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A Different Path: The Global Water Crisis and Rainwater Harvesting

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Abstract

The global water crisis is predicted to kill 34 to 76 million people by 2020. Large-scale infrastructure projects can provide water, but construction of these projects has not proven adequate to meet growing populations and, even where feasible, large-scale projects have significant social, economic and environmental impacts. A different path to solving the global water crisis that emphasizes efficiency and sustainable, community-scale projects in addition to centralized infrastructure, has been mapped by a range of scholars and activists. Small scale rainwater harvesting is one sustainable approach that is proving increasingly effective in both rural and urban settings in the developing world. This paper surveys the use of rainwater harvesting in India and draws some lessons for the application of this approach to other regions.

Keywords: water crisis; rainwater harvesting.

1. The Problem: Improving Access to Water

The dimensions of the global water crisis are massive: Some 1.2 billion people do not have access to safe drinking water, 2.6 billion lack access to adequate sanitation and at least two million people die per year from a lack of clean water—a large portion of them children.[1] An analysis of these numbers finds that by 2020, some 34 to 76 million people may perish from water related disease[2]—potentially a greater toll than that of the AIDS crisis over a similar time scale (see figure 1).

As the global water crisis has received increasing attention from policy makers, activists, corporations and governments, a debate has grown over the best way to help those who suffer without clean water. Despite years of discussion, small-scale approaches like rainwater harvesting continue to get scant attention or support at the international level. This paper argues that rainwater harvesting is a sustainable and widely applicable approach to providing water in both developing and industrial nations—and that it should receive more vigorous support from NGOs and governments.

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[1] Watkins et al, 2006
[2] Gleick 2005

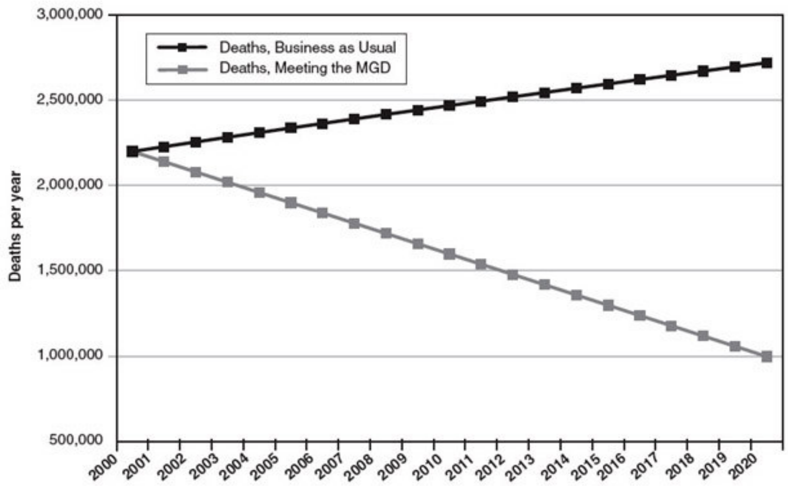

Figure 1: Deaths from the Global Water Crisis; even if the UN Millennium Development Goals are met, the global water crisis could exact a terrible toll over the coming years with 34 to 76 million deaths predicted by 2020. (Source: Gleick and Cain, 2005).

In 2003, the World Water Council, an international water think tank and policy group, released "Financing Water for All".[3] With the laudable goal of laying out various options for providing the massive aid needed to fund global efforts to improve water and sanitation access, the report found that some $100 billion, most of it for large-scale centralized projects, is needed. To fund these massive projects, the report calls for increased privatization and corporate investment.

However, a growing body of scholarship and work in the field has shown that large-scale, centralized projects are rife with ecological, economic and social impacts. The construction of large dams, especially in the developing world, has destroyed ecosystems and communities while failing to provide flood protection, irrigation or other benefits at a sufficient level to justify the project. The benefits that do accrue often fail to impact the lives of those in marginalized urban and rural communities. As the World Commission on Dams states in their report:

> While dams have delivered many benefits and made a significant contribution to human development, in too many cases the price paid to secure those benefits, especially in social and environmental terms, has been too high and, more importantly, could have been avoided. Applying a balance-sheet approach to assess the costs and benefits of large dams that trades off one group's loss with another's gain is seen as unacceptable, particularly given existing commitments to human rights and sustainable development.[4]

Another school of thought, represented by researchers like those at The Council of Canadians, Public Service International, Water Aid, and the Pacific Institute of Oakland, California holds that a different approach is possible. Broadly speaking, this approach has been dubbed the "soft path" for water and emphasizes smaller-scale, sustainable approaches.[5] These researchers have found that a soft path would be a

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[3] Camdessus and Winpenny, 2003
[4] World Commission on Dams, 2001
[5] Gleick 2003

more effective and economical solution to the issue of global water access, with funding needs in the range of $9 to $30 billion per year.

The soft path for water emphasizes the importance of using community-scale and environmentally sustainable approaches before turning to large, centralized infrastructure. One soft path technique that has been the focus of much recent study is small-scale rainwater harvesting. Although rainwater harvesting using current technology shows great promise, it is hardly a new idea: indigenous communities in Africa and Asia have been using similar approaches for thousands of years.

This paper will examine the options for creating or recreating this approach in contemporary settings. Although global issues will be considered, I will focus on the recent experience of India.

2. A Community Scale Approach: Engaging New and Traditional Stakeholders

As critics of the hard path have detailed, the lack of adequate community and individual involvement in project planning is, in many circumstances, the first mistake in a chain of errors that begets future problems with project design, construction, and operations and maintenance. The literature on foreign aid in general, and large-scale water projects in particular, is replete with examples of projects that were designed based on false assumptions and without even considering the needs of those most at risk.[6]

Even when the needs of marginalized urban and rural communities are considered, the hard path solutions put forward are frequently inappropriate or even counterproductive. In some cases, projects that have provided a reasonably functional benefit have fallen into disuse due to lack of operations support and the inability to maintain them.[7,8]

One common thread that links these failed projects is a top-down planning approach that bypasses or ignores community knowledge, concerns and input. Although it is beyond the scope of this paper to examine in detail the best planning approaches for large-scale projects, it is clear that effective planning involves considering the community impacts and engaging all relevant stakeholders—especially traditionally marginalized communities.[9] For water projects, the stakeholders must include affected individuals and communities, governments, finance organizations, and NGOs.

Although many international finance organizations are at least giving rhetorical support to community-level projects, the bulk of international funding still goes to large, centralized projects, such as large dams, reservoirs and irrigation systems (see figures in Box 2). There are scale challenges to small-scale projects: many more may be required to provide access to large numbers of people. International finance organizations and some NGOs may also lack the capacity to engage communities in a productive fashion.

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[6] World Commission on Dams, 2001
[7] Leslie, 2006
[8] Rosenberg et al, 2000
[9] Black, 2001

However, despite potential barriers, ongoing work in Indian cities such as Delhi, Mumbai, Chennai and Bangalore[10] provides strong evidence that not only is rainwater harvesting socially acceptable to poor communities (defined as those without access to basic services such as water, or living on less than $1.25 per day[11]), but also that these kind of efforts can build local capacity to create a self-sustaining movement. There is also some evidence that individual rainwater harvesting programs can help educate consumers about the importance of demand-side efficiency and ensure adequate maintenance by fostering a sense of ownership.[12]

3. Potential for Rainwater Harvesting in Water-Scarce Regions

With positive evidence that small-scale water harvesting is not only socially permissible in developing communities, but can actually help engage and activate a wide range of stake holders, let us look at some of the applications and challenges in more detail.

3.1 Capacity and Climate

The first question we must consider is related to climate, Can rainwater harvesting provide enough water to meet basic human needs, assist with irrigation or be otherwise useful to people in a given region?

John Gould's assessments of the relevant literature has found, "In a semi-humid climate with a mean year round rainfall of 1,000 mm, event a modest sized $50m^2$ roof, can potentially yield up to $40m^3$ of water annually, equivalent to more than 100 liters of water per day." In a semi-arid climate, with annual mean rainfall of 500 mm, a similar sized roof could provide $20m^3$ of water, or about 50 liters per day. The systems would require a storage capacity of 2 to 4 m^3 and 5 to 10 m^3, respectively, to ensure reliability for each system.[13]

Field testing has confirmed these figures and demonstrated that rainwater harvesting is practical in a wide range of environments in India. Efforts by the Rainwater Club, a nonprofit organization based in Bangalore, India, have shown that capacity-wise, small systems based on a $50m^2$ roof and 500 to 1,000 liter storage system are proving effective for urban users in central India[14].

In Rajasthan, in arid northern India, rainwater harvesting is also proving to be successful. The Barefoot College has helped 13 villages in the Rajasthan region build community-scale systems, creating at least a partial water supply for 470 schools and community centers and 150,000 people. The College, dedicated to help "the poorest of the poor"[15] through practical research and education, trains rural youth to help

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[10] See http://rainwaterclub.org/ for details on efforts in Bangalore, accessed: 8/15/07.
[11] See http://go.worldbank.org/RQBDCTUXW0 for a full discussion of global poverty measures, accessed 9/30/09.
[12] Kahmat, 2007
[13] Gould, 1999
[14] See http://www.rainwaterclub.org, accessed 8/15/07.
[15] See http://www.barefootcollege.org/, accessed 9/30/09.

test water quality and trains village women as engineers and mechanics to design and repair systems[16].

Other more urbanized regions of India are also successfully using rainwater harvesting. In Mumbai, India's most populous city, the Rainwater Club is educating residents of all income levels about the benefits of rainwater harvesting and the nuts-and-bolts issues of how to create a system.[17] The city and the state of Gujarat have recently passed laws to mandate the installation of rainwater harvesting infrastructure in new construction.

In fact, a growing number of regional and local governments across India have begun mandating or encouraging this approach[18]. Notable efforts include:

- The city of New Delhi and the state of Kerala, which have mandated rainwater harvesting technology for all new buildings with a roof size of over $100m^2$ or a plot size of over 1000 m^2;
- The city of Hyberabad, which has mandated rainwater harvesting for all new buildings with a plot size of over $300m^2$;
- The southern state of Tamil Nadu, which now requires all new public and private buildings to include the technology. The state has the ability to add the technology to structures that do not comply and bill the users.

And it is not just urban users that are benefiting. Efforts to restore and build traditional earthen rain catchments for agriculture and groundwater recharge are proving popular in northern India[19] and this traditional approach has the double benefit of improving the lives of rural farmers and reducing migration to large urban centers.[20]

Even when rainwater harvesting is not sufficient to provide all of a family's needs, it can still provide substantial benefit.[21] Every liter of water that does not have to be hauled from a communal water source or purchased from a vendor allows poor households to free up time and money for more productive purposes, which, in turn can provide an economic boost.

3.2 Cost Concerns

Although many of the systems covered above are quite inexpensive by Western standards, their costs may still be prohibitive for poor people in the developing world. The basic system pictured in figure 3 costs the equivalent of $60, but for a poor person, that could represent several months of income and would be impossible for them to afford without assistance.[22] Adding to cost concerns is that, in areas with a highly variable rainfall or an arid climate, larger storage systems may be needed to ensure reliable supply—although it is worth noting that other

[16] See http://www.barefootcollege.org/prog_rwh.htm, accessed 8/15/07.
[17] Kamat, 2005
[18] See http://www.rainwaterharvesting.org/Policy/Legislation.htm for a list of recent legislation, accessed 8/15/07.
[19] Suutari, 2007
[20] Rajvanshi, 2002
[21] Gould, 1999
[22] UN, 2006

Figure 3: Basic system design; a basic rainwater harvesting system, such as the one pictured above, can be built of basic materials for the equivalent of $60, depending on local costs and system size; the main technical requirements are an impervious roof and room for a cistern or tank (Photo: S. Vishwanath, Rainwater Club).

alternative options, such as buying water from vendors, may be more expensive or time consuming than even expanded rainwater harvesting systems[23].

Mandating the addition of the rainwater harvesting equipment to new construction, as discussed above, is one relatively easy way to expand its use, but this approach will provide benefit mostly to those of higher incomes. For low-income urban and rural communities, direct aid from governments and NGOs is clearly needed to expand the use of rainwater harvesting. Public-private efforts that mix NGO and governmental aid with small-scale entrepreneurial efforts are also proving effective as demonstrated by the Rainwater Club and Barefoot College programs.

3.3 Water Quality Concerns

Another key technical barrier to the wider adoption of rainwater harvesting is ensuring that the water is fit for drinking, or at least for washing, irrigation, recharge or whatever the intended purpose may be. Although rainwater is generally free of gross industrial pollution, microorganisms, heavy metals and other hazards that plague surface and groundwater, rainwater can become contaminated by atmospheric pollution, which is rampant in developing urban areas.[24] Microorganisms, although usually not present in rainwater, can be picked up during collection and can taint cisterns, tanks and other infrastructure.

Certainly, if the water is to be consistently used for drinking, some kind of treatment is needed. Of course many highly effective approaches like membrane filtration are not appropriate to the developing world. Simple sponge-based filters,

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[23] Gould, 1999
[24] *Ibid.*

such as the one shown in Box 3, can keep out debris and prevent insects from entering storage systems. However, approaches using chlorine, biosands, ceramic vessels, solar-powered UV-disinfection, flocculation, filtration—or, ideally, some combination of these approaches—provide a greater margin of safety and have proven effective in the developing world.[25]

Another interesting alternative to cleaning the water to potability, is to use rainwater harvesting to irrigate small gardens or farms, which has shown to be very effective in Ethiopia. Even if rainwater harvesting is only used for supplementary irrigation— increasing the amount of food that can be grown in small gardens—it can help "millions of people… achieve household food security through home garden micro irrigation, and [create] modest wealth for emerging commercial farmers."[26]

In certain areas of India, untreated rainwater is being used to recharge groundwater aquifers. By channeling rainwater into small-scale storage and then letting it drain directly into borehole wells, aquifers that have been drawn down by pumping can be restored.[27] In turn, this water can be drawn into municipal systems and treated at the community scale.

3.4 Cultural Concerns

Along with any technical barriers, it is also important to consider cultural concerns and, indeed, the Rainwater Club has noted that it takes education and outreach to convince some prospective users that the systems are worth the investment in time, money and space. This area is where a peer-based educational system combined with some third-party oversight by NGOs or governments can be useful.

Despite these challenges, there is substantial evidence that community-scale rainwater harvesting programs can assuage these concerns and that a grassroots approach that focuses on assisting early adopters and empowering them to reach out to their neighbors can be especially effective.

3.5 Environmental Concerns

In most cases, rainwater harvesting has a minimal or even positive environmental impact. By reducing the need to pump groundwater or divert ecological flows, rainwater harvesting can help reduce pressure on ecosystems. In urban areas, rainwater harvesting not only reduces demands on whatever water infrastructure may exist, but it also can greatly reduce storm water and wastewater flows, which, in many poor communities may carry a significant amount of pollution into area waters.

Despite these positives, there are some potential environmental risks, especially in rural areas where large-scale adoption of water harvesting for agriculture could reduce environmental flows.[28]

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[25] Lantagne, 2005
[26] Awulachew, 2005
[27] Gupta and Deshpanade, 2004
[28] Gould, 1999

Climate change also presents a challenge to rainwater harvesting. Any phenomena that reduces rainfall, reduces yields from rainwater harvesting. Climate change, in certain regions, could render existing systems ineffective if storage capacity is not sufficient to hold a reliable supply or if precipitation falls below a practical threshold. However, here too, the positives may outweigh the negatives as rainwater harvesting can be used to adapt to climate change if properly deployed.[29]

4. Policy Recommendations and Conclusion

Rainwater harvesting has a wide range of potential applications in the developing world. From providing potable water to urban areas, to creating irrigation alternatives for farmers, and even assisting with recharge of aquifers, it is a flexible and effective technology that deserves wider support and expanded use.

The approach also has few environmental impacts, is cost-effective and, with proper aid and government funding, can be made affordable to even the poorest people. Rainwater harvesting systems can also be adapted to a wide range of climates. In much of Asia, Africa and the Americas, and in many of the areas hit hardest by the global water crisis, average rainfall is greater than 1,000 mm per year—a more than sufficient threshold for viable rainwater harvesting.[30]

There are challenges to implementing rainwater harvesting on a large scale. It will take time and scores of community-level campaigns to reach even a small fraction of those without access to water. In turn, these small-scale efforts require the trust and support of individuals and communities, who, in some cases, may be skeptical of new technology and outside aid.

However, as many successful examples from India have illustrated, not only is it possible to gain the trust of local communities, but, with proper training and incentives, community members can be empowered to help educate neighbors, design systems and maintain existing infrastructure.

The biggest barrier to the wider adoption of rainwater harvesting seems to be the scant funding it has received from international NGOs and finance organizations. Although this is starting to change, the lion's share of aid and financing continues to go to large, centralized projects. A concerted effort to gather successful case studies, perform quantitative assessments and communicate the results is needed to change these funding priorities.

In some areas, issues of conflict and government support may be the biggest barriers. It can be very difficult to convince hostile governments to provide assistance to marginalized communities and, in a war-torn region, any kind of investment in infrastructure may be seen as aid to one political group or another. However, even in these regions, small-scale projects may be more feasible than large-scale approaches.

In summary, rainwater harvesting can be adapted to a wide range of tasks and settings and should be more widely used. Although cost can be a barrier, simple systems are relatively inexpensive and more complex systems can be cost effective at the community scale. Pollution can be an issue in urban areas, but rainwater is

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[29] Pandey et al, 2003

[30] Gould, 1999

generally cleaner than groundwater or surface water, and inexpensive filtration techniques are available. Compared to large-scale approaches to providing water to those without basic access, rainwater harvesting is a cost-effective and feasible approach that should gain greater support and financing.

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