providing RO water for drinking in villages. About 30% of water comes as rejected water which highly mineralized having very high TDS. Safe disposal of this rejected water is of prime concern failing which local GW will be polluted. It is suggested that a local pond with impermeable bed to be constructed near the RO unit and the rejected water should be stored in it for evaporation. It has been practiced at Matasukh Mine in Nagaur district stored in ponds and allowed evaporate and about 50MLD water is pumped for safe mining of lignite.

7. **Impact of Mining**: There are numerous mines in western region districts. Lignite mines are in Nagaur and Barmer, also oil mining in Barmer. Huge volume of water is being pumped for safe mining of lignite and the quality of that water pumped is very poor, cannot be used directly for irrigation. Thus, in Nagaur the pumped water is stored in artificial ponds and allowed to evaporate. Detail studies have been carried out to ensure that there is no negative impact on fresh ground water. Similarly for secondary recovery of oil in Barmer district saline water is pumped from deeper aquifers and injected without affecting the fresh water at upper level. GW modeling has also been done for Matasukh lignite and Oil mines and approval of CGWA has been taken. However, in most of districts abandoned building stone quarries do exist, huge volume of water is stored in them without use. It is suggested that this water can be used for irrigation and even for domestic use after treatment and/or these abandoned quarries can be converted as recharge structures.

8. **High Chloride in GW:** It has been observed that there is high content of Chloride in GW especially in Jodhpur district. This is because of leaching of soil which contains high sodium chloride and also due to animal waste. Only way is to deal with the problem is to use it after treating the water.

9. **Canal Irrigation and its Impact on GW**: Canal irrigation is spreading very fast in most of the border districts in western region. As narrated above the efficiency of flood irrigation, commonly being adopted, is hardly 30% and the excess water percolate and water logg the area. Additionally in most of the parts a layer of Gypsies clay occurs at shallow depth and that does not allow the applied irrigation water to go deeper to recharge the aquifer. As it stays as aquiclude above the impervious layer creates water logging problem in the area.

In order to overcome this, it is suggested to change the method of irrigation by switching to pressure irrigation.

10. **Construction of new deep TWs:** New technological intervention of deep drilling has picked up very fast and numerous deep tube wells, tapping the deeper aquifer, have come up especially in Sikar, Bikaner, Jaisalmer, etc.[12] In these areas the quality of deeper aquifer water is good and so far there is no adverse impact has been noticed on shallow aquifers, as these deeper aquifer's recharge areas is outside Rajasthan. There is need to monitor and conduct a study the environmental impact of these tubewells.

11. **Strict implementation of new NGT guide lines:** As per new guide Lines of NGT, now all the industrial establishments, whether they are new or old and pumping GW, have to go for artificial recharge as per the stage of GW development and CGWA guide lines. This has to be strictly applied by government and should be enforced for providing water security.

4.6 Some Districts wise specific issues

a) Bikaner: At places the formation are at shallow depth and very compact with Kankar and Beri is most suitable for water storing. This is a very local phenomenon and for that reason large numbers of Beries are constructed for drinking water.

b) Barmer, Jaisalmer and Jodhpur: Khadin's are very common where the slope is steep to harvest the rain water especially for irrigation. More number of Khadins can be constructed in suitable areas and should be promoted.

c) **Churu**: In Churu district the quality of water is very poor and Tanka's are the only source and are constructed even in farm lands to provide water to animals and human being working in field. These are very good source of water existed since olden times and even today continue to provide water security.

d) **Jaisalmer:** In this district some Paleo-channels have been identified and new TW's are coming up very fast as the quality of GW was found good. More work is required to delineate these channels not only for GW development but also for storing rainwater in such zones.

e) **Jodhpur:** In this region Nadi and Talab's are very common as part of area is having hard rock and also hilly, which is feasible for such structures. Thus, ancient rulers constructed number of Talabs to provide drinking water security. While the community constructed Nadi's in each village at suitable sites. There is high cattle and small ruminant population in the district so water demand is

[12] The number of tubewells in Kolayat Blok of Bikaner increased from 342 in 2006 to 3554 in 2015.

high and these structures are best suited to meet the demand. Near the Bap, glacial deposits with boulders are found and the strata are water bearing, so very important location for drinking water storage structure called Beri.

f) **Nagaur:** In this district it observed that Bavari's are in large numbers, surface water is also allowed to enter. All of them were got covered in a drive to eradicate guinea worm problem in the district, which was water born. Some of them have now converted into wells. But because of the drilling technology now TW's are coming up very fast in the area as source of potable water.

g) **Sikar**: In this district dug wells are the common source of drinking water and have very peculiar construction i.e. 4 long pillars with carving. This design was because in ancient time this was trade route and as the pillars are 4-5m in height, it helped traders locate the drinking water source in desert area from distance. Now GLR's have come up for drinking water supply near these structures and the traditional structures are not maintained and got neglected**.**

h) **Jhunjhunu:** The ground water quality is good as it forms part of Kanthli River basin with thick sand aquifer having large water storage capacity. The depth to water level is also less, thus open dug wells are common. Drilling technology also facilitated incoming of large number of tube wells in the district both for irrigation and drinking water supply consequently depleting groundwater very fast.

Note for all the districts:

1. Tube wells have come up by and large in all the districts as they are deep taping multiple aquifers consequently the quality of water varies from good to marginal.
2. Ground water is mainly used through pressure irrigation and irrigated area from GW has increased many fold over last 10 to 15 yrs
3. Traditional System are relevant as on today as they not only harvest rain water but also act as storage structures during the drought/famine for government to transport and store the water
4. Quality of Canal water supplied seems to be not suitable for drinking especially it has bacteriological contamination.
5. Frequency of canal water supply is very poor due to which community is still dependent on traditional sources
6. If we wish make "**Swachh Bharat Abhiyan**" successful the per capita water supply has to be augmented

7. Government is encouraging construction of Tanka which is a good step for this region.
8. Community mobilization is required to maintain the community water harvesting structures
9. More scientific input can be provided to the community to maintain the existing structures e.g. putting the hand pump for withdrawal, fencing of catchment etc. and maintaining the quality of water.

It is important to realize that presently there is no technological alternative to cost effective, simple, user friendly rainwater harvesting for villages. Government is giving priority to water harvesting in a number of rural development programmes. However, what is missing is community participation. Rainwater harvesting needs to be linked with watershed development, land uses planning and wasteland development for promoting sustainable rural drinking water. The issue of rainwater harvesting has to be taken up as a people’s movement for it to be successfully adopted.