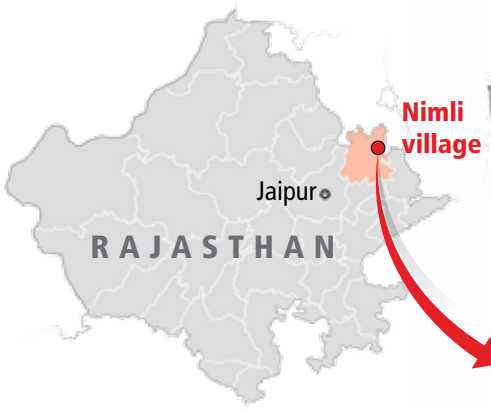
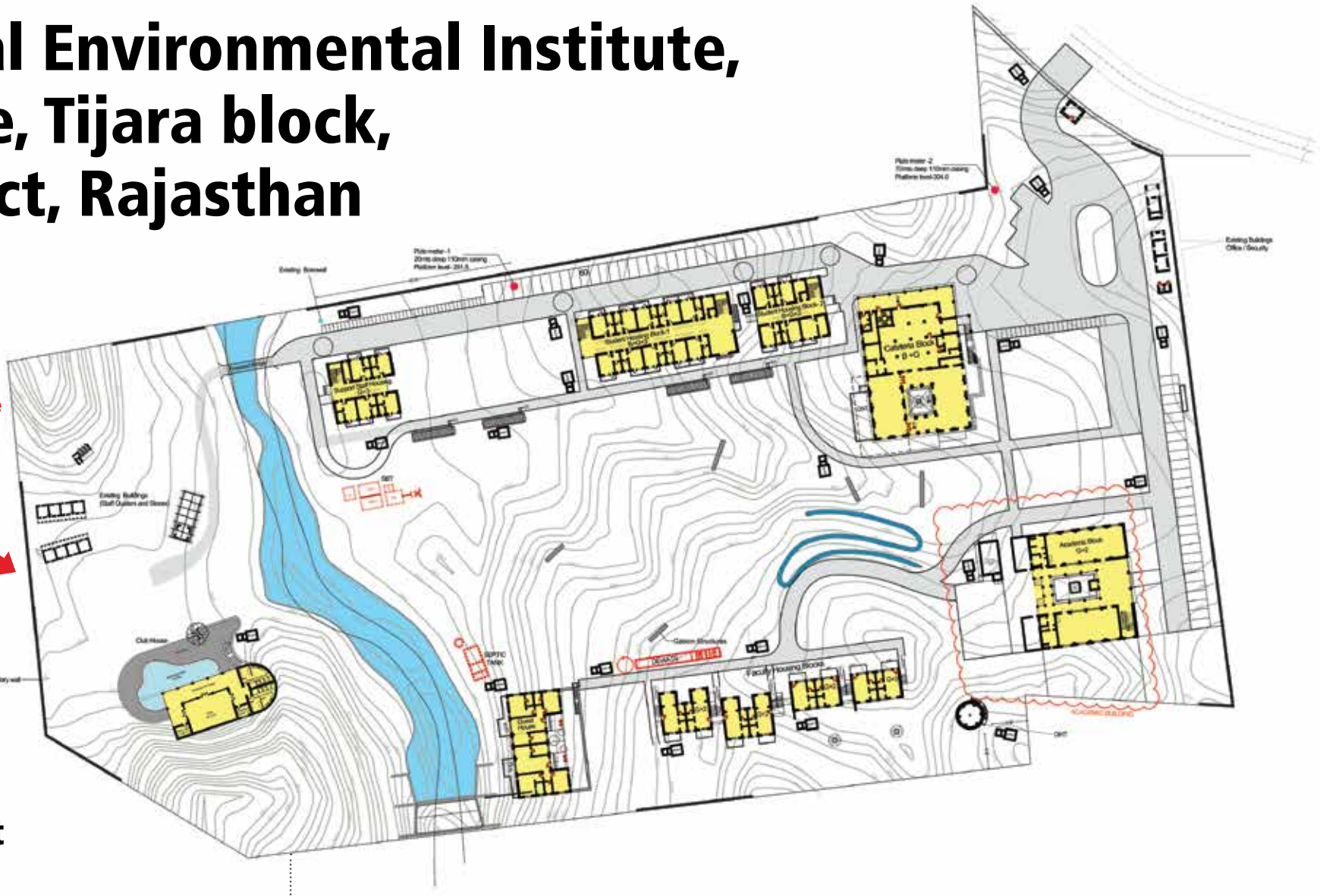
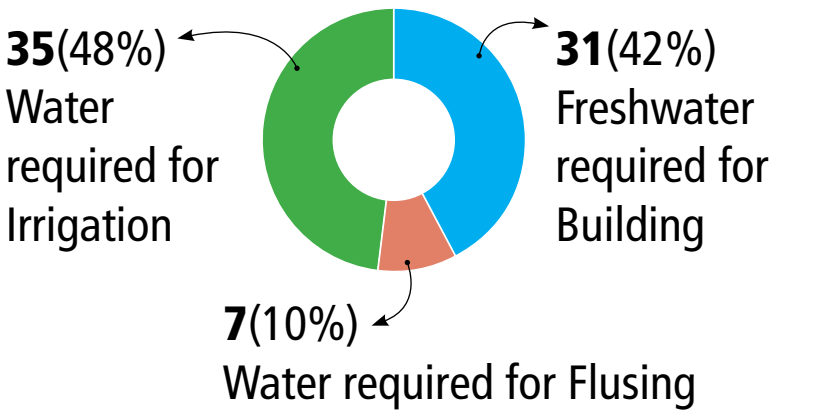
Anil Agarwal Environmental Institute, Nimli village, Tijara block, Alwar district, Rajasthan



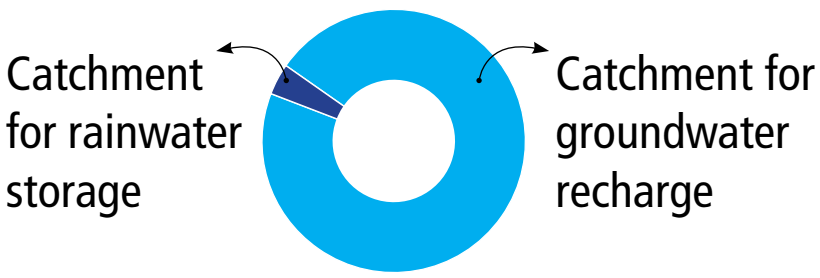


Map with RWH structures

Water requirement at AAETI (in KLD)



Total area of the Site: 39,100 Sq. m

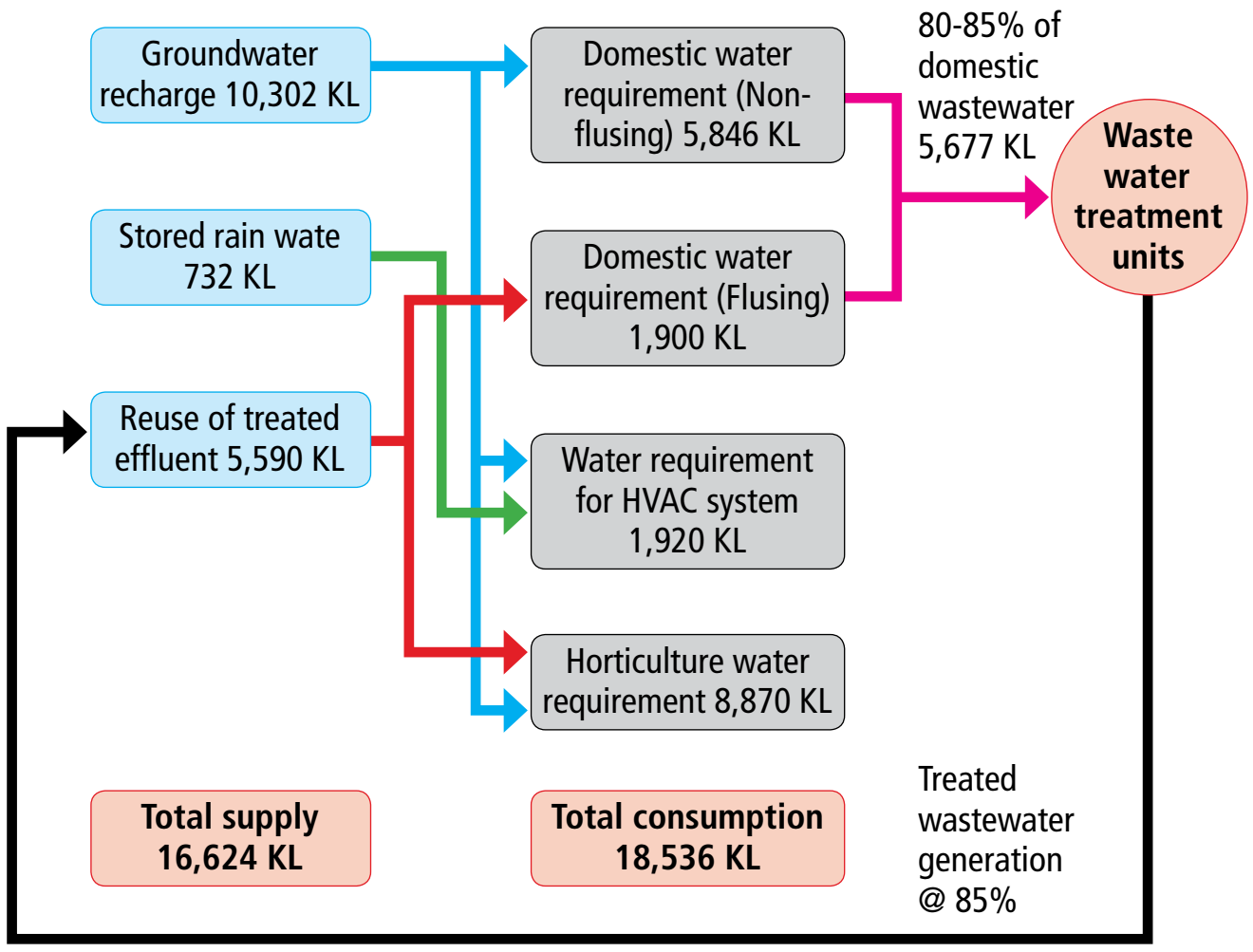


Area = **39,100 sq m**
Located **120 km** southwest of Delhi
Annual rainfall = **550 mm**
Total water requirement = **73 KLD**
Only **50 per cent** will be extracted from the groundwater and the rest will be sourced from recycled wastewater and stored rainwater

Groundwater recharge potential

Catchment harvested for groundwater recharge = **37462 sq m**
Co-efficient of runoff = **0.55**
Annual recharge potential =**10,302 cu m**

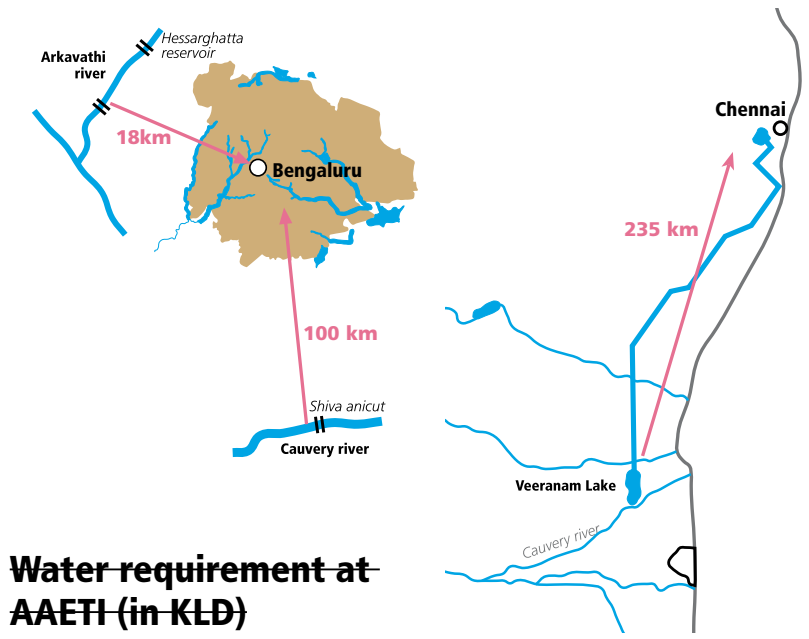
Water balance chart



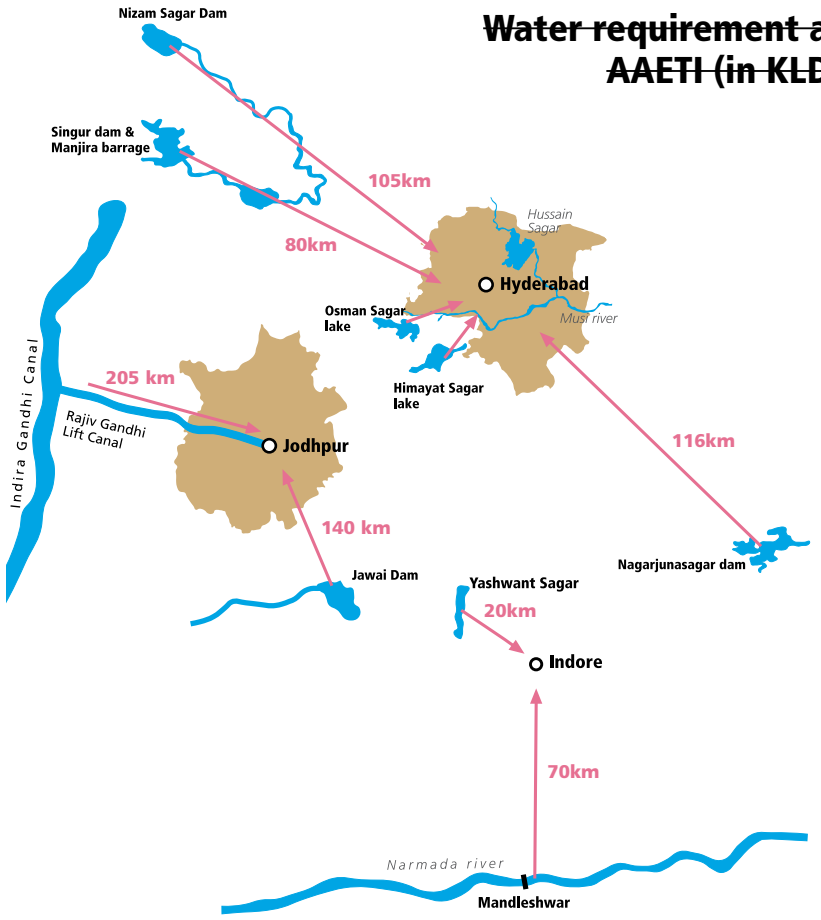
Rainwater storage

Building	Roof Area (Sq.M.)	Collection Potential(KL)		
		1 Day*	Monsoon Season**	Yearly***
1) Academic Block	**604**	**48.9**	**239**	**299**
2) Cafeteria & Recreation	**845**	**69.17**	**338**	**423**
Total	**1,458**	**118.07**	**577**	**732**

Cities and water supply

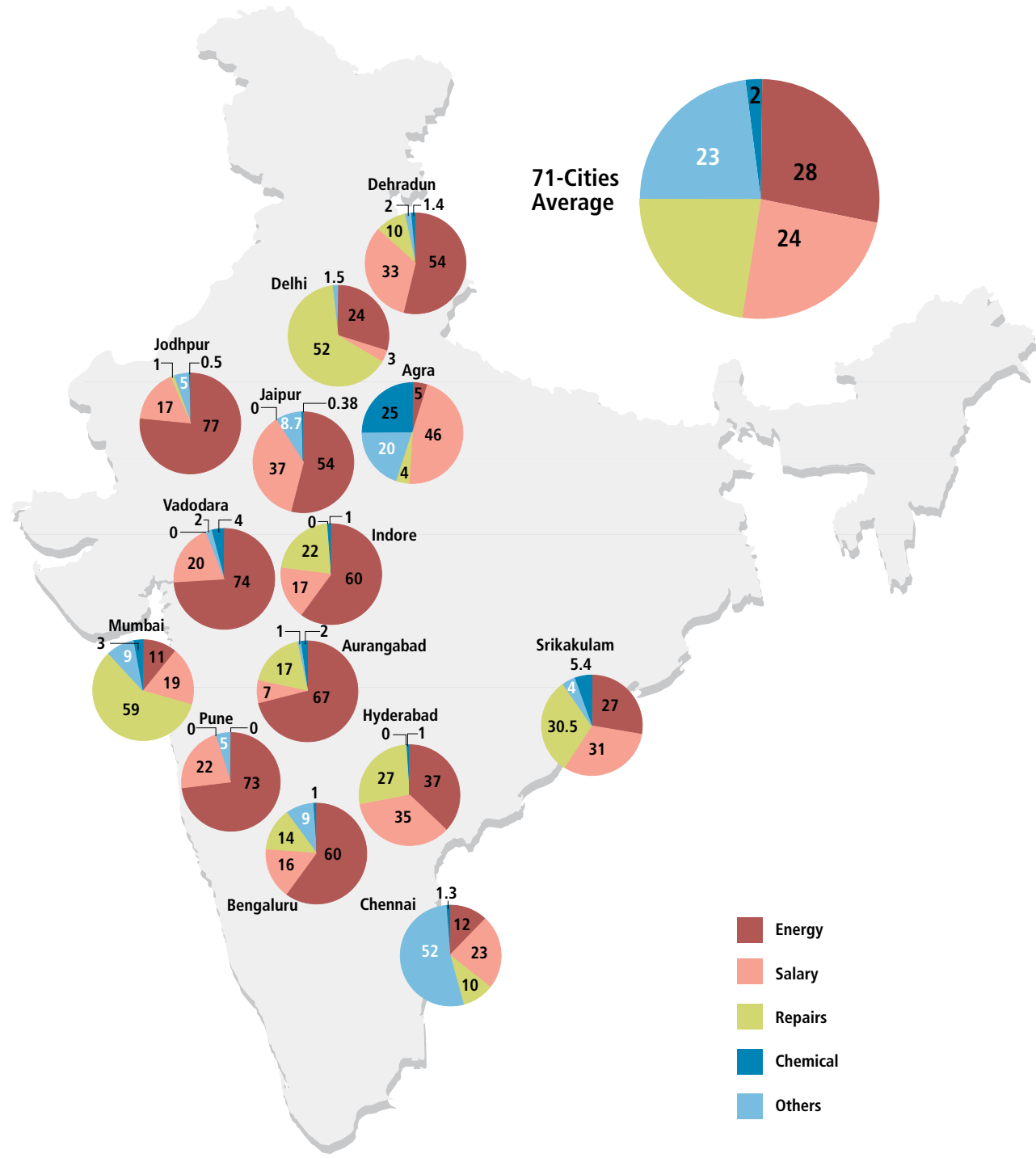


~~Water requirement at AAETI (in KLD)~~



~~Water requirement at AAETI (in KLD)~~

Components of water supply in differnt cities (In %)



Energy costs are highest component of water supply

Make supply expensive

Difficult to reach all

Water highway leaks at both ends

Water is **lost** in distribution, But then this water is distributed to **less people**

Water inequity grows

71-CITY SURVEY: HOW LEAKAGE LOSSES CREATE THE REAL SHORTFALL IN WATER ACTUALLY SUPPLIED

	Demand 2005 MLD	Supply 2005 MLD	Gap in 2005 MLD	Shortfall in supply, 2005 (%)	Leakage loss MLD	Supply after loss, 2005 (MLD)	Demand-actual supply gap, 2005 (MLD)	Shortfall in actual supply, 2005 (%)
Metro	17,987	16,591	1,396	8	6,150	10,441	7,546	42
Class I	2,879	2,775	104	4	706	2,069	811	28
Class II & III	129	123	7	6	21	101	28	22
Total	**20,996**	**19,489**	**1,507**	8	**6,877**	**12,611**	**8,385**	40

MLD: Million litres daily
Source: Anon 2011, *71-City Water-Excreta Survey, 2005-06*, Centre for Science and Environment, New Delhi

How to audit for rainwater harvesting?

Catchment details: Area, type and nature

Meteorological data: Get average annual rainfall, intensity and spatial distribution

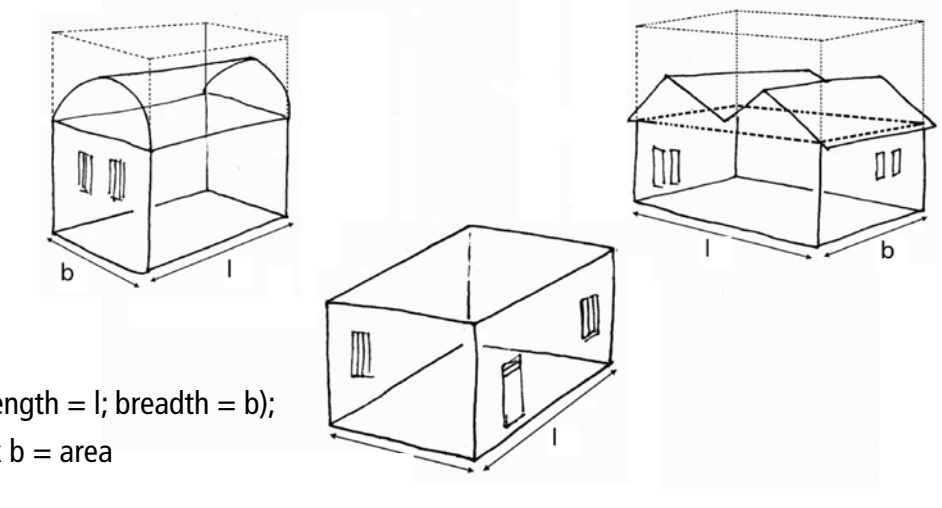
Geological and Hydrogeological data: Nature of rocks soil, aquifer and physiography

User water profile: Total water requirements, proportion already available, source of availability

Objective of the system and what are the uses

Budget available and tentative cost: Legislation and incentives available

Calculation of the rooftop area



(length = l; breadth = b);
l x b = area

How much rainwater can be collected?

Total volume of water = area X run-off coefficient X rainfall

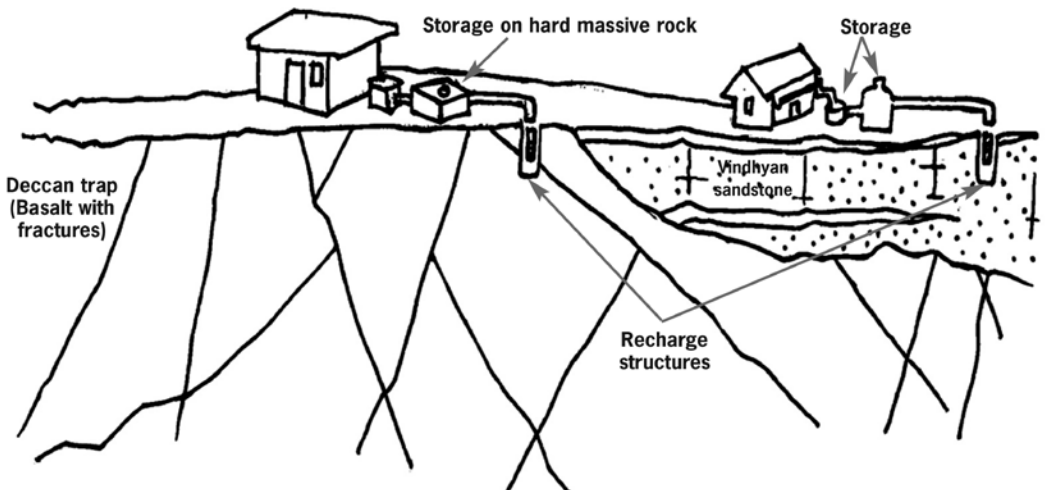
Area = length X breadth = 20m X 10m = 200sqm

Run-off coefficient of roof = 0.8

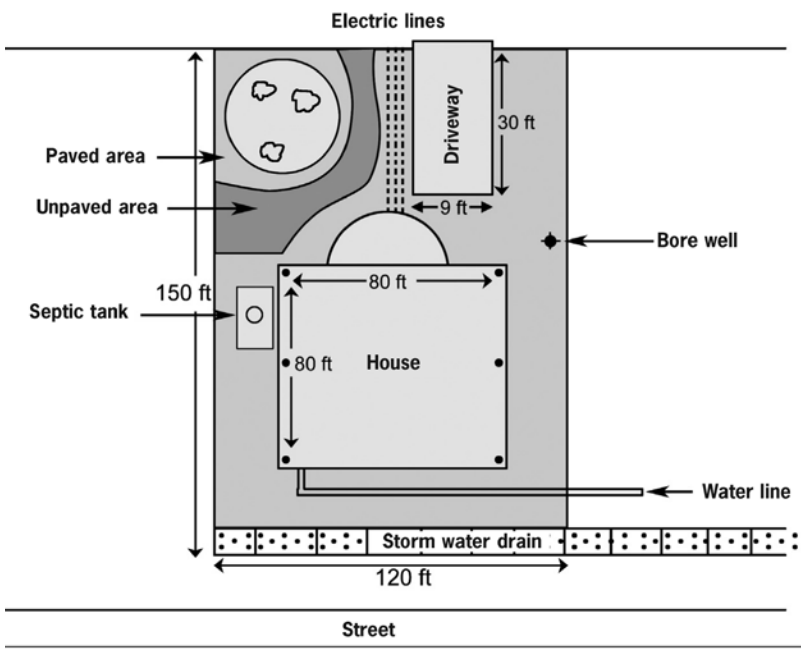
Annual rainfall =500mm

1) Rainwater harvesting potential = 200 X 0.8 X 500 = 80,000 litres
2) Water demand, family of four, consuming 540 litres/day = 540 X 365 = 197,100 litres/year
3) Water demand, family of four, the three driest months = 540 X 90 = 48,600 litres
4) Water demand for toilet flushing and gardening (yearly) at 180 litres/day =180 X 365 = 65,700 litres

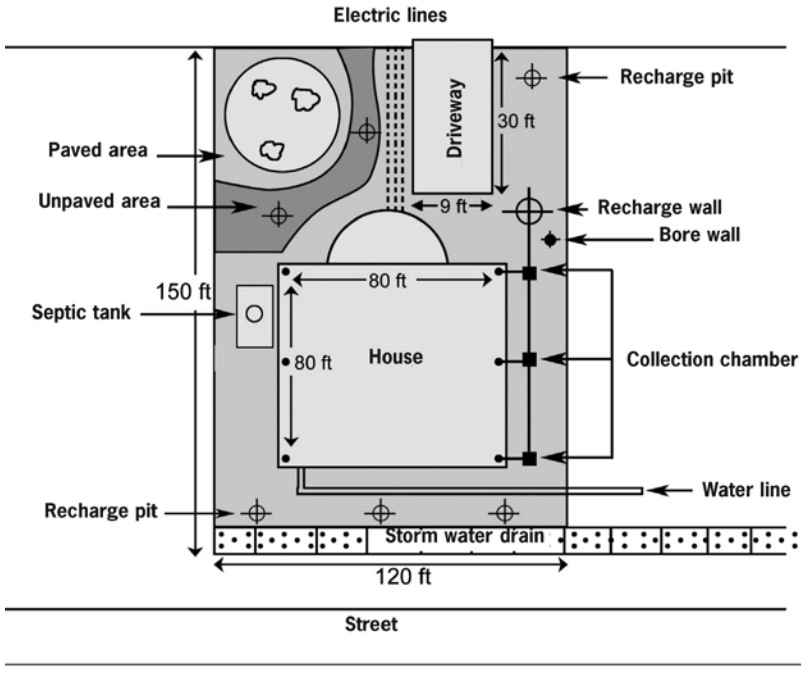
Storage and recharge in Bhopal's Deccan trap



Standard site plan (before RWH)



Site plan (after RWH)



Run-off coefficient for different types of catchment

Catchment	Type of material	Run-off coefficient
Roof	Tiles	0.8-0.9
	Metal	0.7-0.9
Paved area Driveway/courtyard, roads	Concrete	0.6-0.8
	Brisk	0.5-0.6
Unpaved area garden, playground	10% sand	0.0-0.3
	Hard compact	0.2-0.5
	Lawns	0.1

Hydro-geological conditions and type of structure

Parameter	Type/condition	Recommended structure
Nature of aquifer	Impermeable, nonporous, non-homogeneous, hard rock area	Storage
Depth of groundwater table	More than 8 meters	Recharge and Storage
Nature of terrain	Hilly, rocky or undulating	Storage
	Uniform or flat, alluvial and sedimentary	Recharge and Storage
Nature of soil	Alluvial, sandy, loamy soils, gravel, silty, with boulders or small stones	Recharge and Storage
	Clayey soil	Storage
Nature of geological formation	Massive rocks (such as Deccan trap)	Storage
	Fractured, faulted or folded rocks, or comprises of weathered, jointed or fissured rocks	Recharge and Storage
Nature of rainfall and monsoon	Number of rainy days are more, bimodal monsoon, not intensive, uniformly distributed	Storage
	Unimodal monsoon, rainfall available only for a few months	Recharge and Storage

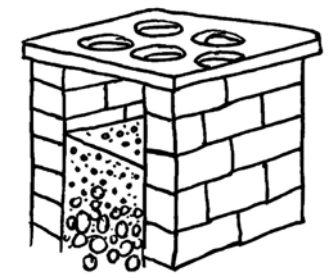
Recharge techniques

Characteristic for different recharge structures

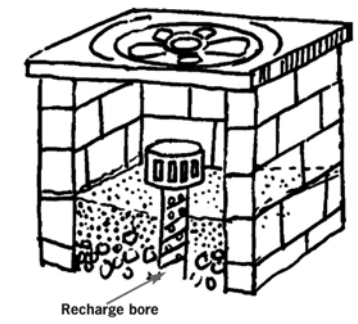
Recharge Pit	Recharge pit (with bore)	Recharge well	Recharge trench
Used in places where soil is sandy	Where the top layers of soil/rock may not be permeable	For large catchments	From paved ground catchments such as near gates
Shallow pits	Shallow pit lined with bricks on the sides. Filled with filtering material and has a recharge bore-pipe	Has a settlement tank, a sump filled with filtering materials and one or more recharge bore-pipes	Large trench with filtering materials and recharge bores
No constructed base, open to the soil at bottom, perforated cover on top	No-constructed base. Open to the soil at bottom with a perforated cover on top	Constructed base. Note open to the soil	Constructed base. Not open to the soil. Metal grill cover
Design consideration: permeability of soil	Design consideration: Availability of permeable layer at relatively shallow depths	Design consideration: Settlement tank to slow down the water flow. Length of bore-pipe should be above groundwater level	Design consideration: Volume of trench to exclude space occupied by filtering material

Casing of tubewell (top), slotted pipe (below)

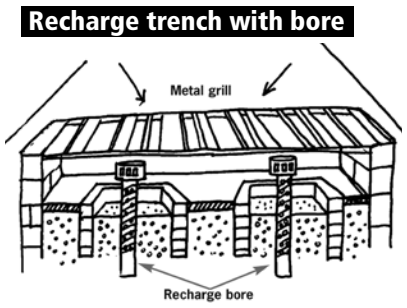
Recharge pit



Recharge pit with bore



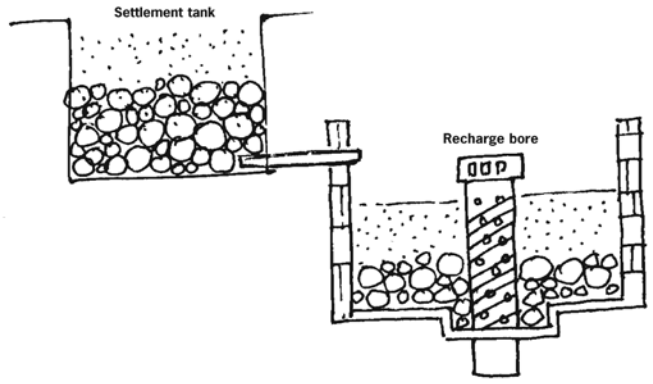
Recharge trench with bore



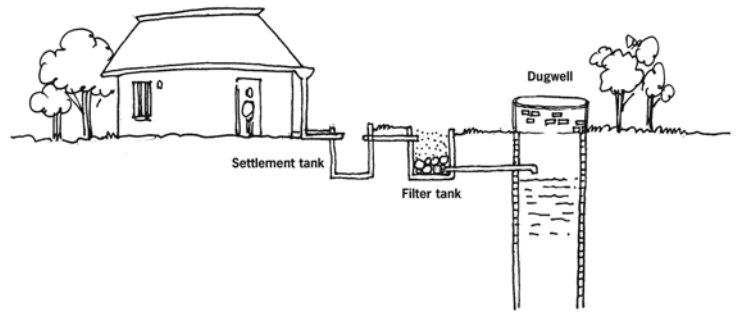
Thumb Rule For Recharge Structures

- Do not recharge soils that have a heavy content of clay, which expands when wet and shrinks when dry. This can cause damage to building foundations
- Do not recharge if the land slopes towards a building. Water will run toward the foundation.
- Good soils for recharge are sand, loan, loamy sand and sandy loam.
- Ensuring the quality of water recharge of water recharged is a very important consideration for recharge systems.

Recharge well with settlement tank



Recharging in-use borewells and dugwells

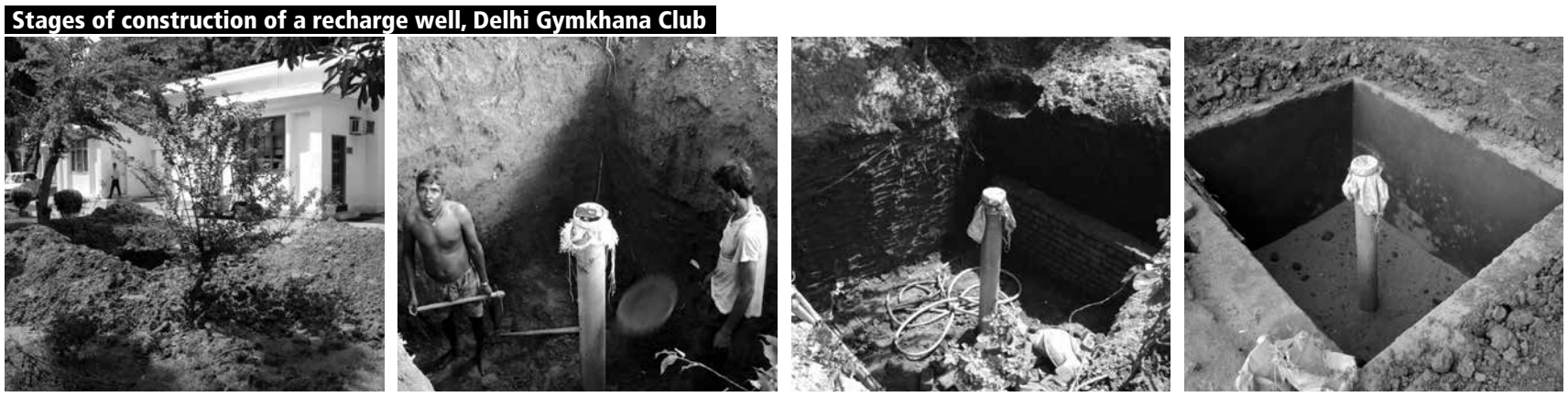


Sizing of recharge structure

Volume of water during most intense period of rainfall determines size		
Description	**Delhi**	**Mumbai**
Catchment area	100 sq m	100 sq m
Duration of intense spell	15 minutes	30 minutes
Average peak intensity of rainfall/hour (based on 25-year average)	64 mm	100 mm
Run-off co-efficient (average of different types of catchments)	0.6	0.6
Volume of water generated x peak rainfall x co-efficient	100 x 16 x 0.6 = 960 litres	100 x 50 x 0.6 = 3,000 litres
Recharge pit volume: 2/3 of rain volume	640 litres	2,000 litres
Dimensions of recharge pit (l) x (b) x (d)	1 m x 0.75 m x 1 m = 750 litres	1 m x 1 m x 2.5 m = 2,500 litres
Space for filter materials and the invert level*	750 – 640 = 110 litres	2,500 – 2,000 = 500 litres

*Note: The invert level is the depth at which the incoming pipe joins the recharge pit will have to be taken into account to calculate desired dimensions

Stages of construction of a recharge well, Delhi Gymkhana Club

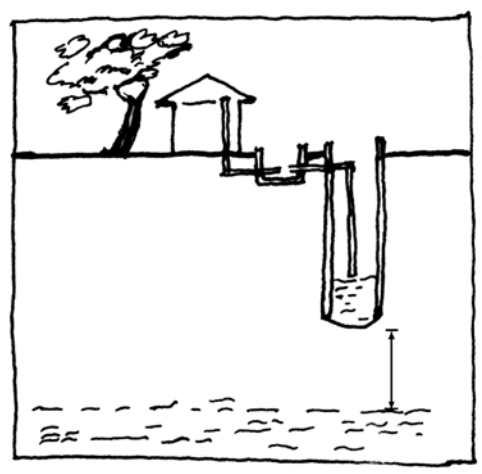


Good practice for recharge

The recharge bore should never reach the aquifer. It should terminate some way above the water table.

This ensures that the water being recharged is further filtered through sufficient thickness of soil before reaching the aquifer.

As a thumb rule, the depth of the bore should be above the postmonsoon level of groundwater.



Recharge techniques

Poorly maintained structures


Rooftop covered over by leaves


Cracked downtake pipe


Downtake pipe not connected to the roof


Settlement chamber filled with debris (malba)


Broken conduit system


Cracked RCC cover of a recharge well

Step by step cleaning of recharge structures

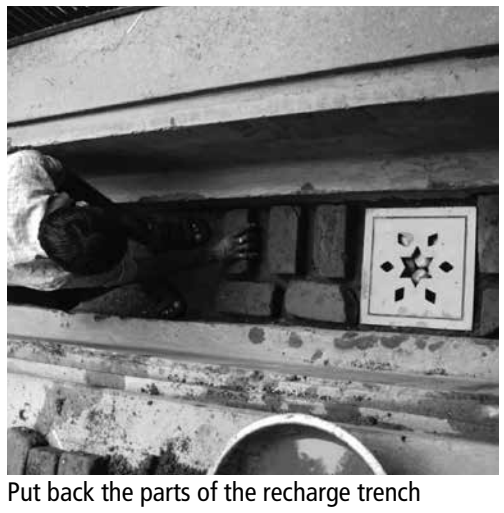

Remove parts of recharge trench for cleaning


Remove silt from recharge bore


Remove filter material (pebbles) from pit


Wash the filter material


Clean recharge bore and filter material


Put back the parts of the recharge trench

Amrish Bhai Vaisav, Residence of Junagadh, Gujarat. Using the system for many generations

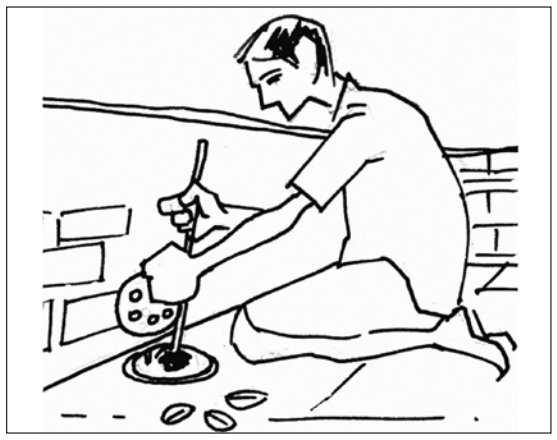

First flush: The left outlet is plugged with cloth during the initial rains. The first flush of rainwater flows into the other outlet wich leads into a stormwater drain outside the house. Water is later diverted into the tanka


Crystal clear water in the bucket drawn from the tanka


Down the generations, grandmother and granddaughter drawing water from the tanka

Maintaining tips

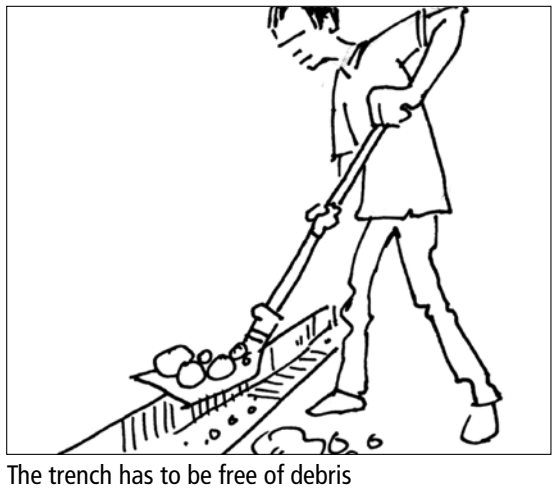

Keep the catchment area clean


Keep the outlets clean

Keep the gutter securely fixed


The filtertannk needs to be kept clean


The storage tank needs to be washed


The trench has to be free of debris

Monitoring

Residence of R. Ramani Chennai

System details

Total rooftop area: 108 sq m

Volume of storage tanks: 6,000 litres (3,500 overhead tank – civil) + 500 (Sintex) + 2,000 (GL sump)

Filter media: 1-2 inch size pebbles (at bottom), charcoal, coarse sand and half-sieved river sand (on top).

No of filter tanks: 5 (1 collection-cum-filtration tank; 2 Sintex tanks, 200 litres capacity each with charcoal, pebbles); 1 Sintex tank, 50 litre capacity each with charcoal, pebbles; 1 ground-level filtration tank)

Recharge structures: Open well, 2 recharge wells, 2 percolation pits

Cost: ₹60,000 in the year 1988

Designed and implemented by: R Ramani, Chennai

Water quality of stored water at Junagadh, Gujarat

System details

Total area: 1,064 sq m

Storage system: 1

Underground sump (volume): 100,000 litres

Recharge system: 1

Recharge well: 2.5 m x 2.0 m x 3.0 m

Recharge bore: 165 mm dia, 200 m deep

Cost: ₹4.73 lakh

Date implemented: 2005

Designed and implemented by: Gujarat Water Supply and Sanitation Board, Junagadh

Microbiological test results

Parameters	Units	Permissible	1994	1999	2012
pH	—	6.5 - 8.5	7	7.1	7.6
Turbidity	NTU	10	5	2	2
Total dissolved solids	mg/l	2,000	3,325	1,335	970
Total hardness (as $CaCO_3$)	mg/l	600	900	540	370
Total alkalinity (as $CaCO_3$)	mg/l	600	380	420	344
Iron (as Fe)	mg/l	0.3	NIL	trace	trace

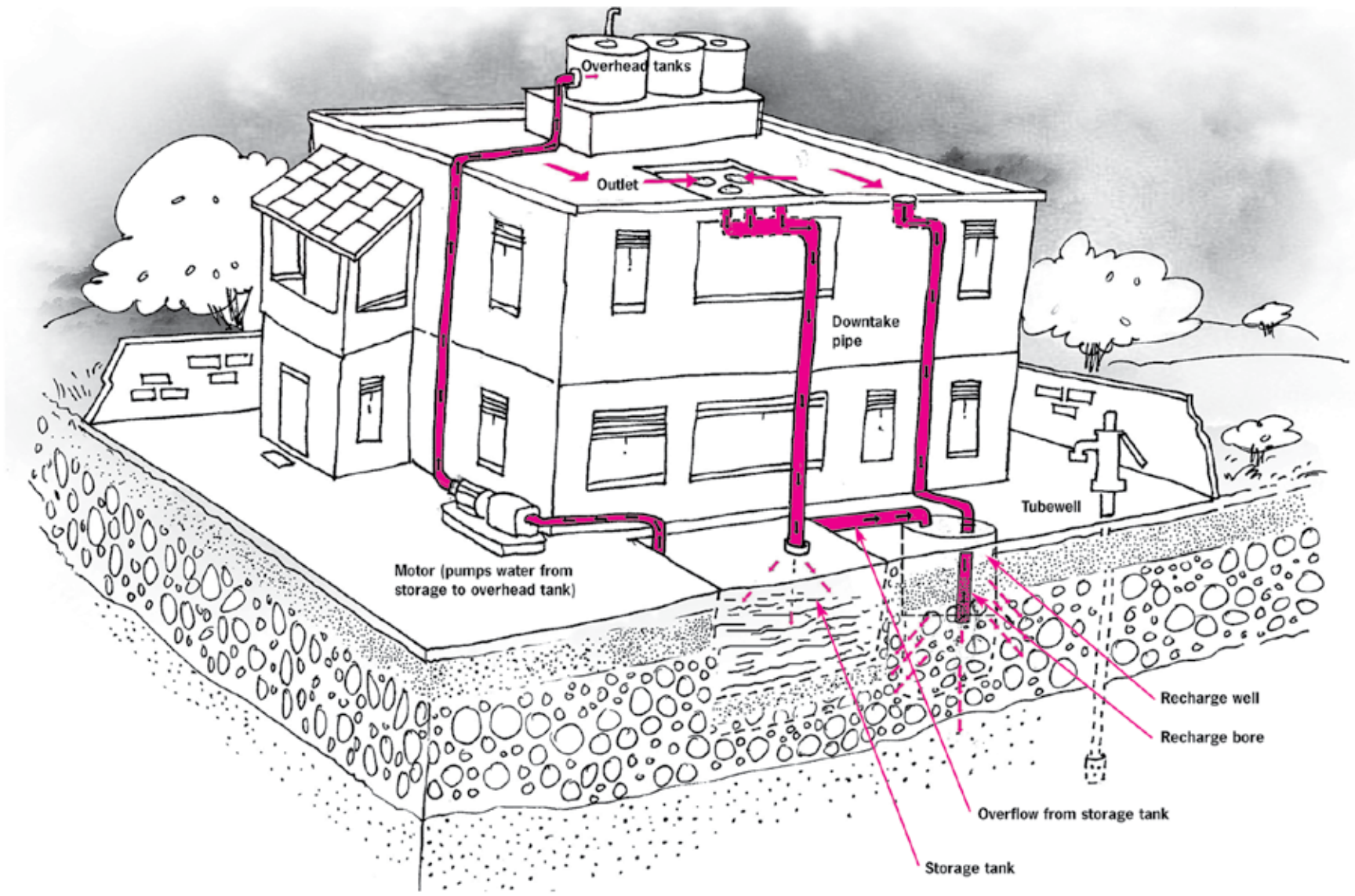
Note: Sample of 12.5.94 was tested in S & S Industries & Enterprises, Madras; Sample of 9.4.99 was tested in the water analyst's lab of Chennai MetroWater; Sample of 6.1.2012 was tested in the water analyst's lab of Chennai MetroWater

Water quality of the tank

Parameters	Permissible limit (mg/l)	Test results (mg/l)
pH	6.5 – 8.5	7.33
Total dissolved solids (TDS)	2,000	500
Total hardness (as $CaCO_3$)	600	160
Total alkalinity (as $CaCO_3$)	600	120
Calcium (as Ca)	200	32
Magnesium (as Mg)	100	19
Chloride (as Cl)	1,000	160
Sulphate as (SO_4)	400	36
Nitrate (as NO_3)	45	34.3
Fluoride (as Fl)	1.5	0.4

Notes: mg/l: milligrams per litre, $CaCO_3$: calcium carbonate; tested: January 2012; Source: Unit Manager, Coordination, Monitoring and Support Unit, WASMO, Junagadh

Harvesting rain in hard rock in individual residence Arunachalam, Madurai, Tamil Nadu



System details

Roof area: 174 sq m

Storage system: 1
Storage tank: 3.66 m x 1.22 m x 2.44 m (stores 10,895 litres)

Recharge system: 1 recharge pit (90 cm dia, 3 m depth)

Year implemented: 2006

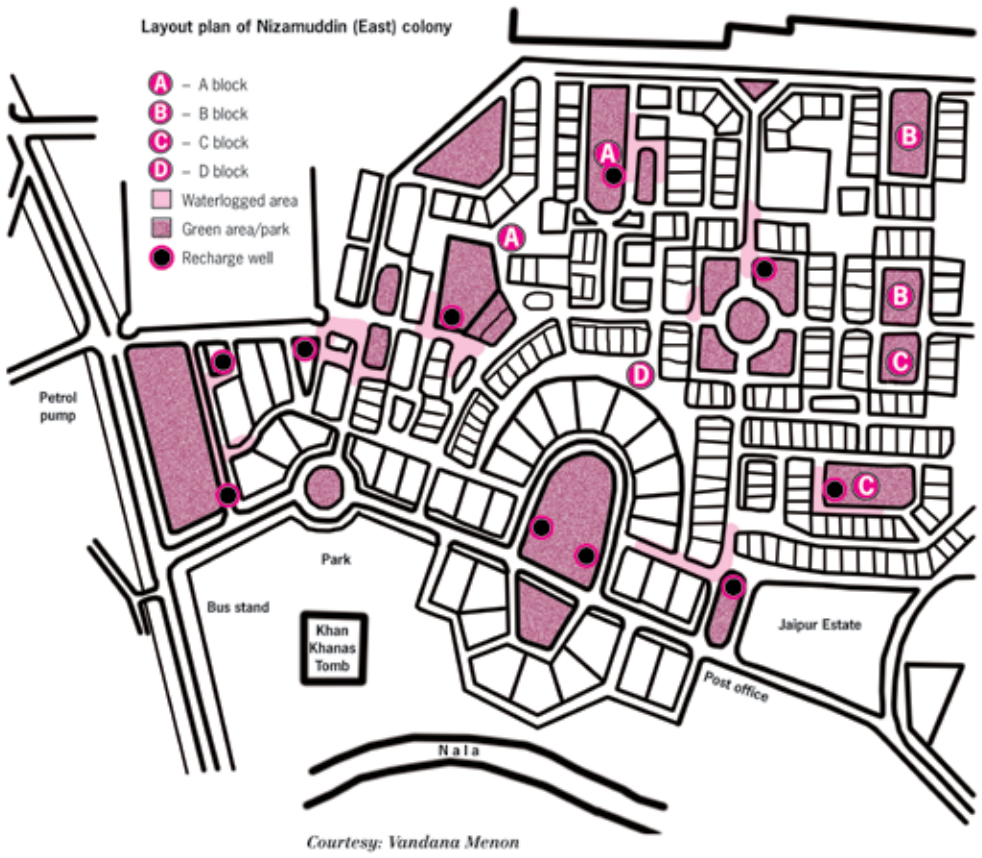
Cost: ₹44,000
Designed and implemented by: N Arunachalam

Rainwater is used for drinking and cooking for this family of four the year round. The municipality does not provide water and the area is entirely dependent on groundwater

IMPACT: The family's monthly cooking and drinking water demand is about 600 litres. The underground sump collects enough water for the whole year.

Monitoring

Harvesting rain in colony East Nizamuddin Colony, New Delhi



Courtesy: Vandana Menon

Rainwater in the stormwater drains was tapped to recharge groundwater. This was an effective antidote to waterlogging

System details

Total rooftop and surface area: 2.01 lakh sq m

Collection chambers (1 per recharge structure): 0.45 m x 0.45 m x 0.5 m

Recharge pits (11): 1 m x 1 m x 2 m

Recharge bore: 10 m deep with 150 mm dia

Cost: ₹1.79 lakh

Designed by: Centre for Science and Environment, New Delhi; **Implemented by:** Resident Welfare Association, Nizamuddin (East)

IMPACT: The system was completed in 2004 and the residents could soon see the results. Waterlogging has reduced greatly in the colony.


A waterlogged lane in the colony


Harvesting the rainwater from the stormwater drain has stopped flooding

Harvesting rain in hard rock in colony Rainbow Drive Colony, Bengaluru, Karnataka

Stormwater drain network was harnessed to initiate a rainwater harvesting system across the colony

This colony has thought beyond rainwater harvesting. Its residents have optimised on the use of rainwater, through recharge, discounts on water bills and a water tariff system that accounts for costs of treatment, supply and sewage treatment.

Quality water from sewage

In 2011, the colony residents approved a plan to set up a new sewage treatment plant (STP) based on soil biotechnology, developed at IITMumbai. This technology will provide river quality water for reuse as opposed to conventional methods which treat water for disposal. The colony intends to supply this water for non-potable use to all residents as well as sell it for use in constructions to recover the cost of the STP.

IMPACT

The wells have a total volume of 2.16 lakh litres and hence can recharge multiples of 2.16 lakh litres at the time of each rainfall. From a situation where only one of six borewells was yielding water, today water is pumped out from three borewells which have enough water even in summer months.


A recharge well in a stormwater drain. The jelly stones desilt the water before it enters the well

Innovative tariff to discourage wastage of water

To enforce conservation, the residents of Rainbow Drive have introduced a tariff system that charges users for the true cost of water. Charges are based on cost of treatment, supply and sewage treatment. The slab-based tariff discourages wastage. Private borewells have also been banned. An incentive is also in place – residents with recharge systems get a discount of ₹100 on their water bills.

System details

Total area: 137,593 sq m (34 acres)

Area of unpaved surfaces (15 per cent of total area): 20,639 sq m

Number of houses: 240

Recharge wells (20 in stormwater drains, 51 in homes): 71 (3 ft dia, 20 ft deep)

Volume of wells: 2.84 lakh litres

Designed by: Biome Environmental Solutions Pvt Ltd, Bengaluru

Implemented by: Rainbow Drive Residents' Welfare Association

Table: Slab-based water tariff

Water consumption level	Tariff (₹/kl)
First 10,000 litres (0-10 kl)	10
Next 10,000 litres (10-20 kl)	15
Next 10,000 litres (20-30 kl)	25
Next 10,000 litres (30-40 kl)	40
Above 40 kl	60

Source: Rainbow Drive Residents' Welfare Association