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12. Water Harvesting: Importance and Techniques

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Abstract:

Water throughout the world is getting more serious attention. Pollution, over consumption and poor water management are decreasing the quantity and deteriorating the quality. Productively per unit of water has still remained low in many areas of the world in general and in developing countries in particular. Rain is the first form of water that we know in the hydrological cycle, hence is a primary source of water. Due to the limited water resources and the rapid increase of population in India. Groundwater is the main source of water; the Indian Government has implemented great efforts to develop new settlements. Therefore, growing awareness of the potential of rainwater harvesting (RWH) for improved water resources management arose in such Northern arid regions: Rajasthan desert, Rann of Kutch, and semi-arid regions of Punjab and Gujarat. Southern arid regions: Rain shadow areas of Maharashtra, Karnataka, and Tamil Nadu. Peninsular interior, western Madhya Pradesh, Haryana, and Punjab: Semi-arid climate. Saurashtra, Kachchh, and Rajasthan: Arid climate. Where collected rainwater can be stored for direct use or can be recharged into the groundwater. In arid and semi-arid regions; the precipitation is low or infrequent during the dry season, it is necessary to store the maximum amount of water during the wet season for use at a later time, especially for agricultural and domestic water supply. Rainwater harvesting (RWH) is a method of inducing, collecting, storing and conserving local surface runoff for agricultural production, domestic uses and ground water recharge. The rainfall occurs during short spells of high intensity, then most of the rain falling on the surface tends to flow away rapidly, leaving very little for the recharge of ground water. This highlights the need to implement measures to ensure that the rain falling over a region is tapped as fully as possible appropriate through water harvesting for provide drinking and irrigation water and recharging the ground water aquifers.

Normally water harvesting is practiced in arid and semi- arid regions for agriculture and it is more effective in areas situated near hillside or where cultivation is difficult due to large portion of bare soil. To enhance irrigation in arid environments, ridges of soil are constructed to collect and prevent rainwater from running down hills and slopes. Water can be collected from roofs, dams and ponds can be constructed to hold large quantities of rainwater so that at the time of little or no rainfall occurs, enough is available to irrigate growing crops. Water harvesting is a method of collecting and storing water for future use. Generally, water harvesting is direct rainwater collection. Rain is primary water source while lakes, groundwater and rivers are the secondary water source. Rainwater harvesting is a type of harvest in which the rain water are collected and stored for the future use, instead of allowing them to run off. However, it is used for orchards/gardens, raising livestock, irrigation, domestic use with proper treatment etc. The harvested water can also be used as drinking water, longer-term storage, and for other purposes such as groundwater recharge.

Keywords:

Water harvesting, Water harvesting techniques, Water harvesting methods, Water harvesting system and Water harvesting importance.

12.1 Introduction:

Rainwater harvesting is the accumulation and storage of rainwater for reuse before it reaches the aquifer. In many places the water collected is just redirected to a deep pit with percolation. The harvested water can be used for drinking water as well if the storage is a tank that can be accessed and cleaned when needed.

12.2 Basic Technical Criteria:

A water harvesting scheme will only be sustainable if it fits into the socio-economic context of the area and also fulfills a number of basic technical criteria:

- **Slope**: The ground slope is a key limiting factor to water harvesting. Water harvesting is not recommended for areas where slopes are greater than 5% due to uneven distribution of run-off and large quantities of earthwork required which is not economical.
- **Soils**: Should have the main attributes of soils which are suitable for irrigation: they should be deep, not be saline or sodic and ideally possess inherent fertility. A serious limitation for the application of water harvesting is soils with a sandy texture. If the infiltration rate is higher than the rainfall intensity, no runoff will occur.
- **Costs**: The quantities of earth/stonework involved in construction directly affects the cost of a scheme or, if it is implemented on a self-help basis, indicates how labour intensive its construction will be. The catchments systems used in the RWH are those where runoff is concentrated, stored and productively used by plants. The coefficient of runoff depends upon the shape, size, soil condition, temperature and geological conditions of the area of the catchment. In summary RWH may occur naturally or by intervention.

Natural RWH can be observed after heavy storms, when water flows to depressions, providing areas for agriculture. RWH by intervention involves inducing runoff and either collecting it, or directing it, or both, to a target area for use.

12.3 Rainwater Harvesting Methods in India:

1. **Rooftop Rainwater Harvesting:** Rooftop rainwater harvesting is one of the most common and cost-effective methods employed in both rural and urban areas of India. It involves installing gutters and downspouts on rooftops to channel rainwater into storage tanks or recharge structures. In urban settings, rainwater collected from rooftops can supplement municipal water supply for non-potable uses such as gardening, washing, and flushing toilets. Additionally, rooftop rainwater harvesting helps reduce storm water runoff, alleviate pressure on drainage systems, and mitigate urban flooding.
2. **Surface Runoff Harvesting:** Surface runoff harvesting involves capturing rainwater from natural or man-made surfaces such as roads, pavements, and open grounds. In rural areas, contour bunding, check dams, and farm ponds are commonly used to harvest runoff water from agricultural fields and watersheds. These structures help retain rainwater, prevent soil erosion, and recharge groundwater aquifers, thereby improving soil moisture levels and enhancing agricultural productivity. In urban areas, decentralized runoff harvesting systems such as percolation pits, swales, and permeable pavements are implemented to capture and infiltrate rainwater into the ground, reducing surface runoff and replenishing aquifers.
3. **Watershed Rainwater Harvesting:** Watershed rainwater harvesting focuses on conserving and managing rainwater at the watershed or catchment level to enhance water availability and ecosystem resilience. In India, community-based watershed development projects, supported by government schemes such as the Integrated Watershed Management Programme (IWMP), promote soil and water conservation practices, afforestation, and the construction of small-scale water harvesting structures. These initiatives help replenish groundwater, restore degraded landscapes, and improve water security for rural communities dependent on rainfed agriculture.
4. **Check Dams and Percolation Tanks:** Check dams and percolation tanks are traditional rainwater harvesting structures built across seasonal streams, rivers, or gullies to impound rainwater and facilitate its percolation into the ground. In India, check dams are commonly constructed in hilly and semi-arid regions to mitigate soil erosion, recharge springs, and augment groundwater recharge. Percolation tanks, on the other hand, are built in flat or low-lying areas to store rainwater for irrigation, livestock watering, and domestic use. These structures play a crucial role in harnessing rainwater runoff, improving water availability, and sustaining rural livelihoods.
5. **Community Rainwater Harvesting:** Community rainwater harvesting involves collective efforts by communities to harvest, store, and manage rainwater for shared benefits. In India, initiatives such as the Jal Shakti Abhiyan and the National Rural Drinking Water Programme (NRDWP) promote community-based rainwater harvesting projects in villages and rural areas. These projects often involve the construction of rooftop rainwater harvesting systems, community ponds, recharge wells, and water storage tanks, coupled with capacity building and awareness-raising activities. By fostering community participation and ownership, these initiatives empower local communities to address water scarcity challenges and improve water resilience.

12.4 General Practices of Rainfall Harvesting:

Rainfall can provide considerable water resource in humid and semi-arid regions. There are several techniques worldwide depending upon rainfall intensity, duration, frequency and seasonality. Brief review of such practices is;

1. **Rainwater collection,** this is mainly roofing water collection in countries where conventional water resources are extremely scarce and each drop of rain has a real value. The ready availability of some form of roof sheeting and innovative ideas for water storage have made roof water a serious water resource consideration. Storage containers (jars) are used by householders from concrete to hold volumes 100 to 3000 lit., and measures may be needed to keep insects away. This is mainly for domestic uses.
2. **Terracing,** is used to collect water for two purposes, a- the horizontal surface reduces runoff and maximizes the infiltration of water into the soil. If the soil surface is kept free of vegetation except for the desirable crop, almost all rain falling on the terrace will be used for crop growth. If there are several terraces down a hill slope it may be possible to grow a crop on alternate terraces each year. b- terraces can be used as temporary water storages to reduce flow velocities of surface water and prevent erosion. The slow flowing water may be directed into a storage facility. Terracing help to provide silt free water for storage.
3. **Small dams,** are used (or even low embankments) across floodways, to increase aquifer recharge. Also, after rain events, it can increase soil water to become available to crop roots. A major difficulty in management of small water supply dams is sedimentation. If no attention is given to sediment control most small headwater dams will fill with sediment within a few years. There are several measures such as protect human activity upstream, sediment trap…etc.
4. **Runoff enhancement** is a technique used in places of water scarcity where the availability of water needs to be increased by partially sealing the soil surface. It can be done by applying surface sealing materials or by compacting the soil surface, which may be long lasting. Natural soil compaction reduces significantly infiltration characteristics and provide up to 80% of all rainfall from a storm runoff. Water can be gathered from a semi sealed surface to flow towards a tree or small vegetable plot to infiltrate to the plant root zone.
5. **Runoff Collection,** the idea is, if large number of very small stream channels can be captured in a small channel and diverted to a different location to fill an excavated hole or small dam, then it is possible to prevent evaporation losses.
6. **Flood Spreading,** some advantage can be gained from large torrential flows by spreading across flat areas if water is retained on flat surfaces the upper soil layer may become saturated, or water may percolate to replenish the aquifer, hence harvested water can be used.

To harvest flood water, wide valleys are reshaped and formed into a series of broad level terraces and the flood water is allowed to enter into them. The flood water is spread on these terraces where some amount of it is absorbed by the soil which is used later on by the crops grown in the area. Therefore, it is often referred to as "Water Spreading" and sometimes "Spate Irrigation". The main characteristics of water spreading are:

- Turbulent channel flow is harvested either (a) by diversion or (b) by spreading within the channel bed/valley floor.
- Runoff is stored in soil profile.
- It has usually a long catchment (may be several km)
- The ratio between catchment to cultivated area lies above 10:1.
- It has provision for overflow of excess water.

7. **Water Holes and Ponds,** natural water holes and ponds can be exploited for water supply purposes. There is a need to ascertain the source of the water, if it is fed by groundwater or by small surface flows following each rainfall event? If the source is groundwater, the pond can be treated as a well, and increasing abstraction by deepening and increasing the hydraulic gradient towards the pond. If the surface water is the source, then an embankment could be raised across the stream bed downstream the water hole to increase the volume of water captured during rain storm. It must be realized that in areas of high potential evaporation, depth of water is the key to effective water storage.
8. **Tanks,** are usually constructed water container, it is fabricated from steel sheets, concrete or plastic. Their particular importance when water resource is very limited and needs to be protected from evaporation and/or contamination. Hence, it is very important to allow water to be removed from the storage tank only via a valve outlet and never ever by manual means. Commercially small capacity tanks range from 1000 lit. to 10 million lit., which can be totally closed and extremely minimum losses.

These different techniques not all will match conditions of each country, therefore, it deemed important to consider each individual country, identify its clear objectives and select the applied research to comply with the local conditions after diagnostic analysis is made. The case in semi-arid regions may require different techniques, as in Egypt. But, since the effective rainfall is not sufficient, supplementary source is required, such as saline water desalination.

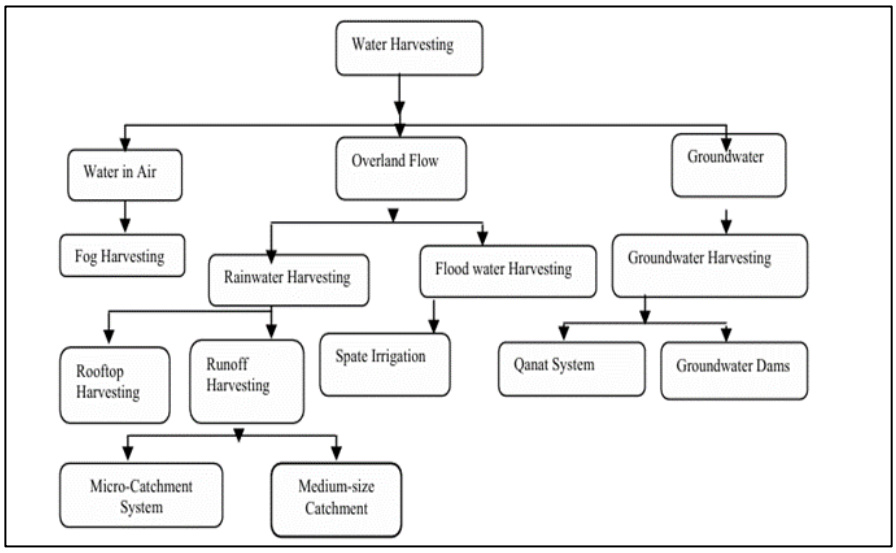
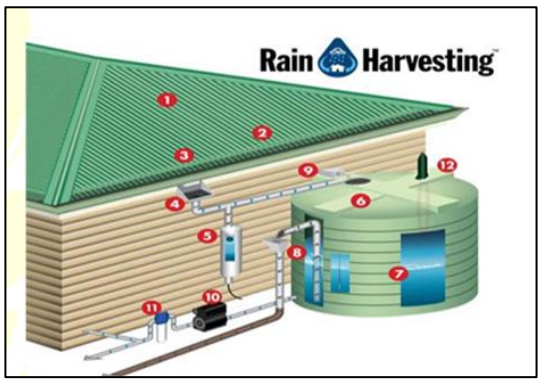


Figure 12.1: Classification of Water Harvesting Techniques



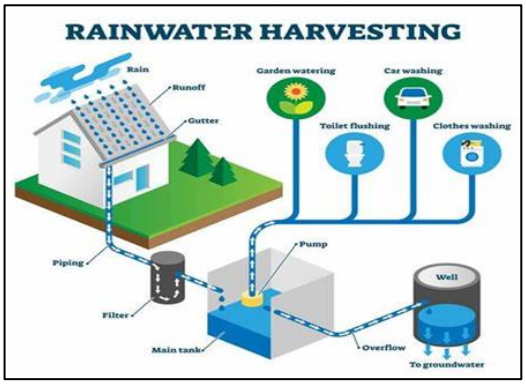


Figure 12.2: Some Important Images of WH

Table 12.1: Recharge to ground water is a new concept of rain water harvesting and the structures generally used are

Pits	Recharge pits are constructed for recharging the shallow aquifer
Aquifer	The aquifer is porous, water saturated layers of sand, gravel or bed rock that can yield significant or usable amount of water. These are constructed 1 to 2 m wide, 1 to 1.5 m deep which are back filled with boulders, gravels, coarse sand. Water from roof top is collected in Recharge Pit where boulders and charcoal filter the water.
Trenches	Trench may be 0.5 to 1 m wide, 1 to 1.5 m deep and 10 to 20 m long depending upon the availability of water. These are back filled with filter materials.
Dug wells	Existing dug wells may be utilized as recharge structure and water should pass through filter media before putting into dug well.

Pits	Recharge pits are constructed for recharging the shallow aquifer
Hand pumps	The existing hand pumps may be used for recharging the shallow/deep aquifers, if the availability of water is limited. Water should pass through filter media to avoid chocking of recharge wells.
Recharge wells	Recharge wells of 100 to 300 mm diameter are generally constructed for recharging the deeper aquifers and water is passed through filter media to avoid choking of recharge wells.
Recharge Shafts	For recharging the shallow aquifer which is located below clayey surface, recharge shafts of 0.5 to 3 m diameter and 10 to 25 m deep are constructed and back filled with boulders, gravels and coarse sand.
Lateral shafts with bore wells	For recharging the upper as well as deeper aquifers lateral shafts of 1.5 to 2 m wide and 10 to 30 m long depending upon availability of water with one or two bore wells is constructed. The lateral shaft is back filled with boulders, gravels and coarse sand.

12.5 Importance of Water Harvesting:

Rainwater harvesting, in its broadest sense, is a technology used for collecting and storing rainwater for human use from rooftops, land surfaces or rock catchments using simple techniques such as jars and pots as well as engineered techniques. Rainwater harvesting has been practiced for more than 4,000 years, owing to the temporal and spatial variability of rainfall. It is an important water source in many areas with significant rainfall but lacking any kind of conventional, centralized supply system. It is also a good option in areas where good quality fresh surface water or ground water is lacking. Water harvesting enables efficient collection and storage of rainwater, makes it accessible and substitute for poor quality water. There are a number of ways by which water harvesting can benefit a community.

- Improvement in the quality of ground water,
- Rise in the water levels in wells and bore wells that are drying up,
- Mitigation of the effects of drought and attainment of drought proofing,
- An ideal solution in areas having inadequate water resources,
- Reduction in the soil erosion as the surface runoff is reduced,
- Decrease in the choking of storm water drains and flooding of roads and
- Saving of energy to lift ground water.

12.6 Challenges and Considerations:

Despite its benefits, water harvesting faces challenges such as:

- **Quality Concerns:** Ensuring harvested water is safe for its intended use through proper filtration and treatment.
- **Maintenance Needs:** Regular upkeep of infrastructure to prevent contamination or deterioration.

- **Legal and Regulatory Frameworks:** Some regions may lack supportive policies or regulations for water harvesting systems.

12.7 Conclusion:

Rainwater harvesting holds immense potential as a sustainable solution to the water crisis facing India and other water-stressed regions around the world. By harnessing rainwater through various methods such as rooftop harvesting, surface runoff management, watershed conservation, and community-based initiatives, India can augment water supply, recharge aquifers, and enhance water security for its burgeoning population. However, realizing the full benefits of rainwater harvesting requires concerted efforts from governments, communities, and stakeholders to promote policy support, invest in infrastructure, and raise awareness about the importance of water conservation.

By embracing rainwater harvesting as a vital component of water resource management, India can pave the way towards a more resilient and water-secure future for generations to come. Water harvesting is a versatile and sustainable practice that addresses water scarcity challenges while promoting resilience and environmental stewardship. Its adoption can enhance water security, support agriculture, and mitigate the impacts of climate change on water resources. As communities worldwide face growing water stress, integrating water harvesting into water management strategies becomes increasingly imperative for a sustainable future.

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