Rain Water Harvesting

Catch the water where it drops

A document prepared on behalf of

Auroville Planning & Development Council

Harvesting Rainwater – Harnessing Life
Care for Groundwater before it become rare

Through an ordinance titled Tamil Nadu Municipal Laws ordinance, 2003, dated July 19, 2003, the government of Tamil Nadu has made rainwater harvesting mandatory for all the buildings, both public and private, in the state. The deadline to construct rainwater harvesting structures was August 31, 2003. The ordinance cautions, "Where the rain water harvesting structure is not provided as required, the Commissioner or any person authorized by him in this behalf may, after giving notice to the owner or occupier of the building, cause rain water harvesting structure to be provided in such building and recover the cost of such provision along with the incidental expense thereof in the same manner as property tax". It also warns the citizens on disconnection of water supply connection provided rainwater harvesting structures are not provided.

Under this momentum, Auroville Planning & Development Council decided to request Harvest to develop a document bringing clarity on the various aspects of rainwater harvesting to allow developers, planners and architects to fulfill the needs in an appropriate way.

A. Using Rainwater

Rainwater Harvesting (RWH) is the well planned collection and storage of rain water that runs off a natural or man-made catchment surface. This is an ancient technique and can be found in all great civilizations. In order to meet the goals of collection and storage, there is a wide range of applied technologies which can be as simple or as sophisticated as required.

Rainwater harvesting has become tremendously interesting to academics, institutions, media and lay people, especially in the past few years, all over India. While rainwater harvesting is broadly described in the rural context as water collected mainly for agriculture purposes in dry land and tank irrigated areas, rooftop rainwater harvesting has a narrower definition as water collected from rooftops chiefly for domestic consumption.

People have relied on rainwater for household, landscape and agricultural water usage for centuries. As communities have become larger and more centralized, community water treatment and distribution systems have gradually replaced the collection of rainwater as our primary water supply. Recently, there has been a renewed interest in collecting and storing rainwater for non-drinking purposes such as toilet, laundry and garden use. Why? Because a typical house roof and 200 liters of tank storage can provide up to a half of the average toilet water use. And rainwater needs little or no treatment for non-drinking, household purposes.

1. A Brief Introduction to Rainwater Harvesting

A good quality Rainwater Harvesting (RWH) system provides people with access to an on-site water supply, either next to their homes or at local public buildings such as schools and health centers. Rainwater has been collected and used for drinking water for centuries, but in recent years the technique has fallen out of favor as it is considered old-fashioned.

Ideally, the RWH collection system should involve basic construction techniques, be inexpensive to maintain, and have a long functional life span (Pacey 1986).

If the system is designed well, it should provide a good safe source of drinking water at a relatively low cost when compared to the main supply.

The RWH system provides a good alternative water supply option, especially for areas where the following characteristics apply:

- Alternate sources of water do not provide sufficient quantities of potable water
- The available sources of water are of a poor quality, so that the construction and maintenance of expensive treatment plants would be prohibitive,
- The rainwater catchment area per capita, i.e. roofs, tends to be large
- It operates independently, and therefore gives people access to water without their being dependent on a grid supply which can be unreliable,
- The cost of supplying grid water is too high,
- Pollution levels tend to be low when compared to average towns and cities, making the water more suitable for consumption without treatment.

2. Why harvest rainwater?

Rainwater harvesting has an important role to play as one of several options available on a demand-responsive basis, as it offers a relatively cheap and interesting way of giving an additional supply above a basic service level. It can of course, in some cases, also be the main supply in its own right.

- ✓ **Save water!** Reduce the demands on scarce surface and ground water sources. Reuse water instead of pulling from the water table (or a freshwater source): in comparison, centralized water systems and wells pull from the water table.

Increase infiltration of rainwater in the subsoil, especially useful in urban areas where saving water has decreased dramatically due to the presence of large, impervious areas.

- ✓ **Reduce erosion and storm water run-off and increase water quality!** Capturing the rain reduces flash floods and storm water runoff. Less storm water run-off may reduce the need for storm water collection networks at the individual household level, as well as at a more complex, collective level, and will certainly improve the health, quality, and biodiversity of our watersheds, as well as replenish the water table (or our freshwater supply).
- ✓ **Save energy!** By reducing water use, energy demands to pump water from groundwater or other sources are reduced. The dependency on polluting power plants will also decrease as a result of collecting rainwater.
- ✓ **Save money**! Avoid the increasing economic and environmental costs associated with a centralized water system. It localizes the process of water collection, which results in a reduction of the amount of civil engineering work associated with a grid connection. Operating costs are lower than the cost of purchasing water from the centralized water system.
- ✓ **And also…**
    - Saves a natural resource presently wasted
    - Prevents ground water depletion
    - Provides a good supplement to piped water
    - Secures a positive cost benefit ratio
    - Is relatively pollution-free
    - Supports water conservation & self-dependence
    - Promotes the reduction of an "ecological footprint"

3. WHO can harvest Rainwater ???

- Rural and urban Industries & Institutions
- Buildings
- Paved & Unpaved land for Ground water-recharge and surface collection

B. The Law

Through an ordinance titled *"Tamil Nadu Municipal Laws ordinance, 2003"*, dated July 19, 2003, the government of Tamil Nadu has made rainwater harvesting mandatory for all buildings, both public and private, in the state. The deadline to construct rainwater harvesting structures was August 31, 2003.

The ordinance cautions, "Where the rain water harvesting structure is not provided as required, the Commissioner or any person authorized by him in his behalf may, after giving notice to the owner or occupier of the building, cause rain water harvesting structure to be provided in such building and recover the cost of such provision along with the incidental expense thereof in the same manner as property tax". It also warns the citizens they may be penalized by the disconnection of their water supply if rainwater harvesting structures are not provided."

CHENNAI, SATURDAY, JULY 19, 2003

TAMIL NADU ORDINANCE No.4 OF 2003

An Ordinance further to amend the Laws relating to the Municipal Corporations and Municipalities in the State of Tamil Nadu.

(i) PART-III

AMENDMENT TO THE TAMIL NADU DISTRICT MUNICIPALITIES ACT, 1920.

Tamil Nadu Act V of 1920. 3. After section 215 of the Tamil Nadu District Municipalities Act, 1920, the following section shall be inserted, namely: Insertion of new section 215-A.

"215-A Provision of Rain Water Harvesting Structure.- (1) In every building owned or occupied by the Government or a statutory body or a company or an institution owned or controlled by the Government, rain water harvesting structure shall be provided by the Government or by such statutory body or company or other institution, as the case may be, in such manner and within such time as may be prescribed.

(2) Subject to the provisions of sub-section (1), every owner or occupier of a building shall provide rain water harvesting structure in the building in such manner and within such period as may be prescribed.

Explanation.- Where a building is owned or occupied by more than one person, every such person shall be liable under this sub-section.

(3) Where the rain water harvesting structure is not provided as required under sub-section (2), the Executive Authority or any person authorised by him in this behalf may, after giving notice to the owner or occupier of the building, cause rain water harvesting structure to be provided in such building and recover the cost of such provision along with the incidental expense thereof in the same manner as property tax.

(4) Notwithstanding any action taken under sub-section (3), where the owner or occupier of the building fails to provide the rain water harvesting structure in the building before the date as may be prescribed, the water supply connection provided to such building shall be disconnected till rain water harvesting structure is provided.

EXPLANATORY STATEMENT

In order to augment ground water resources, it has been decided to make it mandatory to provide rain water harvesting structure in all building. As rain water harvesting structures will have to be put up before the ensuing monsoon, it has also been proposed to give a time limit to be specified in the Rules, to provide rain water harvesting structure by the owner or occupier of every building and in case they do not provide rain water harvesting structure within the above said period, the authorities of the local body concerned will provide the rain water harvesting structure in those buildings and recover the cost of provision of rain water harvesting structure with the incidental expense from such owner or occupier as property tax.

2. It has also been decided that if such owner or occupier of the building fails to provide rain water harvesting structure on or before the date to be specified in the Rules, the water supply connection provided to such building shall be disconnected.

3. The Ordinance seeks to give effect to the above decisions

CHENNAI, MONDAY, JULY 21, 2003

Tamil Nadu Acts and Ordinances.

TAMIL NADU ORDINANCE No.4 OF 2003

An Ordinance further to amend the Tamil Nadu Panchayats Act, 1994.

"257-A Provision of Rain Water Harvesting Structure.- (1) In every building owned or occupied by the Government or a statutory body or a company or an

(1) institution owned or controlled by the Government, rain water harvesting structure shall be provided by the Government or by such statutory body or company or other institution, as the case may be, in such manner and within such time as may be prescribed

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It is with this strong statement that the Directorate of Town Panchayats launched its campaign of Water Harvesting in Tamil Nadu.

C. Rainwater quality

Rainwater gets its composition largely by dissolving particulate materials in the atmosphere and secondarily by dissolving gasses from the atmosphere.

Rain composition varies significantly from place to place because the regional geology can greatly affect the types of particulates that get added to the atmosphere. Particulate load to the atmosphere can also be greatly affected by human activities.

However, in general, the quality of rainwater is very good. The softness of rainwater is valued for its cleaning abilities and benign effects on water-using equipment.

Although rainwater collected from roof catchments has been regarded as a source of safe water for drinking purposes, studies have shown that its quality is affected when the roof is contaminated by diffuse sources of pollution from the atmosphere and with the feces of birds and other creatures, as well as from deterioration of the roofing material itself.

D. Rainwater Harvesting to Augment Groundwater Resources

Rainwater Harvesting is the technique of collecting and storing rain water at the surface or in sub-surface aquifers, before it is lost as surface run-off. The augmented resource can be harvested in time of need. Artificial recharge to ground water is the process by which the ground water reservoir is augmented at a rate exceeding the natural conditions of replenishment.

1. Advantages

- The cost of recharge to the sub-surface reservoir is lower than to the surface reservoirs.
- The water table serves as a distribution system also.
- Ground water is not directly exposed to evaporation and pollution.
- It increases the productivity of the aquifer and raises ground water levels.
- Reduces flood hazards.
- Reduces soil erosion.

2. Design considerations

The important aspects to be looked at for designing a rainwater harvesting system to augment ground water resources are:

- ✓ Hydrogeology of the area including the nature and extent of the aquifer, soil cover, topography, depth to water level and the chemical quality of ground water.
- ✓ The availability of source water, one of the prime requisites for ground water recharge, basically assessed in terms of non-committed, surplus, monsoon runoff.
- ✓ Area contributing runoff like area available, land use pattern, industrial area, residential area, green belt, paved areas, roof top area, etc.
- ✓ Hydrometerological characteristics like rainfall duration, general pattern and intensity of rainfall.

3. Potential Areas

- ✓ Where groundwater level is declining on regular basis.
- ✓ Where substantial amounts of the aquifer are unsaturated.
- ✓ Where availability of groundwater is inadequate.
- ✓ Where due to rapid urbanization, infiltration of rainwater into the subsoil has decreased drastically and the recharging of the ground water has diminished.

2. Urban areas

In urban areas, rainwater available from the roof tops of buildings, paved and unpaved areas goes to waste. This water can be recharged to the aquifer and can be well utilized in time of need. The rainwater harvesting system needs to be designed so that it does not occupy a large space for collection and recharge system. A few techniques of roof top rain water harvesting in urban areas are described below.

3. Rural areas

In rural areas, rainwater harvesting is taken up using the watershed as a unit. Surface spreading techniques are common since space for such systems is available in plenty and there is a large amount of recharged water. The following techniques may be adopted to save water going to waste from slopes, rivers, rivulets and nalas.

By looking at the general concept for Auroville, it is very clear that all of the available techniques should be investigated and evaluated according to the site conditions.

4. METHODS & TECHNIQUES

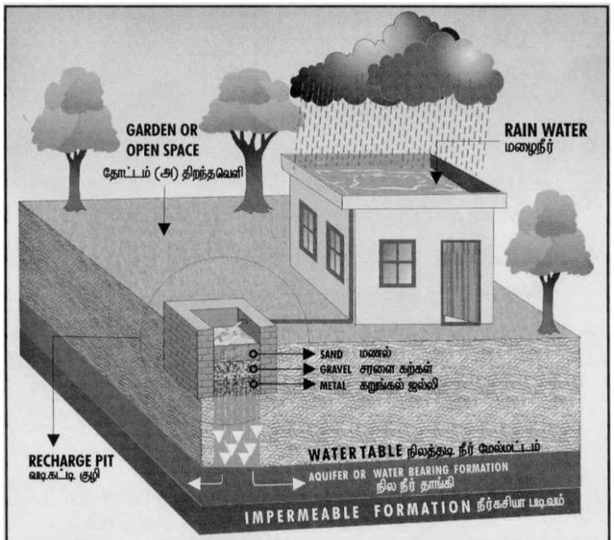
The methods of ground water recharge are mainly

1. Recharge Pit	2. Recharge Trench
3. Tubewell	4. Recharge Well
5. Gully Plug	6. Contour Bund
7. Gabion Structure	8. Percolation tank
9. Check Dam / Cement plug / Nala Bund	10. Recharge shaft
11. Dugwell Recharge	12. Groundwater Dams / Subsurface Dyke

1. ROOFTOP RAINWATER HARVESTING THROUGH A RECHARGE PIT

In alluvial areas where permeable rocks are exposed on the surface or at very shallow depths, roof top, rain water harvesting can be done through recharge pits.

- ✓ It is suitable for buildings having a roof area of 100 m2. They are constructed for recharging the shallow aquifers.
- ✓ Recharge Pits may be of any shape and size and are generally constructed 1 to 2 m wide and 2 to 3m deep which are backfilled with boulders (10-20 mm), gravel (5-10mm) and coarse sand (1 .5-2 mm) in graded form- Boulders at the bottom, gravel in between and coarse sand at the top, so that the silt content that will come with runoff will be deposited on the top of the coarse sand layer and can easily be removed. For smaller roof areas, a pit may be filled with broken bricks/cobblestone.



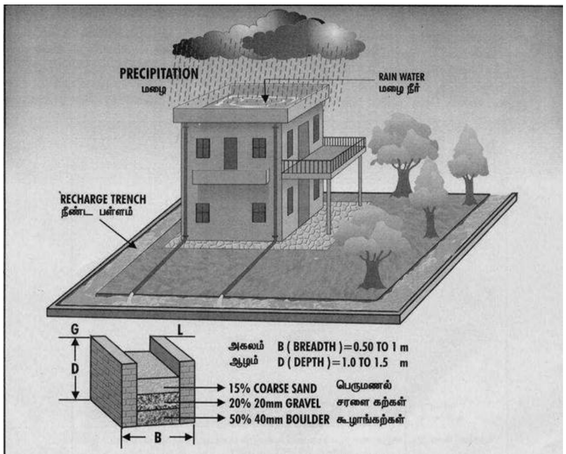
ROOF TOP RAIN WATER HARVESTING THROUGH RECHARGE PIT

- ✓ A mesh should be provided on the roof so that leaves or any other solid waste/ debris is prevented from entering the pit and a desilting/collection chamber may also be provided at ground level to arrest the flow of finer particles to the recharge pit.
- ✓ The top layer of sand should be cleaned periodically to maintain the recharge rate.
- ✓ A by-pass arrangement must be provided in front of the collection chamber to reject the first flow of water.

2. ROOFTOP RAINWATER HARVESTING THROUGH A RECHARGE TRENCH

Recharge trenches are suitable for buildings having a roof area of 200-300m2 and where permeable strata are available at shallow depths.

- ✓ A trench may be 0.5-1 m wide, 1-1.15 m deep and 10-20m long depending upon the availability of water to be recharged.
- ✓ These are backfilled with boulders (10-20 mm), gravel (5-10 mm) and coarse sand (1.5-2 mm) in graded form - boulders al the bottom, gravel in between and coarse sand at the top so that the silt content that will come with runoff will be deposited on the top of the sand layer and can easily be removed.

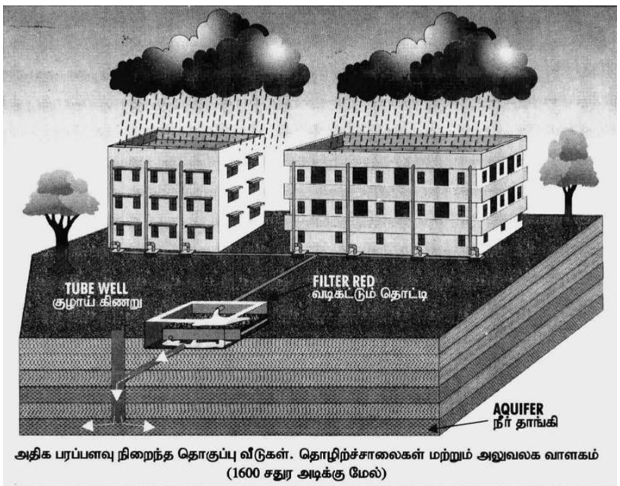


ROOF TOP RAIN WATER HARVESTING THROUGH RECHARGE TRENCH

- ✓ A mesh should be provided at the roof so that leaves or any other solid waste/debris is prevented from entering the pit and a desilting/collection chamber may also be provided on the ground to arrest the flow of finer particles to the recharge pit.
- ✓ A by-pass arrangement must be provided before the collection chamber to reject the first flow of water.
- ✓ The top layer of sand should be cleaned periodically to maintain the recharge rate.

3. ROOFTOP RAINWATER HARVESTING THROUGH EXISTING TUBE WELLS

- ✓ In areas where the shallow aquifers have dried up and existing tube wells are tapping deeper aquifers, rooftop, rain water harvesting through existing tube wells can be adopted to recharge the deeper aquifers.

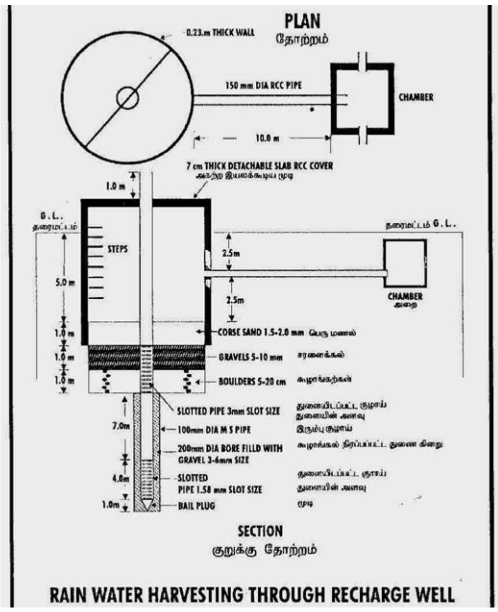


ROOF TOP RAIN WATER HARVESTING THROUGH EXISTING TUBEWELLS

- ✓ PVC pipes of 10cm dia. are connected to roof drains to collect rain water. The first roof runoff is expelled through the bottom of the drain pipe. After closing the bottom pipe, the rain water of subsequent rain showers is taken through a T to an online PVC filter. The filter may be provided before water enters the tube well. The filter is 1-1.2m in length and is made up of PVC pipe. Its diameter should vary depending on the roof area, 15 cm if roof area is less than 150m2 and 20cm if the roof area is more. The filter is provided with a reducer of 6.25cm on both sides. The filter is divided into three chambers by PVC screens so that filtered material is not mixed together. The first chamber is filled with gravel (6-10mm), the middle chamber with pebbles (12-20mm) and the last chamber with bigger pebbles (20-40mm).
- ✓ If the roof area is larger, a filter pit may be provided. Rain water from roofs is taken to collection/desilting chambers located on the ground. These collection chambers are interconnected as well as connected to the filter pit through pipes having a slope of 1:15. The filter pit may vary in shape and size depending upon available runoff and are back-filled with graded material, boulders at the bottom, gravel in the middle and sand at the top with varying thickness (0.30-0.50m) and may be separated by a screen. The pit is divided into two chambers, filter material in one chamber, while the other chamber is kept empty to accommodate excess filtered water and to monitor the quality of filtered water. A connecting pipe with a recharge well is provided at the bottom of the pit for the recharging of filtered water through the well.

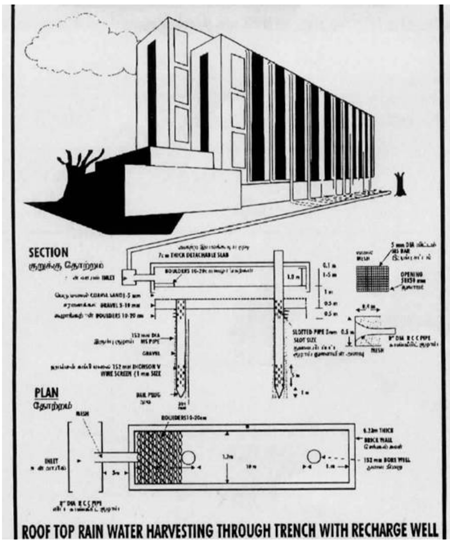
4. ROOF TOP RAINWATER HARVESTING THROUGH A TRENCH WITH A RECHARGE WELL

In areas where the surface soil is impervious and large quantities of roof water or surface runoff is available within a very short period of heavy rainfall, trench/pits are used to store the water in a filter media and subsequently recharge to groundwater through specially constructed recharge wells.



RAIN WATER HARVESTING THROUGH RECHARGE WELL

- ✓ This technique is ideally suited for areas where the permeable level is within 3m below ground level.
- ✓ A recharge well of 100-300 diameters is constructed to a depth of at least 3 to 5m below the water level. Based on the lithology of the area, well assembly is designed with a slotted pipe against the shallow and deeper aquifer.
- ✓ A lateral trench of 1.5-3m width and 10-30m length, (depending upon the availability of water) is constructed with the recharge well in the centre.
- ✓ The number of recharge wells in the trench can be decided on the basis of water availability and local, vertical permeability of the rocks.
- ✓ The trench is backfilled with boulders, gravel and coarse sand to act as a filter media for the recharge wells.



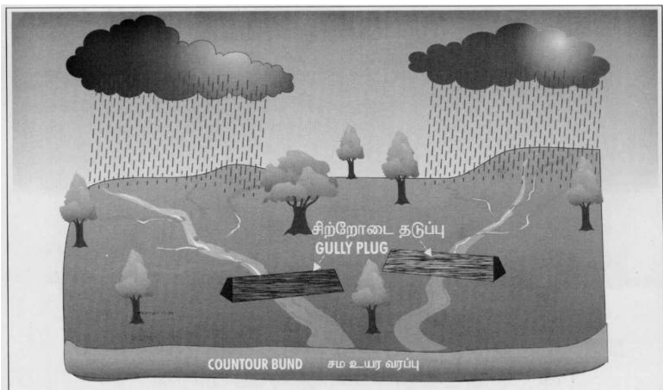
ROOF TOP RAIN WATER HARVESTING THROUGH TRENCH WITH RECHARGE WELL

- ✓ If the aquifer is available at a greater depth -- say more than 20m, a shallow shaft of 2 to 5 m diameters and 3-5 meters deep may be constructed depending upon the availability of runoff. Inside the shaft a recharge well of 100-300mm dia is constructed for recharging the available water to the deeper aquifers. At the bottom of the shaft a filter media is provided to avoid choking the recharge well.

5. RAINWATER HARVESTINGTHROUGH A GULLY PLUG

Gully Plugs are built using local stones, clay and bushes across small gullies and streams running down the hill slopes carrying drainage to tiny catchments during the rainy season.

- ✓ Gully Plugs help in conservation of soil and moisture.
- ✓ The sites for gully plugs may be chosen whenever there is a local break in a slope to permit accumulation of adequate water behind the bunds.



RAIN WATER HARVESTING THROUGH GULLY PLUG

6. RAINWATER HARVESTING THROUGH CONTOUR BUNDS

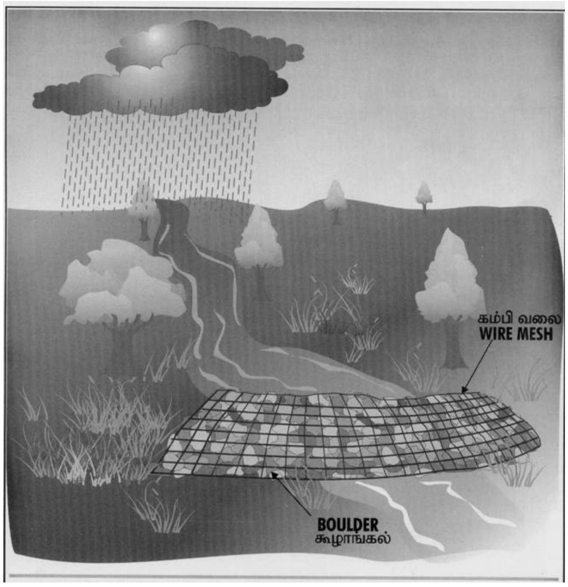
Contour Bunds are an effective method of conserving soil moisture in a watershed for long periods.

- ✓ These are suitable in low rainfall areas where the monsoon run off can be captured by constructing bunds of equal elevation on the sloping ground all along the contour.
- ✓ Flowing water is intercepted before it attains an erosive velocity by keeping a suitable space between bunds.
- ✓ Spacing between two contour bunds depends on the slope of the area as well as the permeability of the soil. The less permeable the soil, the closer the bunds should be spaced.
- ✓ Contour bunding is suitable on land with moderate slopes without terracing.

7. RAINWATER HARVESTING THROUGH A GABION STRUCTURE

This is a kind of check dam commonly constructed across small streams to conserve stream flows with practically no submergence beyond the stream course.

- ✓ A small bund across the stream is made by putting locally available boulders in a mesh of steel wires and anchoring them to the stream bank.
- ✓ The height of such structures is around 0.5 m and is normally used in the streams with widths of less than 10m.

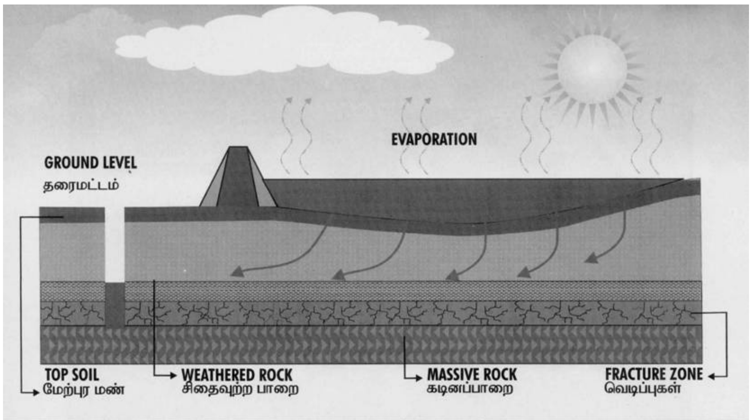


- ✓ The excess water over flows this structure, storing some water to serve as a source of recharge. In time, the silt content of the stream water is deposited in the interstices of the boulders. With the growth of vegetation, the bund becomes quite impermeable and helps in retaining surface water run off for a sufficient time after rainfall to recharge the ground water table.

8. RAINWATER HARVESTINGTHROUGH A PERCOLATION TANK

A percolation tank is an artificially created surface water body, submerging a highly permeable soil in its reservoir, so that surface runoff is made to percolate and recharge ground water storage.

- ✓ A percolation tank should be constructed preferably on second to third order streams, located on highly fractured and weathered rocks which have lateral continuity down stream.
- ✓ The recharged area down stream should have a sufficient number of wells and cultivable land to benefit from the augmented ground water.



RAIN WATER HARVESTING THROUGH PERCULATION TANK

- ✓ The size of the percolation tank should be governed by the percolation capacity of the strata in the tank bed. Normally, percolation tanks are designed for a storage capacity of 0.1-0.5 MCM. It is necessary to design the tank to provide a ponded water column generally between 3-4.5 m.
- ✓ The percolation tanks are mostly earthen dams with masonry structure only for the spillway. The purpose of the percolation tanks is to recharge the ground water in storage and hence seepage below the seat of the bed is permissible. For dams up to 4.5 m height, cut off trenches are not necessary and keying and benching between the dam seat and the natural ground is sufficient.

9. RAINWATER HARVESTING THROUGH CHECK DAMS/ CEMENT PLUGS/ NALA BUNDS

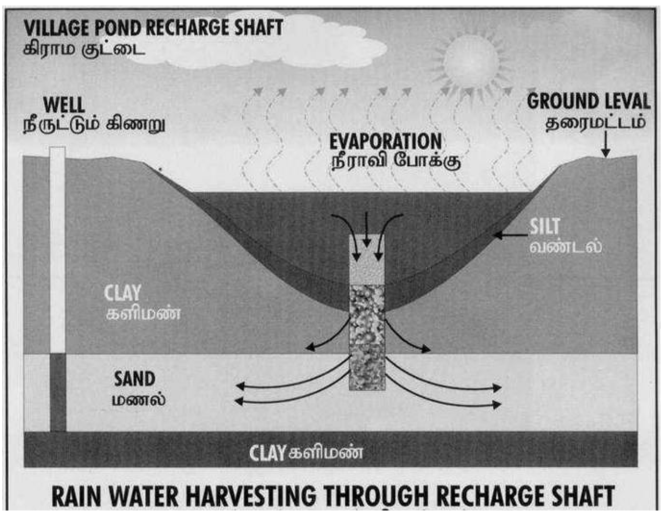
Check dams are constructed across small streams having gentle slopes. The site selected should have a permeable bed of sufficient thickness or weathered formation to facilitate the recharge of stored water within a short span of time.

- ✓ The water stored in these structures is mostly confined to stream course and the height is normally less than 2 m and excess water is allowed to flow over the wall. In order to avoid scouring from excess run off, water cushions are provided at downstream.

- ✓ To harness the maximum run-off in the stream, a series of such check dams can be constructed to have recharge on a regional scale.
- ✓ Clay-filled cement bags arranged as a wall are also being successfully used as a barrier across small nalas. At some places, a shallow trench is excavated across the nala and the space is backfilled with clay. Thus a low cost check dam is created. On the upstream side, clay-filled cement bags can be stacked on a slope to provide stability to the structure.

10. RAINWATER HARVESTINGTHROUGH A RECHARGE SHAFT

This is the most efficient and cost-effective technique to recharge an unconfined aquifer overlain by a poorly permeable strata.



RAIN WATER HARVESTING THROUGH RECHARGE SHAFT

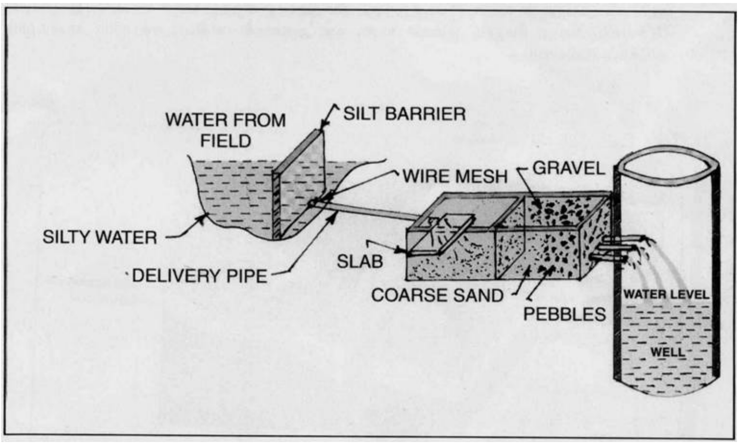
- ✓ A recharge shaft may be dug manually if the stratum is constructed of non-collapsing material. The diameter of the shaft is normally more than 2 m.
- ✓ The shaft should end in a more permeable stratum below the top impermeable strata. It may not touch the water table.

- ✓ The unlined shaft should be backfilled, initially with boulders/cobblestones, followed by gravel and coarse sand.
- ✓ If there is a lined shaft, the recharge water may be fed through a smaller conductor pipe reaching up to the filter pack.
- ✓ These recharge structures are very useful for village ponds where a shallow clay layer impedes the infiltration of water to the aquifer.
- ✓ It is seen that in the rainy season, village tanks are completely filled up, but water from these tanks does not percolate down, due to siltation, and tube wells and dug wells located nearby remain dry. The water from village tanks evaporates and is not beneficial.
- ✓ By constructing recharge shafts in tanks, surplus water can be recharged to ground water. Recharge shafts of 0.5-3 m diameter and 10-15 m deep are constructed, depending upon the availability of water. The top of the shaft is kept above the tank bed level, preferably at half of the full supply level. These are back-filled with boulders, gravel and coarse sand.
- ✓ In the upper portion of 1 or 2 m deep, brick masonry work is installed for the stability of the structure.
- ✓ Through this technique, all the accumulated water in a village tank above 50% capacity would be recharged to groundwater. Sufficient water will continue to remain in the tank for domestic use after recharge.

11. RAINWATER HARVESTINGTHROUGH DUG WELL RECHARGE

Existing and abandoned dug wells may be utilized as recharge structures after cleaning and desilting the same.

- ✓ The recharge water is guided through a pipe from a desilting chamber to the bottom of the well or below the water level to avoid souring the bottom and trapping air bubbles in the aquifer.

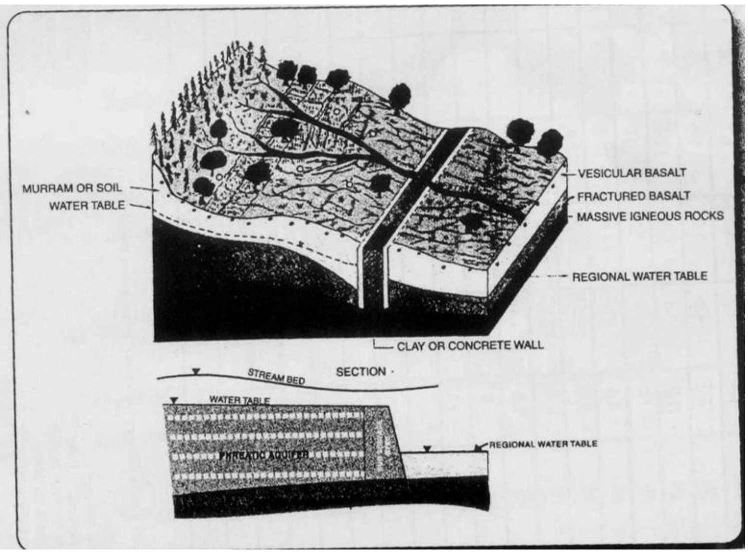


- ✓ Recharge water should be silt-free and for removing the silt contents, the runoff water should pass either through a desilting chamber or filter chamber.
- ✓ Periodic chlorination should be done for controlling bacteriological contamination.

12. GROUNDWATER DAMS OR SUB-SURFACE DYKES

Sub-surface dykes or underground dams are sub-surface barriers across streams which retard the base flow and store water upstream below the surface. By doing so, the water levels upstream of groundwater dams rise, saturating otherwise dry parts of the aquifer.

- ✓ The site where a sub-surface dyke is proposed should have a shallow, impervious layer with a wide entranceway and narrow outlet.
- ✓ After the selection of a suitable site, a trench of 1-2 m wide is dug across the breadth of the stream down to the impermeable bed. The trench may be filled with a clay or brick concrete wall up to 0.5 m below ground level.
- ✓ For ensuring total imperviousness, PVC sheets of 3000 PSI tearing strength at 400 to 600 gauge or low density polythene film of 200 gauge can also be used to cover the cut-out dyke faces.
- ✓ Since the water is stored within the aquifer, flooding of the land can be avoided and the land above the reservoir can be utilized even after the construction of the dam. No evaporation loss from the reservoir and no siltation in the reservoir take place. A potential disaster, like the collapse of the dam, can also be avoided.



5. RECOMMENDATIONS

Following the above descriptions and according to the site conditions and other considerations like ecological impact and sustainability, it appears that several techniques are **not** recommendable for some areas when others may apply.

Accordingly, a classification is proposed on the same:

	Centre	International Zone	Industrial Zone	Cultural Zone	Residential Zone
1. Recharge Pit	YES	Only in upper area	Only in upper area	Only close to RZ	YES
2. Recharge Trench	YES	YES	YES	YES	YES
3. Tubewell	Banned	Banned	Banned	Banned	Banned
4. Recharge Well	After careful study	Only in the upper area and careful study	Only in the upper area and careful study	After careful study	YES
5. Gully Plug	YES	YES	YES	YES	YES
6. Contour Bund	YES	YES	YES	YES	YES
7. Gabion Structure	YES	YES	YES	YES	YES
8. Percolation tank	YES	YES	YES	YES	YES
9. Check Dam / Cement plug / Nala Bund	YES	YES	YES	YES	YES
10. Recharge shaft	Banned	Banned	Banned	Banned	Banned
11. Dugwell Recharge	Not Suitable	Very careful design and maintenance required	Very careful design and maintenance required	Not Suitable	Not Suitable
12. Groundwater Dams / Subsurface Dyke	Not Suitable	YES	YES	Not Suitable	Not Suitable

E. Rooftop Rainwater Harvesting System

1. What is Rooftop Rainwater Harvesting?

- Collection
- Filtration
- Storage
- Usage
- Recharge

2. Advantages of rainwater usage

There are many aspects to RWH, each of which must be studied and managed correctly, if the overall system is going to run efficiently. They may be classified as follows:

i) Water usage management
ii) Water quality and other health issues
iii) Water collection hardware (storage tanks)
iv) Financial considerations.

Amongst the advantages, we can emphasize:

- Possible reduction of detergent consumption over 50 %
- No calcifying of the washing machine, no additives necessary for lime reduction
- The ion-poor rain water reduces the occurrence of urine stones at the WCs
- The soft rain water offers an optimal irrigation medium for plants
- The saving of expensive water and, eventually, wastewater fees.

3. USE of harvested rainwater

Non-potable	**Potable Purpose**
✓ Flushing	✓ after ensuring quality (SODIS treatment)
✓ Floor washing	
✓ Clothes washing	
✓ Gardening	

4. Implementation

Rooftop rainwater harvesting should not be considered in isolation, but rather as part of a total system to meet the overall water requirements of a household or community.

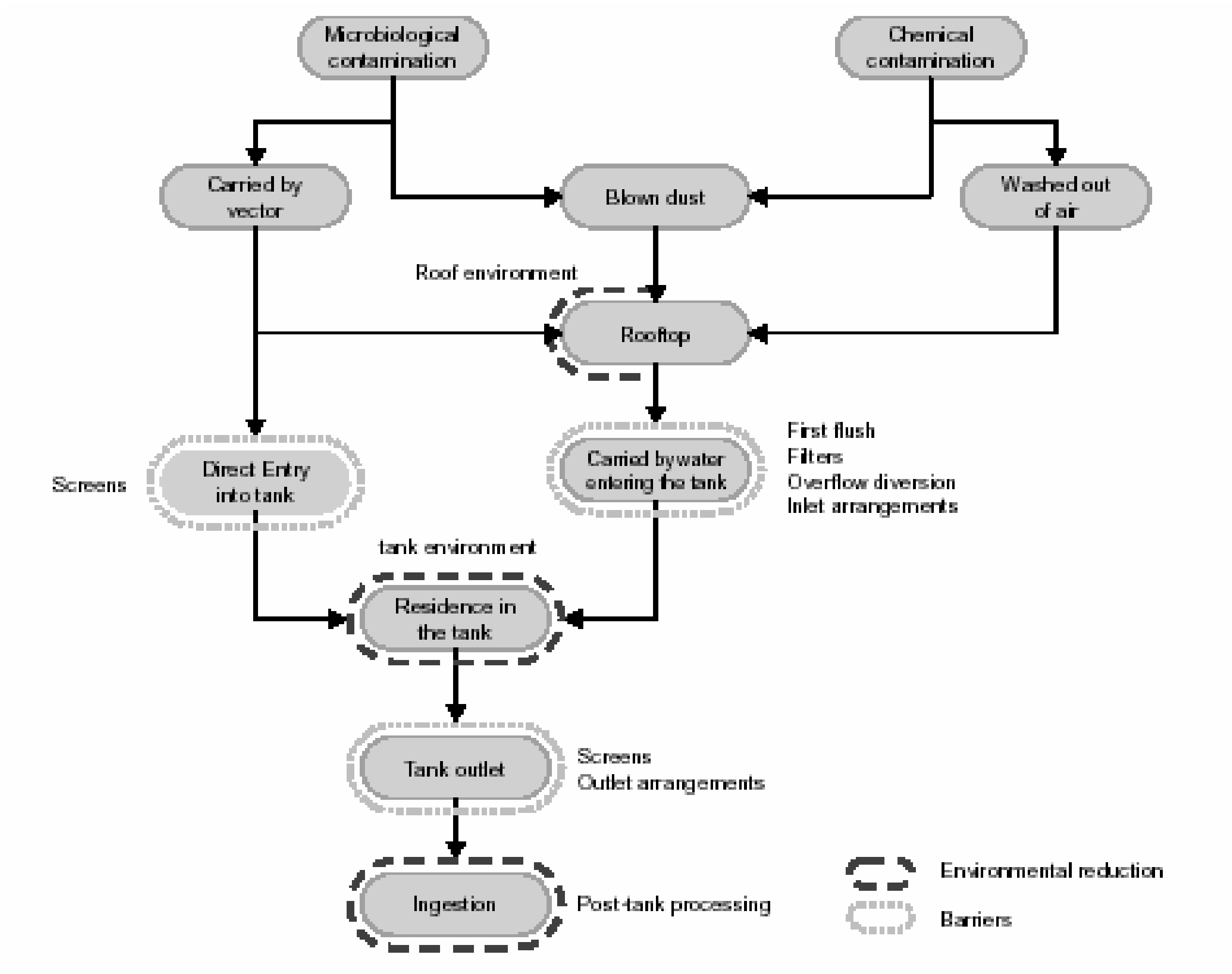
In many cases it may serve as a 'top up' rather than as a main source, and in all cases it should be considered as part of a range of possible supply approaches. Roof water harvesting is fundamentally different from most water supply options. These differences have profound effects on the management and implementation of any project involving roof water harvesting:

• It is based on a finite volume of water that can be depleted if not well managed, making it a poor candidate for community supply unless strong measures are taken to prevent overuse.

• It is highly seasonal in nature, meaning that there must also be another water source available. This source (or sources) must be able to cope with the demands of households using roof water harvesting, especially as the largest demand will be in dry periods. It does not, however, have to be as high in quality.

• *Domestic* roof water harvesting requires a large number of small civil works rather than the large-centralized works of most water projects, requiring different approaches to management.

• The cash flow of roof water harvesting systems is that of a large up-front cost with extremely small maintenance charges. This is in contrast with most water supply systems, where maintenance is a large part of the overall costs. Most water supply projects are cost-based on donor funded initial works with users paying for upkeep – this paradigm is unsuited to DRWH.



Pollution control in RWHS

When installing a rainwater system, please ensure that: NOT SUITABLE FOR DRINKING signage is fixed next to all rainwater system faucets.

5. System Design

The range of opportunities varies from traditional rainwater collecting managed by huge banana leaves up to clever computer management systems used in industrialized nations. Also, there are big differences in the amount and quality of collected water. In some cases, water is caught in small pots to supply the fresh water needed for one day. On the other end of the spectrum, we can see systems which have sufficient collection surface area and storage capacity to provide enough water to meet the full needs of the user (including water for cooking, bathing, washing and irrigation). Between these two extremes exists a wide variety of different user patterns or regimes.

Furthermore, the usage of a Rainwater Harvesting-System (RWHS) is determined by many inter-related circumstances. Some of them are listed below[1]:

- **Rainfall quantity (mm/year)** – This is the total amount of water available to the consumer. It is a product of the total available rainfall and the collection surface area with a loss coefficient included to allow for evaporation and other losses. The mean annual rainfall data will tell how much rain falls in an average year.
- **Rainfall pattern** - Climatic conditions vary widely throughout the world. A climate where rain falls regularly throughout the year will mean that the storage requirement is low and hence the system cost will be low. On the other hand, where rainfall falls in a short time, a big storage capacity is required which.
- **Water quality** – Depending on the quality, collected water is used for different purposes. Water may get polluted due to contact with the environment while falling, from the roof surface and gutter system while harvesting and from the tank material while storing.
- **Collection surface area (m2)** – Logically, where rooftop catchment systems are used, these are restricted by the size of the roof.
- **Storage capacity (m3)** - The storage tank is usually the most expensive component of the RWHS and so a careful analysis of storage requirement against cost has to be carried out.

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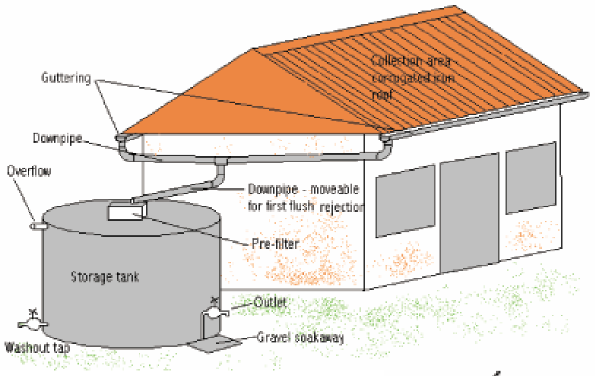
[1] Report A1 - Current Technology for Storing Domestic Rainwater (Part 1)

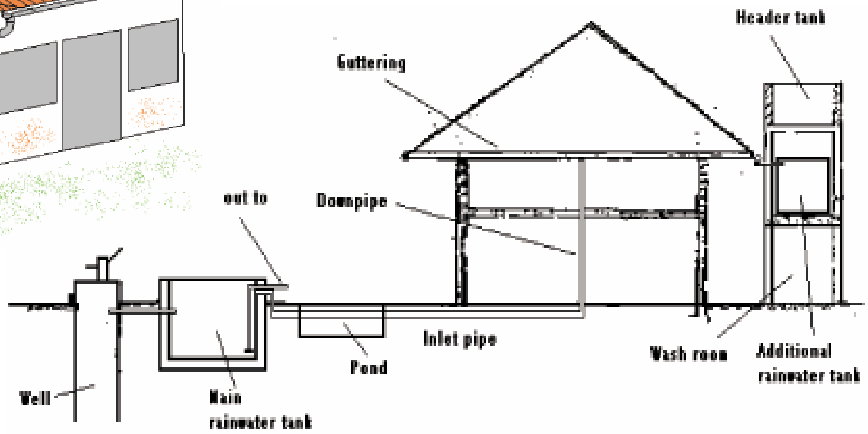
- **Daily consumption rate (litres/capita /day or lpcd)** - This varies enormously – from 10 – 15 lpcd a day in some rural parts of India to several hundred lpcd in some westernized parts of India. This will have obvious impacts on system specification.
- **Number of users** - This will greatly influence the requirements.
- **Cost** – A major factor in any scheme.
- **Alternative water sources** – Where these are available, the water supply ideally is a mixture of different supply systems.
- **Water management strategy** – Whatever the conditions, a careful water management strategy is always a prudent measure.

6. Components of a RWHS

Following the way of the water, the main components of a RWHS include: Catchment Surface Area, Guttering, First Flush Systems, Filtration Systems, Storage Facilities and Recharge devices. All individual parts are discussed below.

Roof	-Collector
Gutters & Down pipes	-Transmitters
First-rain separator	-Segregator
Drums	-Filters/Intermediate storage
Silt traps	-Filter chambers
Sumps & OHT	-Storage systems
Bore well, open wells & percolation pits	-Ground water recharge





1. Collection Surfaces

The most common surface for Domestic Rainwater Harvesting (DRWH) is roof area. Nevertheless, it is not the only possibility for collecting water. Likewise, courtyards, paved walking area, plastic sheeting, rocky surfaces etc. can be used. In this document the main emphasis is put on collection from residential roofs.

Typical materials for roofing include iron or steels sheets, ceramic, cementations, a wide range of tiles and slate. Metal roofs are comparatively smooth and are therefore less prone to contamination by dust, leaves, bird-droppings and other debris than rougher tile roofs. Also, they may get hot enough to sterilize themselves. Aluminum is very inert unless it comes in contact with very acidic water[2]. Still the effect on the health of ingesting small amounts of aluminum is unclear and should be investigated before using aluminum. Stainless steel is a very suitable material, but unfortunately very expensive. Steel mildly protected by hot-dip or electrolytic galvanizing is suitable too. Because plastic is neither durable nor cheap, it is not recommended as surface or guttering material.

The efficiency of collection (also called runoff coefficient) depends on the material used: cement tiles reach a year-round efficiency of some 75% while clay tiles range from 25-50% depending on the production method and annual precipitation (Izhu and Liu, 1998). Plastic and metal sheets have an efficiency of 80-90%.

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[2] Report A1

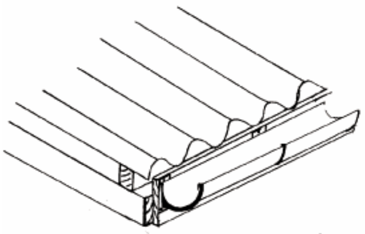
However, this collection efficiency is often greatly reduced because of poor installation and maintenance of gutters and drainpipes.

2. Guttering

Guttering is used for the transport of the water from the roof to the storage facility. Metal is also recommended for guttering. To prevent mixing debris and water, it is recommended to cover the guttering with a sieve.

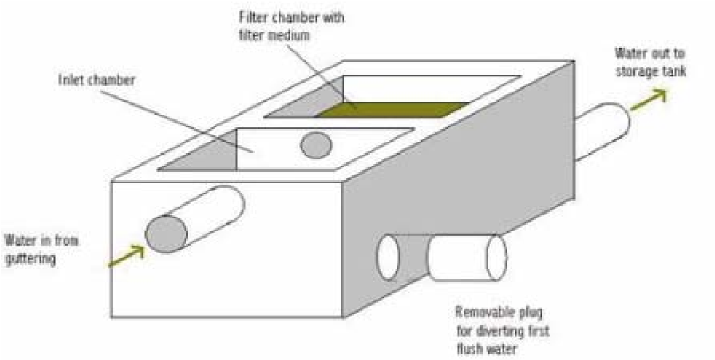
Sizing of Rainwater Pipes for Roof Drainage

Sl.No	Dia of Pipe (mm)	Average Rainfall (mm)	Roof Area Sq.m
I	50	13.4	8.9
II	65	24.1	16
III	75	40.8	27.0
IV	100	85.4	57.0
V	125	---	---
VI	150	---	---



3. First Flush Systems

The first liters of harvested water will contain unwanted matter like debris, dirt and dust. Furthermore, the concentration of fecal coliform and total coliform is considerably higher in the first liter[3].



Without a First Flush System (FFS) these matter will be washed into the tank.

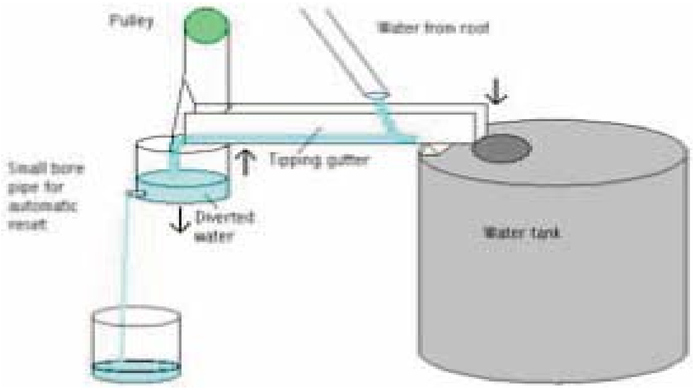
A First Flush System diverts the first liter of the rain and therefore avoids contamination of the water. It is suggested to ensure a minimum of five liters of “foul-flush”.

There are a number of simple systems which are commonly used and a number of other, more complex, arrangements.

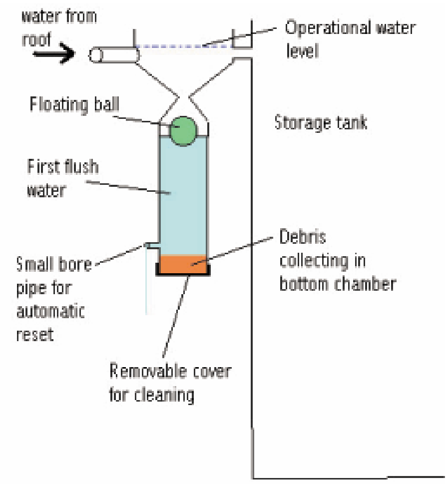
[3] N.,Ghazali, et. Al. June 1989, ”Water Research WATRAG Vol. 23, No. 6” Pertanian Malaysia Univ. Serdang, Dept. of Environmental Sciences

The simpler ideas are based on a simple, manually operated arrangement whereby the inlet pipe is moved away from the tank inlet and then replaced again once the initial first flush has been diverted. This method has obvious drawbacks in that there has to be a person present who will remember to move the pipe.

Slightly more sophisticated methods include arrangements such as those shown below, where the stopper in the inlet chamber can be removed to allow the first flush to be diverted.



The most common system uses a bucket which accepts the first flush.



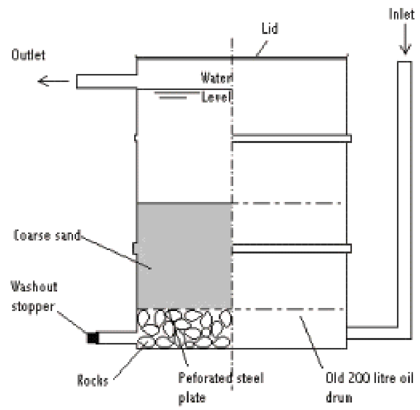
The weight of this water off-balances a tipping gutter which then diverts the water back into the tank. The bucket then empties slowly through a small-bore pipe and automatically resets. The process will repeat itself from time to time if the rain continues to fall, which can be a problem where water is really at a premium. Another system that is used relies on a floating ball that forms a seal once sufficient water has been diverted. The seal is usually made as the balls rises into the apex of an inverted cone.

The ball seals the top of the 'waste' water chamber and the diverted water is slowly released, as with the bucket system above, through a small bore pipe.

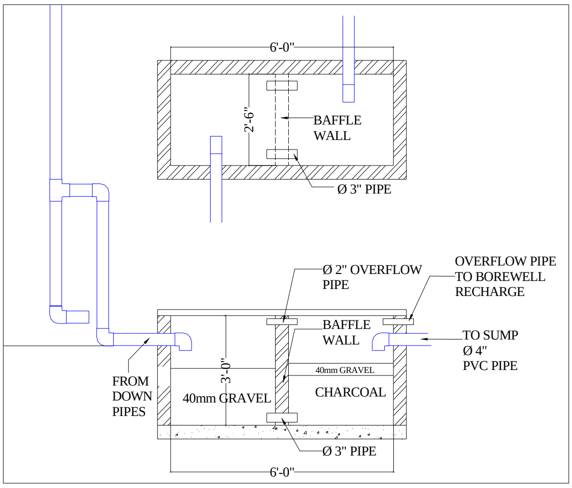
Although the more sophisticated methods provide a much more elegant means of rejecting the first flush water, practitioners often recommend that very simple, easily maintained systems be used, as these are more likely to be repaired if failure occurs.

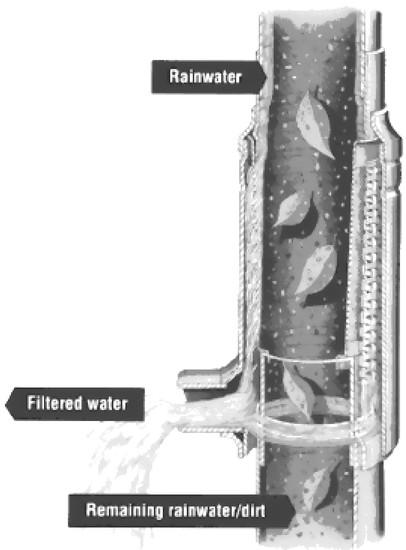
4. Filtration Systems

Again, there is a wide range of possibilities to treat water before it enters the tank. The level of sophistication also varies, from rudimentary to high tech solutions. In general, the technique should be applied depending on the purpose of water usage, the level of pollution and the inflow-speed. To give a basic understanding of filtration, an upflow and filter is shown here.



Silt trap





A German company, WISY, has developed an ingenious filter which fits into a vertical drain pipe and acts as both filter and first-flush system. The filter cleverly takes in water through a very fine (~0.20 mm) mesh while allowing silt and debris to continue down the pipe. Over 90%of the water is collected. Larger models handle run-off from roof areas of up to 500 m2.

The WISY filter (down pipe and high capacity below ground versions) - Source: WISY catalogue Wisyag@t-online.de

5. Storage Facilities

The storage reservoir is usually the most expensive part of the system, so one has to pay close attention to its design and construction. The tank must be constructed so that it is durable and watertight, and so that the collected water does not get contaminated.

There are loads of options for storage facilities. For storing larger quantities of water, usually tanks or cisterns are used. These vary in size, shape, material and price.

There are three categories of storage reservoirs:

1. Surface or above-ground tanks (most common if the collection surface is elevated roof);
2. Sub-surface or underground tanks (common for ground catchment systems);
3. Dammed reservoirs for larger catchment systems.

Materials for surface tanks include metal, wood, plastic, fiberglass, brick, inter-locking blocks, compressed soil or rubble-stone blocks, ferrocement and concrete.

The material and design of sub-surface tank walls must be able to resist the soil and soil water pressures from outside when the tank is empty. An empty tank can float like a boat when the groundwater table rises! Careful location of the tank, and keeping it partly above ground level (and way above the groundwater table) will help to solve this problem; heavier materials are another option, but may have a serious cost implication.

A common technology successfully used in Auroville is based on ferrocement, but others like stone masonry seem to be competitive.

Tank size varies depending on the rainfall pattern and the user group: households may need a tank of from 1m3 to more than 40m3, while schools and hospitals may need tanks up to 100m3. When there are long dry seasons, roof collection area and tank size will be large, but rationing (good management) and the use of alternative sources significantly reduces the surface area and tank volume. In general, required roof area and tank volume increase as total rainfall decreases, or where rainfall patterns become erratic.

From the point of view of cost-effectiveness, in arid areas or areas with poorly distributed rainfall, where very large and expensive surface areas and tank volumes are needed, rainwater is best seen as a supplementary water source. However, in semi-arid areas with well-distributed rainfall, roof catchment supplies are much cheaper than water trucked or piped over long distances (Gould and Nissen-Petersen, 1999).

6. Needs and specification

Tanks need to be watertight. They also need to hold the required volume and to be durable (say 25 years before they become unserviceable). Beyond these basic requirements, we can list many further specific requirements. Tanks should:

- ✓ have a way of being charged with water without unduly disturbing tank-bottom sediments and if possible maintaining stratified flow (the bacterial quality of outlet water is maximized if the flow through the tank resembles 'pipe flow', namely 'last in is last out'
- ✓ be able to handle excess input by overflowing in a convenient and safe manner – preferably without losing water unnecessarily via the tank (such water may drop unwanted sediment in the tank)
- ✓ have a means by which the water can be extracted which is convenient for the user and which does not pollute the water left behind (as dipped buckets may)
- ✓ exclude vermin and, as far as possible, mosquitoes
- ✓ exclude light (so that algae do not grow and larval growth is inhibited)
- ✓ have some form of ventilation, especially if there is not an efficient filter to prevent organic material from entering the tank and decaying there
- ✓ be easy to access for cleaning (where cleaning is needed) and not likely to be damaged during cleaning
- ✓ have a sufficient structural safety factor to withstand wear and tear, some impacts and occasional large natural forces like winds and (in places) earthquakes
- ✓ not present hazards to passers-by or small children
- ✓ not give the water a bad taste

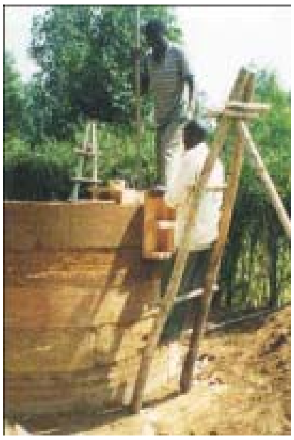
7. Overview of various tank designs.

1. External Reinforced Brick Tanks

Brick material is widely used in India and thus it is readily available. It is ideally suited for wall construction. Due to the poor strength in tension, the poor adhesion of one brick to another, and the relatively large quantity of cement needed, it is not suited very well for larger volume tanks. Nevertheless, there are some options like using external steel reinforcements, to improve the quality.

PROS	CONS
⇨ low material cost ⇨ material locally accessible ⇨ well known and widely used technology	⇨ not ideal for round tanks ⇨ poor in tension - needs reinforcement

2. Rammed Earth Tanks



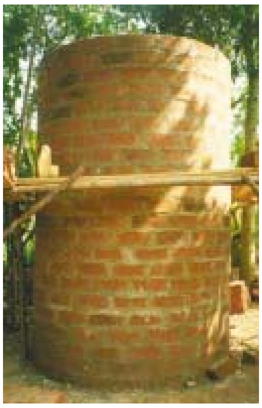
As the name suggests the technique involves earth rammed between two shutters, using a rammer or a tamp. The shuttering is removed to reveal the wall. Walls are usually constructed in sections of a few feet long by a foot or two deep with shuttering moved along to form a continuous wall. The shuttering is then raised and placed on top of the first 'lift' to construct the subsequent 'lifts'.

This "green" architecture is appreciated because it has a low energy input and excellent thermal properties.

Its longevity and stability is attested to by the weather resistance of houses which were built hundreds of years ago. Still there are some particular problems.

PROS	CONS
⇨ very low material cost ⇨ material locally accessible ⇨ simple technology that easily taught to semi-skilled worker	⇨ not suitable for below-ground tanks/cisterns ⇨ in cases of leaks serious problems can develop ⇨ high labour input

3. Stabilized-Soil Tanks



Stabilized, compacted, soil block technology involves compacting suitable soil, which is often mixed with a small percentage (typically 5 – 10%) of cement, using a manual or hydraulically assisted ram or press. This compaction reduces the gaps in the material and hence its susceptibility to attack from water. Special molds can be manufactured to produce blocks of different shapes for special purposes.

PROS	CONS
⮩ Reduced cement content resulting in inexpencive blocks	⮩ Low wet strength ⮩ Reduced cement content must be balanced against lower strength requiring thicker walls ⮩ Needs specialized tools for compacted blocks ⮩ Low tensile strength or block

4. Lining Tanks with Plastic Bags

Plastic linings can considerably reduce the cost of the tank by removing the need for

any construction work to make it watertight. Indeed they can be simply placed in a hole to form a very cheap and portable tank (although a cover should be constructed). Plastic liners also allow removal for inspection, cleaning, maintenance and occasional repair.

The technique uses simple tools and can be taught in a couple of hours to a reasonably skilled craftsperson. It is suggested to use plastics with a woven structure, because they seem to be more resistant.

PROS	CONS
⮩ Greatly reduced cost ⮩ Portable ⮩ No clambering is required during construction ⮩ Can be removed for cleaning/inspection ⮩ Can be batched produced	⮩ Fragile - likely to tear, subjects to pin holes ⮩ UV degradation ⮩ Joining requires specialized technique

5. Simple Underground Tanks in Stable Ground

The Open University in Sri Lanka experimented with creating underground tanks using stabilized soil with bamboo, reinforcing and a plastic liner for waterproofing. Two-third of the cost of these tanks are absorbed for the cover. One problem discovered in the study is that tanks have been broken due to rising water tables and puncturing by tree roots. The pros and cons are listed down below.

PROS	CONS
⇨ Greatly reduced cost sue to lower wall thickness ⇨ More difficult to empty by leaving tap on ⇨ Can be made unobstrusive	⇨ Water extraction is more difficult ⇨ Leaks or failures are more difficult to detect ⇨ Contamination of the tank from surface runoff ⇨ Tree roots can demage the structure ⇨ Sensetive to groundwater level rising

6. Partly Below Tanks

Several problems can be overcome by placing the tank partly above and partly below the ground. These kinds of tanks are already successfully used in Auroville. Manfred is using a 100 m^3 tank at Auromodele. They are combining the advantages of above ground and below ground tanks.

PROS	CONS
⇨ Lower material requirement ⇨ Reasonable unobstusive ⇨ Lower cost due to thinner walls ⇨ Available locally at CSR	⇨ Requires a pump ⇨ Leaks or failures are difficult to detect ⇨ Tree roots can damage the structure

7. Waterproof coatings

Waterproof paints are quite common in the developed world where they are used to seal ponds, swimming pools, etc. These paints are available and local variants may be developed. Quality control may become a major issue, as any uncoated sections could result in a dangerous, catastrophic failure of the tank.

8. Sizing the system

Usually, the main calculation carried out by the designer when planning a domestic RWH system will be to size the water tank correctly to give adequate storage capacity. The storage requirement will be determined by a number of inter-related factors. They include:

- ✓ local rainfall data and weather patterns
- ✓ size of roof (or other) collection area
- ✓ runoff coefficient (this varies between 0.5 and 0.9 depending on roof material and slope)
- ✓ user numbers and consumption rates

The style of rainwater harvesting i.e., whether the system will provide a total or partial supply, will also play a part in determining the system's components and their size.

There are a number of different methods used for sizing the tank. These methods vary in complexity and sophistication. Some are readily carried out by relatively inexperienced, first time practitioners while others require computer software and trained engineers who understand how to use this software. The choice of method used to design system components will depend largely on the following factors:

- ✓ the size and sophistication of the system and its components
- ✓ the availability of the tools required for using a particular method (e.g. computers)
- ✓ the skill and education levels of the practitioner / designer

Below we will outline 3 different methods for sizing RWH system components.

1. Method 1 – demand side approach

A very simple method is to calculate the largest storage requirement based on the consumption rates and occupancy of the building. As a simple example, we can use the following typical data:

Consumption per capita per day, C = 50 liters

Number of people per household, n = 6

Longest average dry period = 200 days

Annual consumption = C x n = 300 liters

Storage requirement, T = 300 x 200 = 60,000 liters

This simple method assumes sufficient rainfall and catchment area, and is therefore only applicable in areas where this is the situation. It is a method for acquiring rough estimates of tank size.

2. Method 2 – supply side approach

In low rainfall areas or areas where the rainfall is not evenly distributed, more care has to be taken to size the storage properly. During some months of the year, there may be an excess of water, while at other times there will be a deficit. If there is enough water throughout the year to meet the demand, then sufficient storage will be required to bridge the periods of scarcity. As storage is expensive, this should be done carefully to avoid unnecessary expense. This is a common scenario in many developing countries where monsoon or single wet season climates prevail.

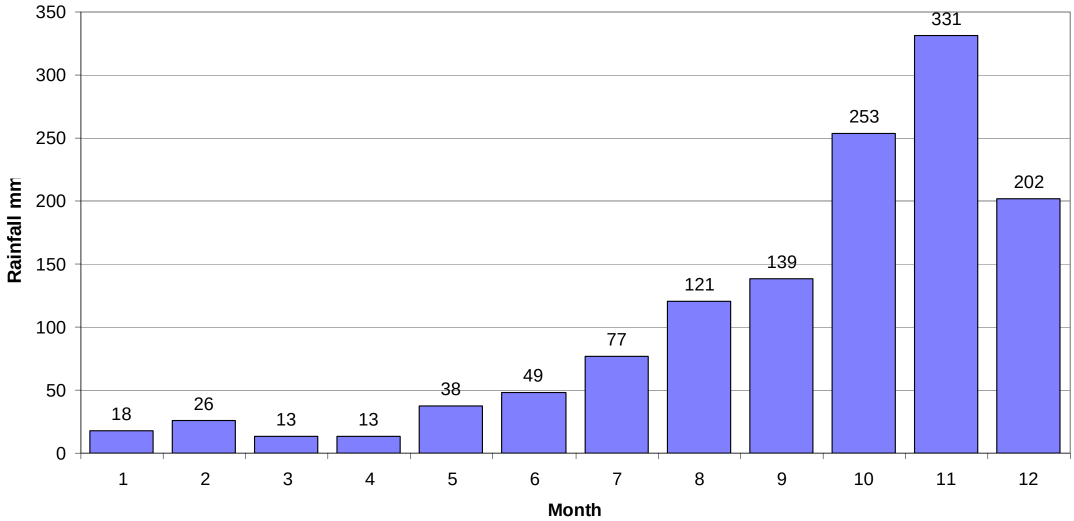
The example is designed for a system at a medical dispensary in a village around Auroville.

Demand	**Supply**
Number of staff: 6	Roof area: 190m2
Staff consumption: 25 l/c/d*	Runoff coefficient** (for new corrugated GI roof): 0.9
Patients: 30	Average annual rainfall: 1280mm per year
Patient consumption : 10 l/c/d	Daily available water (assuming all is collected) = 190 x 1280 x 0.9)/ 365 = 599 litres
Total daily demand: 450 litres	

*l/c/d – litres per capita per day

** Run-off coefficient values vary between 0.3 and 0.9 depending on the material of the catchment area. It takes into consideration losses due to percolation, evaporation, etc.

Monthly Average Rainfall on a 35 years (1968 - 2003) in Auroville area



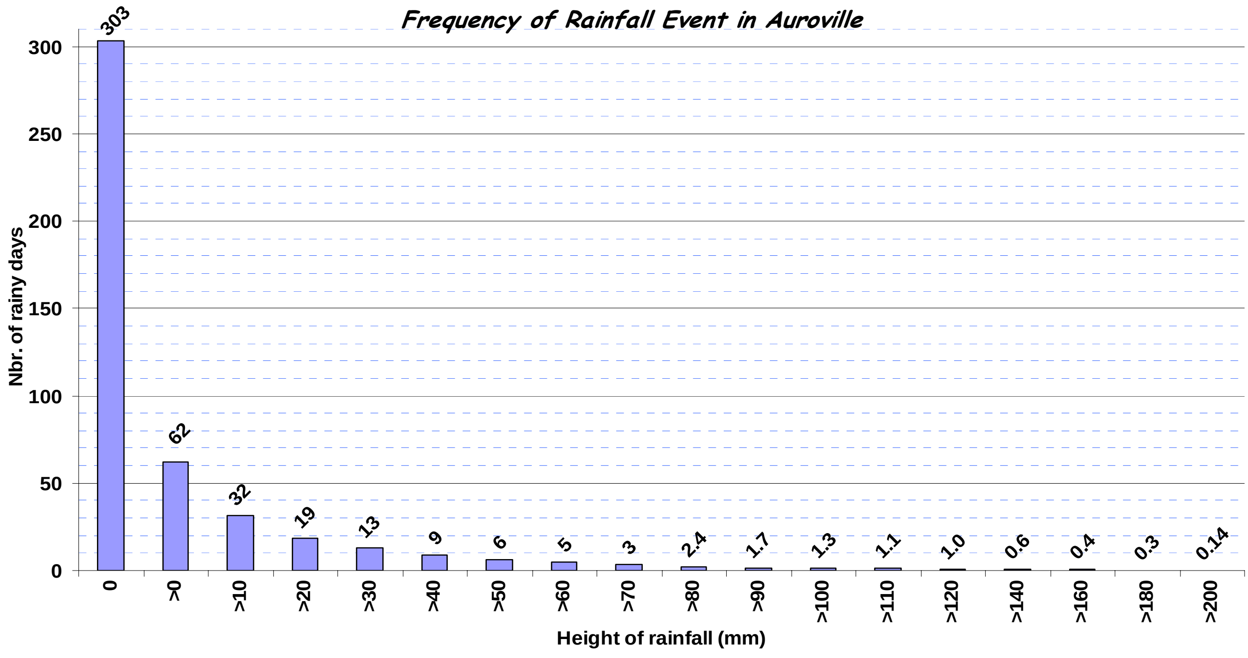
F. Some understanding

While promoting Rainwater Harvesting and Water Saving techniques, it is important to understand their feasibility and practicality.

It seems relatively obvious that an area with a well sprayed rainfall pattern may develop rainwater harvesting structures at a much more affordable price than let's say Rajasthan. However, Rajasthan and other very dry areas are well equipped with such structures, which demonstrates that the problem must be seen in its own context. In the end, if there is no other source of fresh and clean water available, the cost is not anymore the only relevant criteria. But let's see further what it means in the Auroville context.

Period : June 1968, December 2003 Sources: Auroville Certitude, Pondicherry meteorological station , Auroville Harvest	
Average rainy days per year : 62	Maximum rainfall on 1day : 362 mm
Average rainfall per year : 1280 mm	Maximum rainfall in 2 days : 416 mm
Maximum rainfall per year : 1910 mm	Maximum rainfall in 3 days : 478 mm
Minimum rainfall per year : 731 mm	Maximum Rainfall in a month : 700mm

From the Indian Meteorological Department, the heaviest rainfall in 2 days is suppose to be around 600mm and 700 for 3 days, about 50% above the recorded values.



Now, while going through the number of rainy days versus height of rainfall, we can realize that in fact rainfalls of significant value are few and heavy downpours are not ,on the average, frequent. Practically, a first sizing of rainwater harvesting structures as defined earlier may as well follow the same ratio. For example, if one believes that a recharge structure should be able to absorb nearly every rainfall, one can consider it achieved with a system sized for 120mm of rain per day.

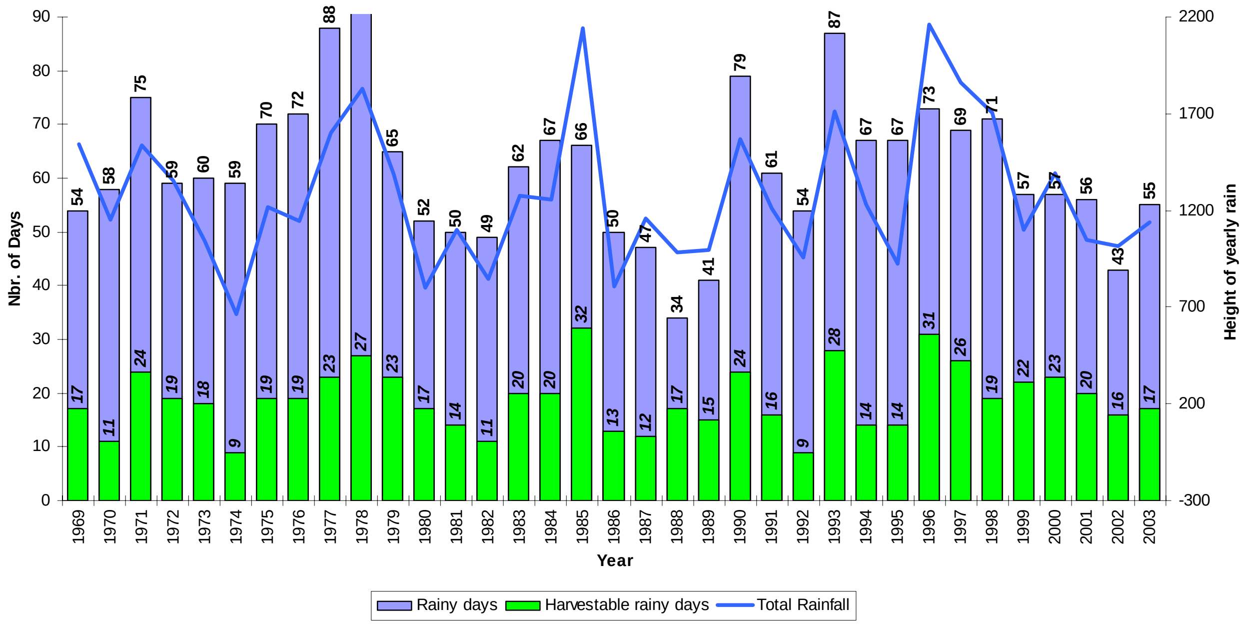
Of course, a storm water control structure should be defined accordingly, starting from evaluated runoff from non-built areas, and then adding extra capacity for times of exceptional rainfall.

When analyzing the requirements for a roof rainwater structure, it is also important to define first how much rainfall it is possible to harvest. While, generally speaking, the method is simply following runoff coefficient values, a careful look at rainfall data may lead to a serious rethinking.

First, it is clear that not all of the rain can be collected: below a certain intensity, the water gets evaporated before it reaches the drain. Then, for the rainfall above this limit, still an important part gets lost through the splash effect, and more through the first flush system (0.90), filtration system and others. Practically, it means that the number of rainfalls creating storable or infiltrable water is even less than what is stated above. Even when there is sufficient rainfall, there is still some water lost before reaching the storage or infiltration devices.

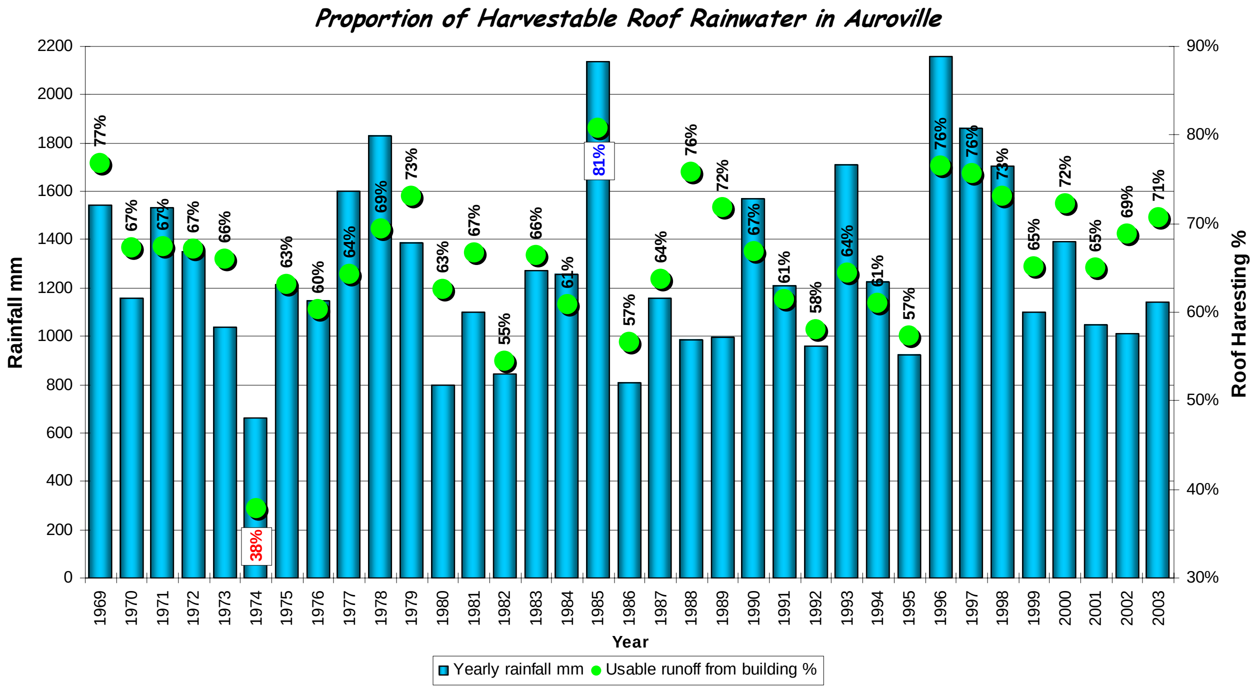
After various simulations, we came to the conclusion that no rainwater is collected below 20 mm of rain per day. Of course, this may fluctuate a bit due to the intensity of the rainfall and roof materials. Moreover, about 5 mm is lost through the components of the system itself.

Number of days Generating Runoff from a Roof in Auroville



The following table synthesizes this analysis with average values, while Sim Tanka values (from a well known software program for the sizing of a roof rainwater system), are somewhat confirming these results.

Harvest evaluation				Sim Tanka`		
Average Yearly Rainfall	1281			Drought year	534	42%
Rainy days	62			Below average rain	676	53%
Harvestable rainy days	19	*30%*		Average rain	819	64%
Harvestable rain	864	*67%*		Above average rain	1077	84%



It is then clear that the recharge of the system is happening sporadically, which means that the storage facility, if any, must have a large capacity if to be useful at all.

We come to the conclusion that it is possible to harvest about 86,000 liters of rain for 100 sqm of drained roof area on the average. This does not mean that the storage system must be that large. The volume of the tank must be evaluated as per rainfall data and water demand.

For example, using daily rainfall data form January 1969 to December 2003, in a building of 100 sqm using 200 liters of rainwater per day, a tank of 65 m3 will cover all the needs, with a shortage of water once every 4 years, and this for a few weeks maximum.

G. Conclusions

In the planning process of Auroville, many types of rainwater harvesting should be integrated, taking into account storm water management and landscaping. The design should be guided by Auroville's rich experience,

The main aim of a Rain Water Harvesting is to reduce dependency on groundwater and to help to create better recharge of the water table even with important impervious area ratio. It is highly recommended to use rain water for gardening, toilet flushing, washing clothes and recharging the water table. The design of the collection area, the filtration and the storage volume or recharge system must be done carefully. By adding purification facilities it is feasible to reach even drinking water quality. Anyhow, looking at the investment and running cost involved and at the proportionally very limited demand, we can consider it valid only for very specific places.

In Auroville, the actual cost for one stored liter, using a variety of techniques, is between 1.5 - 7.0 Rupees. By improving storage technology and increasing the volume, we may expect the price to drop down even more (0.5 Rupees/l as per Indian government). Partly underground tanks combine the economic affordability of underground tanks with the safety and desirability of an above-ground tank. These tanks are already successfully used in Auroville and experiences have been satisfying. The groundwater level and soil characteristics fluctuation in Auroville aer great, therefore the placing and choice of tanks has to be carefully considered as per local conditions

Covering tanks will provide several advantages. First, it avoids people or animal falling accidentally into tanks. Second, darkness will stop photo-synthesis and therefore stop the growth of algae inside the tank. Third, the quality of the water can be more easily maintained.

To protect the water quality it is necessary to control the inflow quality (effective pre-filtration) and protect the tanks against run-off. That is also true for recharge systems where the collected water is infiltrated close to the water table, while direct infiltration in the water table must be strictly proscribed for safety reason.

Also, the regular cleaning of the collecting surface, roof, gutters, filtration system and tank will help maintain water quality. All inflow and outflow pipelines should be protected against mosquitoes.

The choice of an appropriate first flush and filtration system has to be made carefully. As mentioned above, there is a wide range of choices. Basically, the more effective techniques do not need that much maintenance and can be therefore recommended. Besides technical factors, good management is also required to guarantee well-working RWHS.

The necessity of integrating the design of rainwater water harvesting with conventional building practice, i.e. to interfere minimally in the latter, is of great importance in reducing cost. This also includes incorporating aesthetics.

List of know Rainwater Harvesting Structures in Auroville until date

Place	Details	Storage capacity m3	Cost /m3 2004	Comments
Acur	Acur building	100	7,000	Treated up to drinkable quality
American pavilion	American student hostel	80	2,300	
Auromodele	Klara's house	80	2,680	
Auromodele	Shanta & Ulrich's house	?		
AVBC-Earth Unit	Unit Building	No		
Certitude	Arjun & Deepti house (Eco house)	Closed	?	
Fertile	Turya house	200		
Forecomers	Ed's house	No		
Gaia’s Garden	Kireet house	100	2,000	
Grace	Helmut house	?	?	
Mango Field	Individual house	No		
Petite ferme	Manfred's house	120	1,400	
Petite ferme	Dirk's house	14	2,250	
Siddhartha	Herbert's house	220	2,930	
Surya Nivas (Auromodel)	Individual house	No	?	
Transition	Super school	No		
Verite	Yoga hall	200	1,650	
Vikas	Collective housing	No		
NOTE: Many other places include rainwater harvesting techniques, but mostly under the form of field bunding and landscaping				