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Roof Top Rain Water – Harvesting, Collection and Utilization

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Abstract

Water is life and is essential for sustenance of all living organisms. Rapid increase in population, urbanization, industrialization and crop intensification, pollution and climate change can be attributed to increasing water shortage. Rainfall is the primary source for all water bodies on the earth like wells, ponds, lakes, rivers and recharging of underground aquifers. Of many rain water management strategies in rural and urban areas, harvesting rain water from roof tops and utilization for multiple purposes depending on the quality and demand and supply factors, is the need of the hour. However, meticulous planning and designing with all precautions are important for sustainable rain water management.

1. Why Water Crisis is Increasing?

The gap between availability and supply of fresh water is widening and the water crisis looming large at the global, national and local level due to several reasons as detailed below.

➢ The rapid industrialization and urbanization across the globe including India are considered as important positive developments for economic growth of nations, but, they are causing water, air and soil pollution. This is also leading to increase in waterborne diseases costing about USD 600 million per annum in India. This is especially true for drought and flood prone areas. The chemical contamination of water mainly through fluoride (in 19 states) and arsenic (in West Bengal) is present in 1.96 million dwellings in India. Overall, <50% of the population only has access to safe drinking water in the country.

➢ The ground water is the main source for 85% of drinking water in rural areas and 48% in urban areas, 50% of irrigation water and 33% of domestic use water. India is the world's highest user of water. So, the challenges is the fast rate of groundwater depletion in India due to increasing migration of people from rural to urban areas in search of employment.

➢ The ever burgeoning population entailed the need for agriculture

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intensification which in turn has increased the demand for irrigation water. It is also increasing sewage and industrial water due to growing population

➢ The available freshwater resources per person per annum has declined by more than 20% in the past two decades

➢ The rain fall is received in only four months during monsoons season and negligible to less during rest of the period

➢ Partial or complete failure of monsoon, pollution of water resources, faulty and inefficient irrigation management practices

➢ Decline in ground water due to partial or complete failure of monsoon, ever increasing pollution of water bodies, salinization and faulty input (water, nutrient, pesticides and herbicides) management practices

➢ Change in food consumption pattern across all sections of people following increase in income and improvement in the standard of living thus shift towards water intensive lifestyle with high water foot print foods (e.g. meat and dairy products) in the countries like Brazil, China and India

➢ Globally, 3.2 billion people live in agricultural areas with high to very high water scarcity of which 1.2 billion people (one sixth of world population) live in severely water constrained agricultural areas (FAO, 2020)

➢ Poor execution of water related programmes and faulty water management practices

All these factors necessitating need for clean and safe drinking water for ever growing population and other needs.

2. Roof Top Rain Water Harvesting

Rooftop rain water harvesting (RT-RWH) is a technique through which rain water is captured from the roof catchments and stored in reservoirs for further utilization. In this method, the rain water is collected from outlets present on the roof of buildings that flows through vertical pipes arranged along the wall or the rainwater is allowed to flow through the gutters and finally to a collection tank.

3. Mechanism of RT-RWH

The RT-RWH unit contains five elements (Figure 1)

➢ ***Collection area:*** It is generally the roof of houses/ buildings. The type of material used for roof top decides the rain water collection efficiency and quality. The roof top coated with chemically inert materials cement/ concrete/asbestos/aluminum/plastic or fiber glass will produce better quality rain water.

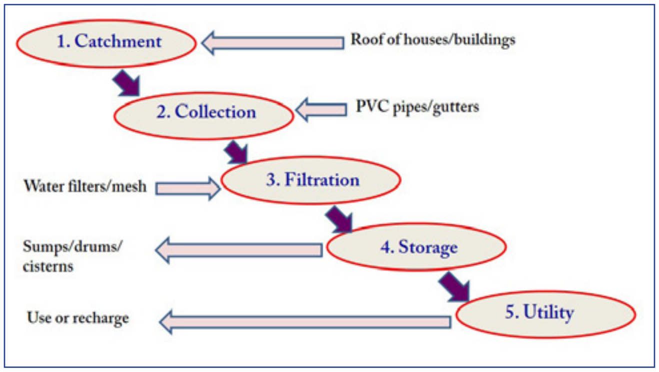

Figure 1: Five elements of RT-RWH

➢ ***Conveyance system:*** It consists of PVC pipes or gutters for carrying rain water from roof top to water storage structures constructed either underground or surface.

➢ ***Filtration/treatment***: There is a possibility that rain water carries dust, dried leaves, twigs, papers etc., depending on the type of roof and vegetation present around the buildings. Hence, rain water has to be passed through suitable filters or treated before storage

➢ ***Storage:*** The rain water storage structures have to be constructed with reinforced concrete or fiberglass or stainless steel. They may be arranged as a part of the building or built as a separate unit in proximity to the building

➢ ***Utility:*** The stored rain water can be used for several purposes depending on the water availability

• *For partial fulfilment of domestic requirements*

• *To purify and use to meet drinking water needs of household(s)*

• *To irrigate crops in kitchen gardens (vegetables, flower crops, Agricultural crops) and back yard poultry and other birds*

4. Planning and Designing Roof Top Rain Water Harvesting for Domestic/ Office Use

The planning and designing roof top rain water harvesting for domestic/office use depending on estimated demand involves five steps as shown in figure 2.

5. Multifarious Uses of Harvested Rain Water

The rain water harvesting and utilization pattern are detailed in figure 3.

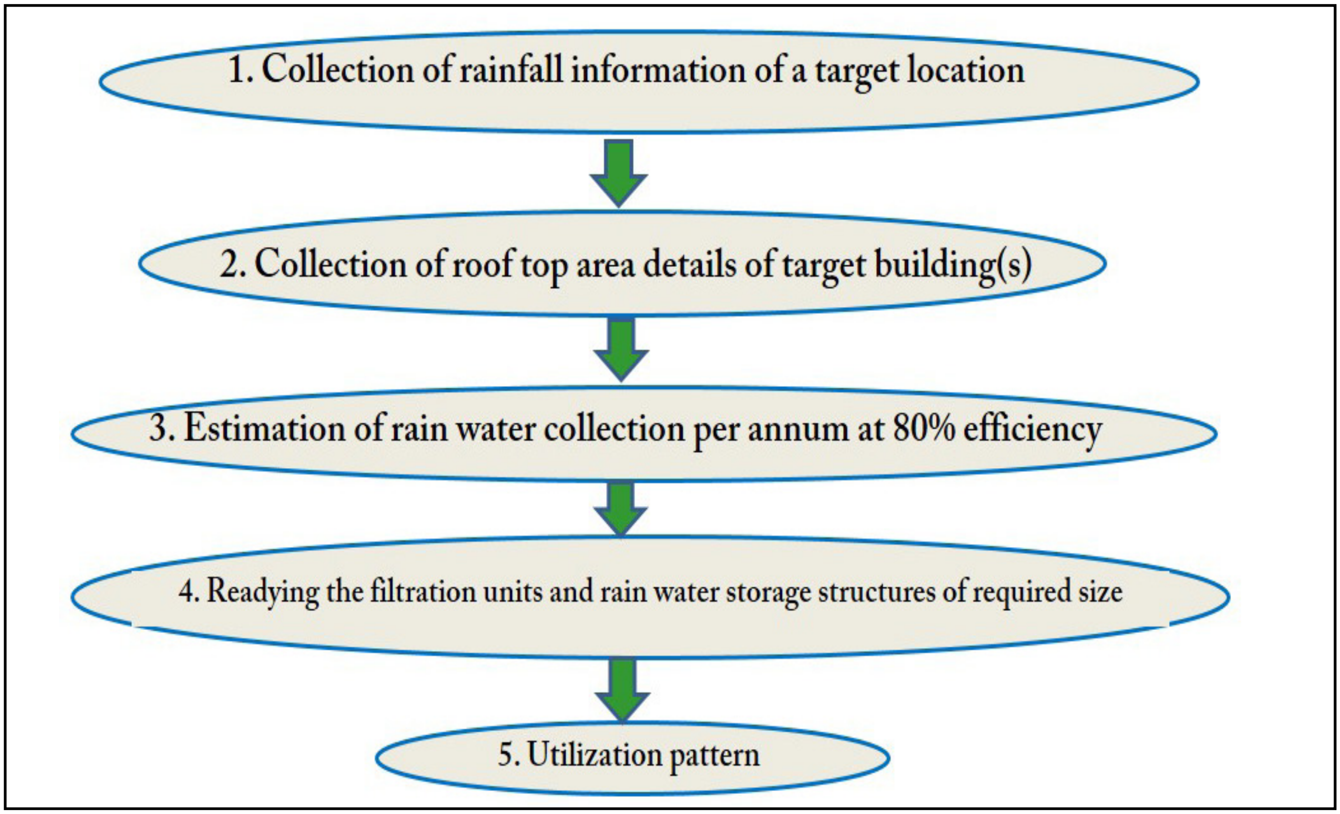

Figure 2: The five steps in planning and designing RT-RWH

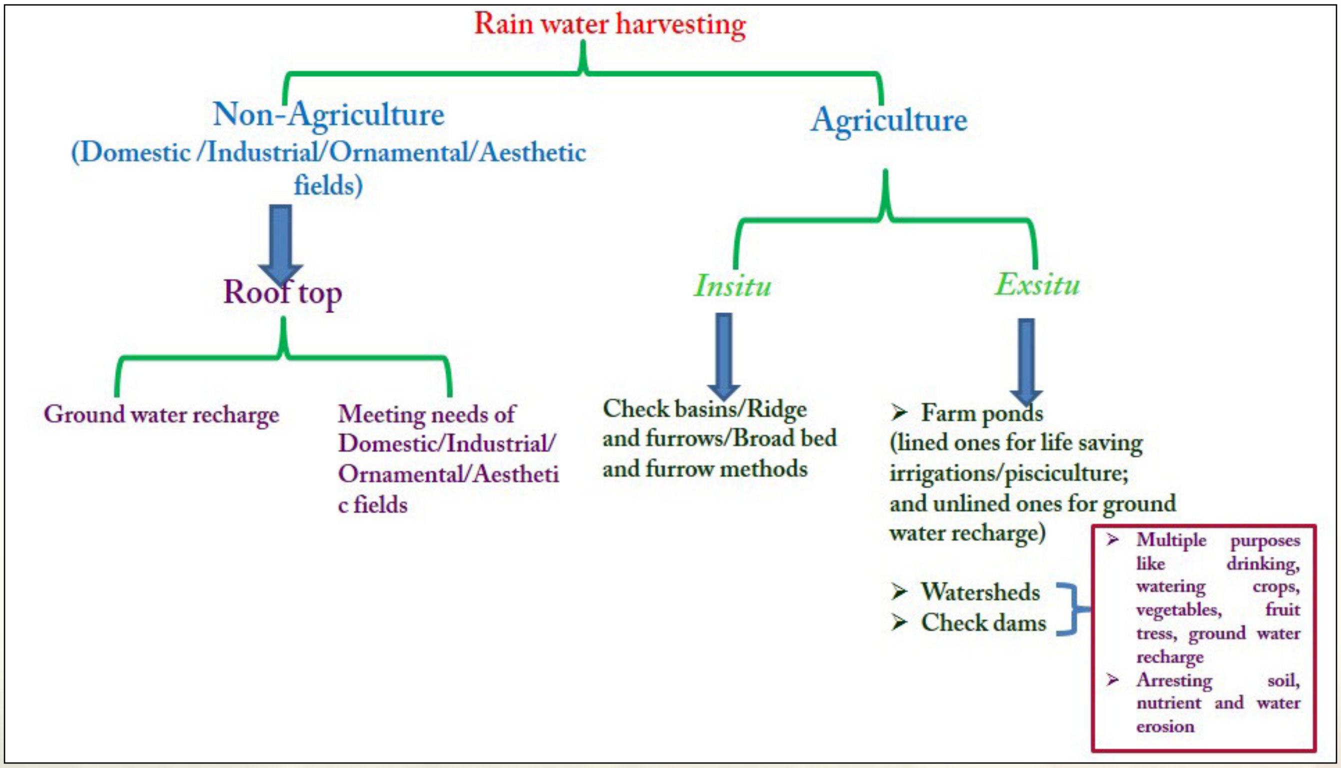

Figure 3: Multifarious uses of harvested rain water

6. Advantages

- RT-RWH is a cost effective solution to supply good quality potable water due to neutral PH, negligible pollutants and low level of minerals, thus, it is safe compared to surface water sources
- It provides water at the point of consumption unlike hand pumps and water tanks
- It is a very important option for rural areas suffering from acute water shortage and also in water inaccessible/ less accessible regions
- It helps improving ground water table and reduces the cost of pumping ground water
- It can be a partial mitigation strategy for water scarcity in domestic, commercial, institutional, individual, agriculture, livestock sectors etc.,
- It is simple and economical, easy to construct, operate and maintain thus can be adopted by individuals which can avoid ownership problems
- This technique has assumed much importance in rural areas in developing countries where piped water system is yet to be fully developed
- This method of water collection and utilization provide benefits to society in a wholistic manner from the view point of economical, environmental, social, hygienic, sanitation and health aspects
- Reduces soil and water erosion
- In saline or coastal areas, when ground water sources are recharged due to rain water, it reduces salinity and also helps in maintaining balance between the fresh-saline water interface thus provides better quality water
- In Islands, rain water harvesting is the most preferred source of water for domestic use due to limited fresh water aquifers
- In deserts, where rainfall is low, rain water harvesting has been providing relief to people by overcoming water shortage
- Avoids flooding of roads in peri urban and urban areas and Agricultural fields in rural areas
- Improves people's accessibility to drinking water
- Avoids privatization of potable water

7. Sustainability of Roof Top Rain Water Harvesting Systems

To make the RT-RWH a sustainable one, following points have to be given due importance

- The roof top has to cement/concrete/asbestos coated for easy harvesting of rain water
- Need to maintain neat and clean the roof top through regular cleaning to avoid accumulation of dust and fungal/ bacterial infestations
- Arrange filters/mesh at all water entry points on the roof top and also in small sumps constructed at ground level for proper filtration and avoiding dust, inert material, crop/tree residue entering the pipelines and storage structures
- Arrange screen filters all along the gutters that convey rain water to storage tanks
- Cover the top of the sumps with iron sheets/Kadapa or Tandur slabs to avoid dry leaves, crop/tree residue entering the water sump
- Check leaks in pipe line system to avoid water wastage
- Construct surface and under ground water sump for proper storage and utilization for multiple domestic purposes based on roof area and location specific rainfall
- Drain out the first flush of rainwater from roofs as it contains dirt, debris and bird droppings and contaminants (Abdulla and Al-Shareef, 2009). So, arrange a standpipe and a gutter down-spout located ahead of the down-spout from gutter to the water storage tanks.

8. Experience at Agricultural Research Station (ARS), Tornala

The ARS, Tornala, Siddipet district, Telangana state (N 18°6'40", longitude of E 78°44'33" and 493 m above MSL) is the only research station present to cater to the needs of farming community of erstwhile Medak district in Telangana. The station has one office building (7500 sq.ft), seed godown (1076 sq.ft) and farm implements shed (1076 Sq.ft), but, at present, only office main building is used for roof top rain water harvesting.

9. Requirements, Cost Economics of Roof Top Rain Water Harvesting Structures, Water Demand and Supply Dynamics at ARS, Tornala

The details of item wise cost incurred in construction of roof top rain water structures are furnished below.

9.1. Roof top rain water harvesting for ground water recharge

The total expenditure (Table 1) for establishing roof top rain water harvesting for ground water recharge at ARS,

3a 3b 3c

Figure 3: Roof top rain water harvesting for ground water recharge at ARS, Tornala
Figure 3a: Five pipes (4 inch diameter) carrying roof top rain water to a common point (small cement lined trench)
Figure 3b: Common point for water collection from roof top
Figure 3c top: Pipe carrying rain water from common point of collection into already existing cement lined small sump (water in this can be reused too)
Figure 3c down: Two dug out pits to absorb excess rain water from cement lined small sump into underground

4a 4b 4c 4d

Figure 4: Roof top rain water harvesting for office use at ARS, Tornala
Figure 4a: Two pipes (4 inch diameter) carrying roof top rain water to a brick+cement lined surface sump (6 feet length x 3 feet width x 3 feet depth)
Figure 4b: Inner side of the brick+cement lined surface sump
Figure 4c: Outlet from surface sump connected to already existing underground sump
Figure 4d: Underground sump for roof top rain water storage (7ft length x7ft width x12ft depth)

Tornala was sponsored under Mahatma Gandhi National Rural Employment Guarantee Scheme (MNREGS), Siddipet district. Of the seven rain water outlets present on the roof, five were used for this purpose. Two pits each one dug with 7 ft length, 6 ft width and 7 ft depth were dug at 10 m distance from office main building. Each pit was filled with stones (300 mm size) followed by coarse gravel (50 mm size), fine gravel (20 mm size) and sand (2 mm size) leaving only one ft unfilled at the top to enable the rain water enter and percolate inside. One more pit lined with reinforced concrete (7ftx6ftx7ft) which was already existing before the newly dug pits, was renovated to retain rain water. First, the harvested roof rain water enters this renovated pit and once it is filled, the excess rain water enters the newly dug percolation pits. So, the rain water collected and stored in the renovated one is being utilized for spraying and drenching plant protection chemicals in various crops in the research farm.

Earlier, the roof top rain water used to enter and drench the experimental plots in the research fields and create excess moisture stress in the event of incessant or high intensity rainfall besides causing soil, water and nutrient erosion leading to decline in yield and loss of soil fertility. The above mechanism is now helping to overcome the said problems.

Table 1: Roof top rain water harvesting for ground water recharge (Two pits each of 7 ft length x 6 ft width x 7 ft depth)

S. No.	Particular	Quantity	Rate (Rs.)	Amount (Rs.)
1	Labour for digging two pits	3 man days	700	2,100
2	Mason work	3 man days	1,100	3,300
3	Stones (300 mm size)	4 tractor loads	2,500	10,000
4	Coarse gravel (50 mm size)	2 tractor loads	2,500	5,000
5	Fine gravel (20 mm size)	1 tractor load	3,000	3,000
6	Sand (2 mm size)	1 tractor load	3,000	3,000
7	Cement bags (50 kg)	4 bags	360	1,440
8	Cement bricks	80	25	2,000
9	PVC bends (4 inch diameter)	07	150	1,050
10	PVC T's (4 inch diameter)	03	150	450
11	PVC pipes (20 feet length and 4 inch diameter)	05	800	4,000
12	Paint	10 L	100	1,000
13	Painting charges	-	500	500
14	Shelf stones (4 feet length and 2 feet width)	02	400	800
15	Mesh for water filtration	01	100	100
16	Small trench for roof top water filtration (4 feet length x 2 feet width x 1 feet depth)		3,000	3,000
17	Renovation of exiting sump (7 feet length x 6 feet width x 6 feet depth)			
	Total (Rs.)			40,740

9.2. Roof top rain water harvesting for office use

Of the seven rain water outlets present on the roof, two are being used for this purpose. Arrangement was made to carry this rain water to a newly constructed surface sump (6 feet length x 3 feet width x 3 feet depth) inside which water filter and outside which gate valve was fixed. It was inturn was connected to already existing underground sump (7 feet length x 7 feet width x 12 feet depth) located at 4 m distance. This mechanism helps to fill the rain water in the underground sump and also store the same in the new sump in the event of high rainfall. The new sump was covered by iron sheets to avoid entry of dust, dried leaves etc., The water stored in these sumps is being utilized for office use like wash rooms by the office staff, cleaning/washing in and outside the office and regular watering of ornamental plants in the office premises. This mechanism is helping in avoiding excess moisture stress for crops and also meeting water needs in office. The details of cost incurred was furnished in Table 2.

Table 2: Roof top rain water harvesting for office use

S. No.	Particular	Quantity	Rate (Rs.)	Amount (Rs.)
1	Labour for construction of surface sump (6 feet length x 3 feet width x 3 feet depth)	3 man days	700	2,100
2	Mason work	3 man days	1,100	3,300
3	Stones (300 mm size) Coarse gravel (50 mm size) Fine gravel (20 mm size)	-	1,000	1,000
4	Sand (2 mm size)	1 tractor load	3,000	3,000
5	Cement bags (50 kg)	5 bags	360	1,800
6	Cement bricks	120	25	3,000
7	PVC bends (4 inch diameter)	7	150	1,050
8	PVC T's (4 inch diameter)	3	150	450
9	PVC pipes (20 feet length) (4 inch diameter)	3	800	2,400
10	Shelf stones (4 feet length and 2 feet width)	3	400	1,200
11	GI roofing sheet (4 feet length and 3 feet width)	1	1,500	1,500
12	Paint	10 lit	100	1,000
13	Painting charges	-	500	500
14	Mesh for water filtration	01	100	100
	Total (Rs.)			22,400

9.3. Estimation of roof top rain water collection

The total rain water that can be collected and stored from roof top can be estimated by using the following formula

Total volume of water collection (m^3) = (A* RF*0.8)/1000

Where

A: Roof top area (m^2)

RF: Average annual rainfall (mm)

0.8: Rain water collection efficiency

The roof top area of ARS, Tornala (considering five outlets only): 27.14m *13m = 353 m^2

Expected volume of rain water collection: 750*353*0.8)/1000 = 212 m^3 = 2,12,000 litres

Approximately 6804 litres (2.1 m x 1.8 x 1.8 depth = 6.804 m^3) of rain water could be stored at a time and used for the purpose of plant protection operations. This can be repeated depending on the rainfall frequency and need. Rest of the rain water will contribute for ground water recharge.

The total water requirement of ARS (including DAATTC), Tornala is estimated to be 33,920 litres annum^{-1} (Table 3). However, the rain water that can be collected from remaining two outlets from the roof top is estimated to be 84708 litres annum^{-1} (750mm*10.86m*13m*0.8/1000 = 84.7 m^3). It means nearly 50,788 litres of rain water could be diverted for irrigating near by field crops in the farm after meeting the demand for office use.

Table 3: Water demand and supply at ARS, Tornala

S. No.	Particulars	Strength	Water requirement (Litres)	Working days annum^{-1}	Total water demand (Litres annum^{-1})
1	Teaching and non-teaching staff	10	12 (per day)	260	3120
2	Skilled workers	03	12 (per day)	285	3420
3	Attenders	03	12 (per day)	285	3420
4	Farm workers	12	12 (per day)	230	2760
5	Watering ornamental plants	200	200 (once in three days)	80*	16000
6	Cleaning office chambers, seminar hall, corridors and wash rooms	10	100 (once in seven days)	52	5200
	Total			1112	33920

*excluding monsoon season of four months (15th June to 15th October)

10. Conclusion

The roof top rain water harvesting has been found cost effective and promising technique to meet the domestic water supply. The central and state governments should make it compulsory for all the governmental and non-governmental buildings to overcome water shortage irrespective of the season especially in rain shadow areas.

11. References

Abdulla, F.A., Al-Shareef, A.W., 2009. Roof rainwater harvesting systems for household water supply in Jordan. Desalination 243(1-3), 195-207.

FAO, 2020. The State of Food and Agriculture 2020. Overcoming water challenges in Agriculture. Rome. https://doi.org/10.4060/cb1447en.