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Rainwater Harvesting: Principle and Practice

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Abstract:

Water resources are not endless and hence its conservation is everyone's duty. Rainwater harvesting is a technique of water conservation. It helps in minimizing the problem of acute water scarcity through recharges of ground water by artificial means. Rainwater harvesting technology is based on the ideas of collecting and storing .the rainwater that falls or collects on the roofs, terraces, courtyards and pavements etc. The collected water is passed through the pipes or other means to underground water table which recharges groundwater table locally. The technology of rainwater harvesting is simple, eco-friendly, and can any body do it with a little capital. The Rainwater harvesting is necessity of the day and it should be given serious consideration.

The paper deals in details the various methods rainwater harvesting, its benefits, cost factors and strategies for development.

A reliable and accessible water supply is essential to human welfare, health and development. But water scarcity is still an important problem. The answer to this problem will be Rain water harvesting.

Rain water harvesting is a simple, economic and affordable process by which rain water that collects or falls on roofs, terraces, courtyards and pavements etc., is directed to a storage tank or well which recharges the ground water. The recharging techniques include collection of rain water and pass it through pipes and other means to under ground water table which is normally lie below the ground.

The primary source of rainwater harvesting is rainfall, which also include snowfall. In India rainfall is mostly available between June and September every year. During these four months rainfall is generally heavy. But a significantly large part of this water runs off into seas and oceans. It therefore goes waste. If rain water can be stored in ground water reservoirs our water situation would dramatically change. In India, the available annual replenishable water resources was estimated at 432 billion cubic metre (BCM) and by adopting different rain water harvesting structures it can be raised by 160 million cubic meter (BCM) i.e., 592 BCM. This would be a great achievement.

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The art of rainwater harvesting in India is as old as our civilization. Indians have been the world's greatest water harvesters. Proof of this is evident in many age-old structures viz. **Tankas, Khadims, Toheel, Bawaries** etc., found in many old forts. Evidence shows that during the **Harappan period** (3000 – 5000 B.C.) there was a very good system of water management, as can be seen in the excavation at **Dholavira** in Kachah. The archeological excavation there shows that every third house had one well and the people understood the importance of harvesting and exploitating the rain and flood water fully. Evidence of irrigation with rain water harvesting system can be found even in **Kautilyas' Arthasastra**. The book refers that the people knew about rainfall regimes, soil types and irrigation techniques. It also mentions that the state rendered help in the construction of irrigation channels initiated and maintained by the villagers of a new settlement. In the ancient times, the people of Tamil Nadu used to share rainwater in public places separately for drinking and bathing purposes and called as **Oravies**. They also dug percolation tanks for recharging ground water for irrigation purposes. In Rajasthan traditional rain water harvesting in **Kund** or **Kundis** (the local name given to a underground water tank) help people to tide over the water need of the scorching day of summer. In drier areas of Rajasthan every attempt is made to harvest spring and rain water. In Jodhpur and Jaisalmer have hawallis (houses) that channel every drop of water into a container usually under the courtyard to store rain water. Even in the cool climatic region such as Spiti valley of Himachal Pradesh, **Kul** (diversion channels) is utilized to carry water from the glaciers to the village. In high rainfall region of North-East India, rainwater harvesting is also evident. In old Assam type houses, rainwater is collected from sloping rooftops through pipes and store for use. The most sophisticated water diversion system in the country had been constructed in Meghalaya about 200 years ago. It consisted of bamboo pipes, tapping water from fast flowing streams and delivering it to the roots of crops at about 20-80 drops per minute. The entire indigenous rainwater harvesting system in India went into decline during British rule and with the steady impoverishment of the rural communities. The time has now come to revive the system for remedy today.

A look outside India gives us records that as early as the 3rd century B.C. farming communities in Baluchistan impounded rainwater and used it for irrigation. Dam built of rubble have been found even today in Baluchistan and Kutch. In Afghanistan, one could find the world's ancient technological marvels to harvest water known as **Karez or qanals**. In ancient times, farmers in eastern and southern Afghanistan built this network of ground water irrigation channels to use the scare ground water for irrigation. The Karez system evolved in North Western Iran some 3000 years ago. By 714 BC, the system spread to Egypt, Afghanistan and far away South India. It is an unlined tunnel with shafts in equal intervals and bring water to the surface using gravity. First, a well is dug to the water level and lines of shafts are dug to enable removal of soil. Water travels down through tunnels to farm field on lower plains (Figure-A). Some **Karez** stretches for several kilometers under ground. Farmers construct and manage such structures through user's groups. The silt must be cleaned annually and hauled to the shaft surface. It takes many years to construct a **Karez**, but the operating cost is low. A **Karez** can irrigate 10 to 20 hectares of land. In Afghanistan, there are some 6500 **Karez** which irrigates about 7 per cent of the total land of the country.

In China, community based approach is being practiced today where villagers are encouraged to harvest rain water from rooftops. In inner Mongolia particularly **Heibei** and **Qingai** provinces rain water harvesting in villages is almost mandatory. In **Heibei province**, villagers build under ground tanks up to 10 cubic metre capacities below their houses where rainwater is diverted during the short rainy season. The stored water is used during the dry season and the water quality is monitored by Government inspectors. Besides, community

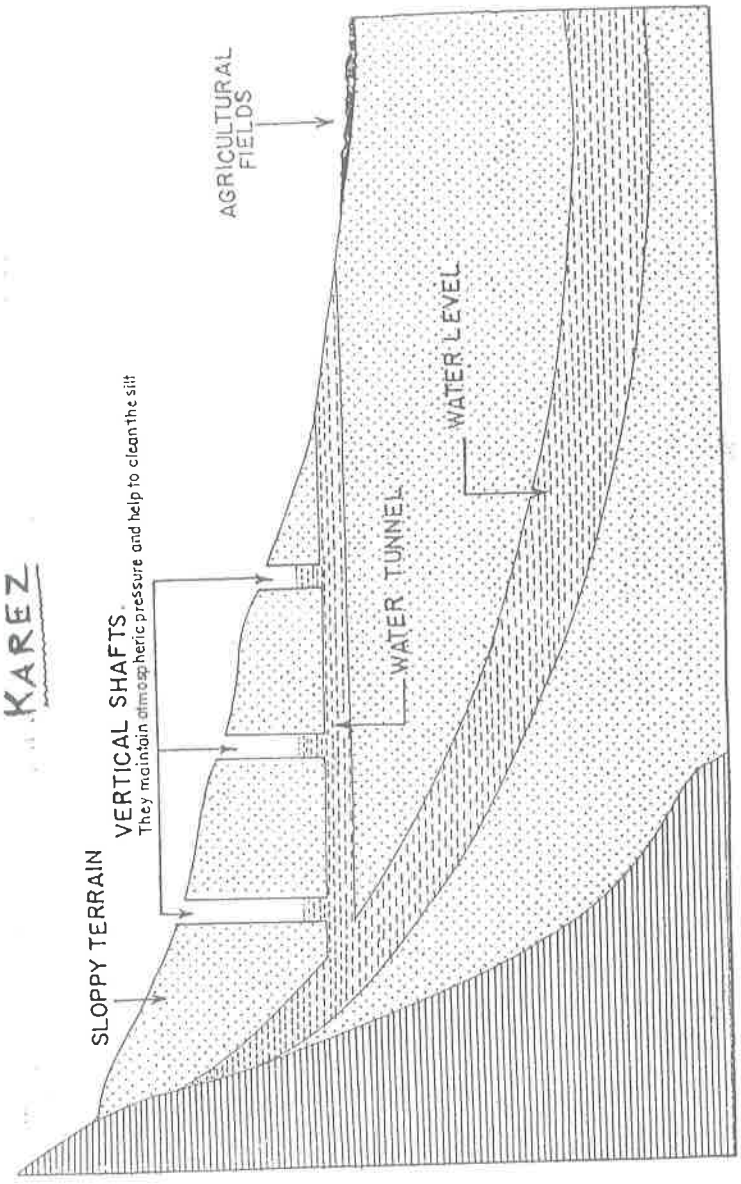


FIGURE - A

drinking water cisterns with a capacity of upto 1000 cubic metre are built in villages by diverting water from a permanent or ephemeral stream or spring (Hasan, 2000).

The quantum of rain water available for harvesting depends upon frequency, duration and intensity of rainfall, nature of catchments area and run off characteristics. By and large rainwater is biologically pure, soft in nature, low in minerals and free from organic matter but it contents pesticides residues. The airborne pesticides concentration is highest at the beginning of the rainfall and decreases gradually (Pravat & Sudhakar, 2001) considering the ever-increasing demand for water, rainwater harvesting is not only beneficial but also necessary for many reasons, as follows :-

(1) Rain water harvesting increases the availability of ground water and raises the water levels in wells and tube-wells which causes reduction of cost in the use of energy for pumping water. It has been calculated that one metre high water level saves 0.40 Kwh. of electricity and at this rate 10 hours pumping of water per day saves 1460 Kwh. of energy annually.

(2) Rain water harvesting work wonders in areas that lacks well distributed rainfall and affected by the problem of excess arsenic, fluorides, chlorides, salt and iron contamination in ground water. It thus, provides relatively better quality of water with low content of hazardous minerals.

(3) It controls flood and reduces the impact of drought, famines and supplement the requirement of water for domestic purposes during the long dry spell of summer.

(4) It reduces soil erosion, silting and contamination of waterways from polluted surface runoff. It also reduces flow of storm water and minimizes chances of overloading drainage system.

(5) It indirectly curbs the reliance on dams, canals and reservoirs and thus reducing the need to build more such structures with high cost.

(6) In addition, rainwater harvesting revives the traditional water harvesting structures viz., ponds, wells, lakes etc. It is through this techniques effective use of millions of defunct wells and tube-wells can be used as recharged structures.

Rainwater harvesting can be done on the following manners.

(i) By digging ponds, tanks and other storage

(ii) By building embankments and check dams

(iii) By storing rainwater on roof tops sources.

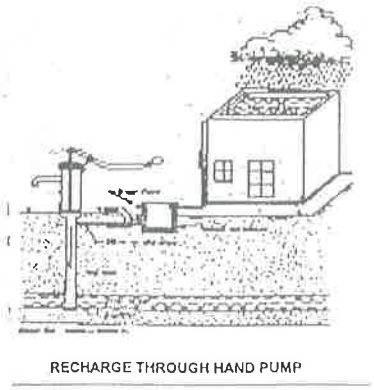
(iv) By constructing concrete reservoir in underground.

(v) By constructing reservoirs in parks and public places, covering them with concrete slabs.

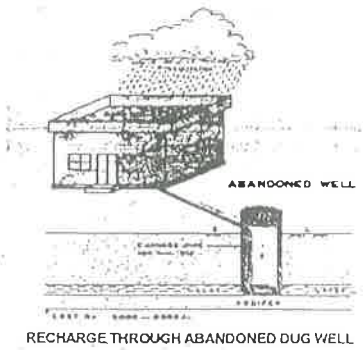
The first two options which require much space is not viable in towns and cities. But the last three options of recharging the ground water is something anybody can go ahead. This do not need large space, a bore well, a percolation pit or a reservoir is sufficient for the purpose.

A rainwater harvesting structure generally consists of a water chamber an an injection well. In a society, where all buildings have pipelines that carry water from the roofs to drains, a fresh network of pipes is not required. At a place where the pipes discharge water, a filter chamber, tank consisting of layers of sand, gravel and boulders may be constructed. The dimension of tank depends upon the Monsoon run off in the area. A tube well dug at the Centre of the tank which is 10 to 20 metres deep, depending upon the ground water level or aquifers. If the area is not clean a desilting tank is to be constructed before the filter chambers.

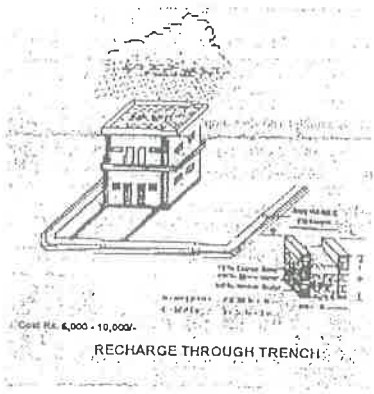
RAIN WATER HARVESTING TECHNIQUES



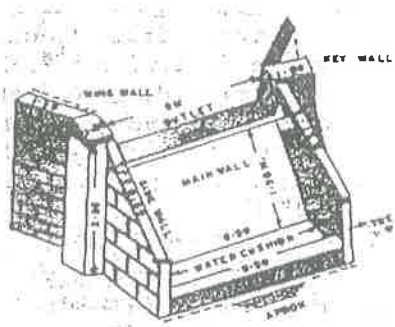
RECHARGE THROUGH HAND PUMP



RECHARGE THROUGH ABANDONED DUG WELL



RECHARGE THROUGH TRENCH



SECTION OF CEMENT NALA BUND

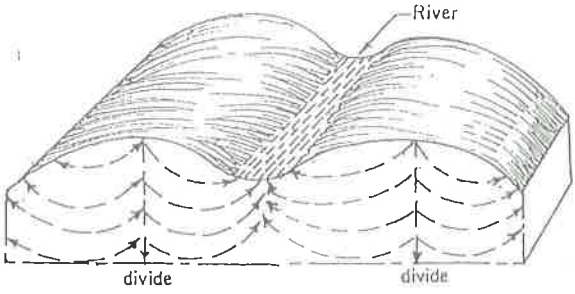
FIGURE - B

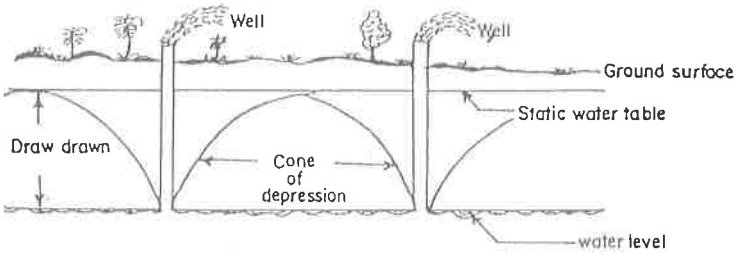
The various roof top systems used for recharging ground water has been shown in the accompanied figure-B.

Developing a recharge structure is not very costly. An abundant **dug well** could be used as a recharged structure and this costs between Rs.5000 and Rs.8000/-. **Recharge pits** to recharge shallow aquifers costs between Rs.2500 and Rs.5000/-. **Recharge trenches** are constructed when a permeable stratum of adequate thickness is available at shallow depths. The cost varies between Rs.5000/- and Rs.10,000/-. In areas where land availability is limited borewells and tubewells could be used as recharge structures for a price that varies between Rs.50,000/- and Rs.80,000/-.

Rain water harvesting has equal importance both in Rural and Urban areas particularly in places that suffer from the lack of well distributed rainfall. In **Urban areas** concrete courtyards and roads do not let the rain water seep back into the soil. This lowers the water table and results in a shortage of water. But if it could be possible to direct all rain water to recharge pit, trench or dug-well it could gradually percolate down, raising the water table in the area and providing a long term solution to water shortages. In **rural areas**, rainwater can easily pass through the soil and recharge ground water as there is no concrete roads and pavements. Even there, a major part of rainfall 75 to 85 per cent, is passed through the surface as run off. In the drought prone districts of West Bengal such as Purulia, Bankura and Birbhum which receives 1200 milimetres of annual rainfall also faces acute shortage of water during mid-June each year. Out of the 1200 millimetres annual rainfall, 80 per cent arrives during the Monsoon. The bulk of the rainfall (95 per cent) amounting to 55,813 million cubic metre is lost due to rapid surface runoff as the land slopes are moderate to high and the recharge to shallow aquifers is limited. This huge loss of surface water can be preserved in ponds, lakes and sub-surface water tables through artificial recharge techniques. In Purulia, Bankura and Birbhum districts of West Bengal there are many storage tanks constructed earlier by erecting earth embankments at the lower ends to hold the runoff water from higher level of land. This indigenous techniques is not expensive and can be further resurrected in the area. In addition, there is a huge possibility of sub-surface recharge of water. In Tulin village of Purulia district and Saltore village of Bankura district where subsurface dykes were constructed in 1988, had shown an increase in the peisometric level of (the water in unconfined conduits) 0.45 metres in the subsequent year.

Knowledge of ground water hydrology is essential to build different water recharge structure. Rain water is the main source of ground water. This source of water makes its way downward through porous permeable rocks under the force of gravity and finally reaches a zone of saturation where all the rock openings are full of water. This is what is known as **water-table**. The flow of water in the soil structure of the under ground strata is based on the principles of the physics of fluids, i.e. water follows paths curved concavely upward, as shown in Figure-C. Ground water does not move directly from divides to the lines of seepage by flow close to the top of the water table. If such were the case, the lower parts of the ground waterbody would be stagnant. Similarly, due to pumping of water, the level of water drops and the surrounding water table is lowered in the shape of a conical surface, termed the **cone of depression**, the height of which is termed the **draw drawn**. The cone of depression may exceed as far as 8 to 10 or more kilometers from a well where heavy pumping is continued.


River
divide
divide


Well
Well
Ground surface
Static water table
Draw drawn
Cone
of
depression
water level

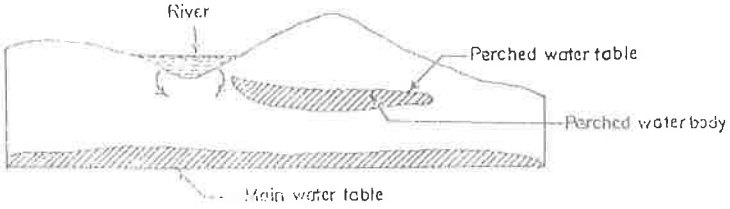

River
Perched water table
Perched water body
Main water table

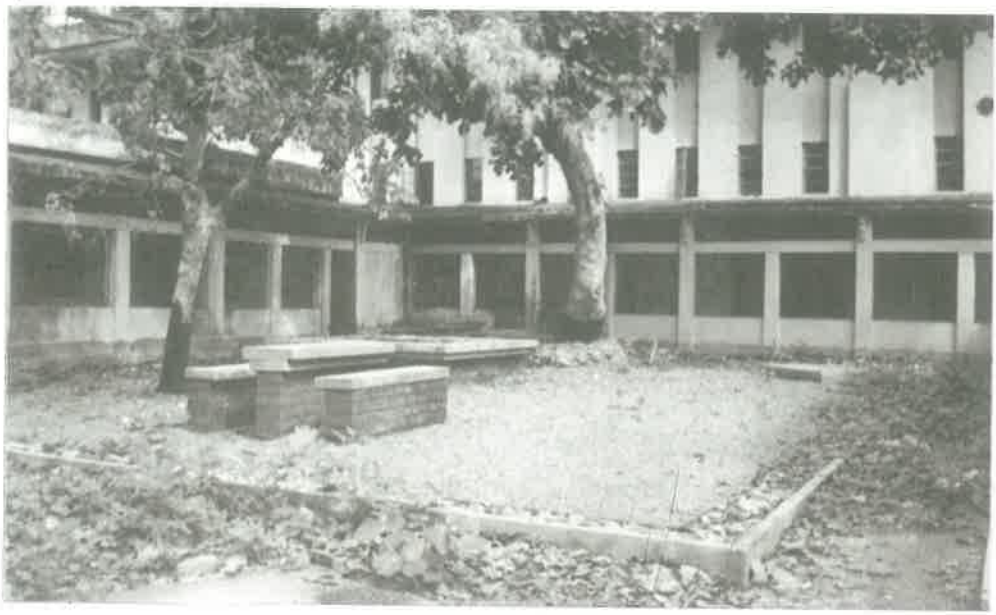
FIGURE - C

Where many wells are in operation their intersecting cones produce a general lowering of the water table as shown in Figure-C.

Ground water in India today supplies 80 per cent of the rural and 50 per cent of the urban water requirements. It's dependence is increasing day by day. There are at present 6 millions tube wells and 20 million bore wells in the country which lift water for irrigation and other purposes. The lifting of water causes the fall of the groundwater level at many places, giving rise to many ecological problems viz., arsenic, fluoride salt intrusion in drinking water. Recent study shows that in 300 districts of 18 states in the country, groundwater level has dropped 4 metres below the surface. The over exploited ground water deficient blocks in the country have increased from 250 in 1985 to 470 in 2003 which necessitates artificial recharge of ground water. Besides, some measures to lessen the problem include (i) restriction on the construction of irrigation wells and tube wells within a distance of 200 metre or less from the source of drinking water supply (ii) creation of rain water harvesting structures near to the drinking water supply source. (iii) restriction in the cultivation of high water consuming crops such as Boro rice (summer rice), Sugar etc. maybe recommended.

For reaching ground water, rainwater harvesting technique would be one of the best option. Planning Commission document refers 'rainwater harvesting is the most powerful management tool to assure sustainability.' This technique will be used more in future not only in urban areas but also in rural areas. In rural areas, it is necessary to keep waterbodies full of water for increasing the peisometric level of water. In urban areas of West Bengal, there is a law that water bodies above 5 Kattahas (36,00110 sq. feet) of land are not to be filled up for any purposes. But no such law is applicable in rural areas. As a consequence, water bodies are filled up at will which resulted in drying up water wells. To come up with this problem some steps are to be taken up immediately which include (i) restoration of all water bodies (ii) enhancement of the water holding capacit1y of the existing water bodies and lastly, (iii) creation of new run off reservoirs as many as possible. The strategy for urban areas will be different as there is not enough open space for holding surface water. In urban areas, runoff storage (small underground) and roof top rainwater harvesting structures would be suitable. Studies have proved that ground water recharge from a house with 100 square meter roof top will be around 55,000 litre per year and the cost of such roof top structure would be around Rs.12,000/-.

Rainwater harvesting today is a necessity both in personal and National interest. Provisions of rainwater harvesting are being made mandatory for group housing societies and some large sized residential, commercial and industrial complexes by many state governments. In West Bengal, State Pollution Control Board (WBPCB) has introduced the norm of rainwater harvesting in housing estates which are built over an area of more than 60,000 square feet or include 100 or more flats. Under this new legislation builders will have to make arrangements in the building to save rainwater in order to tackle the problem of water crisis in the city and suburbs (Nath, 2004). In West Bengal, on experimental basis, some rainwater harvesting structures have been installed in the offices of Salt lake Municipality, West Bengal Pollution Control Board Office, Jal Sampad Bhawan, Purta Bhawan, Bikash Bhawan, all in Salt Lake City. At Santiniketan Central Library (Visva-Bharati), a rainwater harvesting structure has



Rain Water Harvesting structure installed at Santiniketan Central Library, Visva-Bharati (After Completion)

Rain Water structure in under construction at Santiniketan Central Library, Visva-Bharati

been installed recently (see the photographs). In West Bengal, Rs.9 crore will be spent over the next 3 years (2004-2007) for 230 water harvesting structures including dam. This will be part of the 175 crore project involving 5088 schemes of different kinds all over the country (Chowdhury 2004). In other states capitals such as Mumbai, Delhi, Chennai, Chandigarh, Hyderabad in building regulation rainwater harvesting is now mandatory. This has improved the ground water level of the cities impressively. According to Central Ground Water Board (CGWB) and Urban Development Ministry (UDM) rain water harvesting structures should be installed in all buildings built on a plot of 100 square metre or more where the ground water level is below 8 metres. As for those who do not install rainwater harvesting systems the authority can seal their ground water extraction system. In Delhi, according to an estimate of Central Pollution Control Board rainwater harvesting system can meet 10 per cent of the total demand of water in NCT (National Capital Territory). This would be a great achievement.

Rain water harvesting cannot be a government programme. It is basically a **'Movement'** where all sections of people are to be involved. A mass awareness programme involving district administration, Panchayets, NGO's and the users are to be arranged to make the programme demand based and successful. There is a need to constitute Water User Associations (WUA), Village Beneficiary Groups (VBG). These bodies will work with NGO's to implement any project right from the inception to completion stages. Side by side, training will be provided to builders, promoters, contractors, NGO's and Officials working in different development agencies towards building rainwater harvesting structures. Government role will be to act as facilitator and to provide technical know-how, financial support for creating demonstration facilities. Water availability is basically a matter of good governance. Ensure good governance and water will certainly become available to all.

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