RAINWATER HARVESTING IN INDIA WITH SPECIAL REFERENCE TO URBAN AREAS AND THE CHENNAI EXPERIENCE

By

Dr. Sekhar Raghavan,
(Ashoka Fellow),
Director, Rain Centre,
4, 3rd Trust Link Street, Mandavelipakkam,
Chennai 600 028, INDIA
Tel.No. 91 44 2461 6134
Email: sekar1479@yahoo.co.in

I. INTRODUCTION

Water is perhaps the most precious asset on earth. It is one of the five basic elements of nature, the others being air, soil, fire and space. Fresh water is essential for human survival and rainfall is its single largest source. The part of rainfall that is trapped in surface and groundwater sources is all that is available for human consumption. This is what has come to be known as Rainwater Harvesting [RWH].

So far as rainwater harvesting in India is concerned, the entire past can be divided into three time capsules. From (-) infinity upto say, 3000 B.C is the first capsule and in this time period, rainwater got harvested naturally without any human intervention, in rivers and natural depressions. Rivers were the first known secondary source of fresh water. It was during this period that civilizations flourished on the banks of rivers not only in India but the world over. Egypt rose on the banks of Nile, Mesopotamia rose on the banks of Euphrates and Tigris, Europe on the Danube and China on the Yellow river. In India, the Harappan civilization flourished on the banks of Ravi and Mohenjodaro on the banks of Indus.

During the second period extending from 3000 B.C. to 1850 A.D., rainwater was harvested with human intervention. Man must have learnt his first lessons in RWH by looking at natural depressions where water got collected on its own and constructed more of them and learnt to live away from rivers. India being predominantly an agricultural country and water being an essential input for it, Indians were fully aware of the importance of RWH and has had a rich tradition of harvesting rainwater. Bestowed with a good annual rainfall in a large section of the country, different parts of the country had their own traditional harvesting system. A detailed account of this is presented in section II.

Paper presented in the Tokyo Asia Pacific Sky Water Forum held in Sumida city, Tokyo during August 1-7, 2005

While the first two periods formed the golden era of harvesting, the third period from 1850 onwards till date saw the destruction of traditional harvesting structures, mismanagement of water resources, repeated occurrence of floods and droughts, introduction of technology water like in the west and more and more dependence on the government for fresh water. RWH in most parts of India was not given the importance that it richly deserved. The reasons for its neglect both in rural and urban areas, the consequences thereof, the importance of recharging the groundwater source particularly in urban areas and the methodology to be adopted are dealt with in detail in sections II, III and IV.

The last 30 years in this period has seen the revival of RWH in the country as a whole and the introduction of RWH in urban areas in general and in Chennai, a coastal city in Southeast India in particular. The attempts made by a few individuals and organisations to revive RWH in both the rural and urban areas and making it into a mass movement in Chennai city is discussed briefly in section IV and in more detail in another paper titled "The role of Rain Centres in popularising and promoting RWH in urban areas" that is also being presented in the TAP Sky Water Forum.

II. TRADITIONAL RAINWATER HARVESTING IN INDIA

Almost all the water in India is indigenous. Except for a small quantity that flows from Tibet and Nepal, our neighbouring countries, the rest of our supply derives from rainfall within the country. India's average annual rainfall is 1170 mm. It varies from 100 mm in the deserts to 15000 mm in northeast India. Nearly 12% of the country receives an average rainfall of less than 610 mm per annum, while 8% receives more than 2500 mm. But more than 50% of this rain falls in about 15 days and less than 100 hours out of a total of 8760 hours. The total number of rainy days can range from a low of 5 days to 150 days in the northeast. India's total land area is over 300 million hectares (mha). Even if the runoff from 200 mha of land is harvested, each of the 587,000 villages in India can capture as much as 3.75 billion litres of water every year. This is the potential of rainwater harvesting in India and in reality there should not exist any village in India, which cannot meet its drinking water needs through RWH.

Indians knew that if they did not capture the water when it fell, they would have nothing later on. They developed a civilisation built on rainwater and India has a millennial tradition of rainwater harvesting. Our ancestors had learnt to harvest rainwater in a variety of ways. These traditions have developed over centuries in an ecologically sound manner. These were decentralised systems, where communities played an active role in water management. The development of RWH over a period of almost 5000 years is briefly furnished in the Box 1.

Box. 1 RAINWATER HARVESTING IN INDIA THROUGH THE AGES

3rd Millennium B.C	Dams built of stone rubble were found in Kutch
3000 – 1500 B.C	Dholavira, a major site of the Indus valley civilization had several reservoirs to collect monsoon runoff. Wells were probably a Harappan invention. A recent survey revealed that every third house had a well.
321 – 297 B.C	Historical records show that Indians were constructing dams, lakes, and irrigation systems during the period of king Chandragupta of the Maurya dynasty. Kautilya a minister in this kingdom wrote a treatise called Arthasastra where rainfall regimes, soil types and irrigation techniques have been mentioned. Units to measure rainfall is also given.
1st Century B.C	The city of Sringaverapura near Allahabad in North India had a sophisticated water harvesting system using the floodwaters of river Ganges.
2nd Century A.D.	King Karikala of the Chola dynasty in South India built a small dam across the river Cauvery to divert flood water for irrigation and is still functional. Inscriptions found in Junagadh in North India during this period provide information about the repair of an embankment for a lake named Sudarsana. Literature from Tamil Nadu the author's native state, dating back to this period records rice cultivation under tank irrigation.
11th Century A.D.	Several irrigation tanks called cheruvu, kere and eri respectively in the three southern states of India – Andhra Pradesh, Karnataka and Tamilnadu were constructed. King Bhoja of Bhopal in Central India built the largest lake (65000 acres), fed by streams.
12th Century A.D.	Well-maintained irrigation systems existed in Kashmir the northern most tip of India.
17th Century A.D.	West Bengal, a state in eastern India had a system of overflow irrigation which worked well till the advent of the British. It enriched the soil.

There were RWH systems for rainwater utilization as well as infiltration. A few of them are indicated below.

- At the micro level, they collected rainwater directly from rooftops and stored it in below ground level (bgl) tanks called *tankas*. Both at the micro and macro levels, they collected the runoff rainwater from courtyards and open community lands respectively and stored in another kind of bgl tanks called *kundis*. They had also built huge tanks within forts situated on hilltops for storing rainwater for use during wars. These are found in the states of Rajasthan and Gujarat in Northwest India.
- They harvested monsoon runoff by capturing water from swollen rivers and stored it in earthen tanks as surface storage called by different names in different states – *zings* in Ladakh state, *ahars* in Bihar state and *johads* in Rajasthan and *eris* in Tamil Nadu (see Box 2) to name a few.
- They harvested water from flooded rivers in places like North Bihar and West Bengal state.

Box 2: South Indian Tank system of traditional water harvesting

Hailing from South India I would like to briefly explain the tank system of harvesting rainwater that existed since 4th Century A.D. These tanks are earthen bunded reservoirs constructed across slopes by taking advantage of local depressions and mounds. The three states of South India – Andhra Pradesh, Karnataka and Tamil Nadu have 150,000 such tanks among them and most of them are still functional. Though called by different names – cheruvu, kere and eri respectively in these three states, they are identical in structure and performance. These are primarily meant for irrigation and most of them are inter-connected meaning the overflow of one will go to fill up the neighbouring one at the lower level and so on. These tanks are of two types called system and non-system tanks. The former also known as riverfed tanks gets water diverted from rivers by means of embankments called *anicuts* and the non-system tanks have their own catchment and are known as rainfed tanks.

A detailed list of Traditional RWH structures from various states of India is given in Table 1.

II.1 STATE OF DECAY

Traditional RWH systems declined when the British took control of India during 18th Century. The government took over the role of the main provider of water and replaced traditional decentralised systems with centralized ones. After the British left in 1947, the Indian bureaucracy took over the self-appointed role of supplying water. They did not care to understand these traditional systems, remaining equally ignorant as the British. This marked the end of a glorious tradition and today the entire heritage lies in tatters.

Some of the facts responsible for the decline of these systems are listed below.

1. The take over of the maintenance of the traditional water bodies, hitherto in the hands of the village community, by the government even during the British rule led to the apathetic attitude of the society towards these water bodies.
2. After independence, the Indian bureaucracy continued the same policy without returning the water bodies back to the village communities.
3. Centralised schemes by the government to provide piped drinking water to villages encouraging them to ignore their fresh water lakes and ponds and which made them dependent on the state for providing water.
4. Traditional sources of fresh water were ignored citing quality and hygiene as reasons and tapping groundwater for potable use began. No attempt was made till recently to sustain the traditional sources through RWH.
5. Increase in industrialization led to increased consumption of water. The state started looking at them as potential buyers thus ignoring the legitimate rights of farmers. The government started looking at water as an economic good.
6. Increase in pollution of surface water bodies and groundwater by leather, garment, paper and sugar industries.
7. Tendency of the state and a part of the society to depend on use of technology to obtain fresh water like desalination, wastewater treatment etc. considering them to be safer than natural water.
8. The division among both the rural and urban communities - economically, politically and communally leading to an increased dependence on the state.
9. Increase in urbanization and industrial activities resulting in the destruction of water bodies and decrease in open space.

III. RAINWATER HARVESTING IN URBAN AREAS – ISSUES, NEED AND RELEVANCE

Urban areas, which consist of large and medium sized cities, almost all of them face the twin problems of floods during monsoon and shortage of fresh water during non-monsoon months. Both these problems are of a more recent origin and are caused primarily due to lack of harvesting the rainwater that falls in such areas. According to late Anil Agarwal, founder of Centre for Science and Environment, a leading NGO in India, “the idea of water scarcity is absurd – there is scarcity amongst plenty and water must once again become everybody’s business”. The solution therefore lies in understanding the scenario and making sincere attempts to harvest every drop of rainwater either as collection for immediate use or aquifer recharge or both. The author has been struggling hard since 1995 to create awareness among the urban residents about the importance of RWH both as a flood mitigation measure as well as for sustaining the groundwater source.

Traditionally, there would not have been much of a difference between rural and urban areas. Though larger towns would have existed, they would have been very different from the present day cities. They would have had their own traditional water bodies like the tanks, ponds, temple tanks etc. and the entire town would have had large areas unpaved. Rainwater would have got harvested both due to runoff as well as infiltration through unpaved areas. On the contrary, present day urbanization has resulted both in

shrinking of open spaces and very minimal area remaining unpaved. This has ultimately resulted not only in flooding of cities but has also caused water scarcity due to groundwater depletion in general and saline intrusion in coastal cities.

While rural harvesting is mostly traditional and is carried out in surface storage bodies like rivers, tanks, ponds, lakes etc., urban harvesting, due to lack of open space for capturing the runoff, is mostly in sub-soil storage as groundwater by injecting large amounts of rainwater into the soil during rains. RWH in urban areas also consists in reviving whatever water bodies that are left behind without allowing any further construction in them in future. This will be an activity at the macro level and will have to be undertaken by the government. At the micro level every resident/individual should implement both rooftop and driveway runoff harvesting in their respective homes, commercial complexes, office premises, factories etc. The different methods of RWH relevant in urban areas is given in Annexure 1.

IV. THE CHENNAI EXPERIENCE

Chennai is a coastal city located in southeast India and is the capital of Tamil Nadu state (province). Unlike most of the cities in India, Chennai is not located close to any perennial river and is completely dependent on rainwater harvested in traditional surface storage bodies called *eris* and sub-soil water, which is also sustained by rainwater through infiltration. As mentioned above, Chennai as a city is not very old but was formed only a few centuries back. A group of eight villages with their own traditional water bodies to start with was brought together by the Britishers for their own convenience.

Chennai's primary water source used to be a network of eris (traditional tanks meant for irrigation), ponds, temple tanks and dug wells managed by local communities. In 1772, during the British rule, two eris at Redhills and Cholavaram were designated as reservoirs and water was distributed to the city through Municipal waterworks. These were able to meet the city's demand till 1900. Between then and the 1940s one more reservoir was constructed at Poondi, which increased the storage capacity to 180 million cubic metres, and was able to meet the demand.

Till 1970s, the city's public supply system depended exclusively on surface water. This was not enough to meet the growing demand and the municipal authorities started extracting groundwater from different parts of the city. At one point of time groundwater contributed around 60% of the total quantity of water that was being supplied to Chennai.

As mentioned above, rainfall is Chennai's main source of water. It receives rain from the south-west monsoon during the months of June to September and from north-east monsoon during October to December. The annual average rainfall in Chennai city is 1300 mm and around 60% is from NE monsoon and 35% from SW monsoon. Chennai city's population (as per 2001 census) is 4.2 million and at 100 litres per capita per day (lpcd) the city's water requirement is around 420 million litres per day (mld). A

household survey carried out in 1995 to understand the role of the various water sources in Chennai revealed that 33% was met from Municipal pipe supply, about 6% from Municipal supply through tankers and 60% from groundwater sources such as open and bore wells at the household level. A part of the Municipal water itself was from groundwater sources.

There was a clear indication that the city relies quite heavily on groundwater, whose sources will have to be sustained through injection of large amounts of rainwater into the soil during monsoon. Chennai being a coastal city, failure to recharge the aquifer will not only result in depletion of the water table but will also result in saline intrusion into fresh water aquifers creating an irreversible damage to it. Therefore, rainwater harvesting in Chennai city essentially means recharging the aquifer than collecting water for immediate use.

Realising the need and importance of RWH in Chennai, the author initiated a door-to-door campaign in 1995 in two of its coastal suburbs, Besant Nagar and Valmiki Nagar. Both the quality and the exploitable quantity of groundwater in these localities were excellent till about ten years back. But, as construction proliferated, use of groundwater increased steadily even as the amount of bare soil available for direct absorption of rainwater shrank substantially. As a result, the groundwater table level in these areas steadily went down. However, the concept of RWH being new, the initial response to these ideas was none too encouraging; residents were reluctant to invest in RWH systems. It took almost three full years and the help of the print media -- especially neighborhood newspapers -- to convince the residents of the need and relevance of RWH in a city like Chennai.

The author, due to his involvement in creating awareness about the importance of RWH among the residents, was included in a high-level committee formed by the state government in 2001 to promote and popularize RWH not only in Chennai but the entire state. This gave the author an opportunity to work with the state machinery to not only accelerate the awareness raising activities but also suggest enacting a law making RWH compulsory in all existing buildings not only in Chennai but the entire state of Tamil Nadu. The residents were given one - year time – till October 2003 to get it implemented in their respective premises and were told that failure to do so would attract punishments such as disconnection of water and power supply. Tamil Nadu was the first state in the entire country to legislate RWH and the other states are thinking along similar lines. Even our neighbouring country of Srilanka, though rich in water is seriously contemplating enacting a law to make RWH compulsory in all new buildings.

A few like minded harvesters and institutions came together and started a trust called Akash Ganga Trust, which has set up a Rain centre in Chennai, the first of its kind in the country and with the initial seed money coming from Chennaites settled down in U.S. The Centre for Science and Environment, New Delhi has supported this venture by providing the centre with expensive colourful poster panels on the importance of water and RWH. A few state government departments have also sponsored the centre by lending their name and also making monetary contribution. Through this centre, not only

has awareness been created regarding the importance of RWH, but support has also been rendered for its implementation by offering free advice to all those who wanted to implement RWH in their respective premises. In addition, free training has been given to plumbers who wanted to get into this profession of RWH implementation. We also propose to continue these activities in future.

V. CONCLUSIONS

India has had a rich tradition of harvesting rainwater since time immemorial. It is presently in a state of disrepair for reasons mentioned above. The country has started leaning towards the west in the principles of water management thus ignoring the traditional wisdom and seeking more technological solutions to meet the fresh water demands. It is the firm opinion of the author that indiscriminate use of technology is not sustainable and will lead to other environment related problems. It is definitely not correct to ignore the rainwater falling on our heads and looking for other complex solutions to our water problems. For example, it is said that every year, Chennai city discharges into the sea a quantity of rainwater equivalent to one year's needs and then to set up a desalination plant is not a very wise thing to do.

Most of the other metro cities in India, like Chennai is water starved but not rain starved. We should not forget the fact that water harvested is water produced and make sincere attempts to harvest every drop of water that falls within every premises, locality, city and country before thinking in terms of mega projects like interlinking of rivers, desalination of sea water etc. Pollution of rivers and dumping of garbage and industrial and domestic effluents into water bodies and encroachment of them will have to be stopped and the water bodies will have to be revived for capturing rainwater.

Though rainwater harvesting is important in every major town and city not only in India but the world over, it is much more important in coastal cities, since what is not harvested runs off into the sea before we realise and gets wasted. This is not so in inland towns and cities, where, what is not harvested has a good chance of getting into the nearby river and prove to be useful to people living downstream or get into water bodies within the towns. Since India and Japan have long coastlines, implementation of RWH in coastal cities with sandy beaches, which have a great groundwater potential, will have to be taken up on a war footing. Any delay will result in seawater intrusion into its fresh water aquifers and create a permanent and irreversible damage. Our slogan for the future should be HARVEST RAINWATER LEST WE PERISH.

REFERENCES

1. "Dying Wisdom – Rise, fall and potential of India's traditional water harvesting systems" Edited by Anil Agarwal and Sunita Narain, Centre for Science and Environment (1997)
2. "Making Water Everbody's Business – Practice and Policy of water harvesting" Edited by Anil Agarwal et al. Centre for Science and Environment (2001)

3. “Traditional Water Harvesting Systems of India” C.P.R. Environmental Education Centre, Chennai, India (2004)

NAME OF STATE	TANK	LAKE	POND	Well and stepwell	Embankments	Collection and use
Andhra Pradesh	Cheruvu	Guntas, Dona		Bavi	Kolwas, Oddu	Dona [in rocks]
Assam		Jampoi	Dongs			
Bihar	Ahar, Pynes					
Delhi		Dighis		Baolis	Lat	
Gujarat				Vavdis, Virdas		Tankas
Himachal Pradesh					Kuhl	Khatri
Karnataka	Kere	Kalyani [Temple]	Katte, Kunte	Bhavi	Katay	
Kerala				Surangam, Mala	Korambu	
Madhya Pradesh		Talab		Baolis	Pat, Kata, Munda, Bundhan	
Maharashtra	Kohli				Bhandaras, Phad	
Nagaland					Zabo	
Orissa	Kata		Bandha		Munda	
Rajasthan	Johad, Talab	Chandela, Bundela	Rapat, Nadi,	Bavdis, Beris, Kuis, vavdis	Naadal, Khadin	Kundis, Tankas
Sikkim	Kholas		Khup	Kohar		
Tamil Nadu	Eri, Kanmai, Thangal	Kulam [Temple]	Oorani	Kinaru, Keni	Anicut	Large vessels
Uttar Pradesh	Ahar, Pynes	Lat	Nullah			
West Bengal					Dungs, Jampois	

ANNEXURE 1

RWH AT THE MICRO LEVEL

In every premises, whether it be a house, multi-storeyed residential and/or commercial complex, office, factory etc., rainwater falls only on two places: 1) rooftop 2) all around the builtup area, which could be a driveway, garden etc.

ROOFTOP HARVESTING

Rooftop rainwater is of a good quality as it falls on clean terraces and is brought down by the drainpipes called rooftop pipes.

I) Direct at least one or more of these pipes located close to the existing below ground level masonry tank (also called sump, which in Chennai is meant for receiving water supplied by the municipality) into it through a filter.

Note 1. These filters, which are used only to remove suspended impurities in rooftop water, can be masonry tanks measuring 2.5 ft. X 2.5 ft. and about 3 ft. deep. One third of these filters alone should be filled with coarse river sand sandwiched between two layers of pebbles/blue metal. A nylon mesh should be spread in between the bottom layer of pebbles and sand. The remaining two thirds should be left unfilled for smooth flow of water. A PVC drum can also be used for this purpose.

Note 2. In cases of diversion of rainwater into sumps, the filter will have to be located above the ground level and there should be enough space available for it.

Note 3. Diversion to sumps is recommended only in places where there is no or very little municipal supply and where water is purchased or tanker fed even on rainy days.

II) Any overflow from the sump can be led into an open/dug well, if any, within the premises. Pipes not directed to the sump can also be led into the well (fig.1)

III) In the absence of an open well, a percolation/recharge well could be dug (fig.2) and the same can be made use of to put the rooftop water into it.

These are constructed using cement rings, the diameter of which range from 3 ft. to 6 ft. depending on the volume of water that is likely to be ingested into them. The depth to which these wells are dug depends on the nature of the soil. They are left unfilled and covered with RCC slabs of suitable thickness.

IV) In houses/flat complexes where there is not enough space around the built-up area to dig a recharge well, a percolation/recharge pit could be made (fig.3) for the purpose of putting rooftop water into it.

A percolation/recharge pit is a hand bore made in the soil with the help of an augur and filled up with pebbles / blue metal and river sand on top. The depth of these pits will be anywhere between 4 and 8 metres depending on the nature of the soil. The pit has to be dug to a depth till a reasonably permeable stratum is reached. The diameter of the pits will be 25 cm. (10in.). A square/circular collection chamber with silt arrestor is provided at the top. Instead of filling up with pebbles, which is done only to prevent caving in of the bore, a PVC pipe of 6 in. diameter can also be inserted for the entire depth.

V) In areas where the soil is likely to be impermeable up to say, 20 ft. or more, it is advisable to go in for a percolation/recharge well up to 10 or 15 ft. and a percolation/recharge pit within this well up to another 10 or 15 ft. from its bottom till a permeable soil is reached. A PVC pipe of 4 or 6 ins. diameter is inserted into the bore for the entire length (fig. 4).

The above mentioned alternatives pertain to the soil found in and around Chennai and suitable changes will have to be incorporated into them by taking into account the nature of soil found (up to a depth of 10 metres) in places where harvesting is attempted. It should be borne in mind that RWH, as aquifer recharge is soil specific, which will have to be reasonably permeable to take in all the water that is ingested into the RWH structures.

DRIVEWAY RUNOFF HARVESTING

There is a general feeling among people that only rooftop water is fit for harvesting and not the driveway runoff. This is so because surface runoff both at the micro and macro levels appears to be dirty hence thought unfit for harvesting. It should be borne in mind that it is only suspended impurities and can still be put into a recharge well at the micro level, where the soil will be able to filter it. It is true that surface runoff water should not be led into a sump for immediate use or to a source well.

In a large number of houses/flat complexes, office complexes the driveway area (all around the builtup area) will be as much or even more than the rooftop area. Rainwater falling on this area will be quite large and in addition a sizeable quantity of rooftop water will also contribute to this, which eventually runs off to the street through the gate(s). Hence harvesting driveway runoff in such places becomes very important. This should be harvested by intercepting it with the help of a shallow gutter (covered with a perforated RCC slab) or a bump (which will be a cheaper alternative to the gutter) near the gate(s) and directed to a recharge well(s) (fig.5). Such driveway runoff should not be led into a source well or a recharge pit since the runoff will contain large amounts of silt.
Please note that the figures which have been referred to above can be found in the booklet titled "RAINWATER HARVESTING in Urban Areas" published by the Rain Centre.