Technology brief

Rainwater harvesting

Household rainwater harvesting system in Bangladesh

Collecting rain is one of the simplest forms of water supply and provides good quality water. Using and regularly maintaining simple technology to harvest rainwater can protect the water from contamination.

The water resource

Water quality

Unless you are living in or near an industrial city, rain is clean enough to drink. Rainwater is cleaner than surface water and has fewer chemical compounds than groundwater. Once rain reaches the ground however, it will begin to become dirty. Protecting the water until you want to drink it can keep it clean, so it does not need to be treated. If it is being used for other uses, such as growing crops, this protection is not as important.

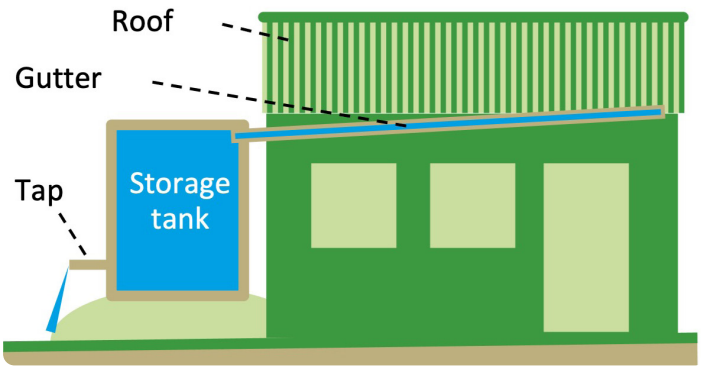
Water quantity

The quantity of water harvested depends on the amount of rainfall and the size of the **catchment** used to collect it. Rainwater is predominantly used for household self-supply or in institutions (alone or to supplement other water sources). Although whole towns can be supplied if the catchment is large enough, this can be uneconomically viable if the amount of rainfall is low or very variable.

Rainfall varies over time. This variation is both annual (with wetter and drier seasons) and daily; even in wet seasons, it does not rain all day, every day. Changing weather patterns due to climate change can make rainfall even more unpredictable. The supply is variable, but the demand for drinking water is constant, so **storage** is needed to balance the quantities.

This is different from groundwater, where the water resource is much more stable. Surface water sources do vary, but not as much as rainwater does.

WaterAid



Typical components of a household rainwater harvesting system

Other forms of precipitation, such as snow or fog, can be harvested, but this is not very common.

Rainwater harvesting can be used together with other water sources. It may only provide a proportion of the water needed, for only part of the year, but its location, quality and speed of implementation can provide benefits other water sources cannot deliver by themselves.

Steps in harvesting rainwater

Rainfall distribution does not change much over short distances, unless areas are sheltered by trees or buildings. This provides flexibility about where to site a rainwater harvesting system, unlike rivers, which are fixed, or groundwater sources, which need careful siting. The location for the system needs to be away from trees (as birds and leaves can pollute the water). Using a roof means rainwater can be harvested near the home, making water collection convenient, even at night or when it rains.

The first step is selecting the catchment the rain falls on. This is often a roof, but roads or rocky areas of land can also be used, although the water collected will not be suitable for drinking. A smooth, hard, durable surface is best, but even thatched roofs can provide some water. Schools, clinics, churches and mosques with a large roof are good locations for rainwater harvesting. The catchment should slope down towards a **gutter**. This channel collects the water and directs it to where it can be stored and used.

Blocked gutters, uncovered tanks, and pools of water from overflow pipes or spillages can become breeding areas for mosquitoes. Regular maintenance can prevent this.

School rainwater harvesting tank in Rubaga administrative division of Kampala city, Uganda

Storing the water

While water can be collected directly in a bowl or bucket when it rains, it is more convenient to collect and store it until it is needed. This can be in a plastic, metal, concrete or masonry **tank**. This tank is placed near the catchment so the rainwater can flow into it. Ideally, the tank needs to be raised up, to allow water to flow into a household water container through a **tap**. The foundation needs to be firm, as a full tank will be very heavy. Some tanks, called **cisterns**, are located underground. These need a pump or bucket to lift the water back to the surface. An overflow pipe is useful to direct excess water away from the house.

There needs to be a balance between the size of the catchment and the size of the tank. A small tank with a large catchment will not be able to store all the water running into it. The excess water will overflow and be lost. A large tank with a small catchment will rarely fill up. This extra storage will not be used often, wasting money.

An engineer will be able to calculate what size of tank is suitable for a certain size of catchment. They will need to consult with the community to find out:

- Rainfall records and patterns for several years
- How much water comes off the roof
- How much water will be used daily
- An idea of how reliable the system should be (Is it just for the wet season and a few weeks afterwards or expected to provide year-round supplies, even in an occasional dry year?)

Having two smaller tanks rather than one large tank may cost more initially, but this can be more manageable and resilient. One can be emptied and cleaned while the other still provides water. If one breaks, then at least some water is available. Buying a small replacement tank may be more affordable than a large one.

Very large schemes may use a pond or open reservoir to store the water. This does mean the water is not protected and will need to be treated before drinking. It can, however, be used directly for agriculture.

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Protecting the water

Usually, water from roofs does not need to be treated, but some steps can be taken to improve the quality and reduce the risk of pollution. These are about protecting the water rather than removing any contamination.

The roof (or other catchment) should be kept clean by cutting back any overhanging trees and discouraging birds from perching there. People should avoid burning rubbish or spraying chemicals nearby.

Protection steps include a net to stop leaves being washed off the roof into the gutter. This screen may be hard to clean, so a fine mesh at the inlet to the tank may be more convenient. The tank should be covered to stop the water becoming dirty and prevent mosquitoes from breeding.

Storage itself is a treatment method, as solids settle out and some pathogens die off. If the outlet tap is slightly above the bottom of the tank, any solids that do get into the water will settle there and be trapped. Cleaning the tank (and gutters) once it is empty or just before the wet season will remove this sediment.

Where there are long, dry periods, the roof and the gutter can become covered in dust and other pollutants. At the start of the first heavy rainfall this can all be washed into the tank. A simple measure is to disconnect the pipework during the dry season and only reconnected it after the rains start and the dust has been washed off the roof. Simple first flush devices can be installed to divert the water automatically.

The proximity of the tank to the house reduces the risk of contamination during collection. If the residents have health issues (such as HIV/AIDS) or are very young or old, then another stage of treatment may be advisable, such as a household water filter or simple chlorination. Simple dosing of chlorine to provide another stage of protection should be considered for public systems, especially those serving health centres.

Rainwater harvesting systems can grow incrementality with the population. Some countries like Bermuda mandate rainwater harvesting systems on all new buildings.

Issues to consider

Environmental issues

Areas with very low rainfall or a long dry season are not viable for rainwater harvesting. Good weather records help to design the system more precisely. Even if rainwater harvesting is only possible for part of the year or can only provide water for drinking, this may be a useful technical solution alongside other water sources. Rainwater harvesting has a low environmental impact, as only a small proportion of water is collected.

Physical issues

The basic physical resources needed to collect water can be minimal and quick to provide. A plastic sheet stretched horizontally, with a slope to a bucket will collect water in an emergency. Using roofs, roads or clear areas of land makes use of existing resources. Gutters and storage tanks can be home-made or bought. Plastic tanks are widely available and can be moved relatively easily. The most complex element is often the tap.

Unlike some intermediate technologies, rainwater harvesting is used globally, both in low-income countries and in economically developed areas. It can be used for a single household or whole towns.

Economic issues

Rainwater harvesting systems can make use of existing roofs but do need capital expenditure for gutters and tanks. These can be added in stages to spread the cost over time. Maintenance costs are low, with simple cleaning being the main activity. Repairs and replacement costs need to be planned for. Their simplicity makes them suitable for self-supply at a household level.

Providing individual harvesting systems for many households may be more expensive than a single, centralised community water supply, unless the houses are very scattered.

Social issues

As rainwater harvesting can be carried out at home, it reduces the collection effort and personal danger for women and girls. People with physical impairments or mobility restrictions will also benefit from a household supply.

Constructing a rainwater harvesting system only requires basic building skills. However, designing the system does require specialist knowledge and access to rainfall data. Operating the system is straightforward.

The purity of rainwater is useful in areas where groundwater has high levels of chemicals such as arsenic, fluoride or dissolved solids. Rainwater may not be able to supply all water demands, all year round, but using this source just for drinking and perhaps cooking can reduce the cumulative dose of harmful chemicals, especially for children.

Management issues

Rainwater harvesting systems do not need much management to keep them running. The technology is suitable for **self-supply** or for scattered rural communities where a centralised water source would not be practical. As household systems can be managed by an individual, community management is not always needed.

Schemes for schools, clinics and other public buildings will require some community coordination, perhaps paying for a caretaker for periodic maintenance, ensuring that the catchment is kept clean. Systems supplying a whole town will need professional management.

A household-level rainwater harvesting scheme can benefit from external support from ministries, local government and NGOs. This includes:

- Promotion of the technology, especially as a self-supply option
- Technical advice and training for builders
- Lists of suppliers of equipment
- Rainfall data to calculate the dimensions of the facilities
- Access to loans or grants to pay for the capital works
- Specific practical or financial help for people with disabilities and other vulnerable groups

Schools and clinics may receive financial assistance from educational and health institutions, but technical assistance and information should be provided by water, sanitation and hygiene professionals.

Water regulators or owners should carry out a sanitary survey every few years to ensure the system is still working safely. A series of simple illustrated check sheets for household level systems are available from the World Health Organization (www.who.int/water_sanitation_health/water-quality/safety-planning/rainwater-collection-and-storage/en). These documents identify common technical problems and provide guidance on how to address them.

Case study – Rainwater harvesting in Pakistan

In the district of Tharparkar in Pakistan, people have practised rainwater harvesting through traditional methods for centuries. However, these methods are only able to provide a small amount of low-quality water. Every year, communities migrate for months at a time in search of water for themselves and their livestock.

Aside from rainwater, there are very limited water resources available in this arid region. The alternative sources are shallow dug wells and poorly protected open ponds, often many hours' walk from households. The groundwater has salinity and fluoride contamination issues, and the wells often dry up in the dry season.

Following research in 2008 into ways to improve the design of traditional rainwater harvesting methods to increase the quality and quantity of water collected, WaterAid and The Sukaar Foundation worked with villages in the region to pilot three methods for rainwater collection from 2014 to 2017. These were large community ponds, ponds for clusters of eight to ten households, and household rainwater harvesting tanks.

Rainfall is low and highly variable in this region, which often suffers long periods of drought, some lasting many years. This variability meant that during the pilot project the larger community and household cluster ponds often did not fill up completely. This reduced their potential water quality improvement benefits and meant the additional quantity was not sufficient to justify the cost of the systems.

However, the pilot of the household-level rainwater harvesting systems, known locally as 'Nadi cisterns', was successful. These continue

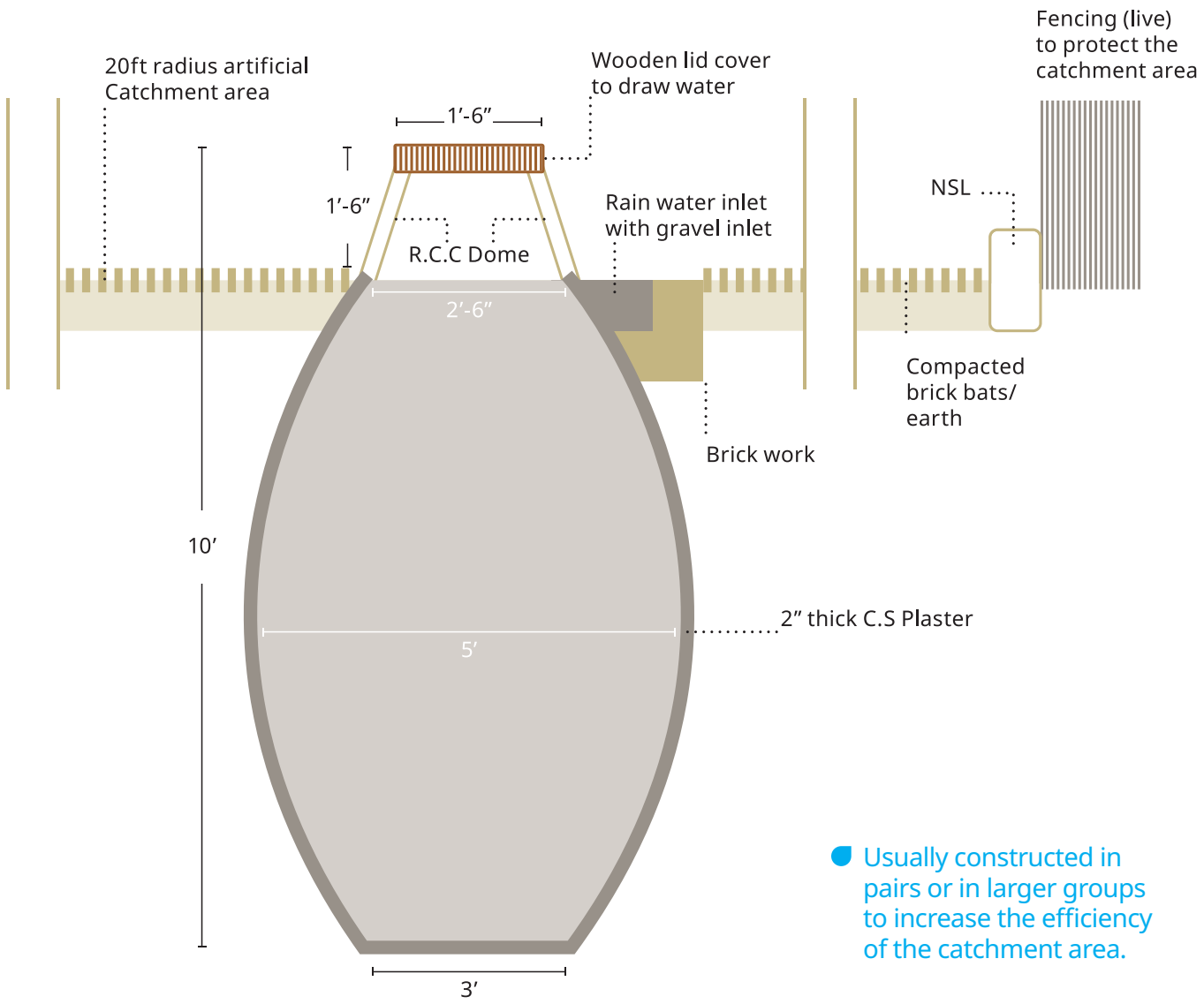
Top: Diya, 35, fetching water from the rainwater harvesting tank in her house in the village of Leeria Bheel, Tharparkar, Pakistan.

to be maintained and used by community members, as well as being replicated by a number of other organisations in adjacent areas.

The Nadi cisterns have reduced the number of months during which the community must migrate each year in search of water. For the months they are in use, they also provide higher quality water than other available sources.

The cisterns are vase-shaped underground water storage containers, plastered with cement sand plaster and sealed with a geo-membrane sheet to minimise water loss from ground seepage. They are connected to a saucer-shaped artificial catchment area and sometimes to household rooftops. They have a dome-shaped cover at ground level, which reduces evaporation losses, and a small, gravel-filled roughing filter installed at the inlet, to improve water quality by controlling turbidity of the rain runoff. A small opening is provided on one side of the dome for drawing water with a simple bucket and rope method.

X-Section of Nadi Pond/ Cistern-HH level Rain Water Harvesting System



- Usually constructed in pairs or in larger groups to increase the efficiency of the catchment area.

Useful resources

For more information on the design and construction of rainwater harvesting systems, see:

Rainwater Wiki. Akvopedia. Available at: https://akvopedia.org/wiki/Water_Portal_/_Rainwater_Harvesting.

Thomas TH and Martinson DB (2007). Roofwater harvesting: A handbook for practitioners [online]. Delft, The Netherlands. IRC International Water and Sanitation Centre. Available at: www.ircwash.org/resources/roofwater-harvesting-handbook-practitioners.

WaterAid is an international not-for-profit, determined to make clean water, decent toilets and good hygiene normal for everyone, everywhere within a generation.

Part of a series of WaterAid technology briefs available at www.wateraid.org/uk/technology

WaterAid (2021). Technology brief: Appropriate technologies for sustainable and inclusive water and sanitation services. London. Available at: washmatters.wateraid.org/publications/technology-resources