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RAINWATER HARVESTING FOR AGRICULTURE

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ABSTRACT

Rainwater harvesting means collecting runoff from within a watershed area, storing it, and employing it for different purposes. Runoff collection is generally distinguished as in-situ management, when the water is collected within the area of harvesting, and ex-situ when it is diverted outside of the harvesting area. The storage is of crucial importance: for in-situ rainwater harvesting the soil acts as the storage, whereas for ex-situ rainwater harvesting the reservoir can be natural or artificial, where natural generally means groundwater recharge, and artificial means surface/subsurface tanks and small dams. The differentiation between the two is often minor, as water collection structures are generally placed in a systematic relation with each other; hence, the runoff from certain structures may be a source of recharge for others. For example, the construction of anicuts (small dams) at frequent intervals in seasonal rivers leads to increased groundwater recharge. In drought prone area there are two critical factors : water and soil. So in such areas main objective is to conserve the water and the soil. Once water is conserved by rainwater harvesting it may be used for irrigation and drinking water. Rainwater harvesting is the need of the hour not only for water conservation for irrigation and drinking but it also has impact on national economy.

INTRODUCTION

Rainwater harvesting is the accumulation and storage of rainwater for reuse by capturing rain where it falls. Water harvesting can be undertaken by a number of ways.

1. Capturing rainwater from roof tops.
2. Capturing rainwater from local catchments.
3. Conserving water through watershed management programmes.

The rainwater collected can be stored for direct use or can be recharged into the groundwater. Rain is the first form of water in the hydrogical cycle so it is the primary source of water. Rivers, lakes and groundwater are all secondary sources of water. In the last three decades we became entirely dependant on such secondary sources of water. We forget that the rain is the ultimate source that feeds all these secondary sources. Rapid use of groundwater has resulted in steep decline in the ground water table. This has led to drying up of a huge number of wells, low well productivity, rapid rise in well and pumping depths, deteriorating groundwater quality and also salinity ingress in many areas. Shallow wells are running dry and the depth of deep wells is increasing every year.

Purposes of Rainwater Harvesting

In general rainwater harvesting serves the following purposes:-

1. Provides irrigation water.
2. Provides drinking water.
3. It increases groundwater recharge.
4. It reduces storm water discharge.
5. It reduces overloading of sewage treatment plants.
6. It reduces groundwater ingress in some areas and sea water ingress in coastal areas.

The rainwater harvesting offers a critical and promising solution to replenish and recharge the groundwater. In a typical setting, much of the rainwater is lost to surface flows. Rainwater harvesting for agriculture generally involves the creation of structures such as check dams, ponds, and percolation tanks to slow the flow of water, and to collect and hold limited quantities at a planned set of places along the flow path. The primary objective is to increase the percolation of the rainwater into the ground to recharge the

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groundwater table. This leads to a rise in the water table levels, increased supply of water in wells, and a longer period of availability of water.

RESEARCH METHODOLOGY

Assumptions in Rainwater harvesting

Water harvesting initiatives are driven by firm beliefs and assumptions, some of which are:

1) That there is a huge amount of monsoon flow, which remains un-captured and eventually ends up in the natural sinks, especially seas and oceans, supported by the national level aggregates of macro hydrology;
2) That local water needs are too small and as such exogenous water is not needed;
3) That local water harvesting systems are always small and, therefore, are cost effective;
4) Since the economic, social and environmental values of water are very high in regions hit by water shortages, water harvesting interventions are viable, supported by the assumption that cost- effective alternatives that can bring in the same amount of water, do not exist;
5) Incremental structures lead to incremental benefits; and
6) Being small with low water storage and diversion capacities, they do not pose negative consequences for downstream uses.

Rainwater harvesting systems

Rainwater harvesting technologies can be divided into two main types depending upon the source of water collected.

(i) In-situ

(ii) Ex-situ

(i) In-situ :- In-situ rainwater harvesting technologies are soil management strategies that enhance rainfall infiltration and reduce surface runoff. The in-situ systems have a relatively small rainwater harvesting catchment typically no greater than 5-10 m from point of water infiltration into the soil. The rainwater capture area is within the field where the crop is grown (or point of water infiltration). In-situ systems are also characterised by the soil being the storage medium for the water. This has two principal effects. Firstly, it is difficult to control outtake of the water over time. Normally soil moisture storage for crop uptake is 5-60 days, depending on vegetation type, root depth and temperatures in soil and overlying atmosphere. Secondly, the outtake in space is determined by the soil medium characteristics, including slope. Due to gradients and sub-surface conditions, the harvested water can act as recharge for more distant water sources in the landscape, including groundwater, natural water ways and wetlands, and shallow wells. The in-situ rainwater harvesting systems are often identical to a range of soil conservation measures, such as terracing, pitting, conservation tillage practices, commonly implemented to counter soil erosion. Thus, harvesting rainwater by increasing soil infiltration using in-situ technologies also counteracts soil loss from the farmed fields or forested areas. In-situ rainwater harvesting often serves primarily to recharge soil water for crop and other vegetation growth in the landscape. The water can also be used for other purposes, including livestock and domestic supplies if it serves to recharge shallow groundwater aquifers and/or supply other water flows in the landscape.

(ii) Ex-situ:- The ex-situ systems are defined as systems which have rainwater harvesting capture areas external to the point of water storage. The rainwater capture area varies from being a natural soil surface with a limited infiltration capacity, to an artificial surface with low or no infiltration capacity. Commonly used impermeable surfaces are rooftops, roads and pavements, which can generate substantial amounts of water and which can be fairly easily collected and stored for different uses.

As the storage systems of ex-situ systems often are wells, dams, ponds or cisterns, water can be abstracted easily for multiple uses including for crops and other vegetation as irrigation water, or for domestic, public and commercial uses through centralised or decentralised distribution systems. By collecting and storing water in dams, tanks, and cisterns the storage time is more dependent on the size of capture area, size of storage unit and rate of outtake rather than residence time and flow gradient through the soil.

The wide variety of rainwater harvesting technologies and end uses of the water also indicates the dynamic and flexible dimensions of rainwater harvesting systems. They also reflect the multiple end uses of the water collected for our benefit, including agriculture and landscape management, domestic, public and commercial water supply, as well as livestock watering, aquaculture and maintaining aesthetic values.

RESULTS AND DISCUSSION

Rainwater Harvesting : Indian Perspective

The normal annual rainfall precipitation in the country is estimated to be 400 million hectare-metres (Mha-m) of water (Majumdar 2002). Out of this, 115 Mha-m enters surface flows, 215 Mha-m enters the ground, and 70 Mha-m is lost to evaporation. Only 25 Mha-m is finally used through surface irrigation, 13 Mha-m is utilized for groundwater irrigation indicating the substantial potential for rainwater harvesting.

Possibilities of rainwater harvesting

One of the reasons for the poor utilization of rainwater in India is the high concentration of rainfall over a few months. As Table 1 shows, about 74 per cent of the rainfall is received during the south-west monsoon period of June to September. As a result, the soil saturates, and much of the water flows away if no structures are made to check this flow. The uneven distribution also creates a situation of long dry periods when cropping is difficult if water is not retained or made available in some other way.

Table 1. Distribution of Annual Rainfall by Seasons in India

Rainfall	Duration	Approx. percentage of annual rainfall
Pre-monsoon	March-May	10.4
South-west monsoon	June September	73.7
Post-monsoon	October-December	13.3
Winter or North-east monsoon	January-February	2.6
Total	**Annual**	**100.0**

Source: Meteorological Department of India.

Besides this, the distribution of rainfall is also geographically highly uneven (see Table 2). Only 8 per cent of the country receives very high/assured rainfall of above 2000 mm, and another 20 per cent receives high rainfall of 1150 to 2000 mm. The rest of the country, that is, 72 per cent, is in the low, dry, or medium rainfall range of less than 1150 mm, with 30 per cent area particularly dry at below 750 mm. Thus, in vast areas, unless wells are present, groundwater is not available with adequate rainwater recharge. In the absence of a proper surface irrigation scheme, crop production becomes difficult. Athavale (2003) indicates that about 50 per cent of irrigation water, 85 per cent of the drinking water, and about 33 per cent of the domestic water in cities comes from tapping of groundwater through dug wells or tube wells. By 2008-09, groundwater accounted for about 61 per cent of the irrigated area in the country (Ministry of Agriculture 2010).

Table 2. Distribution of Area by Annual Rainfall in India

Rainfall classification	Amount of rainfall (mm)	Approx. percentage of area receiving rainfall
Low/Dry	Less than 750	30.0
Medium	750 to 1150	42.0
High	1150 to 2000	20.0
Very high/ Assured	Above 2000	8.0
Total		**100.0**

Source: Meteorological Department of India.

The situation of acute drops in the water tables is highlighted by Table 3. Water table falls of over three metres per year are seen in a large number of states. There appears to be a widespread need to explore the possibilities of rainwater harvesting to alleviate the decline in water tables.

Critical issues in Rainwater harvesting

Some critical issues in deciding the scope of rainwater harvesting and groundwater recharging, are:

1. For rainwater harvesting, rainfall has to exceed a threshold to generate runoff, though the threshold would vary according to the nature of the soil and land cover of the area.
2. Regions with lower mean annual rainfall experience higher variability and vise versa

(Pisharoty 1990). Hence, in regions with lower mean annual rainfalls, rainwater harvesting as a dependable source of water is likely to be low.

Table 3. Observed Annual Fall in Water Table (May 1999 to May 2001)

	May 1999 to May 2000		May 2000 to May 2001	
	Fall in water table level			
	2 to 4 metres	More than 4 metres	2 to 4 metres	More than 4 metres
	Number of Districts			
Andhra Pradesh	8	6	5	3
Maharashtra	11	6	12	3
Madhya Pradesh	3	2	23	11
Rajasthan	All except 5	14	NA	NA
Punjab	2	1	6	0
Haryana	3	2	3	1
Uttar Pradesh	6	4	11	6
Bihar	4	–	NA	NA
West Bengal	3	2	NA	NA
Orissa	2	1	NA	NA
Assam	4	–	5	1
Gujarat All except	4	9	NA	NA
Karnataka	8	3	4	2
Tamil Nadu	13	6	16	10

Source: Ministry of Water Resources (2001), NA- Data not available

3. Generally, it has been found that a greater magnitude of annual rainfall means a larger number of rainy days and smaller magnitude of annual rainfall means fewer number of rainy days spread over the rainy season (Pisharoty 1990). Fewer rainy days also means longer dry spells and thus greater losses from evaporation for the same region.

4. High intensity rainfalls are common in the semi-arid and arid regions of India (Garg 1987; Athawale 2003). Higher intensity of rainfall can lead to high intensity in runoff, occurring in short durations, limiting the effective storage capacity of rainwater harvesting systems to almost equal their actual storage size.

5. High evaporation during the rainy season means losses from surface storage structures. It also means a faster rate of soil moisture depletion through both evaporation from barren soils and evapotranspiration, which increase the rate and quantum of soil infiltration. This reduces the generation potential of runoff.

6. For artificial recharge, the storage potential of the aquifer is extremely important. The storage potential of an aquifer vis-à-vis the additional recharge is determined by the characteristics in geological formations, and the likely depth of the dewatered zone.

7. Soil infiltration capacity can be a limiting factor for recharge. In sandy and sandy loam soils, the infiltration capacity of the recharge area can be sustained through the continuous removal of soils. But clayey soils have inherent limitations. Results of infiltration tests showed that the infiltration rate becomes negligible (< 0.60 mm/hr) within 10 minutes of starting the test in the case of silty clay, whereas infiltration stabilizes at a rate of 129.1 mm/hour within the first 25 minutes in the case of sandy loam (NGRI 2000). If the infiltration rate approaches to zero fast, it will negatively affect the recharge efficiency of percolation ponds. As thin soil cover has a low infiltration (Muralidharan and Athawale 1998), the extent of the problem would be larger in hard-rock areas (ideal for percolation ponds) with thin soil cover.

8. In hilly watersheds, the area available for cultivation is generally very low, keeping agricultural water demand low. At the same time, the surface water potential available for harvesting is generally high due to high rainfall and runoff coefficients. On the contrary, towards the valleys and plains, the area available for cultivation increases, raising agricultural water demand. At the same time, the surface water potential available for harnessing is generally low due to the lower rainfall, and low runoff coefficients.

CONCLUSION

Local harvesting of a small portion of the rainwater through in-situ conservation practices and ex-situ water harvesting structures provides great opportunities for irrigation of farm crops, developing small homestead gardens or even large commercial production facilities and meeting livestock water needs to mitigate the impacts of devastating dry spells.

Furthermore, a secure water resource encourages farmers to add value and diversify their enterprises through the inclusion of vegetable and horticultural crops, improving livestock by moving towards the rearing of large dairy animals. This in turn leads to more value-added outputs and growth in rural employment, both on and off the farm. Strong evidence supports the view that proper development and use of the water harvesting system is the first entry point for success of the farm-level, or regional, development programs.

Investment in rainwater harvesting is important for meeting not only the need of water for irrigation, but also for reducing hunger and poverty. Rainwater harvesting in watershed management may serve as an important incentive to protect woodlands and water resources.

There is a close correlation between hunger, poverty and water: most hungry and poor live in regions where water poses a particular constraint to food production. Water harvesting helps to mitigate the hunger-poverty-water nexus. Through availability of water home garden cultivatoin can be practised which provide diversified livelihood options for women and youth increase resilience during drought years. Upgrading rainfed agriculture has substantial payoffs for society. Rainwater harvesting based watershed programs generated large on-and off-farm employment opportunities, and conserved soil and water resources.

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