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Rain water harvesting

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Introduction

As we all know that about 70 percent of the earth is water but most part of the earth is ocean. Only 3% of total water available on earth is fresh water. Out of the three percent, only 1 percent is accessible as surface fresh water where as the rest 2 percent is locked away in the form of ice caps and glaciers in the polar regions. 1 percent water is regularly renewed by rain fall and other means and thus available on a sustainable basis and easily considered accessible for human use.

Increasing population together with the intensifying urbanization and industrialization affects availability of fresh water both qualitatively and quantitatively. Water is clearly the single largest problem facing India today, though the country was once upon a time categorized as a water rich society because of non-uniform distribution of rainfall.Over the years about 90 percent of its annual rainfall occurs during the summer monsoon i.e. from the July to September whereas the rest of the months the country get less rainfall. Even India is wettest but still there is water scarcity. Water scarcity will be one of the major threats to humankind during this century (Prinz 2000). The problem of water shortage in arid and semi-arid regions is low rainfall and uneven distribution through out the season, which makes rain fed agriculture a risky enterprise.

There were lot of methods which were applied by ancient people, as the available water resources taken from streams, rivers and ground water will not be sufficient in most dry areas to cover the needs of agriculture and urban areas, we have to reassess the value of certain traditional irrigation methods, to find out their value to ease future water scarcity (Prinz and Singh 2000).These traditional methods played a much greater role in the past and were the backbone of ancient civilization in arid and semi-arid areas around the world (Agarwal & Narain 1997, Prinz 1996). Therefore new interest came up in recent decades to evaluate traditional water management techniques (Prinz *et al.*1999) most of them being simple, sure to implement and of low capital investment. The classical sources of irrigation water are often at the break of overuse and therfore untapped sources of (irrigation) water have to be sought for increasing agricultural productivity and providing sustained economic base. Water harvesting for dry-land agriculture is a traditional water management technology to ease future water scarcity in many arid and semi-arid regions of world.

Older Concept

The Indus Valley Civilization, that flourished along the banks of the river Indus and other parts of western and northen 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. A large number of tanks were cut in the rocks to provide drinking water to tradesman who used to travel along this ancient trade route. Each fort in the area had its own water harvesting and storage system in the form of rockcut cisterns, ponds, tanks and wells that are still in use today. A large number of forts like Raigarh had tanks that supplied water.

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 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.

Traditional Method

Traditional rainwater harvesting, which is still prevalent in rural areas, was done in surface storage bodies like lakes, ponds, irrigation tanks, temple tanks etc. In urban areas, due to shrinking of open spaces, rainwater will have to necessarily be harvested as ground water, hence harvesting in such places will depend very much on the nature of the soil viz. clayey, sandy etc. The below listed are the various kinds of traditional rainwater harvesting methods.

1. **Kunds**

In the sandier tracts, the villagers of the Thar Desert had evolved an ingenious system of rainwater harvesting known as kunds or kundis. The first known construction of a kund in western

Rajasthan was during 1607 AD by one Raja Sursingh in village Vadi-ka-Melan. In the Mehrangarh Fort in Jodhpur. Kund, the local name given to a covered underground tank, was developed primarily for tackling drinking water problems. Usually constructed with local materials or cement. Kunds were more prevalant in the western arid regions of Rajasthan, and in areas where the limited groundwater available was moderate to highly saline. Groundwater in Barmer, for instance, nearly 76 percent of the district's area,has total dissolved salts (TDS) ranging from 1,500-10,000 parts per millon (ppm).Under such conditions kunds provided convenient, clean and sweet water for drinking. Kunds were owned by communities or privately, which the rich having one or more kunds of their own. Community kunds were built through village co-operation or by a rich man for the entire community. The kund consists of a saucer-shaped catchments area with a gentle slope towards the center where a tank is situated. Openings 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 large cicular in shape with little variation between the depth and diameter which ranges from 3-4.5 m. Lime plaster or cement is typically used for the construction of the tank, since stone as a building material is not always available and is relatively more expensive. Either of these material can be used to plaster the horizontal and vertical soil surfaces, although cement ensures a longer life span. The success of a kund depends on the selection of the site, particularly its cathments characteristics. An adequately large catchments area has to be selected or artificially prepared to produce adequate runoff to meet the storage requirements of the kund.

2. Kul Irrigation Method

Spiti is an important trading post on the route connecting Ladakh and the plains of Himachal Pradesh. Villages in the Spiti subdivision are located between 3,000 m and 4,000 m, which means they are snowbound six months a year. Rainfall is negligible in spiti because it is a rain shadow area. Spiti's lunar-like terrain was transformed into an agrarian success story by an ingenious system, devised centuries ago to tap distant glaciers for water. But shortsighted developmental policies, though well-intentioned, now threaten both this unique irrigation system and the social conciousness that spawned it. The soil is dry and lacks organic matter. But, despite these handicaps, the spiti valley has been made habitable and productive by human ingenuity. But spiti's unique contribution to farming is kul irrigation, which utilises kuls (diversion channels) to carry water from glacier to village. The kuls often span long distances, running down precipitous mountain slopes and across crags and crevices. Some kuls are 10 km long, and have existed for centuries. The crucial portion of a kul is its head at the glacier, which is to be tapped. The head must be kept free of debris, and so the kul is lined with stones to prevent clogging and seepage. In village,the kul leads to a circular tank from which the flow of water can be regulated. For example, when there is need to irrigate, water is let out of the tank in a trickle. Water from the kul is collected through the night and released into the exit channel in the morning. By evening, the tank is pratically empty, and the exit is closed. This cycle is repeated daily. The culture also is instrumental in maintaining the carrying capacity of the surrounding cultivable land. However, this system, carefully nurtured through the centuries, now runs the risk of being upset through government intervention.

3. Bamboo Rainwater Harvesting

In Meghalaya an ingenious system of tapping of stream and spring water by using bamboo pipes to irrigate plantations is widely prevalent. It is so perfected that about 18-20 litres of water entering the bamboo pipe system per minute gets transported over several hundred meters and finally gets reduced to 20-80 drops per minute at the site of the plant. The tribal farmers of Khasi and Jaintia hills use the 200-year-old system. The bamboo drip irrigation system is normally used to irrigate the betel leaf or black pepper crops planted in areca nut orchards or in mixed orchards. Bamboo pipes are used to divert perennial springs on the hilltops to the lower reaches by gravity. The channel sections, made of bamboo, divert and convey water to the plot site where itis distributed without leakage into branches, again made and laid out with different forms of bamboo pipes. Manipulating the intake pipe positions also controls the flow of water into the lateral pipes. Reduced channel sections and diversion units are used at the last stage of water application. The last channel section enables the water to be dropped near the roots of the plant.Bamboos of varying diameters are used for laying the channels. About a third of the outer casing in length and internodes of bamboo pieces have to be removed while fabricating the system. Later, the bamboo channel is smoothened by using a dao, a type of local axe which is a round chisel fitted with a long handle. Other components are small pipes and channels of varying sizes used for diversion and distribution of water from the main channel. About four to five stages of distribution are involved from the point of the water diversion to the application point.

4. Temple tank

People in ancient time used to store water in temples and other religious places, this was another method for storing water.

As the appropriate choice of technique depends on the amount of rainfall and its distribution, land topography, soil type and soil depth and local socio-economic factors,these systems tend to be very site specific. The water harvesting methods applied strongly depend on local conditions and include such widely differing practices as bunding, pitting, micro catchments water harvesting, flood water and ground water harvesting (Prinz 1996, Critchley and Siegert 1991).

"*the 9th IRCSC (International Rainwater Catchement System Conference), held in Brazil in July 1999,Dr. A.Appan said:*

"The concept of rainwater catchment system technology is as old as the mountains. The standard adage- as in all water supply schemes is- store water (in a tank reservoir) during the rainy season so that you can use it when you need it most during the summer. In other words 'Save for the dry day!' The principle, methods of construction, usage and maintenance are all available. And, most important of all, there are many financial models to suit developing and developed countries. What is most needed is the moral acceptance of the technology and the political will to implement the system."

A non-conventional approach that is gaining significance as an effective long term strategy for supplementing traditional sources of freshwater supplies is the harvesting and utilization of rain water.

Water Harvesting

Suface water is inadequate to meet our demand and we have to depend on ground water.Due to rapid urbanization, infiltration of rainwater into the sub-soil has decreased drastically and recharging of ground water has diminished. Under such circumstances conservation of water by improved technology based on traditional concept has become the need of the hour.

Types of water harvesting

A brief description of these water-harvesting techniques along with sub-types is given below:

1.**Rainwater harvesting:** Rainwater harvesting is defined as a method for inducing, collecting, storing and conserving local surface runoff for agriculture in arid and semi-arid regions (Boers and Ben-Asher 1982). Rainwater harvesting covers three types of water harvesting.

* Water collected from roof tops, courtyards and similar compacted or treated surfaces is used for domestic purpose or garden crops.

* Microcatchment water harvesting is a method of collecting surface runoff (sheet or rill flow) from a small catchment area and storing it in the root zone of an adjacent infiltraion basin. The basin is planted with a single tree or bush or with annual crops (Prinz 2001).

* Macrocatchment water harvesting is also called " Water harvesting from long slopes" or "harvesting from external catchment systems" (Pacey and Cullis 1988). In this case, the runoff from hillslope catchments is conveyed to the cropping area, which is located below the hill foot on flat terrain.

2. Flood water harvesting: Can be defined as the collection and storage of creek flow for irrigation use. Flood water harvesting, also known as 'large catchment water harvesting' or 'Spate Irrigation', may be classified into following two forms:

* **Floodwater harvesting within stream bed:** In this case the water flow is dammed and as a result, inundates the valley bottom of the flood plain. The water is forced to infiltrate and the wetted area can be used for agriculture or pasture improvement.

* **Floodwater diversion:** In this case the wadi water is forced to leave its natural course and conveyed to nearby cropping fields.

It is difficult to give exact figure on the present area under various forms of floodwater harvesting system. Pakistan has more than 1.5 millon ha under floodwater harvesting. Such method of floodwater harvesting is adopted in countries of North Africa and Middle East regions.

3. Groundwater harvesting: It is a rather new term and employed to cover traditional as well as uncoventional ways of ground water extraction. Qanat system, underground dams and special types of wells are few examples of the groundwater harvesting techniques.

Qanats, widely used in Iran, Pakistan, North Africa and Spain consists of a horizontal tunnel that taps underground water in an alluvial fan, brings it to the surface due to gravitational effect. Qanat tunnels have an inclination of 1-2% and a length of up to 30 km. Many are still maintained and deliver steadily water to fields for agriculture production and villages for drinking water supply.

Groundwater dams like ' Subsurface Dams' and ' Sand Storage Dams' are other fine example of groundwater harvesting. They obstruct the flow of streams in a river bed there by water is stored in the sediment below ground surface and can be used for aquifer recharge. Sand filled reservoirs have the following advantages:

* Evaporation losses are reduced.

* No reduction in storage volume due to siltation.

* Health hazards due to mosquito breeding are avoided.

Groundwater harvesting does not play the same role globally as rain and floodwater harvesting.

4. Underground Storage

As several disadvantages are connected with surface storage of water-large evaporation losses, loss of storage caused by siltation, pollution problems and loss of agricultural land, underground storage of water may be an interesting alternative. This storage can be done in near surface aquifers (e.g. in wadi beds), calling for a conjunctive management of water resources, or in cisterns.Cisterns are man-made caves or underground constructions to store water. Often the walls of these cistern are plastered, their water losses by deep percolation or by evaporation can be minimal. The construction of cisterns was already practiced several thousand years ago.

Traditionally, in Mediterranean houses, one cellar room was specifically designed to store rain-water. Similar in-house cisterns are known from Rajasthan, NW India. In the same region, 'Kunds', covered underground tanks with a plastered catchment, are found (Agarwal and Narain 1997). Now a days cisterns are often constructed using concrete.

Modern Methods for rain water harvesting

The Modern methods of rainwater harvesting are categorised under two, they are Artifical Re-charging and Rain Water Harvesting.The former is classified into Absorption Pit Method, Ab-sorption Well Method, Well cum Bore Method and Recharge trench cum injection well. The later is categorised into Individual Houses and Grouped Houses which are further classified into Percolation Pit Method, Bore Well with Settlement Tank, Open Well Method with filter bed Sump and Percolation Pit with Bore Method. In the Indian region over the last few millennia, such climate fluctuations may have given rise to traditional village tanks, ponds and earthern embank-ments numbering more than 1.5 million, that still harvest rainwater in 660,000 villages in India (Pandey 2001).

Artificial Recharging

1. Absorption Pit Method
2. Absorption Well Method

3. Well cum Bore Method

4. Recharge trench cum injection well

1. Absorption Pit Method

A percolation/absorption pit is a hand bore made in the soil with the help of an augur and filled up with pebbles and river sand on top. The depth of these pits will be anywhere between 4 and 8 meters depending on the nature of the soil. If the soil is clayey, the pit has to be dug to a depth till a reasonable sandy stratum is reached. The diameter of these pits will be 25 cm (10 inches). A square/ circular collection chamber with silt arrester is provided at the top.

2. Absorption Well Method

These wells are constructed using cement rings readily available in the market. The diameter of these rings range from 2ft. to 6 ft. The depth up to which these wells are dug depends on the nature of the soil and the diameter depends on the number of roof top pipes that are likely to be connected to each one of these wells. These wells are left unfilled and are covered with RCC slabs of suitable thickness to facilitate free pedestrian and vehicular movement on the ground.

3. Well cum Bore Method

In areas where the soil is likely to be clayey up to say 15ft. and more, it is advisable to go in for a percolation well up to 10ft. or 15ft. and a hand bore pit within this well up to a depth of 10ft.to 15ft. from its bottom. A PVC pipe of 5inch diameter is inserted into the bore for the entire length.

4. Recharge trench cum injection well

This technique is ideally suited for areas where permeable sandy horizons within 3 to 5m. below ground level and continues up to the water level under unconfined conditions, by which copious water available can be easily recharged.

In this technique, 1 to 2m. wide and 2 to 3m. deep trench is excavated, the length of which depends on the site availability and volume of water to be handled. An injection,well of 100 to 150 mm diameter is constructed, piercing through the layers of impermeable horizons to the potential aquifer reaching about 3 to 5 meters below water levels (1 to 10m.)from the bottom of the trenches. Depending upon the volume of water to be injected, the number of injection wells can be increased to enhance the recharging rate.

Rainwater harvesting

Rainwater can be harvested from the following surfaces

Rooftops: If buildings with impervious roofs are already in place, the catchment area is effectively available free of charge and they provide a supply at the point of consumption. Paved and unpaved area i.e., landscapes, open fields, parks,storm water drains, roads and pavements and other open areas can be effectively used to harvest the runoff. The main advantage in using ground as collecting surface is that water can be collected from a larger area. This is particularly advantageous in area of low rainfall.

Waterbodies: The potential of lakes, tanks and ponds to store rainwater is immense. The harvested rainwater can not only be used to meet water requirements of the city, it also recharges groundwater aquifers.

Stormwater drains: Most of the residential colonies have proper network of stormwater drains. If maintained neatly, these offer a simple and cost effective means for harvesting rainwater.

Recharge structures

Rainwater may be charged into the groundwater aquifers through any suitable structures like dugwells, borewells, recharge trenches and recharge pits.

Various recharge structures are possible which promotes the percolation of water through soil strata at shallower depth (e.g. recharge trenches, permeable pavements) whereas others conduct water to greater depths from where it joins the groundwater (e.g. recharge well). At many locations,existing structures like wells, pits and tanks can be modified as recharge structures, eliminating the need to construct any structures afresh. Here are a few commonly used recharging methods.

1. Recharging of dugwells and abandoned tubewells

In alluvial and hard rock areas, there are thousands of wells which have either gone dry or whose water levels have declined considerably. These can be recharged directly with rooftop run-off. Rainwater that is collected on the rooftop of the building is diverted by drainpipes to a settlement or filtration tank from which it flows into the recharge well (borewell or dugwell).

If a dugwell is used for recharge, the well lining should have openings (weep-holes) at regular intervals to allow seepage of water through the sides. Dugwells should be covered to prevent mosquito breeding and entry of leaves and debris. The bottom of recharge wells should be desilted annually to maintain the intake capacity.

Providing the following elements in the system can ensure the quality of water entering the recharge wells:

1. Filter mesh at entrance point of rooftop drains
2. Settlement chamber
3. Filter bed

2. Settlement tank

Settlement tanks are used to remove silt and other floating impurities from rainwater. A settlement tank is like an ordinary storage container having provisions for inflow (bringing water from the catchment), outflow (carrying water to the recharge well) and overflow. A settlement tank can have an unpaved bottom surface to allow standing water to percolate into the soil.

In case of excess rainfall, the rate of recharge, especially of borewells, may not match the rate of rainfall. In such situations, the desilting chamber holds the excess amount of water till it is soaked up by the recharge structure. Thus, the settlement chamber acts like a buffer in the system.

Any container (masonry or concrete underground tanks, old unused tanks, pre-fabricated PVC or ferro-cement tanks) with adequate capacity of storage can be used as a settlement tank.

3. Recharging of service tubewells

In this case the rooftop runoff is not directly led into the service tubewells, to avoid chances of contamination of groundwater. Instead rainwater is collected in a recharge well, which is a temporary storage tank (located near the service tubewell), with a borehold ,which is shallower than the water table. This borehole has to be provided with a casing pipe to prevent the caving of soil, if the strata is loose. A filter chamber comprising of sand, gravel and boulders is provided to arrest the impurities.

4. Recharge pits

A recharge pit is 1.5m to 3m wide and 2m to 3m deep. The excavated pit is lined with a brick/stone wall with openings (weep-holes) at regular intervals. The top area of the pit can be covered with a perforated cover. Design procedure is the same as that of a settlement tank.

5. Soakaways/Percolation pit

Percolation pits, one of the easiest and most effective means of harvesting rainwater, are generally not more than 60x 60x 60 cm pits, (designed on the basis of expected runoff as described for settlement tanks), filled with pebbles or brick jelly and river sand, covered with perforated concrete slabs wherever necessary.

6. Recharge trenches

A recharge trench is a continuous trench excavated in the ground and refilled with porous media like pebbles, boulders or broken bricks. A recharge trench can be 0.5 m to 1 m wide and 1 m to 1.5 m deep. The length of the recharge trench is decided as per the amount of runoff expected. The recharge trench should be periodically cleaned of accumulated debris to maintain the intake capacity. In terms of recharge rates, recharge trenches are relatively less effective since the soil strata at depth of about 1.5 meters is generally less permeable. For recharging through recharge trenches, fewer precautions have to be taken to maintain the quality of the rainfall runoff. Runoff from both paved and unpaved catchments can be tapped.

7. Recharge troughs

To collect the runoff from paved or unpaved areas draining out of a compond, recharge troughs are commonly placed at the entrance of a residential/Instutional complex. These structure are similar to recharge trenches except for the fact that the excavated portion is not filled with filter materials. In order to facilitate speedy recharge, boreholes are drilled at regular intervals in this trench. In design part, there is no need of incorporating the influence of filter materials.

This structure is capable of harvesting only a limited amount of runoff because of the limitation with regard to size.

8. Modified injection well

In this method water is not pumped into the aquifer but allowed to percolate through a filter bed, which comprises sand and gravel. A modified injection well is generally a borehole, 500 mm diameter, which is drilled to the desired depth depending upon the geological conditions, perferably 2 to 3 m below the water table in the area. Inside this hole a slotted casing pipe of 200mm diameter is inserted. The annular space between the borehole and the pipe is filled with gravel and developed with a compressor till it gives clear water. To stop the suspended solids from entering the recharge tubewell, a filter mechanism is provided at the top.

Diversion of run off into existing surface water bodies

Construction activity in and around the city is resulting in the drying up of water bodies and reclamation of those tanks for conversion into plots for houses. Free flow of storm run off into these tanks and water bodies must be ensured. The storm run off may be diverted into nearest tanks or depression, which will create additional recharge.

Formula used for potential of harvested water

Water harvesting potential =Rainfall (mm) x Area of catchment x Runoff coefficient

Benefits of Rainwater Harvesting

Development and augmentation of freshwater supplies through installation of Rain water harvesting systems will offer following benefits:

(1)It provides relatively high quality water, soft and low in minerals at low cost

(2)Direct capturing of rain water significantly reduces our reliance on water from dams/ reservoirs and canal systems. This will exert less pressure on national storage capacity at marco level and can reduce the need to expand dams or build new ones

(3)Rainwater harvesting promotes self-sufficiency and fosters an appreciation for water as a resource. It also promotes water conservation.

(4)Local erosion and flooding from imprevious cover associated with buildings is lessened as a portion of local rainfall is diverted into collection tanks.

(5)Encourages households and institutions to be well equipped with an onsite and decentralized water supply of reliable quality.

Disadvantages

The technical progress of the 19th and 20th century occurred mostly in the so called developed countries in moisture moderate climate zones without a need for rainwater harvesting. Further more emphasis was put on big dams, groundwater development and piped irrigation projects with high input of fossil energy and electricity, this was another reason that rainwater-harvesting techniques have been set aside or totally forgotten. The technical progress of the 19th and 20th century occurred mostly in the so called developed countries in moisture moderate climate zones without a need for rainwater harvesting. As a consequence of colonialization agricultural practices from moderate climate zones were implanted in drier climate zones.Short comings of rainwater harvesting technologies are mainly due to the limited supply and uncertainty of rainfall. Adoption of this technology requires a bottom up approach rather than the more usual top dowm approach employed in other water resources development projects. This may make rainwater harvesting less attractive to some governmental agencies tasked with providing water supplies in developing countries, but the mobilization of local government and NGO resources can serve the same basic role in the development of rainwater-based schemes as water resources development agencies in the larger, more traditional public water supply schemes.

Conclusion

Rainwater harvesting has the potential to increase the productivity of arable and grazing land by increasing the yields and by reducing the risk of crop failure. They also facilitate re/or afforestation, fruit tree planting or agroforestry. With regard to tree establishment, rainwater harvesting can contribute to the fight against desertification. Water harvesting technology is especially relevant to the semi-arid and arid areas where the problems of environmental degradation, drought and population pressures are most evident. It is an important component of the package of remedies for these problem zones. Most of techniques are relatively cheap and can therefore be a viable alternative where irrigation water from other sources is not readily available or too costly. Unlike pumping water, water harvesting saves energy and maintenance costs. Using harvested rainwater helps in decreasing the use of other valuable water sources like groundwater, there is no doubt that implementation of water harvesting techniques will expand. Remote sensing and Geographical Information Systems can help in the determination of areas suitable for water harvesting (Prinz *et al.* 1998).

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