Water Conservation: Traditional Rain Water Harvesting Systems in Rajasthan

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Abstract - *Water is a critical factor for development planning in Rajasthan. Despite heavy investments in water resources, the people of Rajasthan are suffering from water scarcity. Water resource management is largely exploitative rather than conservationist. Tradition methods of water conservation have been neglected. Annual rainfall in Rajasthan is highly variable and scanty. The important task before us is to harvests this seasonal and natural precipitation. The north western desert tract gradually improves from an arid desert in the far west to a comparatively habitable and fertile tract towards and the northwest. Cultivation in the desert region is poor and precarious, though some tracts have better soils and are more productivity. The arid parts of Rajasthan are a near rainless desert. In some areas, rainfall scarcely averages more than 120 mm. irrigation is limited by the scarcity of water in the west of the desert and has traditionally been restricted to deep wells and rain water harvesting systems. By and large, land use in the Thar is dependent on rainfall. In good rainfall years, large areas cropped, cattle thrive on extensive pastures and substantial amounts of hay are stored for future use. Rain water is stored in ponds and underground tanks. Small earthen embankments were constructed by the number of cultivators to enclose as much land as they could and surround it with thorns to keep animals away. Most villages in the desert tract had small ponds, and in a good season there was sufficient water to drink for seven to eight months. If rainfall failed, water was available for only four to six months otherwise the villagers had to bring water from other villages 20-30 km away. In some of the villages had tankas or circular holes in the ground, lined with fine polished chuna (lime) in water was collected during rainfall and used when other supplies failed. In Rajasthan, there are vaious traditional water resources systems – nadi, talab, jojad, bandha, sagar, samand and sarovar, just to name a few. Traditional methods of harnessing surface water may provide some alternatives to meet the problem of water demand. A systematic study of similar traditional water harnessing methods is needed to make policy-makers aware of these alternative sources.*

Keywords — *Water, Conservation, Rajasthan, harvesting, systems, rain, aravalli, thar desert,.*

I. INTRODUCTION

Water is essential for life on the planet, water resources have been a decisive factor in the growth and development of human civilization throughout the history. India receives an average rainfall of around 1050 mm which is the highest in the world among countries of comparable size, and should be sufficient enough to satisfy its ever increasing demand. But the temporal and spatial distribution of rainfall throughout the country is so erratic that drought and floods occurs frequently and simultaneously. Also the alarming rate of population growth at 2.11 percent has led to increasing pressure on the basic life supporting system. The utilization of water resources in the country has increased over the years.

The Thar Desert covers an area of 44.6 million hectare (mha) of which 27.8 mha lie in India and the rest in Pakistan. The desert is bounded by the Aravalli hills in the east, by the fertile Indus and the Nara valleys of Pakistan and the salt marsh of the Rann of Kutch in the west, and by the alluvial plains of Haryana and Punjab in the north.

In India, most of the area of the Thar Desert is situated in western Rajasthan. Of the total area of the Thar, nearly 60 % is being farmed, with varying intensities of cropping, and 30 percent is open pastureland. The annual average rainfall is around 500 mm in the east to less than 100 mm in the west and there is high variability from year to year. Agriculture in the region is extremely precarious and four out of every 10 years on an average, are drought years. Strong winds blow for four to five months in a year over a large part of the desert region. The region has great diversity in vegetation. As many as 700 species of plants are found in the area, of which 107 are of grass alone. These plants are deep – rooted and tenacious enough o withstand extended droughts and yet efficient enough to gain biomass rapidly during a favourable season. The local grasses are generally prolific seeders and most of the species are palatable, fairly good in nutrient content and rich in minerals, including trace elements. The Thar Desert is endowed with some of the best breeds of livestock in the country. Nearly 50 percent of the country's wool is produced in Rajasthan, and the area has been the main supplier of bullocks to the North.

By and large, land-use in the Thar is dependent on rainfall. In good rainfall years, large areas are cropped, cattle thrive on extensive pastures and substantial amounts of hay are stored for future use. Rainwater is stored in ponds and underground tanks.

Rajasthan, located in the north-western region of India, once consisted of a number of princely states. It broadly divided into two climatic and geographic regions by the Aravalli range. To its northwest lies the ill watered sandy tract of the Thar Desert, and to its east lies the elevated Malwa Plateau. In the northeast, the districts of Bharatpur and Bundi lie on a large alluvial plain drained by the Chambal and Banganga rivers.

The north-western desert tract gradually improves from an arid desert tract gradually improves from an arid desert in the far west to a comparatively habitable and fertile tract towards north east. Cultivation in the desert region is poor and precarious, though some tracts have better soils and are more productive. The main towns of the region like Jodhpur and Jaisalmer, are nevertheless well built. The Luni River which rises in the Aravalli hills, runs from Ajmer to the Rann of Kutch, draining a large part of the arid tract, and substantial villages are found along its banks.

The arid part of Rajasthan are a near rainless desert. In some areas, scarcely averages more than 120 mm. Rain clouds from the oceans empty most of their water on the high ranges in Kathiawar in Gujarat or on the slopes of the Aravalli range. Mount Abu, which is at an exceptional elevation for the region, about 1220 meters (m), receives 1,525 – 1,780 mm annually. Irrigation is limited by the scarcity of water in the west of the desert, and has traditionally been restricted to deep wells and rainwater harvesting systems.

II. Status of Water Resource

Western Rajasthan, the state's desert tract, comprises the erstwhile princely states of Bikaner, Jodhpur and Jaisalmer. Rocky ridges surround Jaisalmer city for a radius of 64 km. The depth of the wells varied from 76 – 122 m, and one well was as deep as 150 m. Wells were also the most important source of water in Jodhpur, both for irrigation and for drinking purposes. Land irrigated by wells was referred to as chai. The eastern part of Jodhpur district was full of wells and also more fertile. Both spring and autumn crops were raised. A variety of water lifts were used to raise water from wells.

The Luni is an important river in Jodhpur. Melons were traditionally grown in its dry bed. During rare floods, river water overflowed and crops of wheat and barley were grown on rel (overflow) saturated soil. At the turn of century, British officers reported that they had found 35 tanks in Jodhpur district, of which 24 were in Khalsa village. Dams were thrown across the Luni and Cuhiya rivers to form two artificial lakes, Jaswant sagar and Sardar Samand, respectively. The former, when full, irrigated 8,100 hectares (ha) and Sardar Samand was capable of irrigating by canals from lagre tanks was known as nahri. A number of cultivators would join together to enclose as much land as they could with small earthen embankments and surround it with thorns to keep animals away. Water was allowed to collect within these embanked fields for three months, and after the soil was thoroughly saturated good crops were grown without further irrigation.

Prior to 1897, there was no irrigation system in Bikaner. The erstwhile rulers of the state built the Ghaggar canal system for irrigation, and tanks to store water for irrigation. Villagers also used rainwater, collected in covered pits called kund, or simple excavations called sar, where the ground was hard.

Most villages in the desert tract had small ponds, and in a good season there was sufficient water to drink for seven to eight months. If rainfall failed, water was available for only four to six months, and the villagers had to bring water from other villages 20 – 30 km away. The poor were usually unable to obtain water from distant places and often resorted to drinking brackish water mixed with dahi (curd). In the east, each village had tankas or circular holes in the ground, lined with fine polished chunam (lime), in which water was collected during rainfall and used only when other supplies failed.

There were practices also to ensure optimal use of water. In some households in Jaisalmer district, even today people bathe on a wooden platform under which a vessel is kept. Water that drains into this vessel is used for animal consumption. Similarly, in parts of Jaisalmer, Pokhran and Phalodi, people bathe on a stone block outside the house, from which water drains into an animal watering tank. In villages with a limited supply of sweet water, this was used exclusively for drinking purposes. For washing only saline water was used.

Water harvesting, distribution and its use was regulated by the community. Before the onset of monsoon, the agor or paytan (catchment) of the tanks would be methodically cleaned of all waste and rubbish. Labour for this was contributed by all beneficiaries. Similarly, for desiltaion of tanks, labour was contributed by the entire community.

The anga system ensured a rational and egalitarian distribution of water. Anga literally means unit. The daily requirement of water would be determined in terms of units of households and units of animals. Water consumption was calculated in units, each human household constituted one unit, but animals were counted per head, each head of cattle constituted one unit, 10 heads of goats made one unit, and so on. Once the requirements were determined, each household contributed a day's labour for drawing out water from the source. For carrying water draught animals could not be used. This was basically to ensure that those with more draught animals did not get an unfair proportion of water. The animals had to be brought to a drinking point close to the source. There were made to drink water only during the night as it was widely believed that their consumption needs were less at that time.

Rajasthan is a region where there are no perennial rivers, and most of the water related problems relate to the fluctuating moods of the weather and the river systems. In 1979 and 1990, there were very heavy rains in certain pockets of Rajasthan, and the Luni River was flooded, causing immense damage. But in 1979, the damage could have been worse in certain areas, in the form of loss of cattle, if the local people had not resorted to the ancient communication system of drums. The damage was indeed worse in those areas where this tradition had disappeared.

Water is such a scarce commodity in the arid region that any natural source is literally worshipped. In fact, sources of natural water have become places of pilgrimage. In Rajasthan, there are various traditional water resource systems nadi, talab, johad, bandha, sagar, samanad and sarovar, just a name a few. But each of these is a definitive system.

Wells are another important source of water. There are different types of wells in Rajasthan. A kua (well) is usually owned by an individual. But there are larger wells known as kohar which are owned by the community. Then there are step wells (baollis or jhalaras). Baolis usually have a religious significance and were constructed as a philanthropic deed for punya. The structure and architectural patterns of a jhalara are different from that of a baoli.

In the desert regions of Rajasthan, certain areas are known as par. Par is a place where the flowing water accumulates and seeps into the earth. So the villagers known that if a shallow well was dug there, sweet water would be found. They can also identify a par by the foliage growing there. They would then dig beris (shallow and narrow wells) about 6-8 m deep to collect this par water. These beris provide drinking water for both human beings and livestock. Beris were also dug in the dry bed of a river or a lake. Jai Sindhi is a village very close to the Pakistan border where, for the last several years, there have been no rains. But its sheep population is more than 30,000. At no time the sheep had to migrate for want of water or grass because of the existence of an excellent par there.

The people of Rajasthan traditionally divide the entire state into two areas, one which has palar water and the other wakar water. Palar water is rainwater, which is the purest form of natural water, and can be stored in a tanka for three to five years. Wakar water is underground water which has oozed out of the earth, and hence, has minerals dissolved in it. Crops using palar water (rainwater) are different from those using wakar (groundwater), with different sowing times and irrigation methods.

The people of Rajasthan also have a keen geological knowledge of the land and give local names to the types of soil they encounter. There are certain wells in the state known as Sagar-ka-kua, which have enormous quantities of water. These wells are about 60 m deep and never run dry. Their water is pure, no scum accumulates in them, and the water keeps flowing. In Borunda village, there are 60 such wells fitted with 300 horse power (hp) engines which irrigate hundreds of hectares of land. It is possible to identify a sagar-ka-kua by its architecture and the way it has been dug.

People have other names for other times of wells, for example. Seer-ka-kua, sajay-ka-kua, or jhararey-ka-kua. Sajay-ka-kua has water from watershed which has seeped into the earth. Seer-ka-kua has something like an underground channel which has opened into the well. Different types of crops are grown with water from different types of wells. People also studied and classified the way water behaved in its relationship with the earth. Deir was water which collected in a depression during he rains, and dried up by October. Unirrigated rabi crops of sorghum, gram, mustard and wheat would be grown on such lands. This cultivation was itself known as sevage cultivation in one area and seelmia in another. ***Beir***, was another type of water which spread across the land like a huge sheet 30-45 cms deep. This type of flood never cut the earth, and a particular type of cultivation was associated with it. Rela was like a bier but it had definite shores and it eroded the earth.

Jaisalmer: the chief source of water supply for Jaisalmer town until 1965 was a large tank known as Gadisar. The Gadisar tank was built by Gharsi Rawal in 1367 A.D. Jaisalmer had several other tanks too, namely, Gulabsagar, Govindsagar, Malka, Mooltala and Sudharar but water in these tanks lasted just a few months owing to low rainfall. Only Gadisar had water throughout the year. Gadisar had a very large catchment area, which extended nearly 20 km in one direction. Gadisar was maintained by the king and before the rains, its whole catchment area would be cleaned. Canals bringing water into the tank were also cleaned. Cattle were not allowed to enter the catchment area. No one was even allowed to step into the tank. Bathing in the tank was considered an unpardonable crime. If anyone was caught polluting the tank or letting his cattle stray in the catchment area, he was punished by the king with imprisonment up to six months. Water did not come directly into the Gadisar from the catchment area. A small barrage was built to trap the silt, so that only clean water would flow into the main tank. In 1989-90, LDP film of 200 micron was laid in all the tanks just to prevent the seepage of water and after laying the film the water available in the tanks for more than six months. Today Gadisar is totally neglected. People can be seen bathing in the tank and cattle roam freely in the catchment area. The drainage in the catchment area has also been destroyed and, as a result, the water level in the tank has reduced over the last few years.

Bikaner: Bikaner was found by Rao Bika in 1489 AD. The choice of Bikaner as an urban centre seems to have been strongly influenced by the availability of tracts of mudiya kankar, which possess excellent runoff characteristics. This facilitated rainwater harvesting through an elaborate network of tanks. The catchment area (agor) of these tanks was treated as a sacred area where human activities like defecation were prohibited. Normally, the catchment areas, some of which were quite extensive, were kept well-wooded. In towns around Bikaner, there was an abundance of tanks. The more important ones being Kolayat with a catchment area of 14,900 ha, Gajner 12,950 ha, and Ganga sarovar 7,950 ha. The water needs of the town were met by the innumerable tanks in and around Bikaner, together with the wells and tankas that each house traditionally built for harvesting rain from the rooftops. The water from the tankas was used only for drinking purposes. If in any year there was less than normal rainfall and the tankas did not get filled, water from nearby wells and tanks would be obtained to fill the household tankas. In this way, the people of Bikaner were able to meet their water requirements.

At the turn of Century, Bikaner had 40 odd tanks. Today, except for Harshalao, the catchment areas of all the tanks have been destroyed. Some of the old tanks like the Jassolai, Baghinada and Rangolai have been wiped off the map of Bikaner. In their place, housing colonies have come up. Sursagar, in the heart of Bikaner town, still exists but it has become a drain water dump. The canal that brought water to Sursagar earlier, now carries the city's sewage. As the slope of the canal is towards the tank, the pumps to throw-out the dirty water do no work. Whenever there is a heavy shower, dirty tank water overflows into the surrounding area.

In the catchment area of Kolayat, innumerable brick kilns have come up. The process of excavating mud has created large pits. Water, instead of filling up the tank, now collects in these pits. Trees in the catchment area have also been cut down on large scale for firing the kilns. The entire catchment area of Kolayat is being destroyed, and there has been steady decrease in the water level of the tank over the last few years.

For drinking purposes, every house in Bikaner also had tankas (tanks). These were built inside the main house or in the courtyard. And, along with innumerable deep wells and tanks, they met the town's water requirements. Now a days, in Bikaner only the orthodox Vaishnavs have maintained their tankas, as they do not like to drink water touched by other people. Rainwater is the purest form of water according to them.

Phalodi, Barmer and Balotra: Rooftop harvesting was common across the towns and villages of the Thar. Rain water that falls on the sloping roofs of houses is taken through a pipe into an underground tanka built in the main house or the courtyard. This technique of harvesting perfected to a fine art in the arid region of western Rajasthan. The first spell of rain would not be collected as this would clean the roof and the pipes. Subsequently rainwater would be collected in underground tanks, which would be as large as a big room. One household tanks was found to be 6.1 m deep, 4.27 m long and 2.44 m wide. Unfortunately, with the introduction of tap water, rooftop harvesting has been rapidly declining, especially in the towns of the Thar Desert.

Traditionally, the tankas were one of the most reliable methods of water harvesting in desert towns. Tankas were used judiciously so that their water was easily available in the summer. Whenever there was less rainfall, household tankas would be filled up with water from neighbouring talabs (lakes), nadis or village ponds. Elders in the household took a special interest in maintaining these tankas because they were built for storing rainwater to meet drinking water requirements all their lives. Rainwater collected in tanka, was also given to sick people.

Phalodi town of Jodhpur district, situated on the Bikaner-Jaisalmer road, had a population of 36,000 in the late 1980s. Before the waters of the Indira Gandhi Canal reached the town, every house in phalodi had a tanka. Along with this, there were seven community tanks in Phalodi – Ranisar, Ramasar, Hiwasar, Siwsar, Nyatalah, Khatri and Chiklin. There were also three deep wells in the town. After the rains, lake water was used, and tanka water was reserved for use only in the summer. But after the canal water reached Phalodi, the tankas began to deteriorate. A number of people still use these traditional tankas. There are about 40,000 houses which still maintain their tankas. One house even has a pipe connected to the neighbour's roof as the neighbour was no longer interested in collecting rainwater. Tanks and lakes around Phalodi are suffering the same fate as the tankas. These water bodies had long canals, bringing water to the town. The canals have been destroyed, and the Ranisar talab, which rarely went dry, does not have a drop of water now. Of all the districts in western Rajasthan, the situation in Barmer is the worst. As a result, rooftop harvesting is still done in nearly every house in Barmer. Barmer town is the only major town of western Rajasthan where the art of rooftop harvesting has not died out. Even today, a tanka is built before construction on a new house begins. People have maintained their tankas as these are the only assured sources of sweet water.

Jodhpur: The city of Jodhpur was founded in 1495 AD. While selecting the location of the city, its rulers must have seriously considered its water potential and strategic situation. The Chonka-Daijar plateau is an important physical feature of this region. It is 30 km long, with a maximum breadth of about 5 km at the centre and a height of 120-150 m above ground level. The slopes vary considerably but are very precipitous at some places. The whole plateau serves as the water bodies like nadis, talabs, tanks and lakes and indirectly for about 154 ground water bodies like wells, baoris and jhalaras. The surface water bodies are primarily natural but they have been improved by the local people over the centuries. In the past, these surface water bodies were the main source of water in the city, also providing water through seepage to wells, baoris and jhalaras in their respective areas. Many of the water bodies are more than 500 years old. Their numbers increased gradually in proportion to the demand for water. They were either constructed by the then rulers, philanthropists or by common people. But regardless of who built water bodies, they eventually became common property for all practical purposes and engendered an immense sense of belonging and reverence amongst inhabitants.

III. Surface Water Bodies

Ancient surface water bodies have been serving the local human and livestock population and wildlife for several centuries. These water bodies not only represent an excellent feat of architectural and engineering design but also a high degree of community sharing and social, moral and religious values built around a desire for "water for all" in the society. These values protected, preserved and maintained the water system without any written code of conduct for many years. The survival of surface water bodies of Jodhpur depends essentially on the survival of its magnificent water catchment the Chonka-Daijar plateau. Each water body was provided with an extensive catchment, watercourses and canals to trap the precious rainwater.

Nadis: Nadi, the local name given to a village pond used for storing water from an adjoining natural catchment during the rainy season, was an ancient system for harnessing rainwater. The first recorded masony nadi was constructed in 1520 AD near Jodhpur during the regime of Rao Jodhaji. Most villages had their own nadi, and the nadi site was selected by the villagers based on an available natural catchment and its water yield potential. Water availability from a nadi would range from two months to a year after rains. The location of the nadi had a strong bearing on its storage capacity due to the related catchment and runoff characteristics. Nadis in dune areas varied in depth from 1.5-4 m and were characterized by heavy seepage losses, smaller catchments and lower runoff. Nadis in sandy plains were deeper (3m to 12m), had a larger catchment area and lower seepage resulting in water availability ranging from 7-10 months. Nadis situated in alluvial plains were the largest. They usually had and average depth of 4.4m and an extremely large catchment area. Water lasted in them for eight to 12 months.

Nadis were heavily relied on for human and livestock needs. In Nagaur, Barmer and Jaisalmer there were 1,436, 592 and 1,822 nadis respectively as per CAZRI surveyed. In Nagaur district 13.18 percent of the total water requirements were met by nadis and in the three districts together they accounted for 37.06 percent of the water needs.

A nadi is essential a natural surface depression which receives rainwater from one or more directions. Some nadis have stone walls on one or two sides to enhance capacity and water retention. Periodical de-silting and deepening by the local people was common. In normal rainfall years, most nadis could retain water for about four to eight months, while a few would retain water throughout the year. There were 25 nadis in and around Jodhpur, five are located inside the city and 20 outside. The oldest nadi on record is Jodhnadi, built in 1458 AD. Some nadis are more than 250 years old. The water of these nadis is still used for both drinking and other purposes.

The system of nadis, however is not without drawbacks. Heavy sedimentation, high evaporative and seepage losses and water pollution are some of the factors affecting nadis. Wide variations exist in the annual sediment deposition under different physiographic settings. Nadis situated in older alluvial plains have the highest sedimentation rate, whereas those in the younger alluvial plains have the least. To take care of the capacity reduction of the nadi caused by sedimentation, dredging was carried out by villagers prior to every monsoon. After dredging, sediments were used in the sandy fields or for brick making. The disproportionately large surface area of the nadis in comparison with the volume of water stored, results in heavy water losses on account of evaporation. Seepage losses, on the other hand, increase with the depth of stored water. Evaporation losses, varying from 55 to 80 percent of the total losses, were the highest during the driest season from March to June. Seepage losses were greatest during the monsoon season from July to September when the nadis were completely filled. Poor maintenance and improper utilization of these systems has also resulted in heavy pollution and presence of guinea worms, water hyacinth, mosses and algae in many places.

Talabs: A talab is a popular word used locally for water reservoirs situated in valleys and natural depressions. In old talabs, only the slope side was provided with strong parapet walls to hold the rainwater. Other sides were naturally supported by outcrops of hillocks or elevated rocky formations. On the parapet side, steps were provided to reach the water. Each existing talab has some sculpture and carvings. Most of these talabs are located over the Chonka-Daijar plateau at varying heights and depths. Some talabs have wells called beris in their beds. Special care was traditionally given for the maintenance of the catchment of each talab. These talabs have been main source of water for the human and animal population until recently there were near about 46 talabs out of which 40 found. Of these 40, eight are located inside the city in the hilly terrain and are located inside the city in the hilly terrain and are 00-530 years old. The Nagadari and Barli talabs are the oldest water bodies having been constructed nearly 600 years ago. Jaswant sagar is the youngest talab, built in 1885 AD. The water quality in half of the existing talabs is fairly good and fit for human consumption. In the other half, the water is polluted. Once these talabs served as the main source of drinking water for the local inhabitants but they are now used more for cattle and irrigation purposes. When their water dries up, the beds are used for agricultural purposes.

Tanks: In contrast to talabs, especially those of more recent origin, tanks were constructed in situ with massive masonry walls on four sides and an almost impermeable floor as a standard pattern. They are either square or rectangular and had an enormous water-holding capacity. Tanks were invariably provided with an efficient system of canals to bring rainwater from the catchment areas on the outskirts of the city. Each tank was thus supported by an exclusive catchment area and a system of canals. In almost all talabs and tanks, local material and skill was used for construction.

The five tanks of Jodhpur were constructed in the last two centuries. The oldest, Fatehsagar, was built in 1780 and the newest, Paota, in 1887. Three of these tanks are located inside the city and two outside. The former three, Fatehsagar, Gulabsagar (1794) and Baiji-ka-talab (1877) are massive water reservoir. The latter, Mansagar (1870) and Paota are fairly large. A strict vigil was kept for their maintenance, cleanliness and periodical repairs by the administration.

Lakes: Jodhpur has five large reservoirs located on the outskirts of the city in a more or less natural setting. The oldest is Balsamand, which was constructed in 1126 AD, and was subsequently extended from time to time to increase its water holding capacity. The remaining four, namely, Lalsagar (1800), Kaylana (1872), Takhatsagar (1932) and Umedsagar (1931), are more recent compared to Balsamand. These lakes can hold about 700 million cubic feet of water at a given time, which can support about 0.8 million people for eight months. The Kaylana-Takhatsagar is the largest city lake, and it is linked to major canals like the Chota Abu, Kaliberi, Keru and Nadelao, and supported by several other canals too. All these canals culminate in one canal, the Hathi canal, which is about 6 m deep.

Balsamand is the second largest lake in the city. It is linked to the Mandore-Fedusar canal, which brings rainwater from the Balsamand-Mandor hill ranges. Water from Balsamand was carried to the Gulabsagar tank in the heart of Jodhpur through an open canal. The city's water supply was further augmented when Kaylana and Takhatsagar lakes were constructed and their water carried to Gulabsagar and Baiji-ka-talab through a pipe in 1905. This was followed by the construction of Umedsagar to support the inhabitants of the western part of the city.

The Umedsagar Lake, located to the southwest of the city, is fed partly by the catchment in the Abu hills and a canal called Umedsagar canal. This lake is a good source of irrigation as well as drinking water. Panchkund and Daijar dams are small dams built for the purpose of holding rainwater. The overflow of these dams is received by small tanks like the Nagadari. As considerable runoff is arrested by these dams, the water level of wells and baoris in the area rises considerably. There are six such bunds to collect rainwater from the catchment.

Canals: Jodhpur's canal system consists of numerous watercourses and aqueducts to carry rainwater to the city's various nadis and talab. It is perhaps these canals which led to the construction of a large number of nadis and talabs around Jodhpur before tanks came into existence. The construction of large water tanks in the city, some 200 years agao, gave a further impetus to the canal system. A network of canals slowly came into being, linking each lake and tank to a distant catchment in a bid to enhance the water capacity of Jodhpur's surface water bodies. By 1886, the city had an efficient network of canals.

Jodhpur is perhaps the only city in the country where an all-out effort was made to conserve every drop of rainwater. To achieve this, every catchment and hillock was drained by canals. Not only did each lake, tank and talab have an efficient canal system, there were interconnections between lakes and between lakes and tanks to distribute water to all parts of the city. The city also had underground canals, which seem to have escaped the attention of most experts. These canals carry water to five lakes, two tanks and two talabs. The canals are usually 305 m wide and 1-2.5m deep. Long stretches of canals have been built using local brown sandstone. The dressing and masonry is of high quality, which has ensured durability.

IV. GROUND WATER BODIES

A large number of wells, baoris and jhalaras constitute the major groundwater bodies of Jodhpur. These bodies were built with the sole purpose of ensuring easy and regular water supply to neighbouring areas. They neither have any catchment of their own nor are they connected with any watercourse. Each one collects the subterranean seepage of a talab or lake located upstream. Their shapes, sizes, depths, design, layouts and location vary a great deal. Minimum space has been used in the construction to save money, time and energy.

Wells were dug essentially to enhance drinking water supply while baoris and jhalaras were meant for washing and bathing, a situation which exits to date.

Wells: In old records, some 125 open wells have been listed in different parts of the city. The Jeta bera and Chopasani bera are the oldest wells. The former was constructed in 1460 AD. The age of several other wells could not be worked out in the absence of authentic records. Their ages, vary from 120-530 years.

Baoris: Jodhpur is a city full of baoris, or community step wells. Shallower than wells, they have beautiful arches along their full height. Baoris can hold water for a long time because of almost negligible water evaporation when compared to other water bodies. The baoris are older than other water bodies. Mandor baori, the oldest one, was constructed in 784 AD in Mandor. Bhery baori at Mandor is about 600 years old. Chand baori (1460), Jagu baori (1465) and Idgah baori (1490) are amongst the oldest baoris of Jodhpur. The Shiv baori (1880) is a recent one. By tradition, baori water is not used for drinking. Yet, the waters of Rameshwarji mandir baori, Achalnath baori, Shiv baori, Barli baori and Nathon-ki-baori are regularly used for drinking offerings in the temples. Bathing and washing is prohibited in these baoris.

Jhalaras: there were eight jhalaras in the city, two inside the city and six outside. It was not found that their water was ever used for drinking purposes. Jhalaras were essentially meant for community bathing and religious rites. Often rectangular in design, jhalaras have steps on three or four sides. The Mahamandir jhalaras, which is more like a baori, is the oldest one, having been constructed in 1660. Kriya-ka-jhalara and Mandor jhalara was constructed about 400 and 500 years ago respectively.

V. Rural Water Systems

The near absence of surface water resources and the extremely constrained groundwater potential, both in terms of quality and recharge capacity, the villagers of Western Rajasthan, just their urban counterparts, had traditionally evolved highly ingenious systems of water harvesting to cope with consumption needs of both humans and animals. These systems complemented certain cultural practices which laid a high premium on the conservation of water as scarce resource.

Toba: technically similar to a nadi is the toba, another traditional technique for harvesting water in arid areas. Toba is the local name given to a ground depression with a natural catchment area. A hard plot of land with low porosity, consisting of a depression and a natural catchment area was selected for the construction of tobas. In a good catchment area with no natural depression, an artificial depression was made. In addition to providing water for human and livestock consumption, the grass growing around the tobas provides pastures for grazing around the tobas for livestock. This traditionally led to the evolution of a combined water-grass utilization system. Each village of cattle breeders had five to six tobas, depending on the pressure of overgrazing in any one area. In order to preserve or enlarge the capacity of the tobas, the catchment areas were regularly widened and animals and human beings were not allowed to damage the catchments. Tobas were deepened in the middle so that storage was concentrated and losses occurring through evaporation be minimized.

Kunds: In the sandier, tracts, the inhabitants of the Thar Desert had evolved and ingenious of rainwater harvesting known as kunds or kundis. Kunds, the local name given to a covered underground tank, was developed primarily for tackling drinking water problems. Usually constructed with native materials, kunds were more prevalent in the western arid regions of Rajasthan, and in areas where the limited groundwater accessible is moderate to highly saline. Groundwater in Barmer, in nearly 76 % of the district’s area, has total dissolved solids (TDS) ranging from 1,500-10,000 ppm. Under such conditions, kunds provided convenient, clean and sweet water for drinking. Before the onset of rains every year, meticulous care was taken to clean up the catchment of the kunds. Cattle grazing and entry with shoes into the catchment area of the kunds was strictly prohibited. The proximity of a kund to the house or village saved time and effort in searching for drinking water. Coupled with the benefits of cleanliness and quality of water, the kund became an ideal device to collect drinking water. Water-borne diseases, which are otherwise quite common in the desert area, are thus reduced. The kund consists of a saucer-shaped catchment area with a gentle slope towards the centre where a tank is situated. Opening or inlets for water to go into the tank are usually guarded by a wire mesh to prevent the entry of floating debris, birds and reptiles. The top is usually covered with a lid from where water can be drawn out with a bucket. Kunds are by and large circular in shape, with little variation between the depth and diameter which ranges from 3-4.5 m. Lime plaster is typically used for the construction of the tank. The success of kund depends on the selection of site, particularly its catchment characteristics. An adequately large catchment area has to be selected or artificially prepared to produce adequate runoff to meet the storage requirements of the kund. The catchment size of kunds varies from about 20 sq m to 2 ha depending on the runoff needed and the availability of spare land. A 2 ha catchment area, having a 2-3 percent slope on a heavy textured soil free from vegetation, is generally sufficient for kund of 200 cum capacity.

The catchment areas of kunds were made in a variety of ways using locally available sealing materials such as pond silt, murrum, charcoal ash and gravel. After clearing the soil surface of vegetation, the land was given a smooth gradient of 3-4 percent towards the kund and the cleared surface was lined with pond silt obtained from nearby talabs or nadi beds.

Kui and Dakeiyam: Kuis reveal another aspect of the ingenuity of the local people of western rajasthan. Kuis also known as beris, were dug next to tanks in order to collect their seepage. In this way, a minimum amount of water was allowed to go waste. Beris were normally 10-12 m deep and were entirely kuchcha structures. The opening would generally be covered with planks of wood.

The extent to which local knowledge could help to optimize the harnessing of water resources is reflected in an emergency source locally referred to as dakeriyan. These are shallow wells dug in harvested fields where rainwater is impounded for kharif cultivation. The water which seeped into the ground was, after harvest, harnessed through wells.

Khadins: Khadins, or dhoras in local parlance, were devised by the Paliwal Brahmins of Jaisalmer around 15th century. There are as many as 500 big and small Khadins covering an area of 12,140 ha. Khadins are also found in the adjoining districts of Jodhpur, Barmer and Bikaner. A Khadin is an earthen embankment built across the general slope which conserves the maximum possible rainwater runoff within the agricultural field. It is usually .5-3.5 m high and made on three sides of the lower contours of a farmland with one side left open for rainwater to drain in from the surrounding catchment area. The length of the embankment not only helps to increase moisture in the submerged land prevent monsoon runoff, it also prevents the washing away of the topsoil and the manure added to it.

The khadins is a site-specific system that cannon be developed everywhere. The best khadins are developed at suitable sites having essentially two physiographic components existing in proximity:

1. An upstream drainage area comprising shallow, gravelly or rocky areas with a high runoff potential and
2. A flood plain or gently sloping plain area where soils are suitable for crop production.

The flood plain is called the khadin area and the earthen bund is known as khadin bund.

VI. Conclusion

Traditional methods of harnessing surface water may provide some alternatives to meet the problem of water demand. A systematic study of similar traditional water harnessing methods is needed to make policy-makers aware of these alternative sources. In spite of this, traditional water sources have vast potential.

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