Traditional Domestic Rain Water Harvesting System Suitable for Rajasthan State and Their Sizing-A Review

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ABSTRACT

Rain Water Harvesting (RWH) is an option that has been adopted in many areas of the world where conventional water supply systems have failed to meet people's needs. It is a technique that has been used since olden times. Rajasthan is the largest state of India and more than 70% of its population remains in villages. Geographically it covers 10.5 % of total area but availability of water is less than 1.2 % of total water resources in India. During last fifty years, population of the state has been grown three folds leading to increasing demand of water. In contrary to this, average rainfall in the state is continuously decreasing. Mean annual rainfall of the state is 490 mm ranging from 100 mm in Jaisalmer to 1000 mm in Jhalawar. After decades of work by governments and other organizations to bring potable water to the poorer people of the state, the situation is still dire due to capital intensive and technically complex traditional water supply systems.

The main objective of present study is to review and assess the traditional and conventional water harvesting technologies suitable for Rajasthan state in present context.

***Keywords:* Water Harvesting, Johard, Roof Top and Sizing**

I. INTRODUCTION

Water is essential for the existence and survival of any life form. More than 70% of the world surface is covered with water but large fraction of it is not suitable for human consumption as around 97% of it is saline. Approximately 70% of the remaining 3% is locked in polar icecaps and glaciers and a large proportion of the groundwater is inaccessible. Therefore, ultimately a small proportion of the world's water resource is available for quenching human demands of drinking, irrigation and industrial use. Another major constraint is the fact that freshwater as well as rainfall is very unevenly distributed, which results in inequitable access to this vital resource. Sufficient clean water is essential for human beings for their survival. Millions of people throughout the world still do not have access to this basic necessity. According to the World Health Organization (WHO), on an average a person needs 3 liters of water for drinking, 4 liters for cooking, 20 liters for bathing, 40 liters for sanitation, 25 liters to wash vessels and 23 litres for gardening.

A disproportionate reliance on groundwater adds to the problems of water availability, especially in drought years. Similarly, heavy reliance on 'imported' water from neighboring states adds to the uncertainty. Inefficiency in the storage, conveyance and use of water results in further worsening of an already difficult situation. Iniquitous access to water by different user groups, economic strata, and regions, as well as a steady deterioration of water quality compound this poor situation. Thus, the water situation of the state is quantitatively and qualitatively precarious and the state is faced with formidable, almost insurmountable, handicaps.

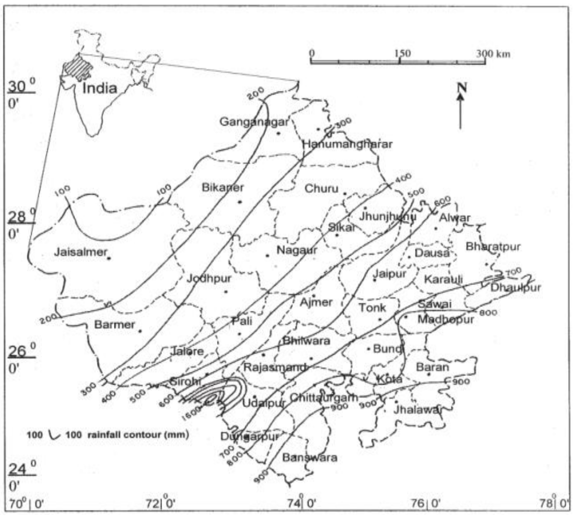
Rajasthan is possibly the driest state in India. Although it has one-tenth of the land area of the country, over 5 per cent of its population and nearly a fifth of its livestock, its share of India's surface and ground-water resources is under 2 per cent each [1]. The situation has worsened over time. The state population growth rate is among the highest in the country. Demand for water from uses such as industry, tourism and sanitation and environmental purposes has grown apace, while the supply has remained unchanged. The primary source is scanty and uncertain rainfall confined to two months of the year. Availability of water from all sources has come down to under 840 cum per person per year as compared to national average of 1140 cum and will soon reach a highly precarious level. Nearly two-thirds of the state is arid or semi-arid.

The rains play a vital role in the life of all parts of Rajasthan as the water deposits in johads or tobas (small ponds) are used for drinking, washing and other purposes. The Desert zone people depend on ground water and rain. But the underground water is rarely found in western Rajasthan. Sometimes after digging a very deep well, water comes out quite sour and undrinkable. Only in some places sweet water comes out of a very deeply dug well. Water scarcity is now the single biggest threat to food production, as falling groundwater levels make less water available for agriculture [2].

The lowest rainfall in India is in the arid districts of Jaisalmer and Barmer of Rajasthan as shown in Fig 1.0. There is a great potential of rain water harvesting in such districts. People in these areas devised water harvesting structures called Kundi [3]. Traditionally rain water is stored in Kunds made in farms or homes for drinking purpose. Some big tanks or Talabs are constructed in villages to store rain water for bathing, animals and also for drinking water. People who are relatively financially capable have a water tank in their houses for drinking and domestic use. But the situation of poor people is very grim. They always have to be dependent on a pond (talab) for common use and drinking purposes. Looking into the present situation, the role of low cost traditional water harvesting techniques becomes very important. The following sections will cover various water harvesting methods and the design methodology.

II. WATER HARVESTING TECHNIQUES

Rainwater harvesting is the collection and storage of rain water from roofs or from unused catchments. Rainwater harvesting can provide lifeline water for human consumption It has been estimated that the amount of rain



water that falls on the terrace of an average size house can take care of the water requirement of a family of four members for one year. Traditionally, rainwater harvesting has been practiced in arid and semi-arid areas, and has provided drinking water, domestic water, water for livestock, water for small irrigation and a way to recharge ground water levels.

1. Kui or Beri

Fig. 2: Kui or Beri Structure

Kui or Beri as shown in Fig 2.0 is a common water harvesting practice in the western Rajasthan region. It is constructed at a common place where the rainwater flows from the adjacent catchment area. Kuis or beris are normally of 5 m to 12 m depth. These sizes of Kuis can store 5000 litres to 10000 litres water during one rain in a year. This much water can fulfil the requirement of one small family for cooking, drinking and bathing by assuming an average consumption of water 25 litres per day for whole year. The structure is constructed by using traditional masonry technology. In larger catchment areas normally five to ten kuis are constructed. In some places of Jaisalmer district more than 20 kuis are also in operation in one catchment. This is the most predominant form of rainwater harvesting in the Thar Desert region in vogue. Rainwater harvested through this technique is known as Patali paani technique.

2. Kund or Kundi

A *kund* or *kundi* structures as shown in Fig. 3.0 is used to harvest the rainwater for drinking and other purposes in Thar Desert in western Rajasthan. Essentially a circular underground well, *kunds* have slightly inclined catchment area that gently slopes towards the centre where the well is situated. A wire mesh across water-inlets prevents debris from falling into the well-pit. The sides of the well-pit are covered with lime and ash to protect water from disinfection. Most pits have a dome-shaped cover, or a lid, to preserve the water. If needed, water can be drawn out with the help of a bucket. The depth and diameter of *kund* depends upon their use (drinking, domestic or irrigation water requirements) as well as the catchment area available.

Fig. 3: Kund or Kundi

3. Roof Water Harvesting (RWH)

Rainwater harvesting' is a techniques whereby rain is intercepted by roof and thus rain water is collected from the run offs of the roofs and other projected surfaces of the building. The essential elements of a roof water harvesting system, as shown in Fig. 4.0., are a suitable roof, a water store in the form of a tank and a means of leading water flow from roof of the house to the storage tank.. In addition, some RWH systems have other components to make them easier to manage or to improve the quality of the water [4].

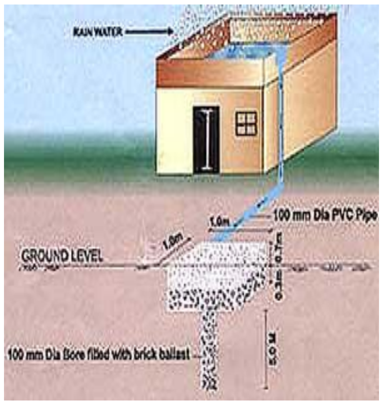


Fig. 4: Roof Water Harvesting

To be suitable for RWH the roof should be made of some hard material that does not absorb the rain or pollute the rain water. Thus, tiles, stone slabs and kiln bricks as used in Rajasthan are most suitable for the purpose of interception of water. The larger the roof size, the higher the run-off flow. The rainwater reaching a roof in a year can be estimated as the annual rainfall times the roof's plan area. In Rajasthan, the average rain fall is very low hence the available roof area is not big enough to capture enough

water to meet all the water needs of people in the building. In this case, either the roof must be extended, or earlier mentioned techniques of water harvesting such as Kundi, kui/Beri shall be integrated to enhance the water collection capacity.
The rainwater collected from the roof flows through the gutters, into a collection tank. The size of the tank is dependant of the amount and purpose of the water but also of the annual rainfall and the size of the roof. A normal sized tank for a roof of 20 to 40 square metres is 10 cubic metres where approximately 10,000 litres of water can be stored.

4. Johard

Fig. 5: View of Johad

These are simple mud and rubble barriers built across the contour of a slope to arrest rainwater. These are meant to catch and conserve rainwater, leading to improved percolation and groundwater recharge. They are built across a slope with a high embankment on the three sides while the fourth side is left open for the rainwater to enter. They are very common in the Thar desert of Rajasthan. In early days, The *rajas*, the kings of small states who gave the region its name, would often finance construction of *johads*, taking a sixth of the crops in return. The plan view of Johard is shown in Fig.5

5. Nadis

Nadis are village ponds, found near Jodhpur and Barmer in Rajasthan. They are used for storing water from an adjoining natural catchment during the rainy season. The site for the nadi is selected by the villagers based on an available natural catchments and its water yield potential. Water availability from nadi would range from two months to a year after the rains. They are dune areas range from 1.5 to 4.0 metres and those in sandy plains varied from 3 to 12 metres. The location of the nadi had a strong bearing on its storage capacity due to the related catchment and runoff characteristics.

6. Naada / Bandara

Naada/bandha are found in the Marwar region of the Thar desert. It is a stone check dam, constructed across a stream of water, to capture monsoon runoff on a piece of land. Submerged in water, the land becomes fertile as silt deposits on it and the soil retains substantial amounts of water.

7. Rapat

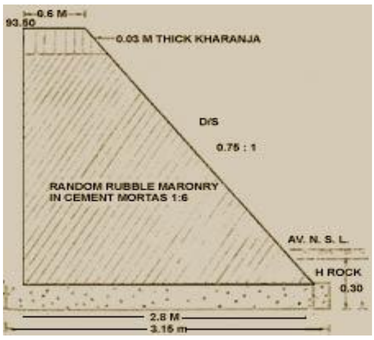


Fig. 6: Rapat

A rapat is a percolation tank, with a bund to impound rainwater flowing through a watershed and a waste weir to dispose of the surplus flow as shown in Fig 6. If the height of the structure is small, the bund may be built of masonry, otherwise earth is used. Rajasthan rapats, being small, are all masonry structures. Rapats and percolation tanks do not directly irrigate land, but recharges well within a distance of 3-5 km downstream. Silting is a serious problem with small rapats and the estimated life of a rapat varies from 5 to 20 years.

III. SIZING OF THE SYSTEM

While designing a domestic RWH system, size of the storage tank has to be calculated correctly. The amount of water to be collected depends upon number of factors which includes {5}:

- Amount of rainfall
- Roof size
- Water consumption, and
- Runoff coefficient which varies between 0.5 and 0.9 depending on roof material and its type

Following two methods are used to calculate the size of the storage tank

i. Method 1

A very simple method is to calculate the largest storage requirement based on the consumption rates and occupancy of the building is explained by taking simple example.

Consumption per capita per day, $C = 7$ litres (only for drinking and cooking)

Number of people per household, $n = 6$
Daily consumption = $C \times n = 42$ litres.

Storage requirement, $T = 42 \times 365 = 15330$ litre /year $= 15.33\ m^3$

ii. Method 2

This method is most useful for the sites like Rajasthan where rain is scanty and uneven. During some months of the year, there may be an excess of water, while at other times there will be a deficit. As storage is expensive, this should be done carefully to avoid unnecessary expenses.

Demand: Consumption per capita per day, C = 7 litres
Number of people per household, n = 6
Total daily demand: 42 liters

Supply: Roof area: 180 m^2, Runoff coefficient= 0.85 for slab stone roof (Run-off coefficient values vary between 0.3 and 0.9 depending on the material of the roof, it takes into consideration losses due to percolation, evaporation, etc.)

Average annual rainfall: 100 mm per year

Daily available water (assuming all is collected) = (180 x 100 x 0.85)/365 = 41.91 liters

Size of the tank required for meeting the annual demand=$41.9\times10^{-3}\times365=15.3$ m^3

IV. CONCLUSIONS

On the basis of the literature survey and personal experience of the authors, the following salient conclusions have been drawn

1. There is a strong need to look into the traditional water harvesting techniques seriously at this particular juncture when water is depleting at a very rapid pace.
2. Efforts shall be made to educate the rural people for this technique of water harvesting by using locally available low cost construction materials.
3. It can also be stressed upon integrating the water harvesting techniques such as roof water harvesting with some low lying catchment area.
4. All possible efforts shall be made to avoid any leakage such as evaporation etc. after storing the water.
5. Suggested techniques for calculating the tank size may be strictly followed to avoid over sizing of the tank which may lead to very high costs of construction.

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