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Better, Faster, Cheaper; Research into roofwater harvesting for water supply in low-income countries

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Abstract

The water situation in many low-income countries is grim. More than one billion people have no access to clean drinking water and those that do often spend considerable time walking and queuing to collect it. Many water professionals are becoming worried about the increasingly difficult problems of finding and improving water sources while some existing water sources are now becoming depleted or polluted. Domestic roofwater harvesting (DRWH) provides an innovative solution to meeting water needs and can be implemented quickly and modularly. It is also very robust against risks of unexpected change. Renewed interest in the technology is reflected in the water policies of many developing countries, where it is increasingly being cited as a useful source of household water.

This paper brings together a number of findings from two studies into DRWH by the Development Technology Unit of the University of Warwick and its partners the Lanka Rainwater Association, FAKT Germany, The Rural Development and Appropriate Technology Centre at the Indian Institute of Technology in Delhi, ACORD Uganda and Water Action in Ethiopia. The results presented here are a summary of a number of papers being presented at IRCSA 11, Mexico City.

1. Introduction

The water situation in many low-income countries is grim. More than one billion people have no access to clean drinking water and those that do often spend considerable time walking and queuing to collect it. Many water professionals are becoming worried about the increasingly difficult problems of finding and improving water sources while some existing water sources are now becoming depleted or polluted. Domestic roofwater harvesting (DRWH) provides an innovative solution to meeting water needs and can be implemented quickly and modularly. It is also very robust against risks of unexpected change such as aquifers dropping or becoming polluted. Renewed interest in the technology is reflected in the water policies of many developing countries, where it is more and more being cited as a useful source of household water.

Rainwater systems are decentralised and independent of topography and geology. They deliver water directly to the household, relieving the burden of water carrying, particularly from women and children. Implementation is similar to managing the installation of on-site sanitation and once systems are in-place they are owned by the householders who can then manage their own water supply.

Roofwater harvesting does have a number of limitations, however. It is not suited to being used as a stand-alone water supply solution in any but the most water-stressed situations as the increase in tank capacity necessary to bridge a long dry season can be prohibitively expensive. The storage provided by a tank does, however give households good security against short-term failure of alternative sources.

Niches where roofwater harvesting is particularly attractive include:

- where groundwater is either difficult to secure or has been rendered unusable by fluoride, salinity or arsenic
- where the main alternatives are surface water sources
- where management of shared point sources has proved unsuitable
- where the carriage of water is a particular burden on household members or where householders are prepared to invest in water convenience.

Despite its advantages, domestic roofwater harvesting remains a niche technology and, when considered at all, is usually only considered when all other options have been eliminated. The problems come under three main categories, high cost, uncertain quality and difficulty in implementation. There is also a fourth category, lack of knowledge, which while important does not impinge upon DRWH's viability and so will not be dealt with here.

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2. Cost

The cost of domestic roofwater harvesting is usually seen as high by most water supply professionals. Table 1 shows the costs of a number of water supply options as reported by water professionals during interviews in 2001.

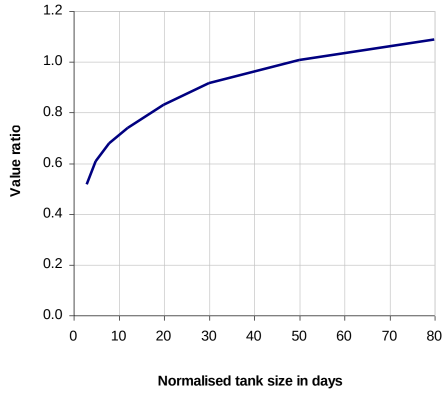
Table 1: Per capita costs of water supply

	Uganda	Ethiopia
Town water		$70 –90 pc
Tube well	$15–40pc (~500hh) < $150pc (~50hh)	> $150pc (~500hh)
Gravity scheme	$15	$17-20 pc
Rainwater Harvesting	$30 pc	

Rainwater harvesting is about twice the cost of the cheapest competitor, but less expensive than deep groundwater in high-risk areas where wells could fail or sources are limited.

Part of roofwater harvesting's reputation as a high cost option is caused by the high expectations of water professionals themselves. Providers tend to think in terms of complete solutions, i.e. all water needs should be met by one source. In low-income countries this is rarely the case and householders tend to use three or four sources depending on need and availability. In this context relatively large storage tanks are unnecessary and costs can fall appreciably. Roofwater harvesting suffers from strong diseconomies of scale (see Figure 1) in terms of supplying water needs, a small (say 1,000 litre) tank may supply 70% of a households water needs over the year (mainly in the wet season) whereas a tank 5 times the size will supply 90%, only a 20% improvement. This is because water is drawn and replenished more often with a small system whereas a large one may only fill once or twice a year.

Figure 1: Diminishing returns with increase in tank size



Another reason for high cost is a narrow view of quality. While other products such as on-plot sanitation have for years been available in a range of qualities, DRWH systems have tended toward fairly high quality structures, partly for practical reasons of water soundness and safety and partly for more aesthetic reasons.

Figure 2: unsustainable DRWH structure.

Figure 2 shows such a structure. The house is wattle and daub, while the tank is a large ferrocement structure worth more than a year's wages. It is unlikely, if not impossible for this kind of structure to be replicated by this family's neighbours.

To redress this situation the DTU has developed a tool called a "roofwater harvesting ladder" which can be used to present a range of designs to a community along with the trade-offs in terms of cost, any other commitment from the household such as labour, amount of water delivered and length of time the system is dry. Coupled with this a number of low-cost tanks have been developed which have reduced the cost of roofwater harvesting tanks by half, bringing DRWH into line with the cheapest water supply options available. Some of these designs are shown in Figure 3. After field testing the Dome and Enhanced Local Materials Roofed tanks are ready for use, while the Tube tank is most useful in a few niches (such as rapid water supply for refugees and a couple (such as the Wattle and Daub tank) need longer-term study before final recommendation.

Figure 3: some of the tanks developed

Dome tank

Enhanced Local Materials Roofed tank

Barrel Tank

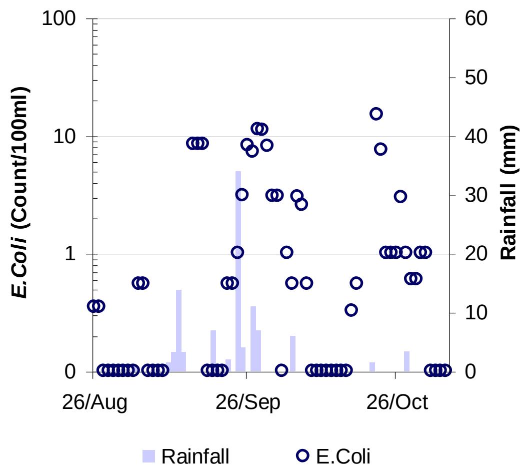
Polythene Tube tank

Wattle and daub tank

3. Water quality

The water quality of DRWH systems has often been in question, particularly when the water is used for drinking. Standards set by the WHO {WHO 1997 #4130} suggest microbiological standards of zero *E.Coli* per 100ml, which is appropriate for treated water supply systems. Roofwater does occasionally meet these standards but the water quality is time dependent, strongly following the rainfall pattern (see Figure 4).

Figure 4: *E. Coli* recorded from Rainwater Tanks in Alaba, Ethiopia (time averaged over 3 days)



Under the recent project, a series of water quality measurements have been carried out on over 120 systems at 6 sites at frequent intervals. This has provided a good picture of the water quality of roofwater harvesting systems and also highlighted several ways to improve it.

Generally, roofwater appears as good or better than rural water sources but (as expected) not as good as chlorinated urban sources (Figure 5). As is apparent in Figure 4, the water also improves with time after the rain, mainly due to sedimentation and bacteria die-off. It takes an average of 3.5 to 4 days to achieve a 90% reduction in *E.Coli* numbers.

Figure 5: Exceedance curves for stored roofwater and other water sources

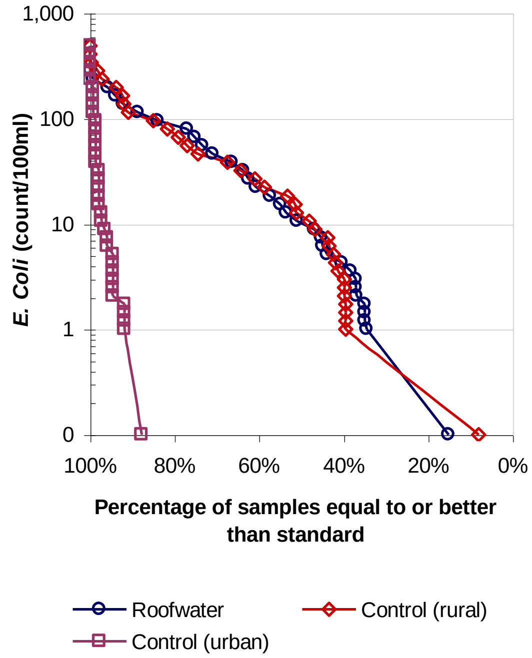
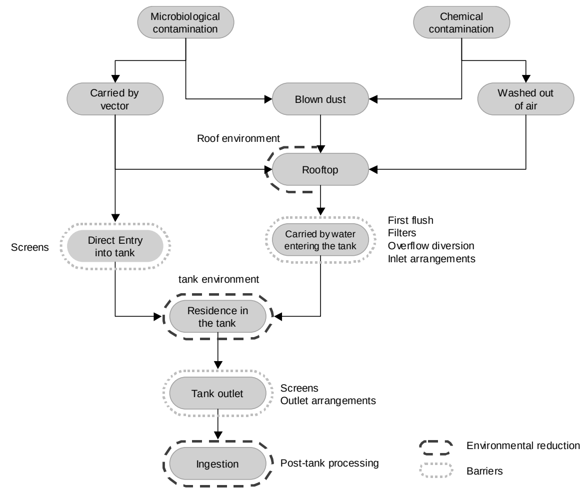


Figure 6 shows the paths of contaminants into a roofwater harvesting system.

Figure 6: contamination paths for roofwater harvesting



Research is currently underway to test the efficiency of a number of low-cost filters intended to stop contaminates from entering the tank with the water as well as a number of inlet and outlet arrangements for reducing mixing in the tank to allow die off to work more effectively.

4. Implementation

Roofwater harvesting is fundamentally different from most water supply options. These differences have profound effects on the management and implementation of any project involving roofwater harvesting:

- It is based on a finite volume of water that can be depleted if not well managed, making it a poor candidate for community supply unless strong measures are taken to prevent overuse
- It is strongly seasonal in nature meaning that there must also be another water source available. This source (or sources) must be able to cope with the demands of households using roofwater harvesting, especially as the largest demand will be in dry periods. It does not, however, have to be as high a quality
- *Domestic* roofwater harvesting requires a large number of small civil works rather than the large-centralised works of most water projects, requiring different approaches to management
- The cash flow of roofwater harvesting systems is that of a large up-front cost with extremely small maintenance charges. This is in contrast with most water supply where maintenance is a large part of the overall costs. Most projects are costed based on donor funded initial works with users paying for upkeep – this paradigm is unsuited to DRWH.

These implementation issues remain inadequately researched and form the main barrier to further support of DRWH in formal water supply.

5. Conclusions

The state of the art of DRWH has advanced considerably in recent years. Costs can be reduced considerably and the water quality of stored rainwater is better understood and ways of improving it identified. While these efforts are in no way complete, the largest challenge remaining is the management and implementation of DRWH in water supply projects.

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