RAINWATER HARVESTING

GUIDELINES

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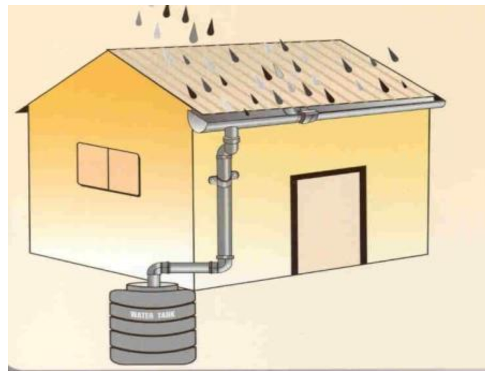
<u>Rainwater Harvesting Guidelines</u>

1 Introduction

1.1 What is Rain Water Harvesting?

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



Water harvesting means to understand the value of rain and to make optimum use of rain water at the place where it falls.
In general, water harvesting is the activity of direct collection of rain water. The rain water collected can be stored for direct use or can be recharged into the ground water.

1.2 Importance/Need of RWH

<u>NEED</u>

- To overcome the inadequacy of waters to meet our demands.
- To arrest decline in ground water levels.
- To enhance availability of ground water at specific place and time and utilize rain water for sustainable development.
- To increase infiltration of rain water in the subsoil which has decreased drastically in urban areas due to paving of open area
- To improve ground water quality by dilution
- To increase agriculture production.
- To improve ecology of the area by increase in vegetation cover, etc.

<u>ADVANTAGES</u>

- Cost of recharge to sub-surface reservoir is lower than surface reservoirs.

- The aquifer serves as distribution system also
- No land is wasted for storage purpose and no population displacement is involved
- Ground water is not directly exposed to evaporation and pollution
- Storing water underground is environment friendly
- It increases the productivity of aquifer
- It reduces flood hazards
- Effects rise in ground water levels
- Mitigates the effects of drought
- Reduces soil erosion

1.3 Where to install RWH structures

Rainwater harvesting structures can be installed anywhere. It includes:

- Individual homes
- Colonies
- Apartments
- Institutions
- Schools/colleges/universities
- Clubs
- Hospitals
- Industries
- Slums
- Everywhere……

The potential for rainwater harvesting is huge!!

2 Types of rain water harvesting system

Rainwater harvesting can be categorized in a number of different ways, the most important of which are according to the type of catchment used and second based on type of collection system.

Broadly there are two methods of rainwater harvesting system based on type of catchment:

(i) Roof top rainwater harvesting: It is a system of catching rainwater where it falls. In rooftop harvesting, the roof becomes the catchments, and the rainwater is collected from the roof of the house/building.

(ii) Surface runoff harvesting: In urban area rainwater flows away as surface runoff. This runoff could be caught and used for recharging aquifers by adopting appropriate methods.

For each type of catchment system different type of collection systems can be adopted. Rainwater harvesting system based on type of collection systems are:

(i) Storage : Harvested rain water can be stored in tanks or lakes and can be used for direct consumption

(ii) Storage and groundwater recharge: In this method rainwater is first stored in tanks or other system and surplus water is conveyed to recharge groundwater. Recharged groundwater can be used for consumption at later stage with handpumps or tubewells.

(iii) Groundwater recharge only: In this method collected rainwater is directly conveyed to recharge groundwater without making any storage provision. Eg: groundwater recharge through storm water drains or conveying water from road run-off to recharge pits.

Rainwater Harvesting Systems

Types of Catchments

Types of collection system

Storage

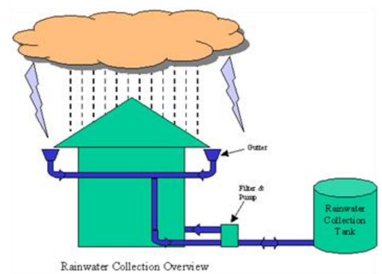
for direct Consumption

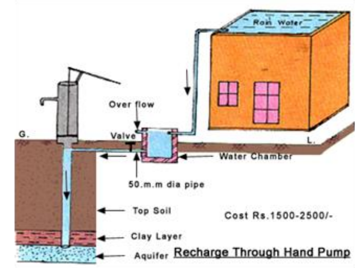
Storage with Groundwater Recharge

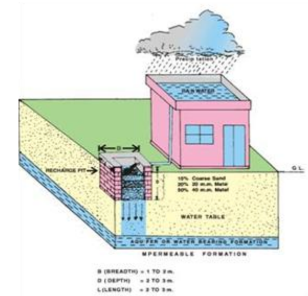
surplus water is recharge into ground and withdrawal with handpump / borewell for usage later

Groundwater Recharge only

Roof Top Rainwater harvesting







Surface run-off Rainwater Harvesting

(open spaces, storm water, roads)

3 Technical details of Rainwater Harvesting system

3.1 Roof-top Rain water harvesting system:

Among various techniques of water harvesting, roof top rainwater harvesting needs special attention because of the following advantages:

a) Roof top rainwater harvesting is one of the appropriate options for augmenting ground water recharge/ storage in urban areas where natural recharge is considerably reduced due to increased urban activities.
b) Rainwater runoff which otherwise flows through sewers and storm drains and is wasted, can be harvested and utilized.
c) Rainwater is bacteriological safe, free from organic matter.
d) It helps in reducing the frequent drainage congestion and flooding during heavy rains in urban areas where availability of open surfaces is limited and surface runoff is quite high.
e) It improves the quality of ground water through dilution.
f) The harnessed rainwater can be utilized at the time of need.
g) The structures required for harvesting rainwater are simple, economical and eco-friendly.
h) Roof catchments are relatively cleaner and free from contamination compared to the ground level catchments.
i) Losses from roof catchments are much less when compared to other catchments.

Collection of rainwater from roof tops for domestic needs is popular in some parts of India. The simplest method of roof top rainwater harvesting is the collection of rainwater in a large pot/vessel kept beneath the edge of the roof. The water thus collected can meet the immediate domestic needs. Tanks made of iron sheets, cement or bricks can also be used for storing water. In this method, water is collected from roofs using drain pipes/gutters fixed to roof edge.

Though the practice of roof top rainwater harvesting is an age-old one, systematic collection and storage of water to meet the drinking water needs has become popular only recently. The popularity of this practice is limited by the costs involved in collection of water by gutters/pipes and its storage in underground tanks made of iron or brick. Use of Ferro-cement technology in construction and maintenance of storage tanks has become popular in recent years as the strength and durability of ferro- cement structures have been found to make the schemes cost-effective.

Rainwater harvesting practices vary widely in size, type of construction material used and methods of collection and storage. Easy availability of know-how on systematic and economic methods of construction will encourage the user households to adopt this practice. There is also a need for creating awareness and for development of simple techniques of construction/fabrication of the components of rainwater harvesting system for popularising this technique as a potential alternative source of drinking water, at least for part of the year.

Design considerations for Roof-top Rain water harvesting:

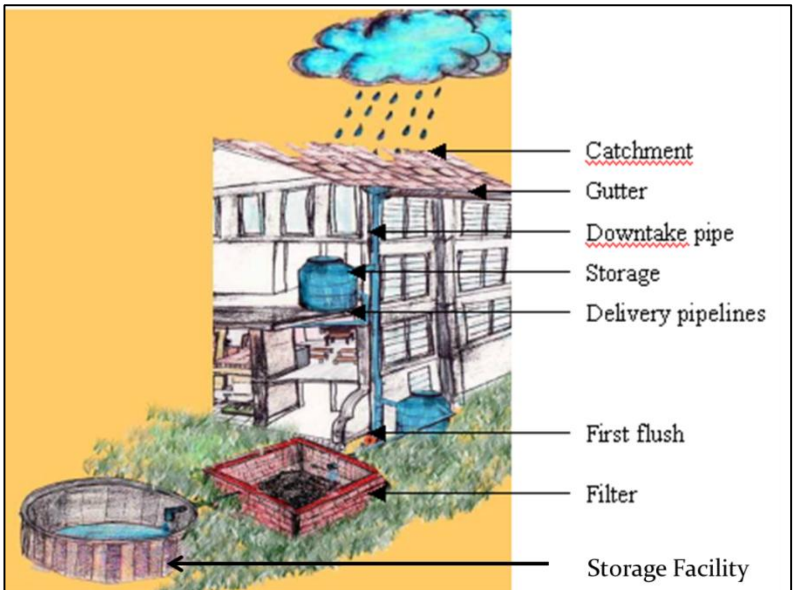
- The material of the catchment surfaces must be non-toxic and not contain substances which impair water quality.
- Roof surfaces should be smooth, hard and dense since they are easy to clean and are less likely to be damaged and shed materials into water
- Precautions are required to prevent the entry of contaminants into the storage tanks.
    - No overhanging tree should be left near the roof
    - The nesting of the birds on the roof should be prevented
    - A first flush bypass such as detachable downpipe should be installed
- All gutter ends should be fitted with a wire mesh screen to keep out leaves, etc.
- The storage tank should have a tight-fitting roof that excludes light, a manhole cover and a flushing pipe at the base of the tank.
- The design of the tank should allow for thorough scrubbing of the inner walls and floor or tank bottom. A sloped bottom and a provision of a sump and a drain are useful for collection and discharge of settled grit and sediment.
- Taps/faucets should be installed at 10 cm above the base of the tank as this allows any debris entering the tank to settle on the bottom where it remains undisturbed, will not affect the quality of water.

Components of Roof Top Rainwater Harvesting System

In a typical domestic roof top rainwater harvesting system, rainwater from the roof is collected in a storage vessel or tank for use during periods of scarcity. Such systems are usually designed to support the drinking and cooking needs of the family and comprise a roof, a storage tank and guttering to transport the water from the roof to the storage tank. In addition, a first flush system to divert the dirty water, which contains debris, collected on the roof during non-rainy periods and a filter unit to remove debris and contaminants before water enters the storage tank are also provided. Therefore, a typical

Roof top Rainwater Harvesting System comprises following components:

1. Catchment
2. Transportation : Conveyance system and gutter
3. First flush
4. Filter
5. Storage facility



Source of picture- http://schools.indiawaterportal.org/principals/rwh

1. **<u>Roof Catchment:</u>** The surface that receives rainfall directly is the catchment. Sloping roof or flat roof. A roof made of reinforced cement concrete (RCC), galvanised iron or corrugated sheets can also be used for water harvesting. Coarse mesh at the roof to prevent the passage of debris. Since rainwater is pure as it falls from the sky it is necessary that the roof be kept clean for it to remain pure when it is collected. This means the roof will need to be swept and cleaned daily during the rainy season.
2. **<u>Transportation -Conveyance system and gutter:</u>** Channels all around the edge of a sloping roof to collect and transport rainwater to the storage tank. Gutters can be semi-circular or rectangular and could be made using:
    a. Locally available material such as plain galvanised iron sheet (20 to 22 gauge), folded to required shapes.
    b. Semi-circular gutters of PVC material can be readily prepared by cutting those pipes into two equal semi-circular channels.
    c. Bamboo or betel trunks cut vertically in half.

The size of the gutter should be according to the flow during the highest intensity rain. It is advisable to make them 10 to 15 per cent oversize.
Gutters need to be supported so they do not sag or fall off when loaded with water. The

way in which gutters are fixed depends on the construction of the house; it is possible to fix iron or timber brackets into the walls, but for houses having wider eaves, some method of attachment to the rafters is necessary.

Conduits

Conduits are pipelines or drains that carry rainwater from the catchment or rooftop area to the harvesting system. Conduits can be of any material like polyvinyl chloride (PVC) or galvanized iron (GI), materials that are commonly available.

The following table gives an idea about the diameter of pipe required for draining out rainwater based on rainfall intensity and roof area:

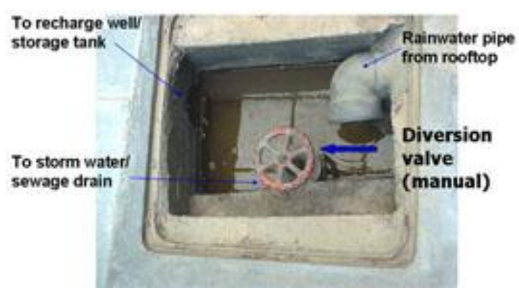
Sizing of rainwater pipe for roof drainage

Diameter Of pipe (mm)	Average rate of rainfall in mm/h					
	50	**75**	**100**	**125**	**150**	**200**
50	13.4	8.9	6.6	5.3	4.4	3.3
65	24.1	16.0	12.0	9.6	8.0	6.0
75	40.8	27.0	20.4	16.3	13.6	10.2
100	85.4	57.0	42.7	34.2	28.5	21.3
125	-	-	80.5	64.3	53.5	40.0
150	-	-	-	-	83.6	62.7

mm/ h - millimeters per hour; m - meters

Source: National Building Code

3. **<u>First flush:</u>** A first flush device is a valve that ensures that runoff from the first spell of rain is flushed out and does not enter the system. This needs to be done since the first spell of rain carries a relatively larger amount of pollutants from the air and catchment surface.



4. **<u>Filter:</u>** The filter is used to remove suspended pollutants from rainwater collected over roof. A filter unit is a chamber filled with filtering media such as fibre, coarse sand and gravel layers to remove debris and dirt from water before it enters the

storage tank or recharge structure. Charcoal can be added for additional filtration.

Selection of a filter depends on followings:

1. Type of catchment
2. Amount of silt load
3. Quality of runoff
4. Purpose of storage
5. Type of recharge structure

(i) Cloth filter: The simplest form of filter is a piece of fine cloth which is even now used in areas like the north-east where they collect rainwater directly form the roof into storage tanks. It is also known as saari filter in Gujarat where people use a piece of saari filter (attire worn by Indian women) or dhoti filter (attire worn by Indian men).

(ii) Charcoal water filter: A simple charcoal filter can be made in a drum or an earthen pot. The filter is made of gravel, sand and charcoal, all of which are easily available.

(iii) Sand filters: Sand filters have commonly available sand as filter media. Sand filters are easy and inexpensive to construct. These filters can be employed for treatment of water to effectively remove turbidity (suspended particles like silt and clay), colour and microorganisms.

(iv) Inverted sand filter: It can filter medium to coarse sized sand & silt particles, other floating debris along with bacterial contamination to limited extent.

(v) Dewas filters: Most residents in Dewas, Madhya Pradesh, have wells in their houses. Formerly, all that those wells would do was extract groundwater. But then, the district administration of Dewas initiated a groundwater recharge scheme. The rooftop water was collected and allowed to pass through a filter system called the Dewas fillter, designed by Mohan Rao, district collecter of Dewas and engineers of the rural engineering services. The water thus filtered is put into the service tubewell.

(vi) Desilting chambers- Very effective & essential for runoff from unpaved and paved areas or from storm water drains carrying huge amount of silt, tree leaves and other debris

(vii) Weave wire filter: It is made up of stainless steel and also of rigid PVC. It can filter out suspended solids coming with runoff. This type of filter is incapable for filtering any bacteriological contaminants if presents. The degree of filtration is 100- 200 microns and capacity ranges between 5000- 45000 litres / hour. Therefore it can be used in the systems where rainwater is harvested for non potable purpose only.

(viii) Pop up filter: Mr Shiva Kumar of Bangalore developed this design. The filtration is the nylon sieve (60 mm dia) inserted inside rainwater pipe to arrest coarse particles. The advantage with this filter is that whenever the filter gets clogged, it comes out of the casing and easy to maintain.

5. **Storage facility:** The rainwater storage tank collects all the filtered rainwater and keeps it for future use. The storage tank is made above the ground and on a platform. It can also be an underground sump.

   Generally, Two basic types of storage system:
   - Underground tank or storage vessel
   - Ground tank or storage vessel

   A variety of materials and different shapes of the vessels are available for the storage of rainwater. The choice of the system will depend on several technical and economic considerations like, space availability, materials and skill available, costs of buying a new tank or construction on site, ground conditions, local traditions for water storage etc.

3.2 Surface run-off Rain water harvesting system

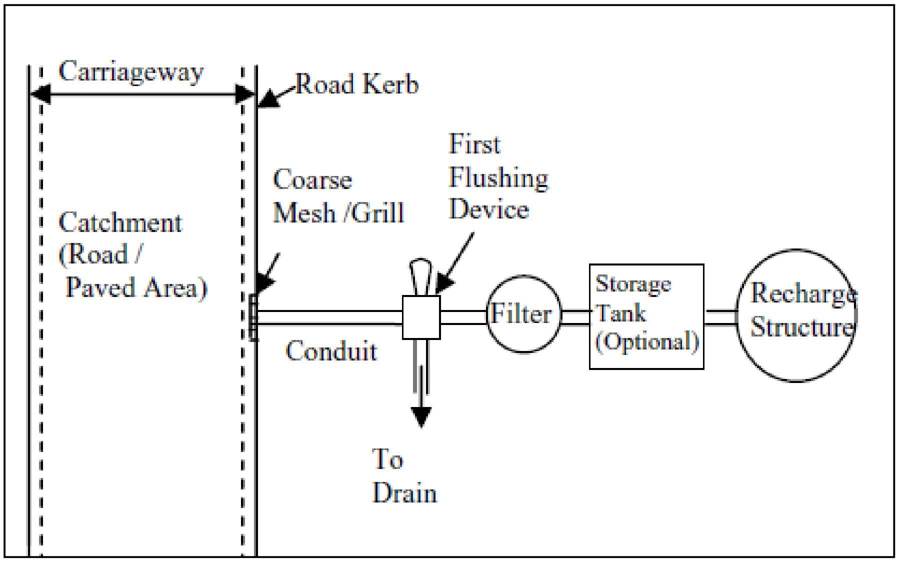
Surface run-off rain water harvesting system is also sometimes called as stormwater harvesting. Stormwater is generally harvested from roads, parks, garden, parking spaces, etc.

Rainwater Harvesting from Roads:

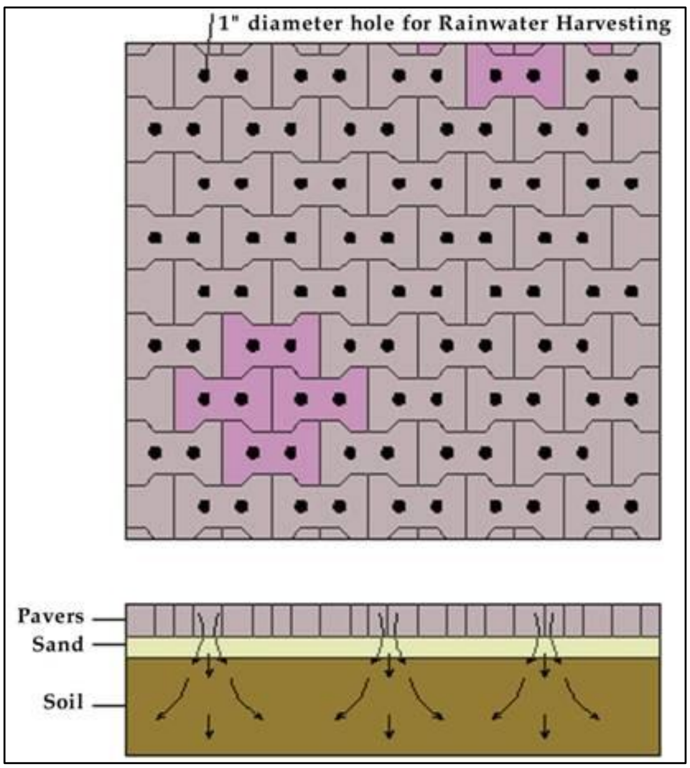
In the recent past, rapid growth in the urban areas has led to asphalted roads and stone slabs or pavers for footpaths. Consequent to this, the rainwater run-off has increased and ground water recharge has declined. As the roads are built sloped towards the sides, rainwater falling on the road is guided to the side drains. When it rains, water flows from the apex to the sides and collects in the sidewalk area and subsequently flows to the storm water drains.

Storage facility in the system may not be provided if stored water is not needed for immediate use. The filter unit and recharge structure may sometimes be combined depending upon the quantity of run-off and the availability of the space. A rainwater harvesting system for an urban road is shown in Figure below. In this case, an open unlined channel is used as conduit. The coarse mesh / grill to arrest the debris is installed at the inlet of the recharge structure. The first flushing device and the storage tank are optional. The filter unit may also be combined with the recharge structure.

Rainwater harvesting system for urban roads:



To increase ground water recharge by percolation and decrease the flooding of storm water drains, an infiltration trench could be built by the side of the drain all along the road, wherever possible. The infiltration trench can be 2 feet wide and 2 feet deep and filled with pebbles or aggregates with a top layer of coarse river sand.



As the rainwater from the road flows into the infiltration trench, water percolates into the ground. During heavy rainfall, excess water spills over to the storm water drains. The infiltration trenches store water temporarily during rainfall and later for infiltration. These infiltration trenches may be exposed as walk ways or paved with inter-locking pavers, specially designed with gaps in between for water to flow into the infiltration trenches.

Rainwater Harvesting from Parks and Open Spaces:

Water harvesting methods in parks and open spaces involve micro-watershed management methods that allow rainwater infiltration and percolation into the ground. The runoff has to be minimized by providing adequate number of percolation pits and dispersion trenches. In large parks, storage of rainwater in small ponds is also possible since the ponds can be integrated with the landscape of the park. Mapping of the contours, planning for rainwater outflow in consonance with natural drainage patterns, identifying appropriate areas for percolation pits / dispersion trenches will be required.

Recharge of pits or trenches : Ground water recharge in parks can be enhanced by a simple technique of providing recharge pits or a trench.

- Width of pit: 1.2 to 1.5 m. Depth: 2.5 to 3.0 m.
- Material: 40-60 mm coarse gravel followed by 20 mm aggregates and 2 mm sand. Pits are conveniently made at suitable low-level micro-watershed locations as collection centers of surface runoff.
- A splash pad is provided on top of the sand layer to cut off the velocity of entry of water to the pit.
- The number of such pits is based on the park area and the small rivulets dissecting the landscapes into micro-watersheds.

Requirements

- Creation of water harvesting ponds in concave depression and low-lying areas.
- Allowing groundwater recharge by the creation of seepage pits.
- Allowing surface runoff to enter into existing wells or artificial water bodies.

Natural flow of water :

Surface runoff water should be trapped in ponds, tanks and lakes when available, so that it can be used for maintenance during dry periods. This practice is similar to dry land technology of agricultural belts. Low-lying areas and drainage channels are earmarked and convenient micro-watersheds are prepared. Water harvesting is followed based on natural flow and surface accumulation of the runoff water. Water follows the lowest contour gradient available for that area. These structures not only provide water for the park, but also increase groundwater recharge. Providing a bore well in these areas will enhance the availability of water in its vicinity. Rainwater run-off from open space and paved areas can be stored in underground sumps by filtering through sand-bed filters and guiding the filtered water through channels.

3.3 Storage Units

Types of storage system:

The storage tanks are provided if the water is intended to be stored for ready use. There are various options available for the construction of these tanks with respect to the shape, size and the material of construction.

Shape: Cylindrical, rectangular and square.

Material of construction: Reinforced cement concrete, ferrocement, masonry, plastic (polyethylene) or metal (galvanised iron) sheets are commonly used.

Comparison of different storage tank materials				
	Brick	**RCC**	**Ferro cement**	**Plastic**
Durability **Water tightness**	Durable Prone to leaks	Durable Less resistant than ferro cement and plastic	Durable Excellent	Durable Very good but leaks can occur near outlet pipe
Cost	Cheap	Between ferro cement and plastic	Cheap	Expensive

Comparison of different storage tank materials				
	Brick	**RCC**	**Ferro cement**	**Plastic**
Above or below ground	Above ground	Above of below ground	Above or below ground (above ground preferred)	Above ground
Installation time and ease of installation	Minimal construction skills required; takes a little time since curing is required	Construction skills required and long curing time required	Construction skills required and time required is between that of brick and RCC	Easiest to install and takes least time
Material and labour availability	Easy -locally available	Easy -locally available	Easy -locally available	Easy -locally available
Tensile strength to weight ratio	Law and a thick wall is therefore neded	High	Very high	High
Affected by weather conditions	Not affected	Not affected	May be affected in dry areas	Not affected
Shape	Suitable only for cuboid	Cylindrical	Different shapes possible, but cylindrical is best	Specific shapes available

Position of tank: Depending upon space availability and the level of the catchment surface, these tanks could be constructed above ground, partly underground or fully underground.

Comparison of different storage tank positioning		
Position	**Advantages**	**Disadvantages**

Comparison of different storage tank positioning		
Position	**Advantages**	**Disadvantages**
Above ground	• Tanks can be bought off-the-shelf • Easy to install and takes lesser time if bought off-the-shelf • Easy to inspect • Ground-level contaminants cannot enter the tank • Pumping systems may not be required and gravity flow can be used for water distribution	• Generally more expensive • Can affect the aesthetics of the building • Space taken up by the tank cannot be used for any other purpose • It is usually not recommended if the storage volumes are very high • Cannot be used to capture rainwater from ground catchments • Cover can be easily removed and cases of the cover being damaged during rough weather have been reported
Below ground	• Generally cheaper than above-ground storage tanks • Water cannot leak out through an open tap • Does not affect the aesthetics of the building and the space above the tank can be utilized for other purposes • Most suited for large volume storage tanks (10000 liters and above)	• Construction is the time consuming • Can affect the foundation of the building if constructed very close to the building if constructed very close to the building • Pumping system required to take out the water •Not easy to detect or repair leaks •Cannot be drained easily and hence cleaning is a problem •More prone to contamination •If the rank or manhole is left uncovered, it can be a safety hazard •The tank can be damaged by tree roots. If not constructed properly, the pressure exerted by the earth can also cause damage to the tank •Heavy vehicles cannot be driven over the tank, since the exerted pressures can cause damage
Partially above the ground	• Generally cheaper than above-ground storage tanks • Water cannot leak out through an open tap •Affects the aesthetics of the building minimally and portion of the tank that is above the ground can be camouflaged easily and used for other purposes	• Construction is time consuming • Pumping system required to take out the water •Not easy to detect or repair leaks • Cannot be drained easily and hence, cleaning is a problem • The tank can be damaged by tree roots if not constructed properly, the pressure exerted by the earth can also cause damage to the tank

Some maintenance measures like cleaning and disinfection are required to ensure the quality of water stored in the container.

Design of storage tanks:

The volume of the storage tank can be determined by the following factors:

1. Number of persons in the household: The greater the number of persons, the greater the storage capacity required to achieve the same efficiency of fewer people under the same roof area.

2. Per capita water requirement: This varies from household to household based on habits and also from season to season. Consumption rate has an impact on the storage systems design as well as the duration to which stored rainwater can last.

3. Average annual rainfall

4. Period of water scarcity: Apart from the total rainfall, the pattern of rainfall -whether evenly distributed through the year or concentrated in certain periods will determine the storage requirement. The more distributed the pattern, the lesser the size.

5. Type and size of the catchment: Type of roofing material determines the selection of the runoff coefficient for designs. Size could be assessed by measuring the area covered by the catchment i.e., the length and horizontal width. Larger the catchment, larger the size of the required cistern (tank).

Dry season demand versus supply approach

In this approach there are three options for determining the volume of storage:

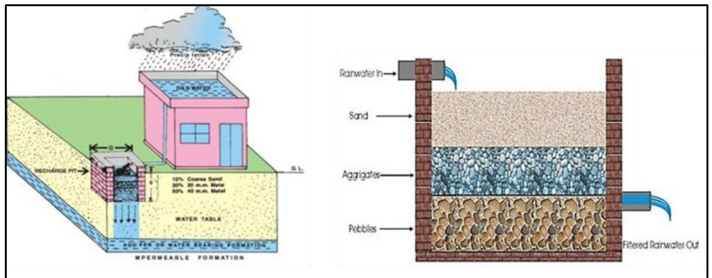
1. Matching the capacity of the tank to the area of the roof
2. Matching the capacity of the tank to the quantity of water required by its users
3. Choosing a tank size that is appropriate in terms of costs, resources and construction methods

In practice the costs, resources and the construction methods tend to limit the tanks to smaller capacities than would otherwise be justified by roof areas or likely needs of consumers. For this reason elaborate calculations aimed at matching tank capacity to roof area is usually unnecessary. However a simplified calculation based on the following factors can give a rough idea of the potential for rainwater collection.

3.4 Recharge units

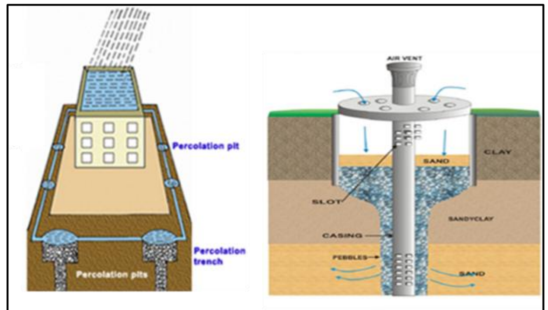
Rainwater may be charged into the groundwater aquifers for withdrawal later. Various recharge structures are possible - some which permit the percolation of water through soil strata at shallower depth (e.g., recharge trenches, recharge pits and permeable pavements) whereas others conduct water to greater depths from where it joins the groundwater (e.g. recharge wells: dug wells and bore wells). At many locations, existing structures like wells, pits and tanks can be modified as recharge structures. Here are a few commonly used recharging methods:

Recharge pits: A recharge pit is 1.5m to 3m wide and 2m to 3m deep. The excavated pit is lined with a brick/stone wall with openings (weep-holes) at regular intervals. The top area of the pit can be covered with a perforated cover.



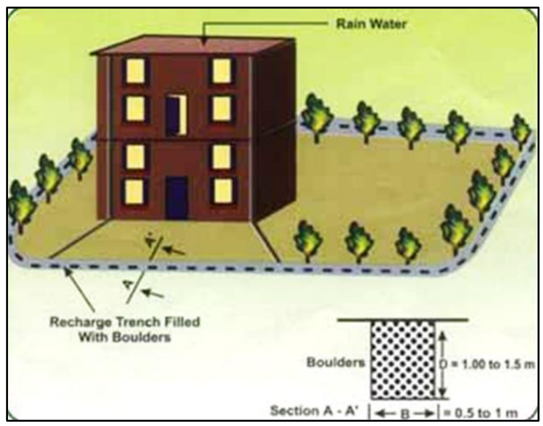
Details of Recharge pit

Percolation pits: Percolation pits, one of the easiest and most effective means of harvesting rainwater, are generally not more than 60 x 60 x 60 cm pits, filled with pebbles or brick jelly and river sand, covered with perforated concrete slabs wherever necessary.



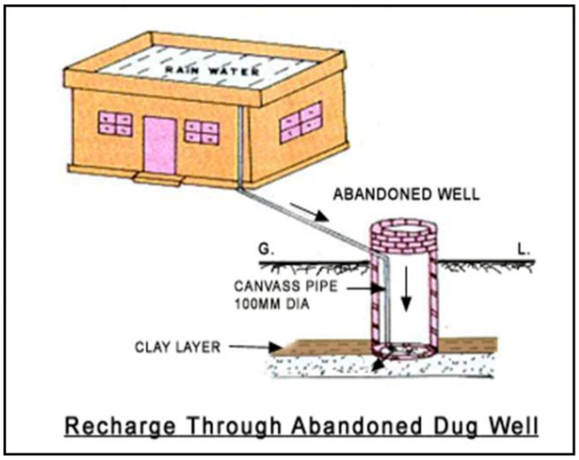
Details of Percolation pit

Recharge trenches: A recharge trench is a continuous trench excavated in the ground and refilled with porous media like pebbles, boulders or broken. bricks. A recharge trench can be 0.5 m to 1 m wide and 1 m to 1.5 m deep. The length of the recharge trench is decided as per the quantity of runoff expected. The recharge trench should be periodically cleaned of accumulated debris to maintain the intake capacity.

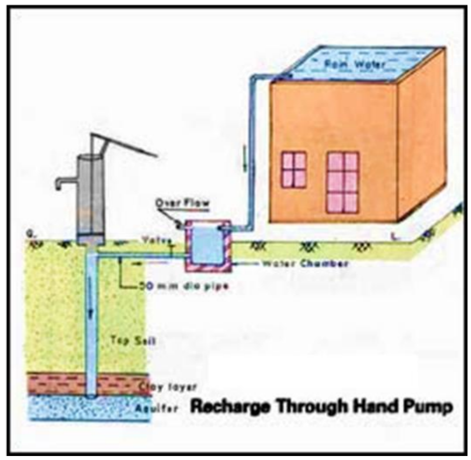


Recharge troughs: To collect the runoff from paved or unpaved areas of a compound, recharge troughs are commonly placed at the entrance of a residential / institutional complex. These structures are similar to recharge trenches except for the fact that the excavated portion is not filled with filter materials. In order to facilitate speedy recharge, boreholes are drilled at regular intervals in this trench. This structure is capable of harvesting only a limited amount of runoff because of the limitation with regard to size.

Recharging of dugwells and abandoned tubewells: Rainwater that is collected on the catchment is diverted by drain pipes to a settlement or filtration tank, from which it flows into the recharge well (borewell or dugwell). If a tubewell is used for recharging, then the casing (outer pipe) should preferably be a slotted or perforated pipe so that more surface area is available for the water to percolate. Developing a borewell would increase its recharging capacity (developing is the process where water or air is forced into the well under pressure to loosen the soil strata surrounding the bore to make it more permeable). If a dugwell is used for recharge, the well lining should have openings (weep-holes) at regular intervals to allow seepage of water through the sides. Dug wells should be covered to prevent mosquito breeding and entry of leaves and debris. The bottom of recharge wells should be desilted annually to maintain the intake capacity.

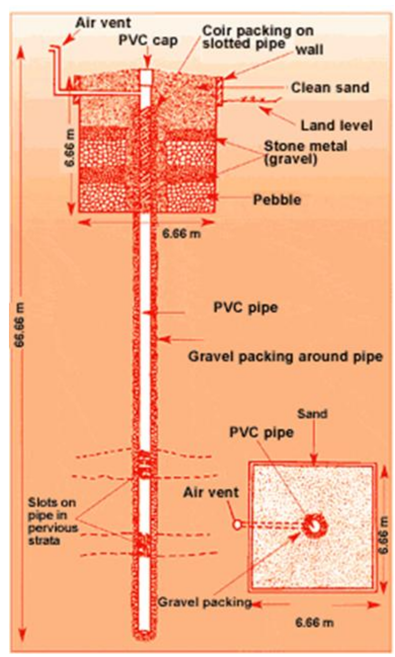


Recharge Through Abandoned Dug Well



Recharge Through Hand Pump

Recharging through tubewells: In this case the catchment runoff is not directly led into the service tubewells, to avoid chances of contamination of groundwater. Instead rainwater is collected in a recharge well, which is a temporary storage tank (located near the service tubewell), with a borehole, which is shallower than the water table. This borehole has to be provided with a casing pipe to prevent the caving in soil, if the stratum is loose. A filter chamber comprising of sand, gravel and boulders is provided to arrest the impurities.



Modified injection well: In this method water is not pumped into the aquifer but allowed to percolate through a filter bed, which comprises sand and gravel. A modified injection well is generally a borehole, 500 mm diameter, which is drilled to the desired depth depending upon the geological conditions, preferably 2 to 3 m below the water table in the area. Inside this hole a slotted casing pipe of 200 mm diameter is inserted. The annular space between the borehole and the pipe is filled with gravel and developed with a compressor till it gives clear water. To stop the suspended solids from entering the recharge tubewell, a filter mechanism is provided at the top.

3.5 Maintenance of Rainwater Harvesting systems

Parts	Maintenance	Frequency
Roof	Wash off roof with water when dust/dirt accumulated diverting run-off away from tank inlet.	Monthly and especially after a long period of dry weather or heavy wind.
	Sweep off leaf litter	Regularly, especially after heavy winds and just before the rains set in, Check daily for leaf litter accumulation during rainy season
	Trim and cut trees around roof	When required
	Fix damage to roof (broken tiles, cracked water-proofing , etc.)	At the earliest and definitely before the rainy season
	Paint if rust is present using lead-free paint	At the earliest and definitely before the rainy season
Gutter and downtake pipe	Clean and wash out bird droppings, leaves, etc., with water	Check monthly and especially after a long period of dry weather or heavy wind. Check daily during rainy season
	Check and repair gutter and downtake pipes	When required
	Ensure guttering /downtake pipes are sloped to ensure steady flow and avoid pooling of water, collection of dirt, debris, etc.	During installation and after periods of heavy rain
	Repairs leaks at elbows	When Required
Filters First-flush devices	Clean	Before and after rainy season
	Check and clean	Before and after the rainy season and after every rooftop cleaning session

Tank	Clean	Before and after rainy season
	Repair leaks	At the earliest
	Cut nearby tree roots(if underground tank)	At the earliest
	Ensure lid is sturdy and secure	At all times
	Ensure there are no gaps where insects can enter or exit	At all times
	Securely fasten insect screen over the end of the overflow pipe/valve	At all times

4 Case studies for Rain water harvesting systems

Reviewing successful case studies help to understand how rain water harvesting system is implemented in other cities and its overall impact in urban areas. Cases are selected to demonstrate different features of rainwater harvesting system like roof top and surface run-off, city level and society level, Indian and international cases.

4.1 Bangalore city level RWH

- **BWSSB Amended Act** by adding para 72-A vide Gazette notification 2009 making "RWH mandatory" for all buildings
- **Regulations framed under the Act,**
  - providing specifications and
  - amplifying on the objectives of the RWH
- **Specifications evolved were simple and easy to follow**

  - **Storage or recharge** to be created for
    - Roof area - 20 litres per square metre
    - Paved area -10 litres per square metre

  - Recharge well to be a minimum depth of 3 metres
- Mass awareness program was taken up: Awareness among school children, TV Programs & Radio Programs conducted, RWH system initiated on all Govt. and BWSSB Buildings including Residences of CM and other dignitaries
- **Training Programs** were arranged: Training program conducted for Plumbers/Contractors
- Logistical Support & creation of Helpdesk
- **Rainwater Harvesting Theme Park**
- **Impact**: Citizens have recognized and understood the value of RWH systems for meeting their needs; which will reduces dependency on BWSSB and conventional sources of water and Residents have put in their monies to harvest rainwater, thus creating a sense of ownership. It will also ensure that they would take care of their systems
- **Uniqueness of BWSSB's RWH:** Technical specifications, simple regulations, Legislative support, Theme park, first of its kind, People involvement and Integrated, cohesive system, easy to understand

Residential colony Case study: A residential colony in Bangalore of about 4 square kilometres has managed to put in place a decentralized water management system incorporating rainwater harvesting more by serendipity than by design. Two small tanks Narasipura 1 and Narasipura 2 collect rainwater and act as percolation tanks to recharge the aquifer. About 15 bore-wells then supply water to the colony of about 2000 houses. Sewage discharged from each house is collected and treated both physically and biologically through an artificial wetland system and led into Narasipura 2. The loop of water supply and sewage treatment is completed within a small geographical area, in an ecologically and economically appropriate manner.

4.2 Chennai city level RWH

- First State in the country to have 100% coverage in Rain Water Harvesting
- The Challenge Of Recurring Droughts in Chennai; In May 2002 – State Govt.,
    - Call for Roof top Rain Water Harvesting
    - Provision of RWH structures is mandatory for availing new Water/Sewer Connections
    - Amendments made in the Ground water Regulations Act / Building Rules for implementing rainwater harvesting
    - Ordinance issued by the Govt. of Tamil Nadu on 19.07.2003 making it mandatory for all buildings in the state to have Rain Water Harvesting structures by 31.08.2003.
- Intensive IEC Campaign : Establishment of Rain Centre, Organization of Seminars/ Workshop, Massive rallies and Human Chains, Advertisement through Papers / Dailies, Booklets / Pamphlets, Posters and Wall Paintings, Door to Door campaign
- People participation- Involvement of NSS students of all college students, Centre for science and Environment, National Rainwater Harvesters' Network, Exnora International, Resident's Welfare Associations, Rotary International
- Rain water harvesting helped in Chennai flood mitigation

- Role of Government / Local in providing Legislative framework: Reward & punitive action, Dissemination of information, Promotion of State's intent in achieving sustainability both in monetary as well as environmental terms in the provision of drinking water

4.3 Rainwater Harvesting in Presidential Estate, New Delhi, India

The Presidential Estate covers an area of 133 hectares (1.33 sq. km.). The water requirements of the presidential estate are huge since there are about 7,000 people residing in the estate. Approximately 3,000 people visit the presidential premises everyday.The Mughal Gardens in the estate require a lot of water. The total demand is about 2 million litres of water per day (730 million litres per year). This demand is met through the New Delhi Municipal Corporation supply and the estate's own borewells.

Since about 35 per cent of the water requirements are being met through groundwater sources, there had been an alarming decline of groundwater levels in the estate. Levels have gone down by 2 to 7 m in the past decade, with one well running dry.

Measures taken for water harvesting

The rainwater endowment of the area is 811 millions litres annually. Estimated cost of installing the system is Rs. 20 lakh (work on some components of the system was still underway in May 2000). Following measure were planned for the estate:

a. Rainwater storage tank: Rainwater from the northern side of roof and paved areas surrounding Rashtrapati Bhavan is diverted to an underground storage tank of 1 lakh litre capacity for low quality use.

b. Well recharging: Overflow from the 1 lakh litre capacity rainwater storage tank mentioned above is diverted to two dugwells for recharging. Rainwater from the southern side of the roof is diverted for recharging a dry open well. Rainfall runoff from the staff residential area is also diverted to the dry well. Water passing into the recharge well is passed through a desilting tank to remove pollutants. The 9 lakh litre capacity swimming pool in the estate is planned to be connected to the dry dugwell, so that during periodic emptying of the pool, water can be used for recharging instead of being drained away.

c. Recharge shaft: 15 m deep recharge shafts will be constructed in the staff residential area. Rainwater available from rooftops, roads and parks will be used for recharging.

d. *Johad:* A *johad* is a crescent-shaped bund which is built across a sloping catchment to capture the surface runoff. Water accumulating in the *johad* percolates in the soil to augment the groundwater. *Johads*have traditionally been used in Rajasthan for harvesting water. A *johad* is planned to be constructed near the Mughal Gardens.

4.4 Delhi- Panchsheel Colony

When almost all the colonies and associations crib about water supply in summer, Panchsheel Cooperative Group Housing Society has set an example by funding a rainwater harvesting project and harvesting each drop of rain.

Panchsheel Success Story–Some Highlights

- Total rooftop and surface area: 3,57,150 sq.m.
- Total volume of rainwater harvested: 1,74,575 cubic metre (m3), or 174,575,000 litres (2002)
- This represents 80 per cent of the total water harvesting potential.
- Before implementing rainwater harvesting, the water level was around 28.6 m below ground level. The water level was 26.1 m in September 2002 and 27.6 m in May 2003. The water level in July 2003 after the monsoon was 27.3 m, representing a total rise of 0.7 m, or 2.29 feet.

The water-harvesting project covering all the plots in the colony involved Rs. 0.8 million (US $20,000) investment and the money was invested by the Society rather than asking for individual financial help. After registering the success for two consecutive years, now the Society is planning to spread awareness to ‘use less water’ in the locality, as the area is largely dependent on tube wells.

After the success of rainwater harvesting, the Society has made a detailed plan of the wastewater treatment project in the colony. The plan has been prepared in association with the Centre for Scientific and Industrial Research (CSIR) which will provide the bacteria to purify the water. As per the plan, initially the pilot project will have the capacity to treat about 20,000 litres per day and the project will involve not more than Rs. 0.1 million. The treated water will be used for irrigation purposes in the colony and major portion of it will also be used in the Society office and Panchsheel Club, including use in the flush. But the Society is planning to take it extensively after the initial success, which will include supplying the treated water to toilets of flats in the coming years. The residents will have to spend to get the water from the main pipe to their toilets. This project can set another example for other associations, as according to experts, the use of specially developed bacteria to purify the water will bring down the cost of wastewater treatment.

4.5 Mumbai Case Study

Sea Crown CHS, Charkop, Kandivali (W)

Water situation before RWH : The supply of water does not meet the demand. Thus the expense on BMC water tankers was Rs. 1 to 1.5 lakhs per month

Type of RWH system installed: Ring well cum rainwater harvesting system

Areas included for RWH: Roof tops and paved surface areas

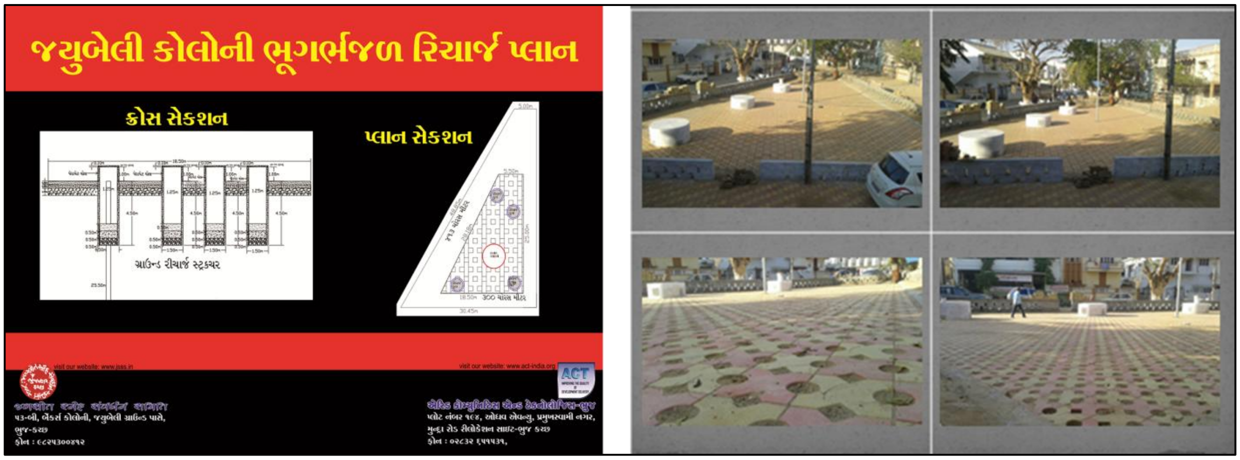
Water situation after implementation of RWH :24 hours water supply for non-potable purposes. Thus the BMC water is used for potable purposes only. The society no more calls for tankers to fulfil their water requirements.

Direct Monetary Benefits: A saving of Rs.1 to 1.5 lakhs per month that was earlier spent on tankers

4.6 Jubilee colony, Bhuj

Jubilee colony in Bhuj was facing problem water logging year after with loss of property and large damage. Many solutions were tried in society for avoiding water logging problem but none of them worked on it. Society members along with JSSS (Jalastrot Sneh Samvardhan Samiti), an community led group working on community-led water management, studied the flooding issues. The society was facing flooding issues because of increased in level of surrounding roads. The outlets that carried water through storm water drain towards Jeevanram Tank were blocked and any solution that required letting the water out of the colony was impossible to work. Solution decided was innovative, to increase the capacity of the ground to absorb the water, which would help the water to permeate in the ground. It could solve the problem of water logging on one hand and recharge ground water on the other. In future, it could help the members of the housing association during summer or whenever there is water scarcity.

The ground of two common plots in the colony was deepened and three recharge wells were dug up to 18’ to 20’ depth. They were filled in layers with big stones, jelly stones (gravel) and rough sand. In one of the wells, a recharge bore-well that went to 100’ depth was dug. This increased the water absorption capacity of the land and solved the problem of Jubilee colony.



4.7 Rainwater harvesting at Fankfurt airport, Germany

In 1992 and 1993, water emergency was declared in parts of the state of Hesse. Groundwater levels in the urban areas of Frankfurt fell so low that plants started dying. Lakes and rivers fell dry. Public water supply in Germany is heavily dependent on groundwater reserves. Most rainwater, mainly from roofs and paved surfaces, flows into the sewer.

Municipalities have developed a tax system to promote rainwater harvesting. Residents are charged separately on the basis of paved and sealed areas in their houses, such as backyards and drive-ins. A tax inspector measures the paved area roof area to calculate the amount of run-off it will generate. Tax is levied according to this. Since July 1992, there is a levy of DM 1 (us $0.58 at present rates) per cubic metre of freshwater flowing into the sewer. The funds are used to protect groundwater resources. Residents who have set up a system to catch rainwater or have left the above-mentioned areas unpaved are exempted from the tax. This is a monetary incentive to popularise rainwater harvesting.

The Frankfurt airport system is biggest in Germany as case of rain water harvesting system and helps to save approximately 1,00,000 cum of water per year. The cost of the system is 1.5 million dm (us$63000) in the year 1993. The combination of huge catchment areas and simple technology has worked wonders. A system of rainwater harvesting was installed with an expectation of handling 13 million people every year, the system collects water from roofs of the new terminal which has an area of 26,800 square meters. The water is collected in the basement of the airport where six tanks have been put up, with a storage capacity of 100 cubic meters (cu m), the water is mainly used for toilet flushing, watering plants and cleaning the air conditioning system with refined river water. Rainwater is being harvested at two huge complexes in Germany.

4.8 The Thai Rainwater Jar Programme

Thailand's National Jar Programme, to supply of clean drinking water to rural areas, was launched in response to the United Nations' Water Supply and Sanitation Decade (1981-1990). The Program's objective was to promote the use of jars in rural households as a means of supplying clean drinking water. Nearly 10 million rainwater jars constructed in 5 years (1985-1990). Jar construction techniques are similar to ferrocement tank construction techniques.

- Factors favouring rapid development RWH programme are:
    - a real felt need for water
    - a preference for the taste of rainwater
    - the availability of cheap cement and skilled artisans
    - a pool of indigenous engineers, technicians and administrators committed to rural development programme

5 Rain Water Harvesting Potential of Bhuj

5.1 Rainwater Harvesting in Bhuj Context

Bhuj city is located in the arid region of Kachchh in Gujarat. Earlier centrally Located Hamirsar Lake was the main source of water for the people of Bhuj. The king at that time created the traditional water management system by linking lakes and wells. The entire water resource management system was designed to satisfy water demand of the city even in a drought year.

Bhuj is characterized by low and highly variable rainfall pattern. The average annual precipitation is 330 mm. But even in the years of low rainfall intensity is high with large amount of rainfall falling in short period of times. Hence most of water is wasted as runoff and very little is absorbed in the ground. Also concerting of roads and paved surface area have reduced water infiltration capacity, which is causing the problems of water logging during rainy season.

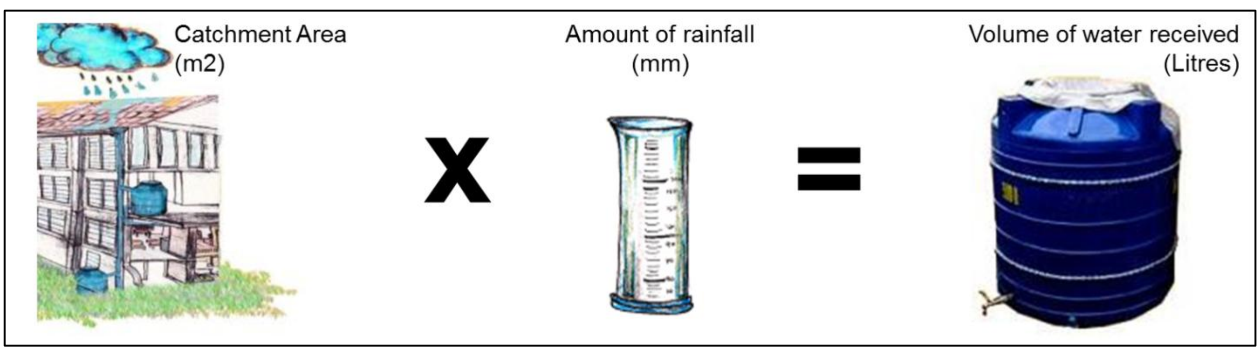
Therefore, there is a need for developing well designed water management system which would collect large amount of surface runoff rapidly and also help in recharging which would increase groundwater levels in Bhuj area.

There is also continuous extraction of ground water with rapid decline in groundwater quantity and quality. Lakes which were traditional sources of water supply are also disappearing.

In order to address above issues, there is a need, for adopting Rain Water Harvesting system in Bhuj.

5.2 Estimation of Rainwater Harvesting Potential in Bhuj

The estimation of quantity of water that can be harvested is the first step in planning and design of RWH systems. The quantity depends on the area of catchment and the annual average rainfall of the region.



5.2.1 City level Rain water harvesting potential

Total area of Bhuj is 56 sq km with annual average rainfall of 330 mm.

Total Area- 56 Sq Km (BHADA Area)

Habitat area- 18.28 Sq Km

Assuming only 50% of habitable area to be roofed and only 70% of water falling on it is collected.

Annual average rainfall of Bhuj- 330 mm

Therefore, Rain water Harvesting potential of Bhuj – 2111.3 ML

Considering 365 days, Rain water harvesting potential per day of Bhuj City is **5.78 MLD**, Which is 18.5% of present water supply.

5.2.2 Residential properties Rain water Harvesting Potential

There are total 30000 residential properties in Bhuj (As per PAS-SLB 2014-15 data).

Considering minimum roof area (A) : 150 Sq mt (Assumed by taking samples of residential properties roof size from google imagery)

Annual average rainfall of Bhuj (R)- 330 mm

Considering 70% of water falling on roof to be harvested

Therefore, Total Rain water harvested : A*R= 34,650 litres

Considering 365 days, rain water harvesting potential per day per household is **95** litres/day. So Total rainwater harvesting potential for all 30000 properties will be **2.85 MLD, which is 10.5% of present water supply.**

5.2.3 Commercial properties Rain water Harvesting Potential

Considering minimum roof area (A) : 250 Sq mt (Assumed by taking samples of commercial properties roof size from google imagery)

Annual average rainfall of Bhuj (R)- 330 mm

Considering 70% of water falling on roof to be harvested

Therefore, Total Rain water harvested : A*R= 57,750 litres

Considering 365 days, rain water harvesting potential per day per property is **158** litres/day.

If we assume that, out of total 11370 non-residential properties, 70% of properties is commercial and remaining 30% is institutional then, total commercial properties RWH potential would be **1.26 MLD.**

5.2.4 Institutional properties Rain water Harvesting Potential

There are large institutional properties in the Bhuj viz. Hospital, temple, universities, etc. This properties covered huge area and has tremendous potential of installing RWH within its campus area.

Considering minimum roof area (A) : 1950 Sq mt ((Assumed by taking samples of institutional properties roof size from google imagery)

Annual average rainfall of Bhuj (R)- 330 mm

Considering 70% of water falling on roof to be harvested

Therefore, Total Rain water harvested : A*R= 4,50,450 litres

Considering 365 days, rain water harvesting potential per day per property is **1230** litres/day.

If we assume that, out of total 11370 non-residential properties, 70% of properties is commercial and remaining 30% is institutional then, total institutional properties RWH potential would be **4.21 MLD.**

This is sizeable quantity as compared to present water supply. Thus, institutional properties should implement RWH within their campus and help city to be water secured and self-reliant.

5.2.5 Parks /Gardens Rain Water Harvesting Potential

In parks and gardens creation of ponds, tanks and shaft storage at low lying can be considered.

Total area in Bhuj under parks and gardens: 0.19 Sq Km

Annual average rainfall of Bhuj (R)- 330 mm

Considering 70% of water to be harvested

Therefore, Total Rain water harvested : A*R= 44 Million litres

Considering 365 days, rain water harvesting potential per day is **0.12** MLD.

Parks and gardens are abstracting huge quantity of groundwater for watering purpose and thus it should start harvesting rain water which would increase groundwater level.

6 Enabling Environment for implementing Rainwater Harvesting system

An enabling environment and governmental support are essential for spreading the concept and implementation of rainwater harvesting systems on a city level scale. Mainstreaming in policy agendas, facilitating regulations, awareness raising, capacity building and technical know-how are all important for enhancing the use of rainwater harvesting systems. It is also necessary to ensure sustainability of rain water harvesting movement. Following main measures can be taken

- **Regulations for Rain water Harvesting system:**

  In India under the constitutional set up, water is a state subject. In urban areas its governance rests with urban local bodies in their areas of jurisdiction as per the 74th constitutional amendment. The need for a policy framework and proper regulations amendment for rain water harvesting system arises mainly because the existing regulation is not very effective along with lack of implementation and monitoring mechanism.

  Based on this argument, review was carried out for rain water harvesting regulations in different cities (Details in Annexure-7.1). Following actions need to be adopted in order to implement RWH in Bhuj city.

  - Make appropriate provision and regulations for rainwater harvesting– based on review of DCRs from other cities.
  - Introduce tax incentives for stipulated timeframe to promote Roof rain water harvesting
  - Need to introduce rational tariff structure to promote RRWH
  - Introduce urban design/ landscape guideline to increase ground water recharge – Define ratio for unpaved area to total open area & Increase permeable surface area to recharge more water through appropriate selection of material

- **Set Up RWH Cell:**

  In order to make RWH effective, Bhuj Municipal council should Set up technical cell at ULB level for Capacity building and sensitize ULB staff towards promotion of rain water harvesting system. The main objective for setting up the RWH Cell is to create awareness and to offer technical assistance to the residents and also to provide to the citizens 'cost effective solutions'. The RWH cell should undertake following points:

  - RWH Cell should have representatives from public, NGOs, Technical representatives, Development Authority

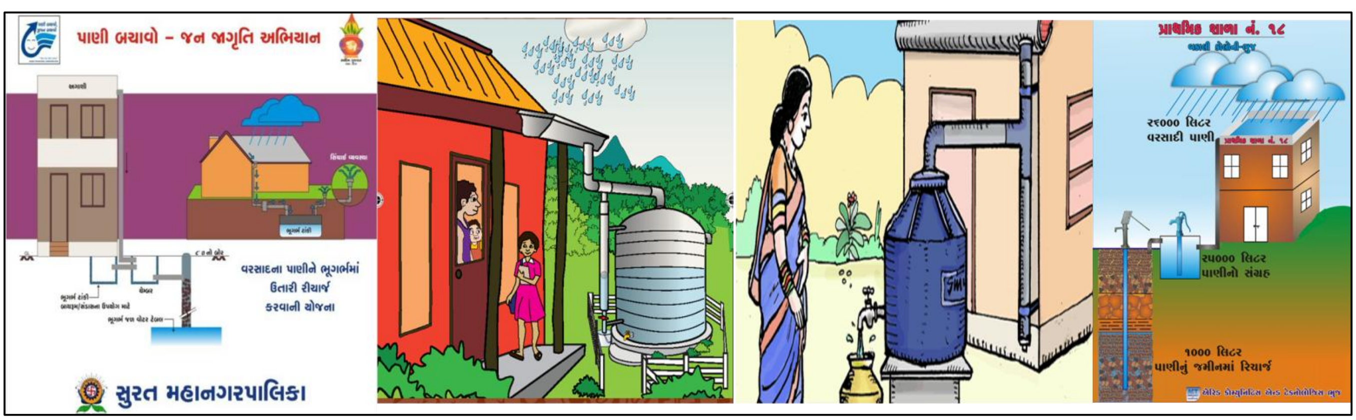
- Develop material for technical details of implementing RWH structures
- Provide RWH information on a website
- Host a list of Architects, Contractors, NGOs, etc. qualified in undertaking design and implementation of RWH structures.
- Plumber and contractor training programme on RWH component – Certification/ Empanelment of contractor and plumber for RWH
- Demonstration models for RWH implementation should be demonstrated in schools buildings, government buildings, etc.

- **IEC Campaign:**

  IEC is an important component in influencing public to adopt Rainwater Harvesting. As they are the direct beneficiaries of these structures, more information dissemination would be required to make them construct Rainwater structures. Public awareness and education are essential in order to improve acceptance of rainwater collection and utilization.

  Efforts should be made to change public perception of rainwater from being viewed as a nuisance to being viewed as an asset. IEC campaign in form of Organization of Seminars/ Workshop, Massive rallies and Human Chains, Advertisement through Papers / Dailies, Booklets / Pamphlets, Posters and Wall Paintings, Door to Door campaign (Chennai Model) need to be undertaken.

  - Vigorous IEC campaign should also be adopted to bring awareness among the public
  - Conduction of awareness programme with the coordination of Self Help Groups, Welfare Associations, NGO's and school children.
  - Erection of hoardings displaying the importance and benefits of the Rain Water Harvesting.
  - Door to Door campaign on Rainwater Harvesting with the participation of NGOs.



7 Annexures:

7.1 Rain water Harvesting Regulations as per DCR/building byelaws in different cities

1. Chennai

Water Conservation:

(1) Effective measures shall be taken within each premises for conservation of rainwater, and rainwater-harvesting structures at least to the following standards shall be provided; the same shall be shown in the plan applied for planning permission.

(a) Buildings of height up to Ground + 1 Floors: - Percolation pits of 30centimeter diameter and 3 metres depth may be made and filled with broken bricks (or pebbles) for 2.85 metres and the top covered with perforated Reinforced Concrete Cement (R.C.C.) slab. These percolation pits may be made at intervals of 3 metres center to center along the plinth boundary. The rain water collected in the open terrace may be collected through a 150 millimetre PVC Poly Vinyl Chloride Pipe laid on the ground and may be allowed to fall in the percolation pits or into a open well through a seepage filter of 60cm x 60 cm (filter media broken bricks) provided before the open well which will improve the ground water level. A dwarf wall of 7.5 centimeter height is built across the entry and exit gates to retain water and allow it to percolate within.

(b) Special Buildings, Group Developments, Multi-storeyed Buildings, Industries and Institutional Buildings: - There shall be a pebble bed of 1 metre width and 1.5 metre depth all round the building and filled with rounded pebbles of 5 centimetres to 7.5 centimetres size. The concrete paving around the building has to be sloped at about 1 in 20 towards the pebble bed, so that rain water from the terrace and side open spaces flow over this pavement and spread into the pebble bed around. Dwarf walls in masonry of 7.5 centimetres, height shall be constructed at the entrance and exit gates to retard rainwater collected into the compound from draining out to the road. Or

(c) Any one of the methods shown in the sketches annexed may also be adopted depending on to the conditions and type of development.

(2) Additional regulations for all buildings:

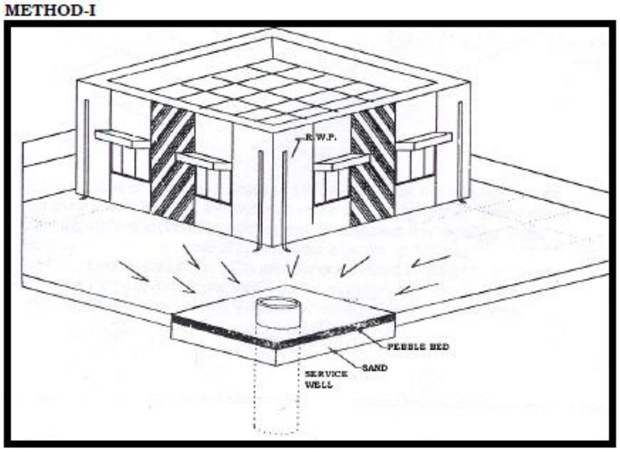
(a) In the ground floor, floor level of water closets shall be at least 0.9 metre above the road level to ensure free flow.

(b) All centrally air conditioned buildings shall have their own wastewater reclamation plant and use reclaimed wastewater for cooling purposes.

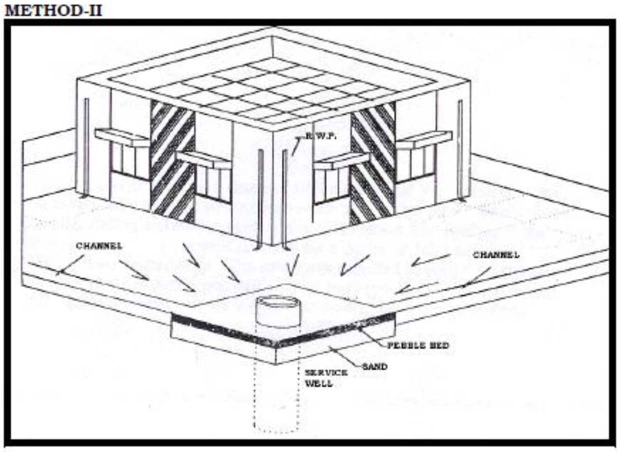
(c) A separate sump shall be constructed for storing potable water supplied by the Chennai Metropolitan Water Supply and Sewerage Board, the volume of sump not exceeding 1,000 litres per dwelling. This sump shall be independent of other tanks, which may be constructed for storing water obtained from other sources.

RAIN WATER HARVESTING METHODS

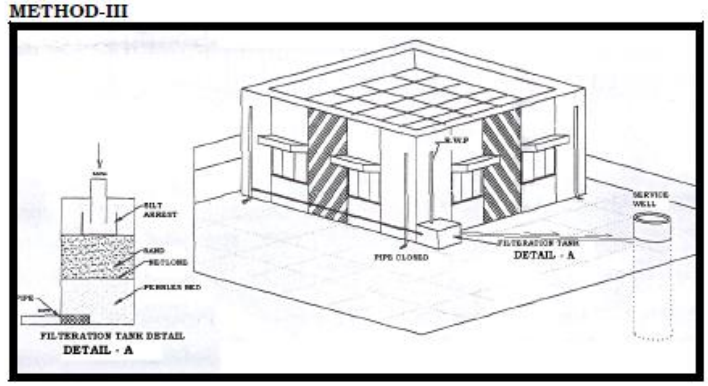
METHOD-I



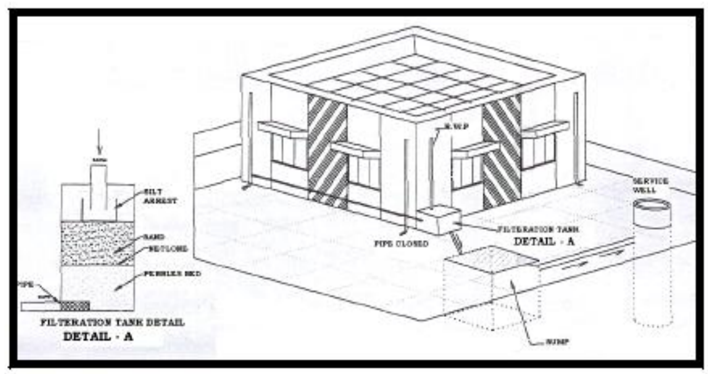
METHOD-II



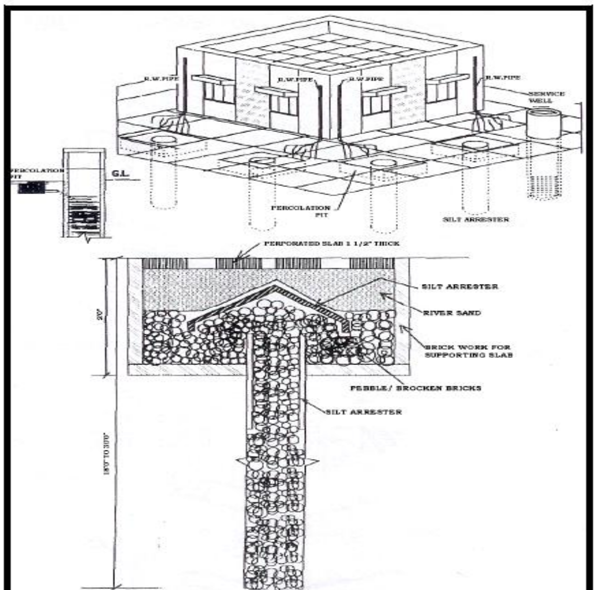
METHOD-III



METHOD-IV

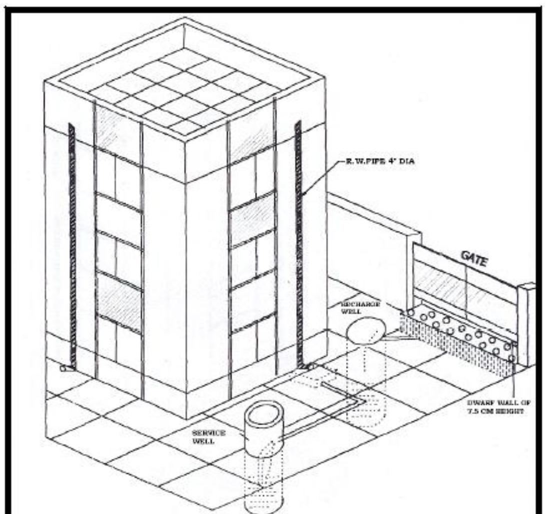


METHOD-V



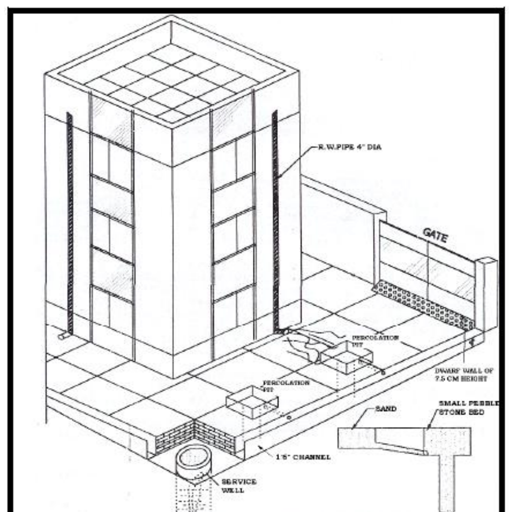
THE CROSS SECTION VIEW OF A PERCOLATION PIT

METHOD-VI



Provide a well of 1.2m for a depth of 10.0m and divert the rain water from the terrace into the well through rain water down-take pipes. Divert the rain waterfalling around the open space surrounding the building to the front gate wherein a gutter is provided for a depth of 1.0m and a width of 0.6m with perforated slabs. The rain water collected in the gutter in front of the entrance is discharged into another recharge well of 1.20m dia. with 10m depth provided near by through necessary piping arrangements.

METHOD-VII



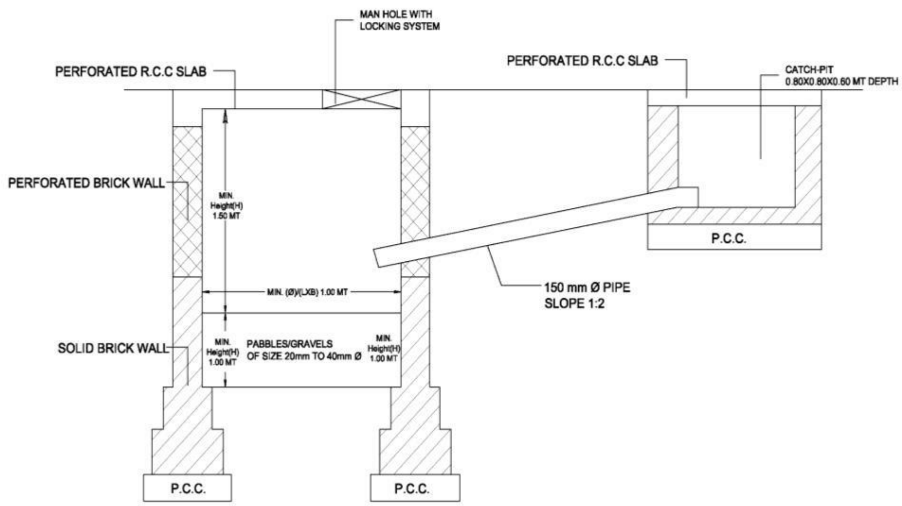
Dig a well of 1.2 m dia for a depth of 6.0m at the rear side of the house plot. Provide a 3.0 x 3.0 x 1.0m deep sand bed surrounding the well. In addition, build a .23 m wide trench around the building either near the compound wall or in the centre of the drive way. The depth of the trench may stary from .23 m near the gate(entrance) and run through 0.45 m at the rear end of the plot towards the well. The trench has to be connected to the deep sand bed constructed around the open well.

2. Ahmedabad

Rain water harvesting provision in AUDA DCR: Rain water harvesting is mandatory for all buildings with ground coverage 80 sq.mts and above. The system of storm water drainage and storage in reservoirs and recharge should conform to one of the following specifications:

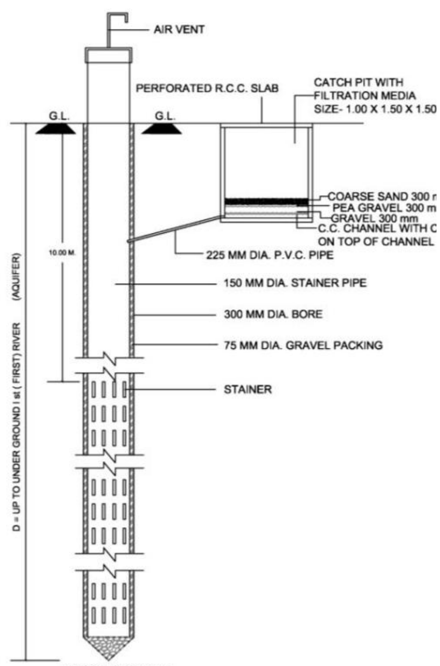
a. For Buildings with ground coverage above 80 sq.mts and below 500sq.mts:

Percolation Pit or Bore Recharge shall be provided in the marginal space around the building. Such pits shall be filled with small pebbles, brick jelly or river sand and covered with perforated concrete slabs:



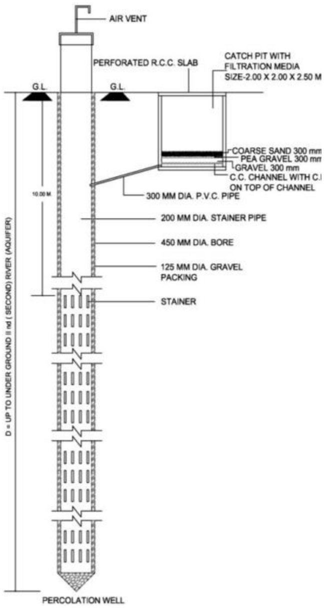
b. For Buildings with ground coverage above 500sq.mts and up to 1500 sq.mts:

Percolating Well with Rain Water Harvesting System shall be provided



C. For Buildings with ground coverage above 1500 sq.mts and up to 4000 sq.mts.

Percolating Well with Rain Water Harvesting System shall be provided as for every 4000sq.mts



Note: Water Retention Pond or any equivalent water harvesting system may be permitted as an alternative to multiple percolating wells, on specific review and approval by the Competent Authority.

Rain Water Storage : For all building units with area more than 1000sq.mts, Rain water storage tank shall be mandatory with adequate storage capacity.

3. Mumbai

a) All the layout open spaces/ amenity spaces of housing societies and new constructions/ reconstructions/ additions on plots having area not less than 300 Sq.Mt. in non gaothan areas of all towns shall have one or more Rain Water Harvesting structures having a minimum total capacity as detailed in Schedule.

Provided that the Authority may approve the Rain Water Harvesting Structures of specifications different from those in Schedule, subject to the minimum capacity of Rain Water Harvesting being ensured in each case.

b) The owner/ society of every building mentioned in the (a) above shall ensure that the Rain Water Harvesting structure is maintained in good repair for storage of water for non potable purposes or recharge of ground water at all times.

c) The Authority may impose a levy of not exceeding Rs.1000/- per annum for every 100 Sq.Mt. of built-up area for the failure of the owner of any building mentioned in the (a) above to provide or to maintain Rain Water Harvesting structures as required under these byelaws.

Rain Water Harvesting in a building site includes storage or recharging into ground of rain water falling on the terrace or on any paved or unpaved surface within the building site.

1. The following systems may be adopted for harvesting the rain water drawn from terrace and the paved surface.
   i. Open well of a minimum of 1.00 mt. dia and 6 mt. in depth into which rain water may be channeled and allowed after filtration for removing silt and floating material. The well shall be provided with ventilating covers. The water from the open well may be used for non potable domestic purposes such as washing, flushing an for watering the garden etc.

   ii. Rain Water Harvesting for recharge of ground water may be done through a bore well around which a pit of one metre width may be excavated upto a depth of at least 3.00 mt. and refilled with stone aggregate and sand. The filtered rain water may be channeled to the refilled pit for recharging the borewell.

   iii. An impervious surface/ underground storage tank of required capacity may be constructed in the setback or other open space and the rain water may be channeled to the storage tank. The storage tank shall always be provided with ventilating covers and shall have draw-off taps suitably placed so that the rain water may be drawn off for domestic, washing gardening and such other purposes. The storage tanks shall be provided with an overflow.

   iv. The surplus rain water after storage may be recharged into ground through percolation pits or trenches or combination of pits and trenches. Depending on the geomorphological and topographical condition, the pits may be of the size of 1.20 mt. width X 1.20 mt. length X 2.00 mt. to 2.50 mt. depth. The trenches can be or 0.60 mt. width X 2.00 to 6.00 mt. length X 1.50 to 2.00 mt. depth. Terrace water shall be channeled to pits or trenches. Such pits or trenches shall be back filled with filter media comprising the following materials.

      a. 40 mm stone aggregate as bottom layer upto 50% of the depth;
      b. 20 mm stone aggregate as lower middle layer upto 20% of the depth;
      c. Coarse sand as upper middle layer upto 20% of the depth;
      d. A thin layer of fine sand as top layer;
      e. Top 10% of the pits/ trenches will be empty and a splash is to be provided in this portion in such a way that roof top water falls on the splash pad.
      f. Brick masonry wall is to be constructed on the exposed surface of pits/ trenches and the cement mortar plastered. The depth of wall below ground shall be such that the wall prevents lose soil entering into pits/ trenches. The projection of the wall above ground shall atleast be 15 cms.

g. Perforated concrete slabs shall be provided on the pits/ trenches.

v. If the open space surrounding the building is not paved, the top layer upto a sufficient depth shall be removed and refilled with course sand to allow percolation of rain water into ground.

2. The terrace shall be connected to the open well/ borewell/ storage tank/ recharge pit/ trench by means of HDPE/ PVC pipes through filter media. A valve system shall be provided to enable the first washings from roof or terrace catchment, as they would contain undesirable dirt. The mouths of all pipes and opening shall be covered with mosquito (insect) proof wire net. For the efficient discharge of rain water, there shall be at least two rain water pipes of 100 mm dia mtr. for a roof area of 100 Sq.Mt.

3. Rain Water Harvesting structures shall be sited as not to endanger the stability of building or earthwork. The structures shall be designed such that no dampness is caused in any part of the walls or foundation of the building or those of an adjacent building.

4. The water so collected/ recharged shall as far as possible be used for nondrinking and non-cooking purpose. Provided that when the rain water in exceptional circumstances will be utilised for drinking and/ or cooking purpose, it shall be ensured that proper filter arrangement and the separate outlet for by passing the first rain-water has been provided. Provided further that it will be ensured that for such use, proper disinfectants and the water purification arrangement have been made.

This new clause for Rain water Harvesting was added vide final sanction under section 37(2) of MR&TP act, 1966 under number No.TPB- 4307/396/CR-124/2007/UD-11 Dated the 6th June,2007

4. Rajkot

PERCOLATING WELL WITH RAIN WATER HARVESTING SYSTEM : For the area of building unit above 500.00 Sq. Mt. and up to 1500.00 Sq. Mt., the owner / developer shall carry out water harvesting system as specified by the authority.

In the case where the area of building unit exceeds 1500 Sq.mtrs. and up to 4000 Sq.mt. owner / developer has to provide / construct percolating well with rain water harvesting system in building unit and at the rate of one percolating well for every 4000.0 Sq. Mt. or part there of building unit.

CONSERVATION AND HARVESTING OF RAIN WATER IN BUILDINGS: Having Plinth built up area of 80 Sq.Mts. or more Every such building/shall be provided with required facilities and infrastructure for conservation and harvesting of rain water viz.

PERCOLATION PITS : The ground surface around the building shall have percolation pit or bore as recommended by Competent Authority covering within the building site, or bore recharge such pits shall be filled with small pebbles or brick jelly or river sand and covered with perforated concrete slabs.

TERRACE WATER COLLECTION : The terrace may be connected to a sump or well bore through a filtering tank by PVC pipe as recommended by Competent Authority. A valve system shall be incorporate to enable the first part of the rain water collected to be discharged out to the solid if it is dirty.

OPEN GROUND : Whenever there is open ground a portion of top soil should be removed and replaced with river sand to allow slow percolation of rain water. Any other methods proved to be effective in conservation and harvesting of rain water may be adopted in each and every construction taken up. However, in case of existing building more than 1000 Sq.Mts. of built up area a moratorium of five years shall be given within which the above requirements of the Development Regulation shall be complied with.

5. Bangalore

Provision of Rain Water Harvesting is mandatory for all plots which are more than 240 sq.m in extent. A 5 % rebate on the property tax is offered for residential property and 2 % for non residential buildings within BMA for the first 5 years, when rain water harvesting is made as an integral part of the building constructed.

6. Delhi

Clause 22.4 Part-III (Structural Safety and Services) of the Building Bye-laws, 1983

(1). 22.4.1: Water harvesting through storing of water runoff including rain water in all new building on plots of 100 sq. meters and above will be mandatory. The plans submitted to the local bodies shall indicate the system of storm water drainage along with points of collection of the water in surface reservoirs or in recharge wells. These provisions will be applicable as per the Public Notice (s) of Central Ground Water Authority issued from time to time.

(2). 22.4.2: All buildings having a minimum discharge of 10,000 liters and above per day shall incorporate waste water-re-cycling system. The recycled water should be used for horticultural purposes

- In the whole of the National Capital Territory of Delhi, except in NDMC area, no person, group, authority, association or institution is allowed to draw ground water through bore-well/ tube-well (both new and existing, drawing ground water without permission of Central Ground Water Authority) for domestic, commercial and or industrial uses without the prior permission of the competent authority i.e. Delhi Jal Board. In respect of area falling under administrative jurisdiction of New Delhi Municipal Council (NDMC), no person, group, authority, association or institution is allowed to draw ground water through bore-well/ tube-well (both new and existing, drawing ground water without permission of Central Ground Water Authority) for domestic, commercial and or industrial uses without the prior permission of the Competent Authority i.e. NDMC.

- If any person, group, authority, association or institution, wants to draw ground water through a bore-well/ tube-well, he/she shall take prior permission from Delhi Jal Board. Such permission shall be obtained through submission of an application to Zonal Offices of DJB.

- The Executive Engineer of DJB, in-charge of the concerned area shall recommend the case, based on the facts on the ground, to the concerned Deputy Commissioner (Revenue) of the district who will issue orders in the light of the recommendations of Executive Engineer of DJB.

- An Advisory Committee in all nine districts of the National Capital Territory of Delhi shall be constituted under the Chairmanship of the Deputy Commissioners of the concerned districts, similar to that constituted by the Deputy Commissioner (South District) vide orders dated December,2007. The Advisory Committee constituted for the purpose shall have one member from the Department of Environment, Government of the National Capital Territory of Delhi.

- Each of the nine advisory Committee will inform DPCC about any water pollution occurring, due to extraction of water from tube-well/ bore-well so that necessary action may be initiated under the provision of the water (Prevention and Control of Pollution) Act, 1974.

- If the plot size of the building is more than 200 sq. meters, the permission to draw ground water through bore well/ tube well (both new and existing, drawing ground water without permission of Central Ground Water Authority) will be subject to the condition that the occupier/ owner of the said plot shall install rain water harvesting system in the respective building.

- Permission to draw ground water through bore well/ tube well (both new and existing, drawing ground water without permission of Central Ground Water Authority) for commercial and or industrial use shall be subject to the condition that the concerned person/ authority shall install the rain water harvesting structure, and shall ensure reuse of the water in horticulture/ cooling/ toilet flushing, etc after proper treatment of waste water.

- Any violation of the directions issued from the office of Secretary (Environment), GNCTD, attracts the penal action under the provision of section 15 of the Environment (Protection) Act, 1986 (29 of 1986).

(Centre for Science and Environment , 2010) (Rishi Aggarwal & Janki Pandya, 2013)

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