



Environment

Water Community



## Solution Exchange for the Water Community Consolidated Reply

### *Query: Promoting Rainwater Harvesting Structures in Hilly Terrain - Examples; Advice*

Compiled by [Nitya Jacob](#), Resource Person and [Sunetra Lala](#), Research Associate

Issue Date: 20 February 2009

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From [Arnab Bhattacharjee](#), Social Activist, Malkangiri, Orissa

Posted 8 January 2009

I am a social activist working with tribal communities in the hilly terrain of the Malkangiri district, Orissa. I am also associated with various NGOs in Orissa.

The Malkangiri district is divided into two distinct physical divisions. The eastern part is covered with steep ghats, plateaus and valleys sparsely inhabited by tribal communities (Bondas, Koyas, Porajas and Didays). The rest of the district is a relatively flat plain broken by a number of rocky wooded hills. The average annual rainfall in the Malkangiri district is about 1700mm. The major rock groups in the area are granite, shale, quartzite, sandstone, limestone and marble (please visit [http://orissadiary.com/orissa\\_profile/district/Malkangiri.asp](http://orissadiary.com/orissa_profile/district/Malkangiri.asp) for more details regarding the district).

The district is backward in irrigation in comparison with other districts due to its high hills and dense forests. The tribal communities of the area have limited irrigation facilities due to constraints in water availability (please visit <http://www.hindu.com/2008/10/20/stories/2008102056860300.htm> for an article that appeared in the Hindu on the lack of rain threatening *Kharif* crops in Orissa). I have found a general lack of irrigation facilities in highlands, and on hilly slopes, especially in tribal areas. This lack of irrigation facilities limits the scope of agriculture in these areas that are usually inhabited by tribal communities. In addition to impoverishing them, it affects their diets and nutrient intake.

From my experience, and experiences of organizations working in the region, it seems harnessing rainwater is the most favourable solution to the problem of agricultural water shortages. However, people here have little knowledge about implementing rainwater-harvesting systems for supplying irrigation water, as the quantity of water required is large and entails construction of large structures. They are unaware of the appropriate structures required for this; lack the experience of constructing such structures and the financial wherewithal to do so. People here also lack the technical expertise required to site and design appropriate rainwater harvesting and management structures for irrigation.

I, therefore, request community members to provide information on the following:

- What are the appropriate rainwater harvesting structures, suitable for hilly terrain that can be designed and made by local communities?
- What are the sources of funding for implementing such structures? Please mention government, international and national organizations that support such activities?

- How can tribal communities be mobilized and trained to design, build and manage these structures?

Your responses will help a network of seven NGOs (with which I am associated) working in the region to design a road map for providing irrigation water through appropriate rainwater harvesting technologies for the tribal communities living in the area.

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### Responses were received, with thanks, from

1. [Puran Singh Yadav](#), Haryana Institute of Rural Development, Karnal
2. Dinesh Kumar, Institute for Resource Analysis and Policy, Hyderabad ([Response 1](#); [Response 2](#); [Response 3](#))
3. [Ashutosh Das](#), Association for Integrated Development, Bhubaneswar
4. [V. D. Sharma](#), Purvanchal University, Jaunpur, Uttar Pradesh
5. [Saurabh Gunjan](#), DIA Trust, Godda
6. [Digbijoy Bhowmik](#), Deloitte Touche Tohmatsu India Private Limited, Gurgaon
7. Raghu Subramaniam, Consortia SBG, Bangalore ([Response 1](#); [Response 2](#))
8. [Dipak Roy](#), United Nations Children's Fund (UNICEF), New Delhi
9. [Ajit Seshadri](#), The Vigyan Vijay Foundation, New Delhi
10. [Shrikant D. Limaye](#), Ground Water Institute, Pune
11. [Vishwanath Srikantaiah](#), BIOME, Bangalore
12. [Murali Kochukrishnan](#), Action For Food Production (AFPRO), Bhubaneswar
13. [N. Lakshmi Narayana](#), Dakshinya Institutes, Guntur, Andhra Pradesh
14. [Surekha Sule](#), Independent Journalist, Pune
15. [Atul Rawat](#), DMV Business & Market Research Pvt. Ltd., Hyderabad
16. [Vijay Kumar](#), Chartered Environmental and Water Resources Exploration and Development Associates, New Delhi
17. [Amitava Basu Sarkar](#), Himalayan Institute Hospital Trust, Dehradun
18. [Venkatesh P.](#), Medical College, Bangalore
19. [S. V. R. K. Prabhakar](#), Institute for Global Environmental Strategies (IGES), Japan
20. [S. V. Vijaya Kumar](#), National Institute of Hydrology, Deltaic Regional Centre, Kakinada
21. [A. L. Khan](#), Uttar Pradesh Irrigation Department, Lucknow
22. [Salahuddin Saiphy](#), Centre for Science and Environment, New Delhi
23. [Nafisa Barot](#), Utthan, Ahmedabad
24. [Uday Bhawalkar](#), Bhawalkar Vermitech Pvt. Ltd, Pune
25. [Pankaj Shrivastav](#), United Nations Development Programme (UNDP), New Delhi
26. [Arunabha Majumder](#), Jadavpur University, Kolkata\*
27. [Sanjeev Kaul](#), Himachal Pradesh Irrigation and Public Health Department, Himachal Pradesh\*
28. [Shailja Kishore](#), Aga Khan Rural Support Programme (India), Ahmedabad\*
29. [Nate Stell](#), BIOME, Bangalore\*
30. [Ruchi Pant](#), United Nations Development Programme (UNDP), New Delhi

*\*Offline Contributions*

*Further contributions are welcome!*

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[Summary of Responses](#)  
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## Summary of Responses

There is an amazing range of structures for harvesting rainwater in hilly terrain that local communities can construct and manage using funds from non-profit organizations, the government or their own sources. These structures use appropriate local material in keeping with the topography of the region and segregate provision of water for domestic and agricultural uses. The tribal people of Malkangiri, Orissa can choose from a combination of models best suited to meet their water needs. They can build them using their own resources or resources available under various tribal area development schemes and/or the National Rural Employment Guarantee Scheme (NREGS). There are also many ways to mobilize them to construct these structures.

For **agricultural purposes**, members suggested harvesting rainwater using check dams, sub-surface dams, percolation tanks, field ponds, nullah bunding, gabion dams, sub-surface reservoirs or brushwood dams. Another low-cost and extremely efficient mechanism for harvesting floodwater from rivers is the ahar and pyne irrigation system used in **Jharkhand**. Pynes are channels that flow with the gradient of the land, while ahars are catchment basins closed on three sides; the fourth faces uphill to allow water to collect. These are suitable for gentle slopes. In [Tamil Nadu](#), artificial ponds collect water runoff from uncultivable lands that irrigate fields lower down.

**Gravity-based irrigation systems are better suited to hilly areas.** This approach employs a combination of check dams, percolation tanks and field ponds. Small structures like brushwood dams or gabions can slow the flow of water rushing down hillside gullies and ensure more even distribution. Brushwood dams comprise thin long sticks tied together, placed across a gully between two rows of stakes planted in the ground; on top of the stakes, people put large objects like boulders. Gabions are 'bags' of rocks, 15-25 cm in size, bound together by heavy-duty galvanized wire or nylon nets. Both are extremely useful in checking the silt load in streams, the bugbear of any water management system. Larger gabions can divert part of this into field ponds, provided the region has enough plains to make fields. On steeper slopes, contour bunding and terrace farming, where steps 'carved' into the hillside check the runoff, can provide water for irrigating at least one crop.

Check dams reduce the velocity of rainwater run-off, allowing it to percolate into the soil and recharge aquifers. They raise soil moisture levels, enabling people to cultivate at least one crop, and the water availability in wells or hand pumps. The exact location, number and type of check dams that would be appropriate for an area like Malkangiri, depends on the topography, but there are certain broad commonalities with similar structures. For example, in the villages of Ralegaon Sidhi and Hiware Bazar in [Maharashtra](#), and in the Arvari river basin area of [Rajasthan](#) people have built an elaborate network of check dams to arrest the flow of water, allowing it to percolate and recharge aquifers. They have used local material such as mud, rocks and in larger structure, concrete, to make the check dams.

Rooftop rainwater systems ideal for collecting drinking water. The prerequisite for this model is that the roofs or catchments have to be made of steel sheets or some other material that will allow water to flow into a collection chamber and they must be cleaned before the rainy season. Along with rooftop systems, another approach is to use water from sandbed filters fed from ponds, although the quality of water for drinking is lower.

In **Uttarakhand**, people have made rainwater-harvesting tanks with capacities of 7,000 litres from [ferro-cement](#). In [Arunachal Pradesh](#), a city government is promoting the construction of rooftop rainwater harvesting systems, which allow participations to avail of an exemption in tariffs for drinking water. In Dahod, **Gujarat**, people are harvesting rainwater to maintain the quality of drinking water.

However, extensive rainwater harvesting systems can lead to conflicts between and within villages. In some cases, farmers divert the runoff from the catchment into their open wells, which can make a lot of difference to flows in drought years. To avoid potential flare-ups, programme implementers can adopt a watershed approach to minimize conflicts between villagers, villages, farmers and non-farmers as well as people living upstream and downstream.

Alongside providing water through rainwater harvesting, people have to reduce water consumption by agriculture since water storage options in hilly areas are always limited. Growing crops that require less water, harvesting at the right time (at physiological maturity of the crop and ploughing fields immediately) and understanding the irrigation needs of different crops can help conserve water. Moreover, communities need to make decisions regarding livelihoods and agriculture based on the water available, rather than the other way around.

Several **organizations provide funds for rainwater harvesting** in India. These include Haryana from the Ministry of Rural Development, the Department of Science and Technology, the Indian Council for Agricultural Research (Water Technology Centre for Eastern Region), National Bank for Agriculture and Rural Development (NABARD), Freshwater Action Network Asia (FAN Asia), Plan International and WaterAid. Two other sources of funding are NREGS in rural areas and the Jawaharlal Nehru National Urban Renewal Mission (JNNURM) in urban areas. In addition, communities can get funds from the local area development funds of Member of Legislative Assembly (MLAs) and Member of Parliament (MPs).

The final issue is the **capacity building of local people** to construct and maintain RWH structures. Several NGOs run training centres on rainwater harvesting, such as [Barefoot College](#) in Tilonia and [Utthan's](#) People's Learning Centre. In addition, various organizations have produced reference manuals on rainwater harvesting that detail these techniques and can be adapted for training the local people. The local people can visit different sites around the country, mentioned earlier, to learn first-hand how to make and maintain these structures.

Promoting RWH necessitates training communities and involving them in constructing rainwater-harvesting structures, so they take ownership of these structures. If implementers adopt a watershed approach, they can avoid conflicts. Community ownership and participation are the two critical inputs that can contribute to a lasting solution in Malkangiri.

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## Comparative Experiences

### Arunachal Pradesh

#### **Change in Building By-Laws to Include Rainwater Harvesting Leads to Water Conservation, Itanagar** (from [Digbijoy Bhowmik](#), *Deloitte Touche Tohmatsu India Private Limited, Gurgaon*)

The state receives heavy rainfall and the water supply is frequently disrupted. Under the Jawaharlal Nehru National Urban Renewal Mission, Arunachal Pradesh has now been mandated to take up rainwater harvesting. Towards this end, the city government is modifying building by-laws to include provisions for rainwater harvesting. Although slow, this initiative is being adopted by residents and is expected to lead to better catchment management. Read [more](#)

### Maharashtra

#### **Community-Based Water Harvesting Leads to Village Prosperity, Ralegaon Sidhi, Parner Taluka, Ahmednagar District** (from [Puran Singh Yadav](#), *Haryana Institute of Rural Development, Karnal*)

Since 1975, the village of Ralegaon Siddhi (aka Ralegan Shindi) has been led by Anna Hazare. During that time, the village has carried out a range of programmes, including planting of trees, terracing to

reduce soil erosion and digging canals to retain rainwater. As a result of these community-led initiatives, the village is now quite prosperous and is serving as a model for rainwater harvesting, environmental conservation and economic revival. Read [more](#)

## Rajasthan

### **Village Shows the Way for Water Groundwater Conservation, Hiware Bazaar Village, Ahmednagar District** (from [Puran Singh Yadav](#), *Haryana Institute of Rural Development, Karnal*)

The village implemented a Panchayat resolution that dictated that no borewells could be used for irrigation. The resolution also called for rejuvenating shallow dug wells for irrigation. Villagers dynamited the bedrock to create fissures and allow rainwater to percolate into aquifers, leading to enhanced rainwater percolation and conservation. Consultations among the gram sabha (village assembly) proved key to the initiative's success. Read [more](#)

## Tamil Nadu

### **Rainwater Harvesting in an Agrofarm Results in Better Irrigation** (from [Raghu Subramaniam](#), *Consortia SBG, Bangalore*, [response 1](#))

Rainwater harvesting was taken up by Consortia SBG on an agro-farm located in a hilly area of the state to help it deal with irrigation water supply problems. Artificial ponds were created at strategic locations to collect run off water from non cultivable land and road run off. As a result, the collected water could be successfully diverted to low-lying land for irrigation on a need basis. The project is currently being implemented and is expected to increase the water supply for irrigation purposes.

## Uttarakhand

### **Construction of Tanks for Harvesting Water Leads to Enhanced Drinking Water Availability** (from [Amitava Basu Sarkar](#), *Himalayan Institute Hospital Trust, Dehradun*)

Until the 1990s, the state faced deficiencies in its drinking water supplies. Starting in the 1990s the state government started constructing rainwater harvesting tanks to meet the drinking water needs of the population. These ferro-cement structures are now being constructed in villages, which do not have any other source of water. Individual families are in charge of the upkeep and maintenance of these tanks, and the project has been successful in meeting the drinking water requirements.

### **Training of Local Community Members Augment Rainwater Harvesting** (from [Ruchi Pant](#), *United Nations Development Programme (UNDP), New Delhi*)

To deal with the water needs in the state, the NGO Pan Himalayan Grassroots Development Foundation worked to popularise the construction of concrete underground tanks for rooftop rainwater harvesting. A cadre of local "barefoot technicians" have been trained to do the masonry, plumbing, etc. for the structures. This initiative has led to the transfer of rainwater harvesting technology to the community level, which has enabled communities to successfully engage in rainwater harvesting. Read [more](#)

## International

### China

### **Applied Research in Rainwater Harvesting Helps More Than One Million People, Gansu Province** (from [Sunetra Lala](#), *Research Associate*)

Until the 1980s, the province faced severe water shortages. Based on a research and demonstration project implemented in the 1980s a "121" rainwater catchment project was sponsored to enable each family in the province to build one rainwater surface collection container and two underground water cellars to enable them to irrigate one piece of land. As a result, by 1996 1.3 million people had solved their drinking water supply problems and have developed 7.8 thousand ha of irrigated land. Read [more](#)

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## Related Resources

### Recommended Documentation

From [Puran Singh Yadav](#), Haryana Institute of Rural Development, Karnal

#### Ralegaon Sidhi

Article; Wikipedia; 7 August 2008

Available at [http://en.wikipedia.org/wiki/Ralegaon\\_Siddhi](http://en.wikipedia.org/wiki/Ralegaon_Siddhi)

*Describes how the village of Ralegaon Sidhi, Maharashtra has set an example for water harvesting, watershed management and overall rural development*

#### Hiware Bazaar: Community Stewardship of Water Resources

Article; by Nikhil Anand; India Water Portal; Maharashtra; July 2007

Available at [http://www.indiawaterportal.org/tt/wbr/case/seed\\_watr.pdf](http://www.indiawaterportal.org/tt/wbr/case/seed_watr.pdf) (PDF, Size: 344 KB)

*Describes how community imposed regulations lead to groundwater conservation and water harvesting, which helped to mitigate water shortages*

From [Vijay Kumar](#), Chartered Environmental & Water Resources Exploration and Development Associates, New Delhi

#### Gabion Tested by Flash Flood

Film; by Bart Santello; Arivaca, Arizona, USA; 2007

Available at <http://in.youtube.com/watch?v=Nppkp6YFC1k>

*Describes Gabion Dams, which have been constructed in the U.S. state of Arizona to harvest rainwater in rocky terrains and reduce the occurrence of flash floods*

#### Soil and Water Conservation Handbook: Policies, Practices, Conditions and Terms

Book; by Paul W. Unger; United States Department of Agriculture-Agriculture Research Service (USDA-ARS); The Haworth Press, Inc; USA; 2006

Available

at

[http://books.google.com/books?id=5IUUWNj2jpMC&pg=PA206&lpg=PA206&dq=iii\)+Brushwood+dam&source=web&ots=IEOTUFTbe9&sig=9u7Dx2o7a6taOtbmJsuCgoq3Gw&hl=en&sa=X&oi=book\\_result&resnum=1&ct=result%23PPR9,M1](http://books.google.com/books?id=5IUUWNj2jpMC&pg=PA206&lpg=PA206&dq=iii)+Brushwood+dam&source=web&ots=IEOTUFTbe9&sig=9u7Dx2o7a6taOtbmJsuCgoq3Gw&hl=en&sa=X&oi=book_result&resnum=1&ct=result%23PPR9,M1)

*Describes Brush/post dams, which can be built in gullies to prevent the flow of water in slopes, and can be used for harvesting rainwater*

#### California Storm Handbook BMP Handbook

Article; California Stormwater Quality Association; USA; 2003

Available at <http://www.cabmphandbooks.com/Documents/Construction/SE-4.pdf> (PDF; Size: 192 KB)

*Discusses how check dams constructed of rock, gravel bags, or sandbags can assist in harvesting rainwater if placed across a constructed swale or drainage ditch.*

From [S. V. Vijaya Kumar](#), National Institute of Hydrology, Deltaic Regional Centre, Kakinada

#### Rainwater Harvesting Techniques To Augment Ground Water

Manual; Central Ground Water Board; Ministry of Water Resources; Faridabad

Available at [http://cgwb.gov.in/documents/RWH\\_GUIDE.pdf](http://cgwb.gov.in/documents/RWH_GUIDE.pdf) (PDF; Size: 1.8 MB)

*Provides techniques for the collection and storage of rainwater from surface or sub-surface aquifers, which can be used to augment groundwater supplies and meet water requirements*

## **Manual for Roof Top Rain Water Harvesting using Cisterns or Storage Tanks for Individual Households, Community and Institutions**

Manual; by S.K. Sharma; National Institute of Hydrology; Roorkee; 2006; Permission Required: Yes, copy can be obtained at INCOH

Available at Secretariat, Member Secretary, Indian National Committee on Hydrology (INCOH), National Institute of Hydrology, Roorkee 247667 or by emailing [incoh@nih.ernet.in](mailto:incoh@nih.ernet.in)

*Guidance manual on how to harvest rainwater using cisterns or storage tanks, which can be taken up both at the both community and household levels*

## **Overview of Rainwater Harvesting in India** (from [Nate Stell](#), BIOME, Bangalore)

Spreadsheet; by Nate Stell; BIOME; Bangalore; 2008

Available at <http://www.solutionexchange-un.net.in/environment/cr/res-08010901.xls> (Excel; Size: 130 KB)

*Document seeking information on the various rainwater harvesting techniques followed across the country, in particular Manipur to assess its feasibility*

## **Concerted Rainwater Harvesting Technologies Suitable for Hilly Agro-ecosystems of Northeast India** (from [Ruchi Pant](#), United Nations Development Programme (UNDP), New Delhi)

Article; by M. P. Samuel and K. K. Satpathy; Indian Council for Agriculture Research (ICAR); Current Science; Bangalore; November 2008

Available at <http://www.ias.ac.in/currsci/nov102008/1130.pdf> (PDF; Size: 76 KB)

*Discusses how rainwater harvesting can be implemented as a viable alternative to conventional water supplies or on-farm irrigation projects in northeastern India*

From [Sunetra Lala](#), Research Associate

## **Jalyatra: Exploring India's Traditional Water Management Systems**

Book; by Nitya Jacob; UNICEF; Penguin Books India; New Delhi; April 2008

Available at <http://www.penguinbooksindia.com/Bookdetail.aspx?bookId=7235>

*Examines traditional water harvesting structures and systems of water use across India, including those in hilly areas*

## **Dying Wisdom-State of India's Environment A Citizen's Report**

Book; by Anil Agarwal and Sunita Narain; Centre for Science and Environment; New Delhi; 1997

Available at <http://www.cseindia.org/html/extra/twhs.htm>

*Discusses the rise and potential fall of India's traditional water harvesting systems, including those in the hilly north-eastern parts of India*

## **Recommended Contacts and Experts**

From [Ruchi Pant](#), United Nations Development Programme (UNDP), New Delhi

### **Manoj P. Samuel, Indian Council for Agriculture Research (ICAR), Umiam, Meghalaya**

Division of Agricultural Engineering, ICAR Research Complex for North East Hill Region, Umiam 793103 Meghalaya; Tel: 91-364-2570257; Fax: 91-364-2570288; [kna@icarneh.ren.nic.in](mailto:kna@icarneh.ren.nic.in); <http://www.icar.org.in/icar2.html>

*Expert on rainwater harvesting, is working on developing appropriate rainwater harvesting techniques that are suitable for the north-eastern areas of India*

### **Indian Council for Agriculture Research (ICAR), Umiam, Meghalaya**

Division of Agricultural Engineering, ICAR Research Complex for North East Hill Region, Umiam 793103, Meghalaya; Tel: 91-364-2570257; Fax: 91-364-2570288; [kna@icarneh.ren.nic.in](mailto:kna@icarneh.ren.nic.in); <http://www.icar.org.in/icar2.html>

*Expert working in the area of rainwater harvesting, particularly for Northeast India on how to use rainwater harvesting increase the supply of water for irrigation purposes*

### **Recommended Organizations and Programmes**

From [Puran Singh Yadav](#), Haryana Institute of Rural Development, Karnal

#### **Department of Drinking Water Supply, New Delhi**

Ministry of Rural Development, Government of India, 9th Floor, Paryavarn Bhawan, CGO Complex, Lodhi Road, New Delhi 110003; Tel: 91-11-24361043; Fax: 91-11-24364113; [jstm@water.nic.in](mailto:jstm@water.nic.in); <http://www.ddws.nic.in/rwh.htm>; Contact Shanta Nair; Secretary; Tel: 91-11-24364113.

*Central government agency responsible for providing drinking water and sanitation services to rural areas across India, including making provisions for rainwater harvesting systems*

#### **Ministry of Rural Development, New Delhi**

9th Floor, Paryavarn Bhawan, CGO Complex, Lodhi Road, New Delhi 110003; Tel: 91-11024361043; Fax: 91-11-24364113; [jstm@water.nic.in](mailto:jstm@water.nic.in); <http://www.rural.nic.in/g1.htm>

*Central government ministry in-charge of all rural development schemes including sanitation, drinking water, rainwater harvesting and other welfare schemes*

#### **Department of Science and Technology (DST), New Delhi** (from [Ashutosh Das](#), Association for Integrated Development, Bhubaneswar)

Technology Bhavan, New Mehrauli Road, New Delhi 110016; Tel: 91-11-26567373, 26962819; Fax: 91-11-26864570; [dstinfo@nic.in](mailto:dstinfo@nic.in); [http://www.dst.gov.in/about\\_us/intro\\_DST.htm](http://www.dst.gov.in/about_us/intro_DST.htm)

*Plays a pivotal role in promoting science and technology and carries out wide ranging activities that promote research and development, including activities on rainwater harvesting*

#### **Jawaharlal Nehru National Urban Renewal Mission (JNNURM), New Delhi** (from [Digbijoy Bhowmik](#), Deloitte Touche Tohmatsu India Private Limited, Gurgaon)

Ministry of Urban Development, Nirman Bhawan, Maulana Azad Road, New Delhi 110018; Tel: 91-11-23061295; Fax: 91-11-23061768; [dirwlsq@moud.nic.in](mailto:dirwlsq@moud.nic.in); <http://jnnurm.nic.in/nurmudweb/defaultud.aspx>.

*Apex authority at the national level that works to formulate policies, along with sponsoring and supporting programmes, including activities on water and rainwater management*

#### **Delhi Development Authority (DDA), New Delhi** (from [Ajit Seshadri](#), The Vigyan Vijay Foundation, New Delhi)

Vikas Sadan, New Delhi 110023; Tel: 91-11-24690431; <http://www.dda.org.in/greens/environment.htm>

*Development agency under the Ministry of Urban Development, which owns property in the municipality, and proposes construction of rainwater harvesting structures on its new buildings*

From [Vishwanath Srikantaiah](#), BIOME, Bangalore

#### **Samaj Pragati Sahayog, Bagli**

Bagli, District Dewas, Madhya Pradesh 455227; Tel: 91-7271-275757; [samprag@gmail.com](mailto:samprag@gmail.com)

*Has developed a Watershed Works Manual for those involved in implementing and monitoring RWH activities through which rainwater harvesting activities can be taken up*

#### **Advanced Centre for Water Resources Development and Management (ACWADAM), Pune**

Plot No. 4, Lenyadri Cooperative Housing Society, Sus Road, Pashan, Pune 411021, Maharashtra; Tel: 91-020-25871539; [acwadam@vsnl.net](mailto:acwadam@vsnl.net); <http://www.acwadam.org/res1.htm>

*Evolved mechanisms of integrating principles of hydrogeology and hydrology for rainwater resource harvesting and management*

#### **National Rural Employment Guarantee Scheme (NREGS), New Delhi**

Ministry of Rural Development, Krishi Bhawan, New Delhi 110001; Tel: 91-11-23063581,23034922; Fax: 23385466; [singhrp@sansad.nic.in](mailto:singhrp@sansad.nic.in); <http://nrega.nic.in/guidelines.htm>; Contact Amita Shama; Joint Secretary; Tel: 23385027 ; [amita712@yahoo.co.uk](mailto:amita712@yahoo.co.uk)

*Provides for 100 days of work per year to one person from each family below the poverty line in India, works taken up under the scheme include construction of rainwater harvesting structures*

**Action for Food Production, New Delhi** (from [Murali Kochukrishnan](#))

25/1-A Pankha Road, D-Block, Janakpuri, New Delhi 110058; Tel: 91-11-28525452; Fax: 91-11-28520343; [afprodel@afpro.org](mailto:afprodel@afpro.org); <http://www.afpro.org/success.htm#16>; Contact D. K. Manavalan; Executive Director; [ed@afpro.org](mailto:ed@afpro.org)

*Socio-technical non-governmental organization working on implementing rainwater harvesting works as part of their efforts to promote effective natural resource management solutions*

**National Institute of Rural Development (NIRD), Hyderabad** (from [N. Lakshmi Narayana](#), Dakshinya Institutes, Guntur, Andhra Pradesh)

Rajendranagar, Hyderabad 500030, Andhra Pradesh; Tel: 91-40-24008526; Fax: 91-40-24016500; [dhiraj@nird.gov.in](mailto:dhiraj@nird.gov.in); <http://www.nird.org.in/Water%20&%20Land%20Management.html>

*Examines and analyses factors contributing to the improvement of the economic and social well-being of people, including promoting rainwater harvesting projects in rural areas*

From [Surekha Sule](#), Independent Journalist, Pune

**Utthan, Ahmedabad**

36, Chitrakut Twins, Nehru Park, Vastrapur, Ahmedabad 380015, Gujarat; Tel: 91-079-26751023; [utthan.ahmedabad@gmail.com](mailto:utthan.ahmedabad@gmail.com); <http://www.utthangujarat.org/livelihood.htm>

*NGO works on issues related to gender empowerment and livelihood security, one approach is to promote rainwater harvesting to meet community level water requirements*

**Barefoot College, Rajasthan**

Village Tilonia, via Madanganj, District Ajmer 305816, Rajasthan; Tel: 91-1463-288204; Fax: 91-1463-288206; [barefootcollege@gmail.com](mailto:barefootcollege@gmail.com); [http://www.barefootcollege.org/prog\\_rwh.htm](http://www.barefootcollege.org/prog_rwh.htm);

*Provides training on implementation of rainwater harvesting; and issues such as drinking water, health and sanitation, social awareness and conservation of ecological systems*

**The World Bank, New Delhi** (from [Atul Rawat](#), DMV Business & Market Research Pvt. Ltd., Hyderabad)  
70 Lodi Estate New Delhi 110003; Tel: 91-11-24610210; Fax: 91-11-24619393; [lconstantino@worldbank.org](mailto:lconstantino@worldbank.org); <http://www.worldbank.org.in/WBSITE/EXTERNAL/COUNTRIES/>;

*Source of financial and technical assistance in the water and sanitation sector, has documented several successful rainwater harvesting and water management case studies around the world*

From [S. V. Vijaya Kumar](#), National Institute of Hydrology, Deltaic Regional Centre, Kakinada

**Central Ground Water Board (GGWB), Faridabad, Haryana**

Bhujal Bhawan, Faridabad 121001, Haryana; Tel: 91-129-2419075; Fax: 91-129-2412524; [chmn-cgwb@nic.in](mailto:chmn-cgwb@nic.in); <http://cgwb.gov.in/>

*Carries out regional hydro-geological studies providing information on groundwater occurrences, which can help determining the need for rainwater harvesting in different terrains*

**Ministry of Water Resources, New Delhi**

Sharam Shakti Bhawan, Rafi Marg, New Delhi 110001; Tel: 91-11-23710343; Fax: 91-11-23710343; [jsadm-mowr@nic.in](mailto:jsadm-mowr@nic.in); <http://wrmin.nic.in/index2.asp?sublinkid=573&langid=1&slid=781>

*Responsible for establishing policy guidelines and programmes for the development and regulation of India's water resources, including implementation of water harvesting projects*

**National Institute of Hydrology, Roorkee**

Roorkee 247667, Uttarakhand; Tel: 91-1332-272106; Fax: 91-1332-272123; [nihmail@nih.ernet.in](mailto:nihmail@nih.ernet.in);  
<http://www.nih.ernet.in/research.html>

*Carried out research on almost all areas of hydrology, including the implementation of rainwater harvesting projects*

**Society for Promotion of Wastelands Development (SPWD), New Delhi** (from [Pankaj Shrivastav](#), UNDP, New Delhi)

14-A, Vishnu Digamber Marg, Rouse Avenue Lane, New Delhi 110002; Tel: 91-11-23236440/387; [spwd\\_delhi@yahoo.com](mailto:spwd_delhi@yahoo.com); [http://spwdindia.org/t\\_water.php](http://spwdindia.org/t_water.php)

*Actively involved in analyzing and documenting causes of natural resource degradation, with a focus on reviving the practice rainwater harvesting in India*

**Swajaldhara, Department of Drinking Water Supply, New Delhi** (from [Sanjeev Kaul](#), Himachal Pradesh Irrigation and Public Health Department, Himachal Pradesh)

Ministry of Rural Development, Government of India, 9th Floor, Paryavaran Bhawan, CGO Complex, Lodhi Road, New Delhi 110003; Tel: 91-11-24361043; Fax: 91-11-24364113; [jstm@water.nic.in](mailto:jstm@water.nic.in);  
<http://ddws.nic.in/swajaldhara.htm>; Contact Shanta Nair; Secretary; Tel: 91-11-24364113

*Drinking water supply scheme, launched in 2002 can be utilized to access funds for implementing rainwater-harvesting projects augment the drinking water supply*

From [Ruchi Pant](#), United Nations Development Programme, New Delhi

**Pan Himalayan Grassroots Development Foundation, Uttarakhand**

Post Bag # 3, Ranikhet 263 645, Almora District, Uttarakhand; Tel: 91-5966-221-516, 91-5966 222-298; [apaul@grassrootsindia.com](mailto:apaul@grassrootsindia.com); <http://www.grassrootsindia.com/drinkingwater.html>; Contact Anita Paul

*Grassroots works to promote sustainable development with a focus on self-help participation across integrated issues such as community rainwater harvesting*

**Indian Council for Agricultural Research (ICAR), New Delhi**

Krishi Bhavan, Dr. Rajendra Prasad Road, New Delhi 110114; Tel: 91-11-23382629; [mrai.icar@nic.in](mailto:mrai.icar@nic.in);  
<http://www.icar.org.in/nrm.htm>; Contact Mangala Rai; Director General

*Apex body for coordinating, guiding and managing research and education in the agriculture sector, including rainwater harvesting implementation to augment the water supply for irrigation*

**Recommended Portals and Information Bases****India Water Portal, Arghyam, Bangalore** (from [Vishwanath Srikantaiah](#), BIOME, Bangalore)

<http://www.indiawaterportal.org/tt/rwh/>; Contact Vijay Kumar; Tel: 91-80-41698941; [portal@arghyam.org](mailto:portal@arghyam.org)

*Provides information regarding the different rainwater harvesting techniques across the country and a list of institutions providing funding for the same*

**Rainwaterharvesting.org, Centre for Science and Environment, New Delhi** (from [Salahuddin Saiphy](#))

<http://rainwaterharvesting.org/Rural/Traditional3.htm#eri>; Contact Gita Kavarana; Tel: 91-11-26066854; [cse@csesindia.org](mailto:cse@csesindia.org)

*Provides information regarding rainwater harvesting techniques practiced across hilly areas of India, which may be suitable for Malkhangiri, Orissa*

**The Rainwater Harvesting e-Toolkit, Margraf Publishers GmbH Scientific Books, Germany** (from [Sunetra Lala](#), Research Associate)

<http://www.rainwater-toolkit.net/index.php?id=18>; Contact Hans Hartung; Tel: 49-15-79343071; [info@margraf-publishers.com](mailto:info@margraf-publishers.com)

*Provides a learning module for understanding rainwater harvesting with several case studies from different countries on successful implementation of rainwater harvesting*

### **Recommended Upcoming Events**

**The 14<sup>th</sup> International Rainwater Catchment Systems Conference 2009, Malaysia, 3-6 August 2009** (from [Sunetra Lala](#), Research Associate)

Sponsored by International Rainwater Catchment Systems Association (IRCSA), USA. Information available at <http://www.eng.warwick.ac.uk/ircsa/IRCSA%20Malaysia%20Announcement.pdf> (PDF, Size: 60 KB); Contact Brett Martinson; Web Master; Tel: Telephone No.; [KLrainwater@nahrim.gov.my](mailto:KLrainwater@nahrim.gov.my)

*Conference will focus on themes such as new approaches and innovations in rainwater harvesting and how it can augment irrigational water supply*

### **Related Consolidated Replies**

**Roof water Harvesting in Urban Areas for Groundwater Recharge, from Mihir Maitra, India Canada Environment Facility (ICEF), New Delhi (Experiences). Water Community, Solution Exchange, India,**

Issued 22 August 2006. Available at <http://www.solutionexchange-un.net.in/environment/cr/cr-se-wes-22080601.htm>

*Discusses the challenges, and available mechanisms/systems through various experiences of roof water harvesting*

**Rooftop Rainwater Harvesting for Rural Schools in Karnataka, from S. Vishwanath, Arghyam and Rainwater Club, Bangalore (Experiences).** Water Community, Solution Exchange, India, Issued 9 May 2008

Available at <http://www.solutionexchange-un.net.in/environment/cr/cr-se-wes-04040801.pdf> (PDF, Size: 500 KB)

*Shares a range of RHW experiences, outlined ways NGOs can facilitate the implementation of these programmes and discussed different types of RWH tanks*

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## **Responses in Full**

**[Puran Singh Yadav](#), Haryana Institute of Rural Development, Karnal**

I am surprised that a region experiencing average rainfall 1700 mm does not have enough water for irrigation. We should learn from the people of Kutch (Gujarat), where average rainfall is sometimes as less as 50 mm. Please read the success stories at [www.ddws.nic.in](http://www.ddws.nic.in).

Regarding the kind of structures that are suitable for hilly areas for water harvesting, we should visit Ralegan Siddhi and Hiwre Bazar (Ahmednagar) Maharashtra and Alwar (Rajasthan). Broadly, check dams, nala bunds, diversion canals, johads etc should be constructed for water harvesting. Local materials can be of immense help to create such structures. I request you to visit the Ministry of Rural Development (MoRD) website at [www.rural.nic.in](http://www.rural.nic.in) to read more about the success stories of watershed development.

Funding water harvesting structures is not a problem. First of all, NREGA has immense funding scope for such activities. Secondly, projects can be sanctioned under Haryanali from the Ministry of Rural Development, Govt.

The million dollar question is community mobilisation. In fact, when we talk about this, I start having

doubts about our intentions. We can mobilise the communities, only when we are in position to win their faith, which we have lost over the years. Once we approach the poor villagers, they start having apprehensions about our presence. Therefore, to mobilise communities, means to sit with them, to understand their issues and problems, to win over them, make them feel that we really are there to facilitate the process. As a second step we should start involving them by bringing them together through the formation of Self Help Groups. Help them upgrade their skills and we will see the results after sometime!

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**[Dinesh Kumar](#), Institute for Resource Analysis and Policy, Hyderabad (response 1)**

Many thanks to Puran Singh Yadav for sharing his ideas with the community. Let me express my views. First of all, to me there is nothing surprising in the fact that a region experiencing 1700mm of rainfall does not have water for irrigation. It is not the rainfall alone, but the topography (in this case) which determine the water availability during different seasons. In steep terrains, the runoff rate would be very high. So, the only option is to create good storage systems depending on the flows, its dependability and demand patterns. There are no magical solutions, which can be applied here.

Secondly, I really don't know what kinds of (modern) water harvesting systems are really working in Kutch (having visited that region several times during the last 17 years) and Alwar. The small structures built only increase the evaporation losses as the reservoir area increases, but reduce the flows downstream into the hundreds of minor and medium schemes there. So, the overall impact on water balance is negative. Please remember that the annual evaporation rate in Kutch is nearly 3,000 mm against an average annual rainfall of 350 mm!

Variability in rainfall in regions like Kutch and western Rajasthan is very high; so is the runoff (catchment yields). In drought years, no runoff is generated from the catchments here or it reduces to 2-3 % of the rainfall. In high rainfall years, the flash floods are common, and these small structures get washed away.

As you have pointed out correctly, we can build as many structures as we want in these regions so long as someone funds these programmes. However, whether that improves the water situation or not would be determined by the hydrological regime—the total runoff in the basin—, the flows that are not “committed” to any use; and the rate of siltation occurring in these catchments. If all the flows are already committed (which is the case in areas like Kachchh and Arwari basin in Alwar, Rajasthan), then increasing the storage capacity only redistributes the water in the basin. Due to high rates of siltation, the structures become dysfunctional very fast (in Kachchh the sophisticated recharge systems don't even last for 2 rains).

After all, if the catchment does not yield enough water, what the poor community can do? Even to grow trees in the catchments to stop siltation, water is needed.

If some area in Orissa is to go for water harvesting systems, it should plan and design the systems according to that area's hydrological, geological, topographical features and socio-economic characteristics, and not following what Ralegaon Sidhi had done (which is pure watershed management; and does not seem to have got anything to do with creating irrigation facilities).

This email is not to antagonise anyone or “rubbish” any idea from my esteemed colleagues, but to express some differing views. I am sure there are better ideas, or I have missed the point. I look forward to them.

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**[Ashutosh Das](#), Association for Integrated Development, Bhubaneswar**

It is good to know about Arnab Bhattacharjee's association in Malkangiri with several NGOs and working on rainwater harvesting in this area. If you are planning for water harvesting structures, you can tap the required financial resources from the Department of Science & Technology, Government of India. Your project should be very innovative. Prior to that you can seek technical help on appropriate technology from different institutions of the Indian Council for Agricultural Research working on water, such as the Water Technology Center for the Eastern Region.

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

I would like to share my ideas on the subject of rainwater harvesting. I have been to hilly area and witnessed the water crisis right from irrigation to drinking purposes. Rainwater should be collected in small dam/lake projects and this approach would not allow the water table in that area to recede. I have witnessed areas that have managed to do so. The collected rainwater can be easily utilised throughout the year.

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**Saurabh Gunjan, DIA Trust, Godda**

I can understand your problem. However, the first and foremost thing is to build good motivational skills within the tribal community. I am also associated with an NGO in the Santhal Parganas of Jharkhand, which is dominated by two tribal communities - the Santhals and Paharias. The Paharias belong to the Dravidian race. The traditional systems of the tribal communities promote nature conservation.

However, I have observed that under the influence of the other communities and the improper implementation of Government schemes these tribal communities are being exploited, not only financially but in many other ways as well. The natural resources of the communities have been deliberately destroyed by the improper implementation of watershed management and other Government programmes. It's not that I feel Government programmes are not in favour of tribal communities, but sometimes organizations working locally are unaware of the long-term consequences of their activities. This has made the communities very inactive and now they seek only Government Grants, which is not sufficient for their survival.

Therefore, I suggest you should motivate the community first to stick to their own traditional systems and practices of nature conservation and plan for their own survival. Further, I think that NABARD, Watershed Programmes, Water Aid and other funding agencies like FAN Asia and Plan International can provide you with their support.

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**Digbijoy Bhowmik, Deloitte Touche Tohmatsu India Private Limited, Gurgaon**

I wish to share an example from the North Eastern State of Arunachal Pradesh, which is now mandated to adopt water harvesting as a conservation tool in urban areas as part of its reforms action plan committed to the Central Government under the Jawaharlal Nehru National Urban Renewal Mission.

Members may be aware that the State is one of the highest recipients of rainfall in the country. Despite this, piped supply to established urban centres such as Itanagar and Naharlagun are frequently disrupted on account of failure of the distribution system.

Traditionally, ground based recharge systems have also been discouraged as the rate of run-off is very high, and the stability of sub-terrain aquifers on slopes cannot be assured. In view of the same, some simple tools are now being incorporated in the building bye-laws being notified by the State. These include:

- Construction/installation of a surface reservoir fed directly from a gutter channel placed strategically along the roof (all roofs in the State are sloping and the material in use is painted and/or galvanised iron sheeting). The bye-laws exempt such surface reservoirs (up to 1,000 liters) to be exempted from Floor Area Ratio.
- Households/ establishments with active rain-fed surface water reservoirs to be provided steady exemption in tariff on piped water supply. There is still some debate on whether flat rate should be used or a metered supply is workable.
- An active set of bye-laws for re-use of recycled water for non-potable purposes, such as arboriculture/ horticulture. Unlike areas with sewerage systems, the cities of Itanagar & Naharlagun generate considerable surplus water from rain water run-off from public areas, which goes into one of the several drainage channels (artificial/ natural) in the city. The bye-laws and zoning regulations provide for creation of isolation and settlement ponds from where such water can be pumped for non-potable use.

At this time, the concept is still new and the rate of internalisation is still low. However, it can be expected with some of the line Departments taking initiatives (including the first municipal council), and the fact that catchment population is still low, there may be some level of increase in awareness and desire to internalise such measures.

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**Raghu Subramaniam, Consortia SBG, Bangalore (response 1)**

I read with interest the valuable contributions for appropriate rain water harvesting structures suitable for hilly areas. I would like to share my experiences on this matter. I am a rainwater harvester and have designed a structure in one of my customer's Agrofarm located in a hill in Tamil Nadu. The problem of irrigation was addressed in a two way approach:

The cultivable land periphery was planted with three rows of vetiver grass to arrest water seepage to lower levels and bind the soil. Following the Malaysian model, artificial ponds were created at strategic locations to collect run off water from non-cultivable land and road run off. The collected water was lead to lower level lands for irrigation on need basis. A slow sand bed filter as per Indian Institute of science recommendations is envisaged to cater to need of drinking water.

The whole project is under implementation currently. If required I can send you conceptual drawings of the project and any other information.

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**Dipak Roy, United Nations Children's Fund (UNICEF), New Delhi**

The topography of Malkangiri and that of parts of Gaya district are probably not very similar, but there are elements in common. Therefore, we could look at models for rainwater harvesting which have been in use for a long time (several centuries, I am told) in parts of Gaya district of Bihar and draw lessons. The farming communities in this region have been using a system of Ahars and Pynes, which take advantage of the natural drainage lines.

The work done by two friends - Mahesh and Sarita over 1999-2004, in reviving these traditional systems of rainwater harvesting and at unbelievably low cost, entirely with community mobilisation, has been very well documented by several journalists. Unfortunately, Mahesh and Sarita did not live long enough to document their own work, or to share their knowledge and the process they had adopted.

Please visit <http://www.hinduonnet.com/fline/fl2104/stories/20040227004902800.htm> for an article titled Shabdo's Shock, which provides a brief overview of their work. Details could be obtained, if necessary. There must be many in the water community, especially in Bihar and Jharkhand, who would be familiar with the work done by Mahesh and Sarita and can provide the details.

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**[Ajit Seshadri](#), The Vigyan Vijay Foundation, New Delhi**

The query is apt, and I am expressing some candid views to be considered for review:

- Most States have passed stringent rules and made it mandatory for new buildings to have RWH in their houses, complexes, etc.
- Having done many environmental projects including Rainwater harvesting in some areas, I have observed that these structures once made are not maintained. Also, the Urban Local Bodies are in league with the builders/owners and right designs are not used. Hence RWH structures are not operational.
- In such a situation, it is best not to have RWH at all. It can only be inferred that since Urban Storm water drainage, planning, design and implementation falls within the purview of the ULBs, the RWH systems also should be in the purview of the ULBs.
- All ULB have many water-bodies, which used to act as sponges in rainy weather, and all these need to be revived. If they have been encroached upon or obstructed, adequate/similar capacities should be made at alternate positions for RWH to avoid disasters, floods, waterlogging, etc.
- There are many parks/lawns in the drain path of urban storm water drainage, these common areas where the urban storm-drain is passing can be utilised for RWH by ULBs.
- Accordingly, some taxation structure can be built in development charges to include RWH mechanism in urban services.
- Two decades ago in Delhi, the Delhi Development Authority had a concept of "DAFUS - Decentralised Approach for Urban Services" This was deliberated upon and a National Level Conference was held at Vigyan Bhawan, New Delhi. But, not much emerged from that.
- It is very important now to have the concept of DAFUS in place for dealing with water supply, wastewater management, storm water management, solid waste management with composting of bio-wastes in common areas, landfill management, etc.

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**[Shrikant D. Limaye](#), Ground Water Institute, Pune**

There are some important points, which need to be considered before practicing RWH in urban areas:

- In areas where the water table is shallow throughout the year and especially during the rains, the soil is not capable of accepting much recharge during the monsoons. In Pune, there are some buildings in which the basements get flooded during rains due to a rise in the water table. These buildings cannot practice RWH and increase the flooding. Instead, they are interested in pumping out water continuously to control the flooding.
  - In rocky areas, the bungalow owners drill borewells to get additional water supply for gardening, etc, but the bores provide little water or are dry. These residents asked me if they could harvest rainwater from the terrace and put it into the bores. Unfortunately, in such cases the bores are dry because they have met with only hard massive rocks and have not tapped any fractured, water-bearing zones. These bores are not useful for recharge. They will accept just a few hundred liters of rainwater collected from the terrace and start overflowing.
  - The only areas suitable for RWH are areas with deep water tables and areas where bores were yielding good water supply a few years ago but the yield has now declined due to increased number of bores and increased withdrawal. Here the aquifer is over-exploited and would benefit from RWH.
-

**Vishwanath Srikantaiah, BIOME, Bangalore**

Let me try and answer the questions directly as the questions were very specific and pertained to livelihoods associated with agriculture/farming.

1. What are the appropriate rainwater harvesting structures, suitable for hilly terrain that can be designed and made by local communities?

This would depend on the requirement for water and soil moisture. Clearly one will need to understand the purpose for which rainwater is required and also the hydro-geology of the terrain before one can come to design decisions. Bringing synergy between water demands and available rain would be important and therefore one would assume that livelihoods would be strung around resource availability (in this case water) rather than the other way around. There is only so much one can do to stretch rainwater for time duration. I am sure you will agree with that and that it should be slow and incremental. Also rainwater harvesting is so location specific that one would hesitate to prescribe solutions without deeper understanding of water with the community.

2. What are the sources of funding for implementing such structures? Please mention government, international and national organizations that support such activities?

You may like to refer to [www.indiawaterportal.org](http://www.indiawaterportal.org) and the list of institutions involved with water and watershed funding.

3. How can tribal communities be mobilized and trained to design, build and manage these structures?

It is with continuous engagement and perhaps visits and discussions with other communities in the immediate vicinity or as close as possible to it that practice water harvesting one would think would be an approach. Smaj Prgati Sahayog and ACWADAM in Pune run practical courses on water harvesting and groundwater recharge including understanding programmes like NREGA and their interface with water management. Perhaps they could be of help. WOTR runs training programmes on watershed management and rainwater harvesting. Perhaps trainers can attend these workshops/courses and then translate that to community learnings.

I hope that I have been specific enough and understood your questions right.

I would urge members to restrict themselves to sharing experiences on questions. That is what makes this community powerful and one is encouraged to open e-mails from the community.

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**Murali Kochukrishnan, Action For Food Production (AFPRO), Bhubaneswar**

The query of promoting rainwater harvesting in hilly terrains of Malkangiri depends up on the location specific conditions like the Geology of the area, Topography and the slope disposition, soil type etc. Areas with fractures and faulted rock system do not hold much of water, as the water will infiltrate and percolate through the weak zones and any structures developed will be an unviable effort. Like wise, if the soil type is more porous then the harvested water will infiltrate and percolate slowly in to the ground and enhance the moisture content of the soil at other fields down slope. However, the region with clay (Black clayey) soils and good catchment areas are the best ones for surface based rainwater harvesting and developing the irrigation methodologies.

As the rainfall in Malkangiri region is quite good, necessary technical corrections can be carried out to develop the appropriate location specific water harvesting systems and community water distribution methodologies to at least provide life saving irrigation for enhancing the crop yield.

Like wise, the diversion or gravity flow based irrigation systems can also be developed, based on the perennial nature of the stream course crossing the project villages which will also be an another good and viable option for provision of irrigation facilities.

The funds can be derived from various government and non-government agencies. Few developmental works can be covered through NREGS as well. The provision of irrigation facilities will of course enhance the crop yield. This will also ensure the food and the nutritional security and secured livelihood in the tribal dominated villages of Malkangiri. This effort will curtail the distress migration aspect too.

The team at AFPRO task force, Bhubaneswar can provide the appropriate and community friendly technologies to the network of NGOs and communities, probably, if at least the costing involved in the technical specialists for carrying out the survey are covered by any suitable funding agencies. (For more details about AFPRO please visit [www.afpro.org](http://www.afpro.org))

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**Dinesh Kumar, Institute for Resource Analysis and Policy, Hyderabad** (*response 2*)

I request [Raghu Subramaniam](#) to kindly provide us with crucial data on the following to assess if the same can be applied in Malkangiri district, Orissa:

- The cost of building these artificial ponds; the bunds with vetiver grass; and the slow sand filter (with break ups)
- The total amount of land (both uncultivable and cultivated) available for runoff harvesting
- Most importantly, how much water is being harvested, or expected to be harvested from these structures, and how much land could be brought under irrigation?

These can provide some clues on the economic viability of the entire scheme in order to know if the same can be appropriately applied in the case of Malkangiri district.

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**N. Lakshmi Narayana, Dakshinya Institutes, Guntur, Andhra Pradesh**

**1. What are the appropriate rainwater harvesting structures, suitable for hilly terrain that can be designed and made by local communities?**

Yes, rainwater harvesting and watershed development are the most important aspects to solve water crisis in general, and in particular for the given area. The structures like ponds, storage tanks, recharge well etc. can be constructed based on the need for it by the local community. Knowing the topography, geology, etc. certainly helps us to plan for the same. However, before that a field visit is necessary to see and plan for the same. Once the design is approved with the help of geologist/geophysicist/civil engineer and participation of the local community members/NGOs they can be constructed and managed by the local communities with referral services on a need basis.

**2. What are the sources of funding for implementing such structures? Please mention government, international and national organizations that support such activities?**

Funding may not be the problem. It may be available with the community, local leaders, peoples' representatives, rural development/ministry of water resources/irrigation / NIRD/government schemes etc., both at state and central level, funding from international agencies and private companies, etc. Even the local MP can support from his/her MPLADS. As it is the tribal area, government has several schemes for integrated development and certainly, water gets the top priority as water controls everything.

**3. How can tribal communities be mobilized and trained to design, build and manage these structures?**

The best way of initiating this is through "Community Based Rehabilitation (CBR)". The local NGOs under the supervision of a geologist/geophysicists/civil engineer can do the needful with the participation of the community members. They need to be trained from time to time by inviting suitable resource persons.

To conclude it is possible to provide the solution, which can be sustained on a long-term basis. A field visit is necessary with the concerned technical persons. Feel free to ask for more information if required.

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**Raghu Subramaniam, Consortia SBG, Bangalore (response 2)**

Please find below the break up of costs in rainwater harvesting scheme as requested by Dinesh Kumar:

- The cost of slow sand bed filter of 25 Kilolitre per day is approximately Rs 54,450
  - The cost of creating ponds is difficult to quantify since the earth excavation was done using JCB for about 10 days. The machinery was provided by customer. The necessary embankment was built with available stones at site and local labour
  - In all 3 ponds of surface area was an approximately 150 square meters, with an average depth of 1.5.
  - The site has 7 sheds with a roof area of 500 square meters. Each of these roof runoff is being led to separate sump tanks. The collections from these tanks are again pumped to SSB
  - The total area of the farm is 85 acres. 50% is under cultivation and approximately 25 % the land has steep slope. The balance 25% is used to house labour quarters
  - The rainfall in the area is 925mm p.a.
- 

**Surekha Sule, Independent Journalist, Pune**

People are made to believe that water harvesting is '*Lakh Dukhon Ki Ek Dava*'. While it is the hydrological cycle of the terrain that is important, who should study and provide solutions are the moot questions. Does the administration have the capability and the willingness to do so?

Social sector efforts fall short and governmental agencies are far from delivering the right solution. That leaves out communities who need to be made technologically capable. Can government/non-government agencies take up this aspect seriously and sincerely and can we have more of Barefoot Colleges such as Tilonia in Rajasthan and People's Learning Centres run by Utthan in Gujarat?

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**Atul Rawat, DMV Business and Market Research Pvt. Ltd., Hyderabad**

**The appropriate rainwater harvesting structures, suitable for hilly terrain that can be designed and made by local communities:**

The methods generally used for rainwater harvesting are:

- Roof top Rain Harvesting
- Tanka / Kund / Kundi
- Ponds / Tanks

Specifically for hill terrains are:

- Spring Water Harvesting
- Check Dams

- Percolation Dams
- Sub Surface Dykes: Contour Building and Gully Plugging
- 

**The sources of funding for implementing such structures:**

Can be made by the local community, as they do not require huge investment. Construction of Check dams and Percolation dams can be funded through the various development schemes run by state and national government, such as Swajal Uttarakhand Pariyojna, National water mission and Jal Nirmal Pariyojana of World Bank. Generally, Panchayats have the powers to plan, implement, operate, maintain and manage all Water Supply and Sanitation schemes.

**Mobilization and Training of Tribal Communities to design build and manage these structures can be ensured through:**

Adoption of a demand-responsive, adaptable approach along with community participation based on empowerment of villagers to ensure their full participation in the project through a decision-making role in the choice of the rain harvesting method, planning, design, implementation, control of finances and management arrangements.

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

I think the best solution to harvest rainwater in hilly terrain and dense forest like conditions as explained by you is the combination of following structures that are normally made with a Ridge to Valley approach to harvest rainwater. For one of the approach structures (Gabion Dam) please view the Video Clipping on Flash Flood [Please visit the link <http://in.youtube.com/watch?v=Nppkp6YFC1k>] in dense forests.

The other suitable structures are:

- Continuous contour trenching is a device by which the velocity of the run-off water is checked through the digging of trenches on hilly terrain. CCT are constructed around the hill slope
- Brushwood dam [please read about to how check gully erosion at [http://books.google.com/books?id=5IUUWNj2jMC&pg=PA206&lpg=PA206&dq=iii\)+Brushwood+dam&source=web&ots=IEOTUFTbe9&sig=9u7Dx2o7a6taOtbmJsuCgoqq3Gw&hl=en&sa=X&oi=book\\_result&resnum=1&ct=result](http://books.google.com/books?id=5IUUWNj2jMC&pg=PA206&lpg=PA206&dq=iii)+Brushwood+dam&source=web&ots=IEOTUFTbe9&sig=9u7Dx2o7a6taOtbmJsuCgoqq3Gw&hl=en&sa=X&oi=book_result&resnum=1&ct=result)
- Nullah Bunding
- Percolation tank
- Gabion dam
- Check dam - Formal design is not required. The following standards should be used.
  - Drainage Area
  - For stone check dams, the drainage area should not exceed one acre.
  - For stone rock check dams, the drainage area should not exceed five acre. For details on check dam please visit <http://www.cabmphandbooks.com/Documents/Construction/SE-4.pdf>

**Suitable Applications of check dams**

Check dams may be appropriate in the following situations:

- To promote sedimentation behind the dam.
- To prevent erosion by reducing the velocity of channel flow in small intermittent channels and temporary swales.

- In small open channels that drain 10 acres or less.
- In steep channels where stormwater runoff velocities exceed 5 ft/s.
- During the establishment of grass linings in drainage ditches or channels.
- In temporary ditches where the short length of service does not warrant establishment of erosion-resistant linings.

Limitations of check dams

- Not to be used in live streams or in channels with extended base flows.

g) Farm pond

The tribal communities will find their own the best spots/locations for drinking water as well.

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**Amitava Basu Sarkar, Himalayan Institute Hospital Trust, Dehradun**

Rainwater harvesting has been prevalent in India for long. The ultimate use of the harvested water decides the specifics of the structures that should be built. In Uttarakhand, rainwater harvesting tanks are being built in large numbers to meet domestic water needs, mainly for drinking, since the 1990s. To make it affordable 7000 litre tanks are being built using ferro-cement. This option is being used in villages, which do not have access to any other water source.

The individual families are maintaining and operating these tanks and these initiatives have proven to be sustainable. The State Government and the NGOs/CBOs/communities are well aware of the intricacies of the option. Members can visit Churredhar, Khuret, Dhanolti-Lagga-Goth (to name just a few villages) in the state to know more about these tanks.

Extensive training by various agencies is needed to mobilise and ensure proper transfer of knowledge to the grass root level. For generating funds, one may approach SRTT, in Mumbai. Government/non-government agencies take up this aspect seriously and sincerely and have the capability and the willingness to do that at least in Uttaranchal.

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**Venkatesh P., Medical College, Bangalore**

It is nice to see members mention community mobilisation. The details that accompany the responses are also worth reiterating in all community development activities. I would like to stress the fact that when we sit with the community members, work with them and try to win their confidence, it often happens that some of those in the community take the lead and try to control the rest of the community.

Instead, we should enable every person in the community to take up a participatory role, not one dominating the others. We should enable them and at critical points of programmes, enable them to become leaders acceptable to people. So I would suggest to the members of the Water Community not to let communities down by allowing this behaviour, but to adopt other methods to achieve the goals and empower communities.

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**S. V. R. K. Prabhakar, Institute for Global Environmental Strategies (IGES), Japan**

I would suggest the following points regarding rainwater harvesting before you go ahead with the project:

- Take into consideration the possible climate change and future developmental needs while you plan for investing in the project and design of structures. With good quality construction and design, these structures would last more than 30 years and hence are influenced by the future climate change (the rainfall patterns) and local developments. Such consideration would make

their design 'future proof', well if not very long term but in near and medium term. Typically, designs are made based on the past rainfall patterns and peak rainfall events which may not hold good in the future.

- Efficient use of harvested water: Preparation and adherence to a set of do's and don'ts would help. Promote efficient irrigation practices in combination with practical crop and varietal planning. I said practical since beneficiaries would often feel elated after seeing so much water being harvested and may often go for water intensive crops. There is a need to have lot of education and training programs so that communities take right decisions on their own without a conflict of interest. This brings us to the next point.
- Equity: Equitable management of harvested water is important. There are several case studies showing that farmers and communities living near these structures gain undue benefit while the ones living far away are either ignored or not treated on equitable basis. Equity can be promoted by forming local tank level water user groups and making sure that communities whose fields are near these structures do not indulge in inefficient practices such as raising paddy etc but allow the water to be used by everyone. Make sure that communities know who is going to get benefit and who is not in advance to avoid any future conflicts. Let them know the 'boundary of influence' of each erected structure and see that maximum number gets benefited.
- Establish a revolving fund for maintenance of structures. This revolving fund could either come from your project funds to begin with or you could raise by auctioning rights to raise and capture fish etc. There are several models available in this. Maintenance is very important and make sure that the local panchayat or other self-help body is responsible for it. This should lead to sustainability of the initiative so that it thrives even when you are done with the project phase.

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**S. V. Vijaya Kumar, National Institute of Hydrology, Deltaic Regional Centre, Kakinada**

The suitability of a structure depends on not only the terrain but also the way of life of the users. In addition, the proximity of stream to the local population is important. Another important aspect is whether the available river flow is of acceptable quality to avoid cost for its treatment. The local ground water flow gradient conditions determine whether groundwater from artificial recharge is available when needed or not.

To select a suitable structure the manual on 'Rain water Harvesting Techniques To Augment Ground Water' by Ministry of Water Resources, Central Ground Water Board, Faridabad available at MOWR website <http://cgwb.gov.in/> may be referred to.

Also a state-of-art report on the status of "Manual for Roof Top Rain Water Harvesting using Cisterns or Storage Tanks for Individual Households, Community and Institutions" (Report No: INCOH/SAR-27/2006) by Dr. S.K. Sharma may be referred to. This is available at INCOH Secretariat, Member Secretary, Indian National Committee on Hydrology (INCOH), National Institute of Hydrology, Roorkee – 247667, India, E-mail: [incoh@nih.ernet.in](mailto:incoh@nih.ernet.in). For more details visit [www.nih.ernet.in](http://www.nih.ernet.in).

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**A.L. Khan, Uttar Pradesh Irrigation Department, Lucknow**

Rainwater harvesting structures can be promoted in hilly terrain by:

- Roof top water harvesting structures by constructing water tank, this water may be utilised for domestic uses, surplus water may be used for recharging the ground water and for irrigation purposes.
- Collecting the rain water in tanks in agricultural fields for irrigation purposes.
- Making checks dams in streams for diverting the water from stream in fields for irrigation and domestic purposes.
- Planting trees, shrubs, etc. at the boundary of fields, this will help in irrigation as well as the recharge of ground water.

- Afforestation on non-agriculturable land of the hills will recharge the ground water by retention and detention period of flow of water. Trees also help in percolation of water and this will rejuvenate the springs of the area.
  - Plugging the gullies of the area will also recharge the ground water
- 

### **Salahuddin Saiphy, Centre for Science and Environment, New Delhi**

Rainwater harvesting is no doubt the need of the day. Increasing water requirements for domestic, agriculture and industrial requirements have put great stress on available surface and groundwater. A large number of surface water bodies are facing threat of pollution. Groundwater is also not spared from this problem but it also has a major problem of overexploitation resulting in a rapid decline in groundwater levels.

Rainwater harvesting uses variety of techniques to meet drinking and agricultural requirement. There are large numbers of examples from different parts of India on how people have been managing rainwater. As India is a vast country and experiences large variations in its climate, geology, hydrogeology and social systems, traditionally, people developed systems to match their local conditions and requirements. Kunds, Baolis, Johads, Khadin, Zings, Eris, Surangam, Bhandara, Kuhls/Guhls, Apatani, Zabo, Dong, Aharpyne, Flood irrigation, Dighi, Virdas, Pat, Rapat, Katas, Cheruvu, Phad, Korumbu and Ooranis are some of the structures. Please refer to <http://rainwaterharvesting.org/Rural/Traditional3.htm#eri> for more information on these systems.

In Orissa the katas, mundas and bandhas were the main irrigation sources in the ancient tribal kingdom of the Gonds (now in Orissa and Madhya Pradesh). Most of these katas were built by the village headmen known as gountias, who in turn, received the land from the Gond kings. Land here was classified into four groups on the basis of its topography: aat, (highland); mal (sloped land); berna (medium land); and bahal (low land).

This traditional floodwater harvesting system is indigenous to south Bihar. In south Bihar, the terrain has a marked slope - 1 m per km - from south to north. The soil here is sandy and does not retain water. Groundwater levels are low. Rivers in this region swell only during the monsoon, but the water is swiftly carried away or percolates down into the sand. Here, people construct ahar and pyne. An ahar is a catchment basin embanked on three sides, the 'fourth' side being the natural gradient of the land itself. Ahar beds were also used to grow a rabi (winter) crop after draining out the excess water that remained after kharif (summer) cultivation. Pynes are artificial channels constructed to utilise river water in agricultural fields. Starting out from the river, pynes meander through fields to end up in an ahar. Most pynes flow within 10 km of a river and their length is not more than 20 km.

Bengal once had an extraordinary system of inundation canals. Sir William Willcocks, a British irrigation expert who had also worked in Egypt and Iraq, claimed that inundation canals were in vogue in the region till about two centuries ago. Floodwater entered the fields through the inundation canals, carrying not only rich silt but also fish, which swam through these canals into the lakes and tanks to feed on the larva of mosquitoes. This helped to check malaria in this region. From the 18<sup>th</sup> century onward and the subsequent British conquest of India, this irrigation system was neglected, and was never revived.

According to Willcocks, the distinguishing features of the irrigation system were:

- The canals were broad and shallow, carrying the crest waters of the river floods, rich in fine clay and free from coarse sand;
- The canals were long and continuous and fairly parallel to each other, and at the right distance from each other for purposes of irrigation;
- Irrigation was performed by cuts in the banks of the canals, which were closed when the flood was over.

Methods suitable for Malkangiri will depend on understanding of following factors:

- Rainfall pattern
- Geological conditions
- Hydrogeological set up of the region
- Recharge rates in different formations
- Water requirements
- Customs and traditions of managing water

A suitable method should be based on this information coupled with site visit of experts including geologist, hydrogeologist, engineers, social activist and grassroot level people involved in water management systems.

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**Nafisa Barot, Utthan, Ahmedabad**

I would like to respond to some of the questions below. Utthan has a long-standing experience working in Dahod - Panchmahal (tribal areas of Gujarat), on rainwater harvesting either for livelihood security or as a means for transforming conflicts for long intended peace, equality and justice.

We have found roof rainwater harvesting, with appropriate filtration system and a hand pump for maintaining the quality of drinking water very effective. In addition, as mentioned - well recharge, watershed, ponds, etc. are effective ways of recharging.

We could use NREGA funds and Swajaldhara funds for rainwater harvesting. In addition, available well schemes under tribal programme could be used. The recharging cost may not be so high - and if communities are convinced about the benefit, some contribution could come from them. Some of our women's group members have also taken loans from their savings credit group for the same.

We have found that field visits/exposures of the community leaders or members of the NGO facilitating the process in such places where communities are already practicing and managing rainwater harvesting structures and overall distribution systems could help greatly in learning. Utthan has a People's Learning Centre for drinking water and sanitation where tailor made trainings are imparted to cater to various needs of the community and NGOs.

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**Dinesh Kumar, Institute for Resource Analysis and Policy, Hyderabad (response 3)**

Let me congratulate S.V.R.K. Prabhakar for bringing in some excellent insights on the basis of field observations on some of the drawbacks of decentralized local water harvesting. This has been found in many areas where water harvesting work is intensive, be it in Aji basin in Rajkot, Ghelo basin in Bhavnagar or Arwari basin in Alwar Rajasthan, or Kundi sub-basin of Narmada basin. It leads to inter-village, intra-village (amongst farmers) conflicts and between irrigators and drinking water users within the small catchments and basin.

So, the inequitable distribution of benefits is not the characteristic feature of large water resource systems alone. Simply creating the village institutions is not going to help in addressing equity issues. Most often these institutions have the limited mandate of doing the routine maintenance – de-silting, repair of structures, etc. We also expect them to do these activities voluntarily.

When the government provides funds for this, it essentially means public funds being spent for a “private cause”, as they do not create welfare benefits, but only benefits to a few individuals. On the other hand, the negative welfare impacts (social costs) due to “drying up of streams in the downstream areas” are visible.

In nutshell, we are creating some private benefits at public cost. May be it is high time to rethink government sponsoring at least some of these decentralized water harvesting schemes, and make distinction between "communities", and "a few individual farmers" when it comes to defining the "beneficiary".

In some of the efforts like "dug well recharging", common property (runoff from the catchment) is being converted into private property as farmers are encouraged to divert water from catchments into their open wells (which act as temporary storages in hard rock areas). In drought years, this might make a lot of difference in the flows. It may not be a big issue today, but has the potential to create big basin-wide conflicts in future, if everyone in the upper catchment starts doing it. But, clearly, the view is myopic.

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**Uday Bhawalkar, Bhawalkar Vermitech Pvt. Ltd, Pune**

I have one suggestion to improve the performance of the slow sand filter, used for rainwater harvesting such that nitrates can be removed. With nitrates, the stored water can breed dengue mosquitoes. In addition, forcing the nitrate-polluted water into the groundwater is an eco-crime.

You may wish to use 100 mg of BIOSANITIZER 7.0 to pre-treat the rainwater; this is a one-time input and put BIOSANITIZER in the rainwater collection tank. The slow sand filter will not get choked up and allow higher flow. The filter will grow diverse vegetation and the new ecosystem will remove the nitrates to less than 1 mg/L, the preferred value in warm region such as India.

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**Pankaj Shrivastav, United Nations Development Programme (UNDP), New Delhi**

Uttarakhand and Himachal Pradesh have a rich experience in construction of low cost rainwater harvesting structures. Numerous designs are available here and I would recommend you visit GB Pant Institute of Himalayan Environment and Development at Almora, and their experimental farm at Kosi to see for yourself the various designs available.

While working for Society for Promotion of Wastelands Development at Dehradun, I was part of a team that also brought out a "do-it-yourself" manual in Hindi for a World Bank funded project on construction of low cost Polythene lined tanks, polyhouses and compost pits - targeted at farmers. The same is available from the Water Community Resource Team of Solution Exchange. I request them to scan the same and make it available to the community.

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**Arunabha Majumder, Jadavpur University, Kolkata\***

In order to store harvested rainwater in hilly terrain, impounding reservoirs in cascading plain surfaces can be built. Local stone materials with cement mortar can be used during construction. The stored rainwater can be upgraded by the application of Horizontal Roughing Filter and Slow Sand Filter to meet the domestic need, where necessary. For irrigation, no treatment is required. Other conventional structures can be built for rainwater harvesting. Villagers can be involved under NREGA for the construction work.

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**Sanjeev Kaul, Himachal Pradesh Irrigation and Public Health Department, Himachal Pradesh\***

I would like to respond on two points:

Since Irrigation demands considerable quantity of water the required storage would obviously be high and creating such large storages becomes a challenge in the hills. Also the land holding pattern in terms of its spatial distribution and ownership needs to be studied while planning such systems. One of the

methods successfully adopted in the hill areas of Himachal Pradesh is by construction of small storages at suitable places and harnessing the rain water, preferably using the natural drainage system with small diversions. Rooftop water can also be harvested by the same manner but its contribution would be marginal compared to the total requirement. But high sediment load, which is very common in hills, remains a challenge and calls for regular cleaning and maintenance.

Swajaldhara funds are for drinking water purposes and cannot be utilised for irrigation schemes. NREGA or similar State Govt. schemes can be an appropriate source of funding.

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**Shailja Kishore, Aga Khan Rural Support Programme (India), Ahmedabad\***

It is good to look into modern day technological options but you should not forget/miss out on the Traditional Skills & Knowledge of the people of the area. They have been leaving in the area for ages and they very well know about the storage of water in the scarce area and how best they can be used for irrigation. Let me share you some examples -

In Bunny grassland of Kuchchh (Gujarat) People construct small virdas in the RANN ( Desert) which stores drinking water for their use in need. The people who live there know its importance and they judiciously use it and maintain it.

Rajendra Singh through the Tarun Bharat Sangh, in dry areas of Rajasthan used very low cost traditional structures for water harvesting and replenished the depleted ground water of the area, which was evident with the perennial flow of the river.

The bhil and Bhilala tribes of Khandwa and Khargon in the Nimar plateau of Madhya Pradesh channel their water from a small storage and irrigate their farms on the hill top against the law of Gravity. It is unbelievable but true. You need to see it to believe it. According to the tribal experts, running water on every 100 yards can climb up one yard.

If you can identify their practices and build upon it, it will be readily acceptable to the people of the area and the cost of construction of the same will be very low. This can be funded the people on their own or with very little support from outside. But the outside technology will be cost and managing funds for them in bulk would even be a bigger problem.

Rural People are very creative and innovative and if we sit and discuss with them their solutions, you will get feasible & cost effective solution from them.

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**Nate Stell, BIOME, Bangalore\***

In response to the query I would like to share a document (available at <http://www.solutionexchange-un.net.in/environment/cr/res-08010901.xls>; Excel; Size: 130KB) regarding our experiences on rainwater harvesting in the state of Manipur.

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**Ruchi Pant, United Nations Development Programme (UNDP), New Delhi**

I would like to share with you some work going on in Uttarakhand and the North East India in the area of rainwater harvesting especially in the hilly terrain.

An NGO called Pan Himalayan Grassroots Development Foundation has popularised the construction of concrete underground tanks for rooftop rainwater harvesting. The initial capital cost of construction of the storage tanks along with gutter and down pipes is roughly Rs. 2 per litre of storage. For this purpose, the organisation has trained a cadre of local barefoot technicians to undertake masonry, plumbing and

other works. This team is organised in a team called the Kumaon Artisans' Guild. Members of this guild have been responsible for providing critical training inputs to various communities in the states of Uttarakhand and Himachal Pradesh in construction and maintenance of the rainwater harvesting structures.

The Guild has also acquired participatory management skills including accounting and accepted the principles of social audit. The creation of such guilds is of great importance for the success of appropriate technology transfer at the community level. For details, contact Anita Paul at [apaul@grassrootsindia.org](mailto:apaul@grassrootsindia.org).

The other appropriate technology based on traditional knowledge which entails harvesting of rainwater for groundwater recharge being tried out in Uttarakhand is that of digging trenches (Khaals) and erecting small check dams (bandhs). These khaals and bandhs are placed along the mountain slopes to catch the flowing surface water and to enhance infiltration and moisture retention in the soil.

I would also like to share some work done by the scientists of the Indian Council for Agriculture Research (ICAR) in their north eastern regional office based near Shillong in Meghalaya.

A study carried out in the hilly terrain of North East India, based on the estimated annual costs and returns and other financial viability criteria IRR, NPV and BCR, found investment on plastic lined water harvesting tanks (capacity >40 m<sup>3</sup>) integrated with micro-irrigation systems and fish farming, to be the most favorable. These technologies were found to be sustainable, locally adoptable, cost effective and affordable to the farmers.

For a detailed analysis of several techniques and technologies in rainwater harvesting being used in North East India, contact: Dr. Manoj P. Samuel and Dr. K.K. Satpathy at the Division of Agricultural Engineering, ICAR Research Complex for North East Hill Region, Umiam, PIN 793103.

Also read, "Concerted Rainwater Harvesting Technologies Suitable for Hilly Agro-ecosystems of Northeast India" by Dr. M. P. Samuel and K. K. Satpathy in Current Science, Vol. 95, No. 9, 10 November 2008.

*\*Offline Contributions*

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***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 the Water Community in India at [se-wes@solutionexchange-un.net.in](mailto:se-wes@solutionexchange-un.net.in) with the subject heading "Re: [se-watr] Query: Promoting Rainwater Harvesting Structures in Hilly Terrain - Examples; Advice. Additional Reply."*

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