Environment

Water & Environmental Sanitation Network (WES-Net India)

Solution Exchange for WES-Net India Consolidated Reply

Query: Roof water harvesting in urban areas for groundwater recharge, from ICEF, New Delhi (Experiences).

Compiled by Pankaj Kumar S., Resource Person; additional research provided by Ramya Gopalan, Research Associate
22 August 2006

Original Query: Mihir Maitra, India-Canada Environment Facility (ICEF), New Delhi

Posted: 26 July 2006

Recent discussions on the Solution Exchange WES-Net community have underlined the phenomenon of falling water table in the country and its consequences. The efficacy of roof water harvesting as a solution for recharging ground water has already been demonstrated by a number of agencies such as the Centre for Science and Environment. The Central Ground Water Authority has also laid down basic designs and guidelines for roof water harvesting in India.

Despite these favourable initiatives, roof water harvesting - particularly for groundwater recharge in urban areas - has not taken root on a large scale in India. In this context, I request the community to respond on the following:

1. Members' experiences on the **challenges** in large-scale propagation of roof water harvesting for groundwater recharge in urban areas. Members may also suggest **mechanisms** for its promotion such as subsidies and promotional, quality control and monitoring measures?
2. Should adoption of roof water harvesting be made mandatory for certain category of buildings, as is the case with fire safety, for example? What has been the experience in implementation of roof water harvesting laws/ regulations in states where roof water harvesting has already been made mandatory? Of special interest would be the experience in Delhi.

Responses received with thanks from:

1. **S. Vishwanath, Rainwater Club, Bangalore (Response 1; Response 2)**
2. **R. Santhanam, Indian Society of Agribusiness Professionals, New Delhi**
3. **Kalika Mohapatra, Disaster Mitigation and Vulnerability Reduction Hub, Orissa**
4. **K. Murali, Hydrogeologist, AFPRO**
5. **Steven Forth, Vancouver, Canada**

6. **K. A. S. Mani, APFAMGS Project, Hyderabad**
7. **Arunabha Majumder, All India Institute of Hygiene of Public Health, Kolkata**
8. **S. D. Umrikar, Ground Water Specialist, Government of Maharashtra**
9. **N. Lakshmi Narayan, Dakshinya Institutes, Guntur, Andhra Pradesh**
10. **D. Derashri, Water People and Pani Wale, Bhilwara**
11. **G. Misra, Directorate of Economics and Statistics, Port Blair**
12. **V. D. Sharma, VBS Purvanchal University, Jaunpur, Uttar Pradesh**
13. **Areti Krishna Kumari, Institute of Chartered Financial Analysts, Hyderabad**
14. **Nandini Gopalamenon, Health & Family Welfare Trg Centre, Kozhikode, Kerala**
15. **Vijay Kumar, Chartered Environmental and Water Resources Exploration and Development Associates, New Delhi**
16. **Shubhang Pandya, Sarvangi Vikas, Ahmedabad**
17. **Divya Sehgal, Freelancer, New Delhi**
18. **Vinod Chopra, Independent Consultant, New Delhi (Response 1; Response 2)**
19. **Ajit Seshadri, The Vigyan Vijay Foundation, New Delhi**
20. **Premesh Balan, PRAVAH, Ahmedabad**
21. **Sarbeswara Sahoo, Kalpataru, Angul, Orissa**
22. **Biswajit Padhi, SRUSTI Khariar, Orissa**
23. **M. M. Sharma, International Agricultural Research Institute, Hyderabad**
24. **Bharath Jairaj, Citizen, Consumer and Civic Action Group (CAG), Chennai**
25. **Rahul Banerjee, Aarohini Trust, Indore**
26. **M. S. R. Murthy, Sri Venkateswara University, Tirupati**
27. **Ravi Nayse, Ambuja Cement Foundation, Chandrapur, Maharashtra**
28. **Prabhjot Sodhi, UNDP GEF Small Grants Program, New Delhi**
29. **Dinesh Kumar, IWMI, Gujarat**
30. **Amitava Basu Sarkar, Himalayan Institute Hospital Trust, Dehradun**

Further contributions are welcome!

Summary of Responses

The monsoons have been pouring across the country, so the weather seemed just right for a query on roof rainwater harvesting (RRWH), members noted. The shower of responses received made for a lively discussion on the challenges, mechanisms/systems and various experiences with RRWH.

Members were unanimous about the advantages of RRWH, considering that the demand is increasing and supply shrinking. They also pointed out that while the concept is age-old the use of RRWH for groundwater recharge is of recent origin. Members distinguished RRWH from artificial recharge by defining it as collecting and storing rainwater for future productive use. They contended there is no alternative to RRWH and that it must be encouraged in all possible ways.

Respondents listed a number of **challenges** in the large-scale propagation of RRWH. Firstly, there are the geological factors affecting recharge- most areas in the country have hard subsurface rocks, limiting the impact of natural recharge methods. Another issue is ensuring the quality of water sent into ground water (GW) aquifers. They mentioned several ways that RRWH contaminate GW, including unhygienic conditions on rooftops; not allowing the first rains to wash the roof before recharge; fertiliser and pesticide residue from roof gardens; and combining

surface and rooftop harvesting. Additionally, the lack of low cost and efficient filters is a bottleneck in removal of GW contamination.

Members mentioned several **constraints** when trying to scale up RRWH. The technology is not standardised, few within the building industry have the necessary skills, the initial costs are high (as compared to the highly subsidised water utility rates), and most of the time there is a "minimum water bill", regardless of usage. Another hurdle, members noted, is the attitude of water consumers, who often prefer to purchase water rather than harvest it and wish to keep RRWH pipes "hidden" from view. Furthermore, the lack of underground space in residential plots and the scale of recharge possible under natural conditions given the pattern of rainfall in India are also constraints. The amount of surplus water available during monsoons is too much to store and it is prohibitively expensive for individual households to build large enough storage structures. Additionally, the currently available process for RRWH for individual houses is very cumbersome, requiring a wide variety of technicians and material to be assembled.

To address the storage constraint problem, members suggested collecting the runoff from individual roofs for households to use and divert the surplus water to large storage tanks built by local authorities. Then after adequate quality control, the water could be pressure injected into aquifers to ensure quick recharge. Another method suggested was to use storage structures with larger surface areas such as ponds and lakes to allow for recharge. However, when promoting RRWH, the government must also conserve natural water harvesting areas. Respondents mentioned that the rapid drive to cover up every inch of ground with pavement has reduced natural infiltration and in some places caused floods. They also pointed out that hydrologically, some portions of cities are in recharge zones and others are in discharge zones, requiring different technologies.

The group shared different technological, economic and legal **mechanisms to promote RRWH**. Among **technological options**, members argued that instead of investing huge sums of money in building storm drains to transport water away from cities, this water could easily be treated and used for groundwater recharge (GWR). They suggested using perforated slabs and paving alternate sections to allow for increased percolation. Pointing out that centralised sewage systems are water and cost intensive, decentralised sewage treatment conserves water and saves rivers from pollution. Members advised using government buildings as well as buildings at higher levels to collect water for smaller houses and houses at lower levels, to increase the surface area available for RRWH.

Members identified a number of **economic measures** to use as mechanisms for encouraging RRWH. Offering rebates on property taxes and one-time subsidies to people building RRWH structures, like some state governments are doing, was one suggestion. Along this line, they recommended targeted RRWH subsidies for economically weaker sections of society, rather than blanket subsidies, and national banks making loans available to install RRWH systems. Another measure suggested is rationalising the pricing of water by various supply agencies so it is not at wide variance with the per litre cost of RRWH, thus making it a more economically viable option for consumers. Members also shared their personal/ project experiences with RRWH projects in **Andaman and Nicobar Islands**, **Andhra Pradesh**, **Haryana**, **Madhya Pradesh,** **Tamil Nadu** and **Delhi,** all with varying levels of economic viability.

The **legal mechanism** mentioned by members is making RRWH mandatory like in Chennai, Hyderabad and **West Bengal**; in the former, there is even a separate RRWH department. Along with enacting and implementing laws, there must also be an effort to inform the public about the various aspects of the law to prevent misuse and corruption. Respondents emphasised making RRWH mandatory for all users, especially major water users such as hotels, car washes and golf courses, and all government buildings. They advised using municipal bodies to ensure

enforcement of RRWH laws and setting up multi-stakeholder task forces to implement and monitor RRWH systems at the local level.

It is vital to **generate awareness** on RRWH, in order to implement the above recommendations. Respondents stressed the importance of changing attitudes so water users understand the government cannot "create" water" and those with money cannot "buy" as much water as they want- it must be carefully managed by the community. They emphasised that RRWH must not be forced but be owned by communities, because if people install systems but are not convinced, they tend not to maintain them. Additionally, members suggested including "water management" in the curriculum in schools and higher education (such as for architects and civil engineers). Similarly, corporations could promote RRWH projects, like a company, which has launched a Total Water Management project in their housing complexes in **Maharashtra** and **Gujarat**.

Respondents cautioned that perhaps the "romantic" concept of RRWH is obscuring more mundane but dependable options for GWR such as wastewater, which unlike rainwater, is available all year round. They also emphasized the need for dependable and well-built systems, especially in areas where rainwater plays a very important role in supplementing the fresh water supply.

Comparative Experiences

Tamil Nadu

Citywide Use of Roof Rainwater Harvesting *(from Kalika Mohapatra,, Disaster Mitigation and Vulnerability Reduction Hub, Orissa)*
The state government has rigorously promoted RRWH structures in Chennai, creating a department solely for their maintenance. Most houses in the city are using a RRWH structure, adopting either percolation pits or recharge-well methods. Households with structures connected to sumps, report that good recharge takes place with only 1/3rd of the length of filters filled up. However, there are problems relating to cleaning them and their limited durability.

West Bengal

Mandatory RRWH *(from Arunabha Majumder, All India Institution of Hygiene of Public Health, Kolkata)*
All large housing projects, office complexes, and industries (especially new units) must adopt rainwater harvesting after due consent from the statutory organisation, after ensuring proper identification of recharging zones and recharging in a manner that prevents polluting groundwater. Rural schools are also encouraged to use rainwater roof catchment systems in rural schools for use of the water for sanitation (toilet and urinals cleaning).

Andhra Pradesh

Residential Experience with RRWH *(from N. Lakshmi Narayan, Dakshinya Institutes, Guntur, Andhra Pradesh)*
A household constructed a RRWH system with a bore well 200 ft. deep for recharging all the rainwater from the roof. Neighbouring households did not adopt RRWH and within a few years, bore wells in the entire area went dry. In response, residents started RRWH leading to an increase in groundwater levels in the entire region.

Andaman and Nicobar Islands

RRWH Supplements Fresh Water Supply *(from G. Misra, Directorate of Economics and Statistics, Port Blair)*
RRWH is an important source of fresh water for the islands, since groundwater reservoirs do not meet all the islands' needs during summer months, thus restricting water supply. Various government buildings have RRWH installations. However, often these installations break down due to stormy weather conditions. Judicious planning could help secure a consistent water supply for the islands.

Maharashtra

Corporation Launches Successful RRWH System *(from Vijay Kumar, Chartered Environmental and Water Resources Exploration and Development Associates, New Delhi)*
Asian Paints recently launched a concept of Total Water Management in one housing society having a high-rise building. The project considered an innovative and cost-effective system given the existing infrastructure of building with a dome structure and terrace used as catchment areas. The arrangement allows for direct delivery of water from dome to overhead supply tanks, benefiting by reducing intake of water from Bombay Municipal Corporation.

Household Use of RRWH *(from Ravi Nayse, Ambuja Cement Foundation, Chandrapur, Maharashtra)*
One household in a community adopted a RRWH system and promoted it within the neighbourhood, sensitizing the community to the issue of water saving. They use the harvested rainwater for cooking, washing cloths, etc. and sometimes share with residents of other colonies in emergencies. This effort has set an example for other neighbourhoods to replicate.

Madhya Pradesh

Effective Individual RRWH System in Indore *(from Rahul Banerjee, Aarohini Trust, Indore)*
A household RRWH system drilled five 30 cm diameter recharge bores, 5 M deep into the ground and filled them with layers of gravel and sand. The system has worked very well in recharging the water from the roof without any overflowing. Calculations show that the system has recharged 40,000 litres annually. The cost of recharge is less than the Municipal Supply, indicating it is an economically viable proposition.

Haryana

National Security Guard (NSG) Manesar Campus Recycles Sewage Water *(from Vinod Chopra, Independent Consultant, New Delhi; response 1)*
A sewage treatment plant operates 2-3 hours/day, treating the sewage with EM bacteria, resulting in over 800,000 litres of clean water available to spray the campus, thus preventing groundwater depletion. Regular tests show that the water has no smell and the BOD/COD is well below limits for horticulture. Results indicate that the water's high nutrient content nourishes plant, and reduces suspended particulate matter in the air.

Delhi

New Delhi Household Using RRWH Method *(from Vinod Chopra, Independent Consultant, New Delhi; response 2)*
Every roof on the house is sloped into pipes bringing rainwater into a single 1.5m^3 unlined pit containing layers of gravel and sand to filter out mud. Because the pit is 1.5m deep, it never overflows, allowing water to percolate into the ground. In experiments over the past four years,

15,000 litres easily percolate through the pit, even in peak monsoons. The cost was about Rs. 15,000 and estimates reveal that collection of water is 45,000 litres per year.

International

From Ramya Gopalan, Research Associate

Singapore

RRWH System in High-Rise Buildings
Almost 86% of Singapore's population lives in high-rise buildings and most of these buildings use a light roofing material on their roofs to collect rainwater. The collected roof rainwater is stored in separate cisterns on roofs for non-potable uses. This system has proved quite effective; one establishment in Changi Airport collects and treats water, which accounts for 28 to 33% of its total water used, resulting in savings of approximately S$ 390,000 per annum.

Japan

Large-Scale Rainwater Usage in Tokyo
A Sumo-wrestling arena in Sumida City utilizes rainwater on a large scale. The 8,400m^2 rooftop of this arena serves as the catchment surface for the rainwater utilization system. The system drains the collected rainwater into a 1,000m^3 underground storage tank and uses it for toilet flushing and air conditioning. Following this example, many new public facilities including the City Hall has begun to introduce rainwater utilization systems.

Germany

Car Manufacturer Employs Rainwater Harvesting System
In October 1998, DaimlerChrysler Potsdamer Platz introduced rainwater utilization systems as part of large-scale urban redevelopment, to control urban flooding, save city water and create a better microclimate. Rainwater falling on rooftops (32,000m^2) of 19 buildings is collected and stored in a 3,500m^3 rainwater basement tank, then used for toilet flushing, watering of green areas (including roofs with vegetative cover) and replenishing of an artificial pond.

Related Resources

Recommended Organizations

Rainwater Club *(from S. Vishwanath, Rainwater Club, Bangalore)*
264, 6th Main, 6th Block, B.E.L Layout, Vidyaranyapura, Bangalore 560097; Tel.: 080-23641690/ 672790; http://www.rainwaterclub.org/

For information on examples of rainwater harvesting undertaken in the urban context, design of RWH systems, workshops and trainings conducted and related research work.

Total Water Management (TWM), Asian Paints *(from Vijay Kumar, Chartered Environmental and Water Resources Exploration and Development Associates, New Delhi)*
http://www.apaints.com/twm/index.html

Recommended for its RRWH initiative in 2002 at Bhandup factory installing a scientifically correct and well designed system, also promoting other similar systems in its CSR policy

From Ramya Gopalan, Research Associate

International Rainwater Harvesting Alliance (IRHA)
Maison Internationale de l'Environnement II, Chemin de Balexert 7-9, 1219 Genève, Switzerland; Tel: 41227974157; Fax: 41227974159; secretariat@irha-h2o.org; http://www.irha-h2o.org/

This international alliance provides a unified voice for the RWH movement, disseminating and building on achievements this field, working towards fulfilling the MDGs

UTTHAN Development Action Planning Team
36, Chitrakut Twins, Nehru Park, Vastrapur, Ahmedabad 380015 Gujarat; Tel.: 910796751023/ 6752875/6732926; Fax: 91079 6750935/6763624; utthan@icenet.net
http://www.utthangujarat.org/achive.htm

Recommended for information on community-based rain water harvesting systems

Rainwater Harvesting
http://www.rainwaterharvesting.org/Urban/Latest-Designs.htm

Page has some of the latest designs provided by the Centre for Science and Environment as technical expertise to individuals and organizations interested in undertaking RWH

Recommended Documentation

From S. Vishwanath, Rainwater Club, Bangalore

Draft Policy on Rain Water Harvesting in Urban Areas of Karnataka
http://www.solutionexchange-un.net.in/environment/cr/res07080602.doc (Size: 45 KB)

Details the Karnataka State Draft Urban Rainwater Harvesting Policy, which the government is in the process of finalizing

Rainwater Harvesting to be Compulsory
The Hindu; January 19, 2006
http://www.thehindu.com/2006/01/19/stories/2006011918600400.htm

Article on new law in Bangalore making rainwater-harvesting compulsory for all new buildings within city limits, same rules to be extended to urban local bodies in the state

Vadose Zone
Wikipedia; July 2, 2006
http://en.wikipedia.org/wiki/Vadose_zone

Encyclopaedia article elaborating on the issues related to the recharge of the 'Vadose Zone' also termed as unsaturated zone and the difficulties with recharging the zone

Glen-Reaping the Harvest *(from Vijay Kumar, Chartered Environmental and Water Resources Exploration and Development Associates, New Delhi)*
http://www.apaints.com/twm/index.html (and click on "Success Stories")

Explains Asian Paints' success story using an innovative and cost-effective rainwater harvest scheme in a housing society, which enabled them to reap significant benefits

Awareness Campaign on Water Management and Rain Water Harvesting *(from Prabhjot Sodhi, UNDP Global Environment Facility Small Grants Program (GEF SGP), New Delhi)*
UNDP GEF SGP and Centre for Women's Development and Research (CWDR)
http://www.solutionexchange-un.net.in/environment/cr/res07080601.doc (Size: 40 KB)

Provides details on two experiences, which have been undertaken within the UNDP GEF SGP, focusing on creating awareness about Roof RWH systems

Roof Water Harvesting in India *(from Dinesh Kumar, IWMI, Gujarat)*

By Dinesh Kumar; Water International, International Water Resources Association; 2004
http://www.solutionexchange-un.net.in/environment/cr/res07080603.pdf (Size: 64 KB)

This article argues that roof water harvesting systems (RWHS) are not alternative to public systems in urban and rural areas of regions receiving low rainfall.

From Ramya Gopalan, Research Associate

Rainwater Harvesting and Utilization
Newsletter and Technical Publications; United Nations Environment Program, Division of Technology, Industry and Economics
http://www.unep.or.jp/ietc/Publications/Urban/UrbanEnv-2/9.asp

Provides examples from countries across the world discussing various rainwater collection systems and discusses contextual differences existing between

Water and Community Development: Rainwater harvesting and Groundwater Recharge
By Robert Davies and Bunker Roy; The Global Rainwater Harvesting Collective; December 2004
http://www.globalrainwaterharvesting.org/pdfs/SDI13-14-4.pdf (Size: 471 KB)

The paper aims to present some ideas and practical applications concerning rainwater harvesting in India and other countries

Rainwater Management in Korea: Public Involvement and Policy Development
By Mooyoung Han and Jusuk Park; University of Tokyo
http://env.t.u-tokyo.ac.jp/furumailab/crest/workshop05/june10am_1.pdf (Size: 1,933 KB)

Presents the movement and involvement of public to promote RWH in Korea together with some of the demo projects

Recommended Website

Rainwater Harvesting *(from Ramya Gopalan, Research Associate)*
Hosted by Tamil Nadu Water and Drainage Board (TWAD)
http://www.aboutrainwaterharvesting.com/sucessstories_individual_krg.htm

Provides details on the available methods, costs and benefits, individual and community experiences through a record of success stories in the State

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Responses in Full

S. Vishwanath, Rainwater Club, Bangalore *(response 1)*

I wish to share some experience on rooftop rainwater harvesting that would perhaps answer the questions posed by Mihir.

Firstly rooftop rainwater harvesting is collection and storage of rainwater for future productive use - a definition we need to arrive at; otherwise it is sometimes understood only as artificial recharge.

Secondly, rooftop rainwater harvesting works best when it makes economic sense to the consumer. In Bangalore, for example, industries pay Rs. 66/- a kilolitre for water. If they harvest rainwater, the typical costs of water vary between Rs. 5 a kilolitre to Rs. 20 /- a kilolitre. Payback periods also vary between 6 months to 4 years, thus making rainwater harvesting meaningful for industries.

Subsidies can harm rooftop rainwater harvesting. Again, in Bangalore, domestic water is priced at Rs 6/- a kilolitre (a subsidy of Rs 12 per kilo-litre). This makes rainwater harvesting uneconomical and therefore uninteresting for many domestic households.

Minimum tariffs on piped water are also a disincentive. Many households that have adopted rainwater harvesting have found to their dismay that they are given a minimum bill of Rs 135/- by the water supply department, even though they have not used a drop of piped water. The minimum bill is for a minimum consumption of 15 kilo-litres. Therefore, it does not make sense for the household to not use the 15 kilolitre and anyway pay for it.

Additionally, the issue of recharging groundwater is tricky business. In hard rock terrain, infiltration and percolation rates are limited and therefore recharge is not fast enough to handle the intensity of rain and the volume of discharge. There is also a question that often arises - If I recharge the groundwater how much of the water will I get? Difficult questions to answer.

Typically, many parts of the city are recharge zones and many are discharge zones. For example, valleys could be prone to water logging without artificial recharge. Therefore, great care is needed not to make a mandatory One-Size-Fits-All law. Like solar energy (or virtue/honesty/goodness), rainwater harvesting should be its own reward. Only then it succeeds.

After some debate, the state of Karnataka now has a draft urban rainwater harvesting policy. This has either gone to the Cabinet for approval or is in the process. It seeks to make rainwater harvesting mandatory for new buildings with plot area more than 200 square metres or plinth area more than 100 square metres. It also seeks to make harvesting of 20 mm of rain mandatory, either through storage or recharge as appropriate, based on the site. This means a 100 sq. meter roof area has to make a provision to harvest at least 2000 litres of water. The economic incentives being offered are through two measures - a rebate on property tax to the tune of 20% for 5 years OR a one-time subsidy of Rs 1500/- to Rs 2500/- for the first X number of houses (left to the Municipality/Corporation to decide). The policy also focuses separately on water harvesting in parks and open spaces, roads, institutional areas and industries.

The biggest concern in using rooftop rainwater for groundwater recharge remains the quality of the water being used for recharge. Storage and reuse is therefore seen as a better option though costlier and perhaps inappropriate in some conditions.

There are of course clearly issues related to recharge of the vadose zone [*See http://en.wikipedia.org/wiki/Vadose_zone for details - Moderator*] and the top aquifer or that of secondary porosity relating to deep bore wells. In many a case recharge through open recharge wells is much easier than recharging a bore well.

For some examples of rainwater harvesting in urban context, I request interested members to see www.rainwaterclub.org.

R. Santhanam, Indian Society of Agribusiness Professionals, New Delhi

Observations of Mihir Maitra are very pertinent. I wish to state two points here:

1. Water recharge systems could also utilise wastewater streams besides tapping the few months of monsoon downpour in India. The usage of sewage and sullage in ground water recharge after treatment will have additional benefits in that the treated water will help improve the brackishness of water, which is now more or less common in most

urban areas. Additionally, sewage and sullage is also available throughout the year and can help in steadily recharging the ground water.

2. Some scientists have pointed out that rainwater is contaminated with excess nitrates, probably due to NOx emissions resulting from intensive exploitation of fossil fuels. Additionally, modern chemical based farming has increased the nitrification of soils, as leachates from farm chemicals get washed down into ground water reserves. Other studies show that mineralisation causes formation of impervious mineral layers preventing seepage of rainwater into ground. Thus, rain water would require treatment for reduction of excess nitrates.

Kalika Mohapatra, Disaster Mitigation and Vulnerability Reduction Hub, Orissa

To the best of my knowledge, Chennai has promoted roof top rainwater harvesting structure in the city and almost all houses have installed these structures. The state government has promoted this rigorously and has created a department dedicated to looking at maintenance of all roof top rainwater structures. Most houses in the city have adopted either percolation pits or recharge well methods.

However, cleaning the percolation pits may not be possible, as it resembles a bore well with four-inch pipe laid 20 feet deep. These structures would function only for one or two years and residents may have to replace these with recharge wells. Households, which have structures, connected to sumps report that good recharge takes place with only 1/3rd of the length of filters filled up.

K. Murali, Hydrogeologist, AFPRO

The thought of making roof water harvesting mandatory in urban areas is very much appreciable. However, to ensure that citizens in urban areas do not take it as a burden, good IEC campaigns may be taken up to disseminate the philosophy and necessity of roof top rainwater harvesting. This can be followed by appropriate technical inputs.

Also, care should be taken that polluted water does not flow into productive aquifers. Water quality can be maintained by ensuring that roofs are clean of bird droppings, and other pollutants.

Once people are aware of all these aspects, subsidies and bank loans can be arranged for the same. In Chennai, when roof top rain harvesting was made mandatory, some nationalized banks came forward to offer loans.

The above needs to be done with the full participation of people and should not be forced on communities, as it may have negative repercussions. For example, in Chennai, due to improper construction for recharge, most recharge structures get clogged and water logging during floods or heavy rains are a common sight. Recharge also depends on the geology of a region.

The efforts also need good monitoring by the government or a suitable statutory.

Steven Forth, Vancouver, Canada

For roof water harvesting to really be acceptable on a large scale, what is needed is a deep cultural change, one where people are able to re-imagine what a roof is and the function it plays

in their lives. For most of us, a roof is just the least differentiated part of our home, and we only care about it when it leaks or gets blown apart by the wind. We need to change this so that roofs (i) become part of where we live (ii) are a place for water collectors, wind generators, solar panels and gardens.

A multi-dimensional approach is therefore needed -

- Building standards and practices must be reviewed
- People in construction trade must be trained
- Small companies that support a new technology supported
- Major public buildings need to set an example
- Songs, movies, books, TV, web sites, comics need to include roof water, roof gardens, etc.
- Tax incentives and subsidies will play an important role
- Prominent public people can take the lead - actors, singers, sports heroes, local leaders

We are talking of a big change here and no city has really succeeded in the effort of roof water harvesting yet, but I think it is an important step towards creating sustainable cities.

I look forward to seeing what ideas come up in this thread.

K. A. S. Mani, APFAMGS Project, Hyderabad

Roof water harvesting (RWH) has been used since historical times to meet drinking water requirements at times of stress and has proved successful for meeting needs for a few days to a few months in many parts of India. However, RWH for stabilizing groundwater levels is probably a new phenomena and its utility for large scale impact on a regional level is still to be proven, while at local levels it has had limited impacts.

New designs in RWH promoted by various municipalities/Urban bodies/ Govt agencies for groundwater recharge have failed to capture peak flows (because of size limitations) at time of storms, and consequently have been of limited use for recharge. However, if this infrastructure had been used to transfer harvested water to large surface or sub surface reservoirs and water injection could be done pressure into aquifers, they could have had a larger impact.

In my opinion, therefore, the need is to have a regional network of individual RWH. In all RWH locations, the harvested water could initially flow into a lined subsurface reservoirs/sump to meet local non drinking water needs. All sumps may have additional overflow outlet, which may be connected to storm water drains (similar to septic tank). These storm water drains may flow into unlined surface reservoirs having injection wells to facilitate gravity flows with a provision for pressure injection at times of peak flows.

Arunabha Majumder, All India Institute of Hygiene of Public Health, Kolkata

I submit my response on rain water harvesting and recharge.

1. Rainwater recharging may be subsurface or specific to the selected deep aquifer. Subsurface recharging through designed pits and sand-gravel filtration arrangement may be useful. The recharging rainwater can be collected from roof as well as from the courtyard and open spaces of the building area. This is suitable for Housing Societies or Cooperative, School/College premises, Office complexes, IT Parks etc. Deep aquifer recharging requires adoption of proper method. One has to take consent from the

Statutory Organisation (PCB). One has to be very particular about the misuse of the recharging phenomenon and has to ensure that recharging by any means should not create ground water pollution problem. One has to identify actual recharging zone for the proposed area to give benefit.

2. In West Bengal, it has been made mandatory for large Housing Projects, Office Complexes, and Industries (especially new units), etc. to adopt rainwater harvesting for use of the same for various purposes. In addition, they are encouraged to undertake rainwater recharging.

3. Rainwater roof catchment system is encouraged in rural schools for use of the water for sanitation (toilet & urinals cleaning).

S. D. Umrikar, Ground water Specialist, Government of Maharashtra

It is good that many of us are talking seriously about roof top rainwater harvesting. We know that for any form of water, whether it be surface or subsurface, replenishment is done only by rain water. There is no alternative to rain water harvesting and a day may come when only this form of water is available if we draw ground water indiscriminately. Let us join hands and make people aware about this activity.

N. Lakshmi Narayan, Dakshinya Institutes, Guntur, Andhra Pradesh

I wish to share my experience of roof water harvesting in my own house in Hyderabad, which had a bore well 200 feet deep in which all the rainwater from the roof was sent. However, my neighbours did not pay attention to this, and within a few years, bore wells in the entire area went dry. At this, they started recharging groundwater by roof water harvesting. This has led to an increase in groundwater levels in the entire region.

I therefore feel that roof water harvesting for groundwater recharge should be made compulsory.

D. Derashri, Water People and Pani Wale, Bhilwara

I strongly favour making rooftop rain water harvesting as mandatory. However, the only draw back is that if it is used for recharge, one has to ensure that the quality of water being sent into aquifers is reliable. For this, efficient and economical filters need to be designed & made public, if necessary with subsidies.

Moreover, recharge in hard rock terrain is not feasible due to a lower rate of percolation and methods to tackle the issue in such problem areas must be evolved. Additionally, the cost of storing water varies from Rs.1 to Rs. 3 per litre, thus becoming expensive. For this, community based and government owned large storage may be constructed.

G. Misra, Directorate of Economics and Statistics, Port Blair

Rooftop water harvesting is used for ground water recharge in urban or other places, but in Andaman and Nicobar Islands, it is used to supplement the needs of fresh or sweet water. Thus, rainwater harvesting is a major concern in such areas. The reservoirs do not meet all needs in summer months and often water supply is restricted to 200 litres for three days for a household.

Various government buildings also have such installations. However, due to heavy rains and stormy weather, often these installations break down do not collect water.

Judicious planning can help us to further tap this resource. The Andaman and Nicobar Islands are hilly terrain. Rooftop rainwater harvesting can be placed in such a way that the water is available at various levels. Thus, buildings at higher level may help households or users at lower level down the hill. Often government buildings are found in big sizes, which can harvest water for smaller houses are small in urban wards.

Members have also rightly pointed out that sewage is perennially available in abundant. If this is treated, the large amount of waste poured untreated in rivers like Ganga and Yamuna can be prevented and the rivers can be saved.

V. D. Sharma, VBS Purvanchal University, Jaunpur, Uttar Pradesh

The issue of rooftop RWH shows that sincere efforts can really be very much fruitful. Rooftop RWH could be made mandatory through government orders for government colonies. For colonies developed by colonisers as well as for private constructions, the municipalities/municipal corporations can ensure it while passing the building designs. It should also be made compulsory for educational and other institutions.

Areti Krishna Kumari, Institute of Chartered Financial Analysts, Hyderabad

In Hyderabad, one of the scientists of ICRISAT, whose native place is Rajasthan constructed an underground tank and made arrangements to collect rain water into this. The water is not exposed to sunrays and stays clean and safe throughout the year for his use. The cost is around 10,000 rupees.

Nandini Gopalamenon, Health and Family Welfare Training Centre, Kozhikode, Kerala

It has been made mandatory in Chennai for builders to create facility for ground water recharging. No flats or buildings are licensed without the provision for ground water recharging facility.

For more information on ground water recharging, please contact: Centre for Water Research Development & Management, Kerala

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Vijay Kumar, Chartered Environmental and Water Resources Exploration and Development Associates, New Delhi

I would like add to Vishwanath's experience on rooftop RWH and the concerns of people residing in cities like Bangalore.

As we all know, most water supply agencies are also managing sewage network in their respective towns/ cities. Although the minimum charges are linked to water consumption by the consumers, the water supply charges also reflect the use of the drainage system even if consumers do not use water.

The concept of roof top rainwater harvesting is very simple but its utility varies from person to person in urban areas.

The prevailing scenario and understanding on RWH in urban areas

The preferences of the owner affect the collection area, conveyance, filtration system, storage system, and the condition of the borehole / tube well. Owners also desire that the roof water harvesting system is concealed and does not distort the elegant look or occupy undue space in the house. Also, most houses already use available underground space for sub surface tank and sewer systems, and therefore. , over and above the space problem is over riding the layout designs.

The cost of the layout is equally a concern; we prefer to spend on cars/ACs/cell phones etc. but on water only on ROs/deepening of tube wells, big size of storage tanks. Also would prefer to purchase water rather do our own to harvest from rooftop. The situations are changing but with slow pace. Chennai people have realized but there are still many better solutions to be evolved, innovative types too.

In most of the case the RWH system are made for per-say to meet the regulatory requirements of the notified areas / buildings. There effectiveness reduces considerably with time and people even want to improve its effectiveness but gets reduced considerably and RWH system works very slowly and system gets clogged due silt. Reason being the first-roof-wash is not being followed in most of the case. Hence, under such circumstances, how cloud it help in rise in water levels and improve the ground water conditions.

Also, it does not help the individual, and need a collective actions by most feasible roof /house units to diver the rain water to collection system and then for storage and re-charge of ground water.

Hence scaling of rooftop RWH in urban area is not easy to adopt, since actions are required by the individuals in collective manner, even if it has been made mandatory on covered / plot size.

Quality surveillance and monitoring of collected rainwater

The facilities for water quality monitoring are not available with all agencies, and very few municipal authorities are equipped with water quality monitoring labs or GIS applications to monitor it. There is need for development/municipals authorities to be equipped with GIS application usage to do so.

Asian Paints in Ankleshwar has done remarkable job in this respect. But others are yet to follow in the town. Sree Gattu Vidhyala, Ankleshwar has shown its interest but yet to implement.

Most of institutions those have adopted rainwater harvesting, it is a combo type; surface run-off and some selected rooftops. No proper quality control when it comes to monitor and then allow on-line into recharge of groundwater.

Are rooftops fit for RWH?

The condition of the rooftop will decide the quality of water collected. However, most roof tops are poorly maintained and are dumping places for domestic waste materials, such as empty toxic/paint cans, broken furniture, motor wheel tyres, etc. During rainy season, such places are breeding places for mosquitoes too. In other rooftops, gardens are maintained which may use pesticides and inorganic and may cause nitrate contamination of ground water, which would be injurious to health.

Thus utmost care & caution needs to be taken while designing the RWH layout, ensuring that the collected rainwater should not carry any contamination.

In addition, scaling of roof top RWH would be better when both individual and collective roof /house RWH units in a locality divert rainwater to a collection system and then to a storage structure with due care to water quality. This should then be allowed to recharge the ground water.

Shubhang Pandya, Sarvangi Vikas, Ahmedabad

What surprises me is the extent to which civic administrations go to prevent rain water harvesting even through natural ground seepage. An example is the large scale paving of curbs and footpaths, compounds of public buildings, where every square centimetre of the exposed and absorbing soil is covered with cement concrete products. Ahmedabad town municipal authorities have this summer undertaken an exercise to pave the footpaths edge to edge, thus completely preventing any natural water seepage, and heavy runoffs leading straight to storm drains, leaving very little soil moisture for trees which are planted in thousands and die a natural death due to lack of water.

Public buildings are similarly paved. A large public building in Jaipur, which was the venue of a seminar on water issues in Rajasthan, to my surprise, is completely and solidly paved!!

The right solution would be to (i) avoid paving, leaving the ground exposed to the falling rain (ii) pave alternate paving blocks to leave open land to allow ground seepage.

Architects and town planners need to be sensitized to the grave damage being done by these practices. Citizens need to assert themselves on this point, as capital expenditure of any type is always welcome to civic administrations, as it allows siphoning off public funds. In this case, it also adds to prevention of natural recharge.

Divya Sehgal, Freelancer, New Delhi

RWH can be seen at three levels- domestic users, institutions, commercial establishments etc.

All users of private bore wells need to do RWH on a priority basis. Simply put, they owe it to the well. This holds true for individual owners as well as big guzzlers of water such as hotels, automobile wash stations, bus depots, golf courses, restaurants, etc.

Additionally, we need to invest in storm water drains, for which budgets need to be earmarked for improvement and maintenance. MCD wards need to see that community RWH has been done in their respective wards. The educated elite need to be sensitized to not permanently cover these drains and perforated slabs may be introduced for easy maintenance. The year can also be declared as RWH year. Thus things need to be done on war footing. We need to find permanent urban solutions rather than going for piecemeal or half-hearted measures. We also need to get rid of the menace of water logging, which is so endemic to Indian cities. Let water go where it belongs. Sanitation is another area that cannot be ignored in the total arena of water management. 80% of our water needs are for non potable purposes such as Sewage. We need to conserve water in this area.

The water bodies are now cesspools of sewage and construction material, and need to be revived. Can the Government think of Public private partnership on this? Advertisements in print

or electronic media can be sent out, asking interested individuals or corporations to come forward to give a helping hand. A task force comprising of government, NGOs active in this area, and elected representatives etc. may be formed.

Vinod Chopra, Independent Consultant, New Delhi *(response 1)*

I have witnessed the remarkable results to be found in the National Security Guard (NSG) campus in Manesar, where a sewage treatment plant is operated 2-3 hours a day and has been additionally treated with EM bacteria. The result is that over 800,000 litres of clean water are available for spraying on the grounds of this campus. Please note that:

- The water has no smell.
- Is regularly tested to show BOD/COD well below the limits for horticultural use.

The results are:

- Since the water has high amount of nutrients, plants grow well and add plenty of oxygen to the air.
- Since the grounds are wet- there is very low suspended particulate matter (SPM) in the air.
- The ground water levels are not depleted due to percolation of the treated water, in spite of the unit drawing out nearly 1 million litres per day.

Ajit Seshadri, The Vigyan Vijay Foundation, New Delhi

This topic on RWH, which has come for discussion, is very apt and ideally suited at this time of the season. There are points to be taken up for discussion and for due assessment and work towards conclusion with good intention for way forward for sustainable future.

The situation as it stands is that no single urban or rural, central or from the states is accountable or responsible for this initiative of RWH for surface storage and for storage to ground aquifers. Ground Water Management/Rainwater Management could be taken up by a special task force in Ministry of Water Resources, GoI.

Dependent on site conditions there are many types of RWH which members are aware off and as complex and there lies its diversity.

Suggested methods are to take up mega RWH using ponds and lakes and more centralized systems, as their cost effective. The other method is to contain, process or filter and take up for recharge to ground water for reuse in decentralized versions. Innovative and effective systems are in service for RWH using old dried-up village dug-wells being nearby to storm drains in urban scenario. The ground water recharge thus done is effective in enhancing the ground water resource and also improving the quality of ground water.

Our NGO has had experience in implementing varied RWH systems both in urban and rural areas, and more than 200 watersheds applied with RWH in the last 5 years. It is tough to state openly that no one is concerned and it is very apt now, to put our thoughts and assess as to how it can be bettered.

Tamil Nadu gave a lot of impetus to RWH and emerged with pros and cons, but overall 20 to 30% benefits would be forthcoming. Making rules and regulations, how implementation is to be done, legal strictures, penalties, grants, subsidies, rewards all have been done but to no avail.

What we ought to know is that even in the curriculum of Architects/Civil Eng. in the subject of "Services" after urban drain or storm water design, there is no mention of RWH.

Let us take up the case of Delhi with its expanse 60km by 60 km and a river within which can provide enough catchment potential for storage and or recharge to ground. Next is to assess the components for an effective RWH in the city:

1. Urban drain /storm- rainwater- Nalis and Nallahs
2. Bigger network of Nallahs- Najafgarh and Shahdara drains and many smaller ones
3. Water bodies in downstream - drain channels
4. Ground water regimes/Water levels etc.
5. Sewerage systems
6. Finally the River Yamuna - Flood plane of river

When the above are assessed there is gross deficiency in their upkeep and neglect from the part of the urban local bodies. All these are to be working in tandem for an appropriate Rainwater management. The same status applies to other Indian cities as well.

Suggested Ways Forward:

1. To try and opt for mega RWH, Colony based RWH linked with urban drains, which can take care of making, operating and maintaining with control and monitoring features added.
2. Education and awareness at school, college and community levels on water conservation and optimum usage of water.
3. To get the most value from the available water resources by simple mantra-"Reduce, Reuse, Recycle and Recharge"
4. Govt. mechanisms to take charge of RWH and its management.
5. As part of Corporate Social Responsibility, water using factories and industries can be more prudent and take more effective part in water management and in RWH.

Vinod Chopra, Independent Consultant, New Delhi *(response 2)*

I wish to share my personal experience in rooftop RWH for groundwater recharge.

Every roof in my house is sloped into pipes that bring the rainwater into a single 1.5 Cu M unlined pit containing layers of gravel and sand to filter out the mud. Because the pit is 1.5M deep, it never overflows. The pit allows water to simply percolate into the ground.

In experiments over the past 4 years, I have found that 1500 litres of water will easily percolate through the pit, even in peak monsoons.

Using this RWH method, I estimate I have been able to collect (150 sq. m. X 30cm) = 45000 litres per year. This is assuming that 50% (30cm) of the 60cm annual rainfall is harvestable as light rain would simply evaporate or dissipate in the top soil.

Since this is in my own house, there is no additional expense in respect of staff - we are able to maintain the pit and pipes ourselves. But in large projects, the maintenance cost of a team that comprises labour, supervisors and managers, this would be a significant additional and would require some running costs every month.

Since the cost of making this RWH method was about Rs. 15,000/-, I estimate that the cost of enhancing ground water below my house is Rs. 33.33 per Kilolitre (over a 10 year period). If you

compare that with the Rs. 6/- per Kilolitre that is the cost of water received from the municipality, it seems that RWH is too expensive.

I would hesitate to spend such a high rate for ground water recharge. However, if the same money or more was applied to recycle grey and waste water, the sheer volume of water available for re-charge would be so high as to bring down the per Kilolitre cost.

It would be worthwhile to do a cold-hearted reality check on the cost of RWH. I fear that RWH has got romanticized when recycling seems to be the only viable solution.

Premesh Balan, PRAVAH, Ahmedabad

Greetings! I have been following up with the query on roof water harvesting in urban areas since last two days and I feel I should send you some of our observations:

Firstly we will have to consider that:

1. The availability of land in urban areas is not much; hence, the only use of RWH is not going to solve the problem.
2. The additional systems like recycling have to be promoted to reduce the pressure on the water requirement in urban areas.
3. Though we have a clear understanding of the Panchayat functioning in rural areas, most of us do not have the understanding of the Urban Local bodies.

Following this some of our experiences in urban rainwater harvesting has been:

- People are ready to invest in structures but a technical and cost wise break up is necessary to convince them.
- The expectation of subsidy or "Government scheme" has to go with Government taking initiatives in rewarding the individuals or societies undertaking rainwater harvesting.
- The rainwater harvesting has to be seen in continuation with how recycle can be promoted for use in toilets or garden or other such purposes. this would reduce the burden on water demand and many communities would be managing their own systems.

In addition, there is a requirement of community mobilization in the urban areas on Water Sanitation and Hygiene, which would enable greater discussion on the local level solutions!

Sarbeswara Sahoo, Kalpataru, Angul, Orissa

Given the growing water scarcity especially in metros, roof top water harvesting is the need of hour. In some city as discussed by some of our friends, this is made mandatory. This may be one solution. Discussion regarding environmental crisis has been limited to English educated academics and development practitioners. The technique will be proved more effective, if its value is understood by masses. This however requires a larger effort by all.

Biswajit Padhi, SRUSTI Khariar, Orissa

I agree with Shubhang Pandya

Recently I saw earthen tiles (of the thickness from 2 inches above - the thickness is proportional to the weight it can withstand - in tonnes) which can be used in pavements. Water can soak to

the ground through it while maintaining the cleanliness of the place. It looks very good also. Hopefully municipal administration can promote that.

M. M. Sharma, International Agricultural Research Institute, Hyderabad

I give our own experience with water conservation and try to relate to others.

1. We constructed our house in Sainikpuri area of Secunderabad in 1995. I think this was the first attempt in Andhra Pradesh where rooftop rain water was collected in an underground tank of about 90,000 litres tank (I had a very difficult time to get the house plan approved, as it was not like "normal" houses). We get over 125,000 litres rainwater from our roof and since 2005 monsoons; our neighbours' roof has also been connected to our underground tank. Therefore, we conserve (store) 250,000 litres of water in a year. We use this water for drinking, cooking, bathing and washing clothes for the whole year. In our case, the used water goes to soak pit to enrich groundwater table.
2. Since year 2002, our colony has municipal tap water supply. However, this is supplied only on alternate days (and every third day in summer) for about 45 minutes to an hour. Since this is obviously is not enough, all houses need to have their own dug wells or bore wells. Most dug wells (except those in low-lying areas) have dried up in the last 10 years as the water table is going down. Before municipal supply, we used water from our bore well for washing floors, watering plants, flushing toilets and cleaning in kitchen. Therefore, 50% of our water consumption came from rainwater tank and 50% from bore well. Now 50% comes from rainwater and 50% from municipal supply and we do not use bore well at all.
3. In 1995 when we dug our bore well, its depth was 170 feet. In the last four years the new houses in my colony have 6-inch diameter bore wells (not 4 inch as it was before) and depth is 800-1100 feet deep. I think the mentality is that "we go deeper and we get more water", and secondly "I can put money for a deep bore hole [because I have money] and therefore can get the lion's share of this important natural resource".
4. I think it is a question of awareness that government cannot create water. Identification of dependable source of water is technically not easy and its dependable supply is expensive. We as consumers do not respect water (polluted Ganga and Yamuna are best/worst examples) and we are wasteful. In addition, we want water virtually free. Water consumption meters, wherever supplied must be enforced in a dependable manner. In areas where water is supplied for a fixed duration and not every day, regulation by meter could be enforced later. A more realistic cost must be charged for the water supplied to all, irrespective to the labels "rich" "middle class" or "poor".
5. All apartments could have water supply meters even for their own overhead tanks supplied system (by govt. system, or bore wells or water bought through private takers). If a family in an apartment consumes more water a meter will make them pay more, and that will discipline the family. As long as all are to share an equal amount of water, nobody behaves or helps save water.
6. In AP, we have a law for rainwater conservation. Most people do not know this and those who know, do not respect this. In most cases, the Government does not enforce the law strictly, as it fears it will lose votes. Not enforcing the law also benefits many parties. For example, when you construct a new house, you need to show that you have built a rainwater harvesting pit to the authorities. However, you can get away by not constructing and paying a small bribe rather than spending a larger amount on constructing the tank. In already constructed houses, it is practically very difficult to make a soak pit. See how many people you have to deal with – 1. the digger 2. someone to bring a tractor trolley and take away dug sand, 3. stones (kantar) of three types (they

all are different suppliers and don't sell less than one lorry load and we don't need full load) 4. sand (again getting less than one lorry sand is either not easy or it is very expensive. If all this is done, the designs suggested are such that they get choked and it is not easy to maintain soak pit. Therefore, if my fellow residents in my colony just get rid of the law by paying 300 rupees, they are not foolish. The Govt. offered a carrot of house tax rebate earlier, which even I could avail (with my perfect rainwater conservation system) because that law also expects me to have 10 trees in my boundary. Now having ten trees in a plot of 300 yards with a two-bed room house is just not possible. Yes, one can have 300 pots (that we have) but not 10 trees. For good reasons, let us try to find answers of this problem by bringing awareness for benefits by conserving, instead of bringing more laws on this. A law, with many faulty provisions will only harm the purpose. The Government in Delhi is satisfied as long as enough water is supplied to about MPs, MLAs and the army of bureaucrats in Delhi and state capital. As long as these are supplied enough water, the problem is not perceived.

7. We have to stop looking at the government for creation of Laws on water. Enough water has always been available in our country by a socially developed and dependable system.
8. It is true that I had to spend almost 10% of the whole house construction money on the rainwater conservation system, but I am convinced that in my case, the costs are recovered and now the system gives us net savings. Also not using bore well pump of two horsepower has helped me save substantially our monthly electricity bill. I know about 10 such families who have developed systems like ours and are happy about the quality of very good water that we have compared to others.
9. Educating and bringing awareness is the key, not laws.

Bharath Jairaj, Citizen, consumer and civic Action Group (CAG), Chennai

In the case of Chennai, most households have indeed carried out rooftop RWH in conformity with the law brought out by the GoTN a couple of years ago. I might be steering away from your two carefully drafted queries to the group, but I am taking the liberty of bringing a few additional perspectives to this issue.

I would submit that rooftop RWH can at best only have limited success, if the governments of the day do not realise that existing groundwater recharge zones need to be first protected. Look around any urban settlement and you will find the river beds, flood plains, lake beds, wetlands, old tanks including temple tanks, low-lying areas, open spaces, playgrounds, parks being either filled in and built on or being used as garbage dumps.

It is ironical and foolish to destroy these vast spaces and then mandate that individual houses and buildings collect and store rainwater. This is not to say that household RWH is not desirable, but that it can never replace the kind of recharge one can expect and depend on from protecting natural RWH areas. The first responsibility therefore is to identify such areas and protect / revive them.

The absence of this will ensure that even the most water-starved city will face floods when the rains do come - as Chennai, Bangalore and Mumbai faced in 2005 - no matter how many households do rooftop RWH. And in a few months, one will be back in the water-scarce mode!

There is one other aspect to this - and this pertains to collecting rainwater from the vast road networks that our cities have. Most cities either allow this rainwater from the city roads to flow into the sewage system or spend enormous amounts of money (as Chennai did) and construct a storm water drainage system to collect all this water and release it into the sea. Surely, rainwater

from the roads could be collected and released into community level RWH spaces (temple tanks etc.)

In the end I would submit that we need to look at rooftop RWH as merely complementing more serious efforts made by the State and its agencies at community level measures. A State that mandates rooftop RWH in the absence of these larger efforts (or worse, while actively supporting the destruction of existing natural RWH areas) is clearly not serious about resolving the water supply issue.

Rahul Banerjee, Aarohini Trust, Indore

I would like to respond to Vinod Chopra's estimates of the cost of RWH. In our house, here in Indore too we have implemented RWH. We have drilled five 30 cm diameter recharge bores five meters deep into the ground and filled them up with layers of gravel and sand the same, just as Vinod has done with his recharge pit. This system too has worked very well in recharging the water from the roof without overflowing. Using the same assumptions as he does in calculating the recharged water volume we arrive at an annual figure of 40 cum or 40,000 litres for our house.

However, our cost of recharge is much less. Firstly the pipe cost has not been counted because these pipes have to be installed anyway to drain water from the roof, regardless of whether one uses the water for recharging groundwater, (if this is not done, the water flows directly on to the street from the rooftop, which is against municipal rules). The recharge bores have cost us just Rs. 1,000 each thus giving a total cost of Rs. 5,000. This means that in our case, over a ten-year period the cost comes to Rs. 12.5 per kilolitre. The Indore municipality (which has taken a loan from the Asian Development Bank for implementing a water supply scheme and therefore has to follow the Bank's dictates regarding pricing of water) has just taken a decision to hike water rates to a commercially viable value of Rs. 16.67 per kilolitre from the present subsidized rate of Rs. 6.67 per kilolitre. Thus, our recharge cost per kilolitre is competitive to the new commercial rate of the Indore Municipal Corporation. Moreover, we have spent another Rs. 15,000 in constructing septic tanks and soak pits to treat and recharge all wastewater that we produce into the ground. In this way, we are saving the municipality the tremendous cost of carting our wastewater away. Since the above RWH systems are well designed, they work without a hitch and in the three years since construction, we have faced no problems.

Thus if actual costs are taken into account, recharging of storm and wastewater is definitely a viable economic proposition. More importantly, it is an environmentally sane mode of using scarce water.

M. S. R. Murthy, Sri Venkateswara University, Tirupati

The comments of Bharath Jairaj are pertinent and relevant. Many water bodies in Bangalore, Chennai, and my own town Tirupati have been allowed to be occupied and concrete structures have come up on these places. The Bangalore City Bus Stand was a big tank. The percolation from this tank would have charged at least the ground water around it. In 1970s, I have seen a number of tanks dotting Bangalore and Tirupati. Now they all of these are occupied. Asking people to be saner and adopt RWH at this point in time is therefore a laughing matter. In Tirupati, there is a bore well at every 40 feet. The Municipality and Panchayats around Tirupati are also paving the roads, preventing seepage of rainwater.

In Telugu, we have a proverb, which roughly translated into English reads "Touching the leaves after hands have been burnt for relief".

Ravi Nayse, Ambuja Cement Foundation, Chandrapur, Maharashtra

I agree that roof top rainwater systems are essential for urban areas compared to rural areas, as there are more roofs in urban areas. However, apart from roofs of households, there are many other sources from where rainwater can be harvested and stored to use in scarcity period.

Storm drains may be one answer. In urban areas, almost 15% land is occupied by roads and community places, which again is potential for RWH. Further, private and public establishment have a major share of the occupied land. I feel that it should be an integrated effort, where individuals as well as such establishments should think of harvesting rainwater as per their capacity and potential. A task force can work out the potential of possibility of roof top rainwater harvesting in all major urban cities with priority in water crises area and suggest possible means of using this rainwater.

I personally did RWH and promoted other neighbours. I realize that this makes me and my neighbours sensitive towards water use. We use this water for cooking, washing cloths etc. and sometimes even gave water to residents of other colonies in emergencies, with a message that they should also get RWH done at their house. I suggest that all government buildings, NGO, School/College building and all those who are sensitive towards this issue should go for RWH and its storage and stop using underground water or tap water. This will be ideal example for others to follow. We have to do it ourselves first and only then we can tell others. This is the best way of convincing people.

Prabhjot Sodhi, UNDP Global Environment Facility Small Grants Program (GEF SGP), New Delhi

I am also sharing details on two small experiences, which have been undertaken within the UNDP GEF SGP. The details have been mentioned in the following link and the same can also be accessed from the concerned partners.

See http://www.solutionexchange-un.net.in/environment/cr/res07080601.doc

We are sure that this will meet the needs of the communities. We are keen this important aspect is addressed effectively.

Looking forward to hearing about any more things, that maybe required.

S. Vishwanath, Rainwater Club, Bangalore *(response 2)*

Of some, help perhaps, a Draft Urban Rainwater Harvesting Policy, which the government of Karnataka is in the process of finalizing. Please find the Draft Policy at the following link,

http://www.solutionexchange-un.net.in/environment/cr/res07080602.doc

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Dinesh Kumar, IWMI, Gujarat

I am enclosing my paper on the topic of **Roof Water Harvesting in India**, published in *Water International,* the official journal of International Water Resources Association (IWRA), in 2004. See http://www.solutionexchange-un.net.in/environment/cr/res07080603.pdf

Upon reading this, colleagues may like to debate on the issues raised.

Amitava Basu Sarkar, Himalayan Institute Hospital Trust, Dehradun

Engrossing discussion. My observation based on personal experience:

1. State initiatives in this respect is a must. State initiative is needed in the form of both in drafting suitable laws to vigorous IEC campaign, to ensure a balance between ground water extraction and recharge. In this regard giving subsidy blindfolded will not help. It may certainly be considered for economically weaker section of the urban society.

2. The role of NGOs/CBOs in this regard must also be explored to motivate and mobilize people.

3. We must have to standardize the roof-top-rain-water-harvesting-system technically, be it for consumption or for ground water recharge. Feasible technology is available to urban society. It is a question of acknowledging and realizing our responsibility as citizen of a civil society. Only then will this work. For that in the beginning, we might need to make it mandatory for at least all the government buildings, as the administration of Andaman and Nicobar and Delhi has already done.

4. Sustainable IEC campaign through various media has to be done. The media also has to extend its full support. It may be ensured by giving then some economic benefit.

5. Personally speaking I have seen rural communities to use this technology to solve their acute drinking water shortage. It is a question of realizing the need for it. Only then will it be a peoples' movement - the only way to make this feasible. To do that we need to involve all the stakeholders right from the inception of the initiative.

Many thanks to all who contributed to this query!

If you have further information to share on this topic, please send it to Solution Exchange for WES-Net at se-wes@solutionexchange-un.net.in with the subject heading "Re: [se-wes] Query: Roof water harvesting in urban areas for groundwater recharge, from ICEF, New Delhi (Experiences). Additional Response."

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