RAINWATER HARVESTING

Introduction

A sufficient, clean drinking water supply is essential to life. Millions of people throughout the world still do not have access to this basic necessity. After decades of work by governments and organisations to bring potable water to the poorer people of the world, the situation is still dire. The reasons are many and varied but generally speaking, the poor of the world cannot afford the capital intensive and technically complex traditional water supply systems which are widely promoted by governments and agencies throughout the world. Rainwater harvesting (RWH) is an option that has been adopted in many areas of the world where conventional water supply systems have failed to meet peoples needs. It is a technique that has been used since antiquity.

Figure 1: Sigiriya, Sri Lanka. This reservoir cut into the rock was used centuries ago to hold harvested rainwater. ©Practical Action

Examples of RWH systems can be found in all the great civilisations throughout history. In industrialised countries, sophisticated RWH systems have been developed with the aim of reducing water bills or to meet the needs of remote communities or individual households in arid regions. Traditionally, in Uganda and Sri Lanka, for example, rainwater is collected from trees, using banana leaves or stems as temporary gutters; up to 200 litres may be collected from a large tree in a single storm. Many individuals and groups have taken the initiative and developed a wide variety of RWH systems throughout the world.

It is worth distinguishing, between the various types of RWH practised throughout the world. RWH has come to mean the control or utilisation of rainwater close to the point rain reaches the earth. Its practice effectively divides into

- Domestic RWH
- RWH for agriculture, erosion control, flood control and aquifer replenishment.

It is worth bearing in mind that rainwater harvesting is not the definitive answer to household water problems. There is a complex set of inter-related circumstances that have to be considered when choosing the appropriate water source. These include cost, climate, hydrology, social and political elements, as well as technology, all play a role in the eventual choice of water supply scheme that is adopted for a given situation. RWH is only one possible choice, but one that is often overlooked by planners, engineers and builders.

The reason that RWH is rarely considered is often due to lack of information – both technical and otherwise. In many areas where RWH has been introduced as part of a wider drinking water supply programme, it was at first unpopular, simply because little was known about the technology by the beneficiaries. In most of these cases, the technology has quickly gained popularity as the user realises the benefits of a clean, reliable water source at the home. the town supply is unreliable or where local water sources dry up for a part of the year, but is also In many cases RWH has been introduced as part of an integrated water supply system, where often used as the sole water source for a community or household. It is a technology that is flexible and adaptable to a very wide variety of conditions, being used in the richest and the poorest societies on our planet, and in the wettest and the driest regions of the world.

Components of a domestic RWH system

DRWH systems vary in complexity, some of the traditional Sri Lankan systems are no more that a pot situated under a piece of cloth or plastic sheet tied at its corners to four poles. The cloth captures the water and diverts it through a hole in its centre into the pot. Some of the sophisticated systems manufactured in Germany incorporate clever computer management systems, submersible pumps, and links into the grey water and mains domestic plumbing systems. Somewhere between these two extremes we find the typical DRWH system used in a developing country scenario. Such a system will usually comprise a collection surface (a clean roof or ground area), a storage tank, and guttering to transport the water from the roof to the storage tank. Other peripheral equipment is sometimes incorporated, for example: first flush systems to divert the dirty water which contains roof debris after prolonged dry periods; filtration equipment and settling chambers to remove debris and contaminants before water enters the storage tank or cistern; handpumps for water extraction; water level indicators, etc.

Typical domestic RWH systems.

Storage tanks and cisterns

The water storage tank usually represents the biggest capital investment element of a domestic RWH system. It therefore usually requires careful design – to provide optimal storage capacity while keeping the cost as low as possible. The catchment area is usually the existing rooftop or occasionally a cleaned area of ground, as seen in the courtyard collection systems in China, and guttering can often be obtained relatively cheaply, or can be manufactured locally.

There are an almost unlimited number of options for storing water. Common vessels used for very small-scale water storage in developing countries include such examples as plastic bowls and buckets, jerrycans, clay or ceramic jars, cement jars, old oil drums, empty food containers, etc. For storing larger quantities of water the system will usually require a tank or a cistern. For the purpose of this document we will classify the tank as an above-ground storage vessel and the cistern as a below-ground storage vessel. These can vary in size from a cubic metre or so (1000 litres) up to hundreds of cubic metres for large projects, but typically up to a maximum of 20 or 30 cubic metres for a domestic system. The choice of system will depend on a number of technical and economic considerations listed below.

- Space availability
- Options available locally
- Local traditions for water storage
- Cost – of purchasing new tank
- Cost – of materials and labour for construction

- Materials and skills available locally
- Ground conditions
- Style of RWH – whether the system will provide total or partial water supply

One of the main choices will be whether to use a tank or a cistern. Both tanks and cisterns have their advantages and disadvantages. Table 1 summarises the pros and cons of each.

	Tank	Cistern
Pros	x Above ground structure allows easy inspection for leakages x Many existing designs to choose from x Can be easily purchased 'off-the-shelf' x Can be manufactured from a wide variety of materials x Easy to construct from traditional materials x Water extraction can be by gravity in many cases x Can be raised above ground level to increase water pressure	x Generally cheaper due to lower material requirements x More difficult to empty by leaving tap on x Require little or no space above ground x Unobtrusive x Surrounding ground gives support allowing lower wall thickness and thus lower costs
Cons	x Require space x Generally more expensive x More easily damaged x Prone to attack from weather x Failure can be dangerous	x Water extraction is more problematic – often requiring a pump x Leaks are more difficult to detect x Contamination of the cistern from groundwater is more common x Tree roots can damage the structure x There is danger to children and small animals if the cistern is left uncovered x Flotation of the cistern may occur if groundwater level is high and cistern is empty. x Heavy vehicles driving over a cistern can cause damage

Table 1: Pros and cons of tanks and cisterns

Figure 3: a) An owner built brick tank in Sri Lanka. b) A corrugated iron RWH tank in Uganda.

Much work has been carried out to develop the ideal domestic RWH tank. The case studies later in this document show a variety of tanks that have been built in different parts of the world.

Collection surfaces
For domestic rainwater harvesting the most common surface for collection is the roof of the dwelling. Many other surfaces can be, and are, used: courtyards, threshing areas, paved

Figure 4: A typical corrugated iron sheet roof showing guttering ©Practical Action

walking areas, plastic sheeting, trees, etc. In some cases, as in Gibraltar, large rock surfaces are used to collect water which is then stored in large tanks at the base of the rock slopes.

Most dwellings, however, have a roof. The style, construction and material of the roof affect its suitability as a collection surface for water. Typical materials for roofing include corrugated iron sheet, asbestos sheet; tiles (a wide variety is found), slate, and thatch (from a variety of organic materials). Most are suitable for collection of roofwater, but only certain types of grasses e.g. coconut and anahaw palm (Gould and Nissen Peterson, 1999), thatched tightly, provide a surface adequate for high quality water collection. The rapid move towards the use of corrugated iron sheets in many developing countries favours the promotion of RWH (despite the other negative attributes of this material).

Guttering
Guttering is used to transport rainwater from the roof to the storage vessel. Guttering comes in a wide variety of shapes and forms, ranging from the factory made PVC type to home made guttering using bamboo or folded metal sheet. In fact, the lack of standards in guttering shape and size makes it difficult for designers to develop standard solutions to, say, filtration and first flush devices. Guttering is usually fixed to the building just below the roof and catches the water as it falls from the roof.

Some of the common types of guttering and fixings are shown in figure 5.

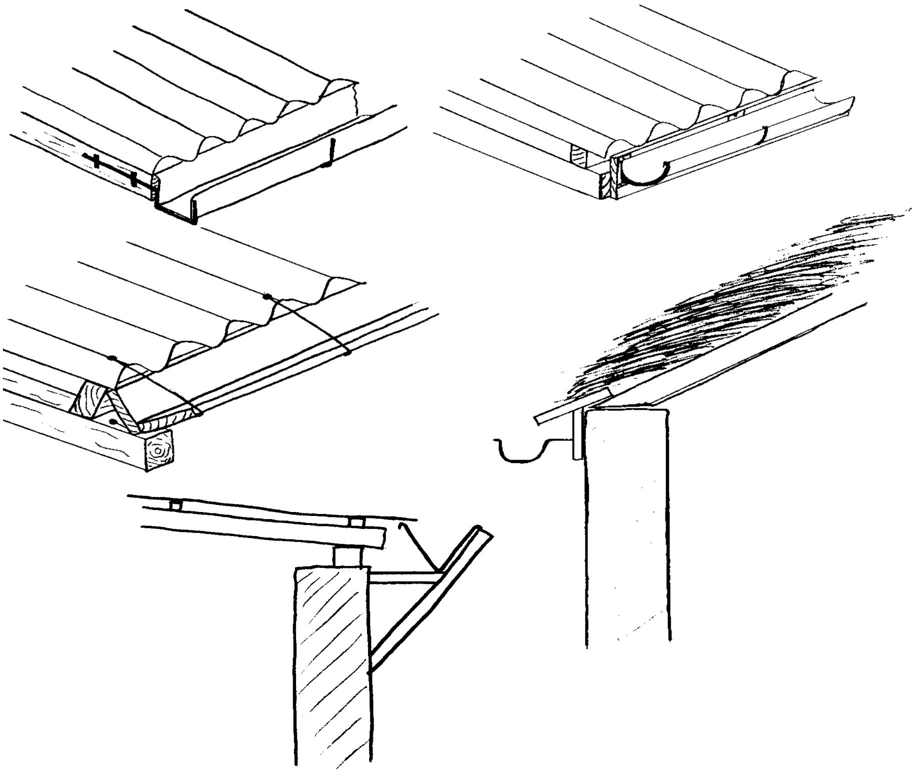


Figure 5: a variety of guttering types showing possible fixings

Manufacture of low-cost gutters

Factory made gutters are usually expensive and beyond the reach of the poor of developing countries, if indeed available at all in the local marketplace. They are seldom used for very low-cost systems. The alternative is usually to manufacture gutters from materials that can be found cheaply in the locality. There are a number of techniques that have been developed to help meet this demand; one such technique is described below.

V- shaped gutters from galvanised steel sheet can be made simply by cutting and folding flat galvanised steel sheet. Such sheet is readily available in most market centres (otherwise corrugated iron sheet can be beaten flat) and can be worked with tools that are commonly found in a modestly equipped workshop. One simple technique is to clamp the cut sheet between two lengths of straight timber and then to fold the sheet along the edge of the wood. A strengthening edge can be added by folding the sheet through 90^o and then completing the edge with a hammer on a hard flat surface. The better the grade of steel sheet that is used, the more durable and hard wearing the product. Fitting a downpipe to V-shaped guttering can be problematic and the V-shaped guttering will often be continued to the tank rather than changing to the customary circular pipe section downpipe. Methods for fixing gutters are shown in figure 5.

Figure 6: folding galvanised steel sheet to make V-shaped guttering

First flush systems

Debris, dirt, dust and droppings will collect on the roof of a building or other collection area. When the first rains arrive, this unwanted matter will be washed into the tank. This will cause contamination of the water and the quality will be reduced. Many RWH systems therefore incorporate a system for diverting this ‘first flush’ water so that it does not enter the tank.

The simpler ideas are based on a manually operated arrangement whereby the inlet pipe is moved away from the tank inlet and then replaced again once the initial first flush has been diverted. This method has obvious drawbacks in that there has to be a person present who will remember to move the pipe.

Other systems use tipping gutters to achieve the same purpose. The most common system (as shown in Figure 7a) uses a bucket which accepts the first flush and the weight of this water off-balances a tipping gutter which then diverts the water back into the tank.
The bucket then empties slowly through a small-bore pipe and automatically resets. The process will repeat itself from time to time if the rain continues to fall, which can be a problem where water is really at a premium. In this case a tap can be fitted to the bucket and will be operated manually. The quantity of water that is flushed is dependent on the force required to lift the guttering. This can be adjusted to suit the needs of the user.

Figure 7 – a) the tipping gutter first flush system and b) the floating ball first flush system

Another system that is used relies on a floating ball that forms a seal once sufficient water has been diverted (see Figure 7b). The seal is usually made as the ball rises into the apex of an inverted cone. The ball seals the top of the 'waste' water chamber and the diverted water is slowly released, as with the bucket system above, through a small bore pipe. Again, the alternative is to use a tap. In some systems (notably one factory manufactured system from Australia) the top receiving chamber is designed such that a vortex is formed and any particles in the water are drawn down into the base of the vortex while only clean water passes into the storage tank. The 'waste' water can be used for irrigating garden plants or other suitable application. The debris has to be removed from the lower chamber occasionally.

Although the more sophisticated methods provide a much more elegant means of rejecting the first flush water, practitioners often recommend that very simple, easily maintained systems be used, as these are more likely to be repaired if failure occurs.

Filtration systems and settling tanks

Again, there are a wide variety of systems available for treating water before, during and after storage. The level of sophistication also varies, from extremely high-tech to very rudimentary. A German company, WISY, have developed an ingenious filter which fits into a vertical downpipe and acts as both filter and first-flush system. The filter, shown in Figure 8, cleverly takes in water through a very fine (~0.20mm) mesh while allowing silt and debris to continue down the pipe. The efficiency of the filter is over 90%. This filter is commonly used in European systems.

Figure 8: the WISY filter (downpipe and high-capacity below ground versions) - Source: WISY Catalogue

The simple trash rack has been used in some systems but this type of filter has a number of associated problems: firstly it only removes large debris; and secondly the rack can become clogged easily and requires regular cleaning.

The sand-charcoal-stone filter is often used for filtering rainwater entering a tank. This type of filter is only suitable, however, where the inflow is slow to moderate, and will soon overflow if the inflow exceeds the rate at which the water can percolate through the sand. Settling tanks and partitions can be used to remove silt and other suspended solids from the water. These are usually effective where used, but add significant additional cost if elaborate techniques are used. Many systems found in the field rely simply on a piece of cloth or fine mosquito mesh to act as the filter (and to prevent mosquitoes entering the tank).

Post storage filtration include such systems as the upflow sand filter or the twin compartment candle filters commonly found in LDC's. Many other systems exist and can be found in the appropriate water literature.

Sizing the system

Usually, the main calculation carried out by the designer when planning a domestic RWH system will be to size the water tank correctly to give adequate storage capacity. The storage requirement will be determined by a number of interrelated factors. They include:

- local rainfall data and weather patterns
- size of roof (or other) collection area
- runoff coefficient (this varies between 0.5 and 0.9 depending on roof material and slope)
- user numbers and consumption rates

The style of rainwater harvesting i.e. whether the system will provide total or partial supply (see the next section) will also play a part in determining the system components and their size.

There are a number of different methods used for sizing the tank. These methods vary in complexity and sophistication. Some are readily carried out by relatively inexperienced, first-time practitioners while others require computer software and trained engineers who understand how to use this software. The choice of method used to design system components will depend largely on the following factors:

- the size and sophistication of the system and its components
- the availability of the tools required for using a particular method (e.g. computers)
- the skill and education levels of the practitioner / designer

Below we will outline 3 different methods for sizing RWH system components.

Method 1 – demand side approach

A very simple method is to calculate the largest storage requirement based on the consumption rates and occupancy of the building.

As a simple example we can use the following typical data:

Consumption per capita per day, C = 20 litres
Number of people per household, n = 6
Longest average dry period = 25 days

Annual consumption = C x n = 120 litres

Storage requirement, T = 120 x 25 = 3,000 litres

This simple method assumes sufficient rainfall and catchment area, and is therefore only applicable in areas where this is the situation. It is a method for acquiring rough estimates of tank size.

Method 2 – supply side approach

In low rainfall areas or areas where the rainfall is of uneven distribution, more care has to be taken to size the storage properly. During some months of the year, there may be an excess of water, while at other times there will be a deficit. If there is enough water throughout the year to meet the demand, then sufficient storage will be required to bridge the periods of scarcity. As storage is expensive, this should be done carefully to avoid unnecessary expense. This is a common scenario in many developing countries where monsoon or single wet season climates prevail.

The example given here is a simple spreadsheet calculation for a site in North Western Tanzania. The rainfall statistics were gleaned from a nurse at the local hospital who had been keeping records for the previous 12 years. Average figures for the rainfall data were used to simplify the calculation, and no reliability calculation is done. This is a typical field approach to RWH storage sizing.

The example is taken from a system built at a medical dispensary in the village of Ruganzu, Biharamulo District, Kagera, Tanzania in 1997.

Demand:	**Supply:**
Number of staff: 6 Staff consumption: 25 lpcd* Patients: 30 Patient consumption : 10 lpcd Total daily demand: 450 litres	Roof area: 190m^2 Runoff coefficient** (for new corrugated GI roof): 0.9 Average annual rainfall: 1056mm per year Daily available water (assuming all is collected) = (190 x 1056 x 0.9)/ 365 = 494.7 litres

*lpcd – litres per capita per day
** Run-off coefficient values vary between 0.3 and 0.9 depending on the material of the catchment area. It takes into consideration losses due to percolation, evaporation, etc.

In this case, it was decided to size the tank to suit the supply, assuming that there may be growth in numbers of patients or staff in the future. Careful water management will still be required to ensure water throughout the year.

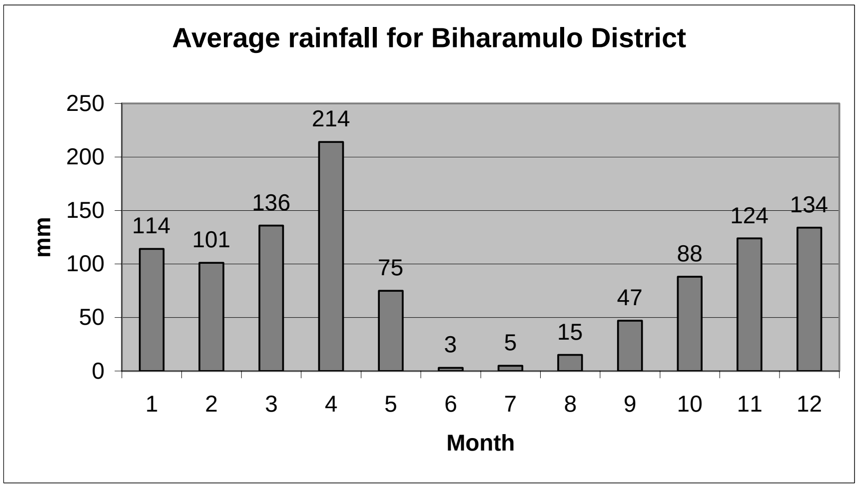
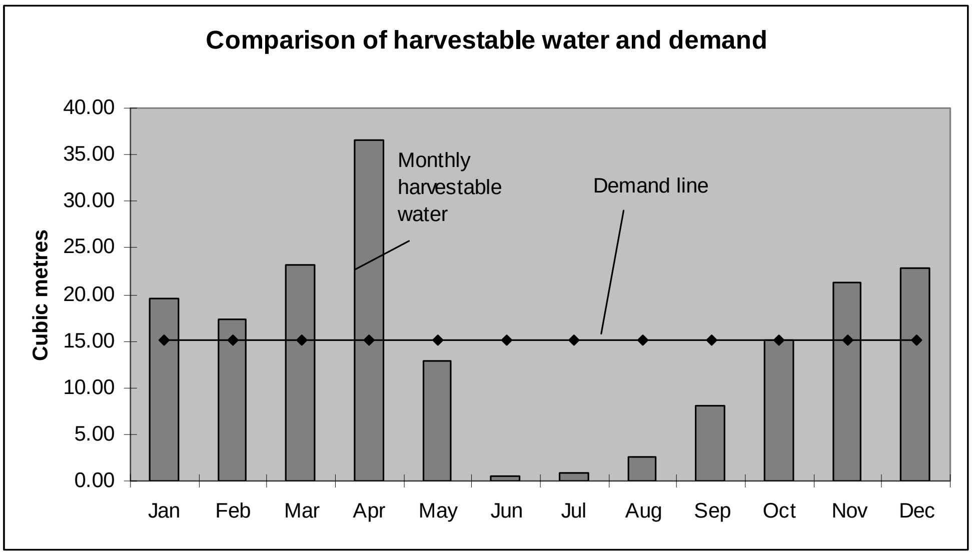


Figure 9: Average monthly rainfall for Biharamulo District

Figure 10 shows the comparison of water harvested and the amount that can be supplied to the dispensary using all the water which is harvested. It can be noted that there is a single rainy season. The first month that the rainfall on the roof meets the demand is October. If we therefore assume that the tank is empty at the end of September we can form a graph of cumulative harvested water and cumulative demand and from this we can calculate the maximum storage requirement for them dispensary.
Figure 10: Comparison of the harvestable water and the demand for each month.



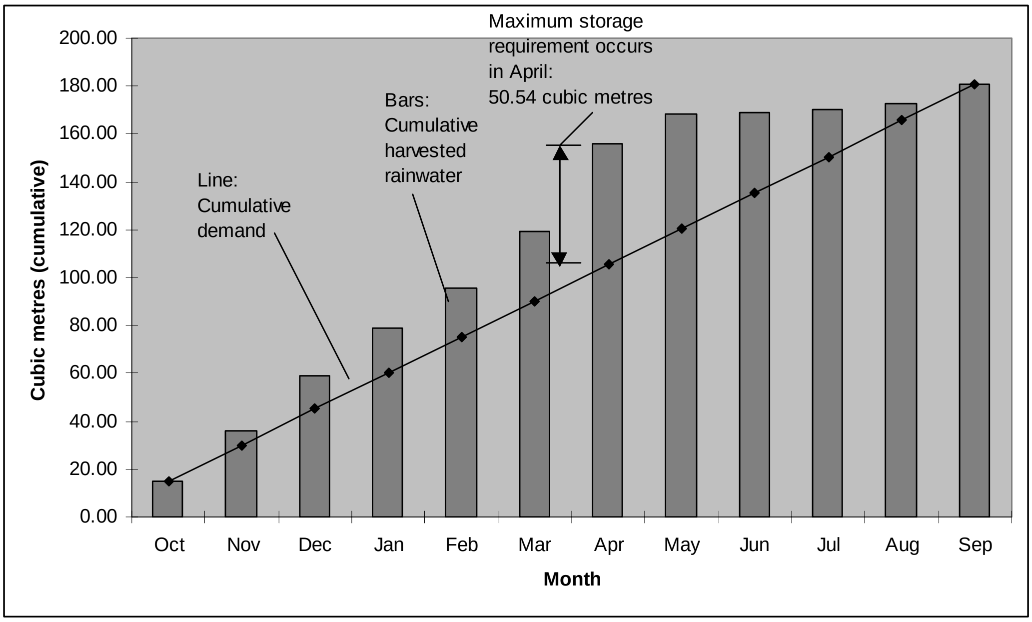


Figure11: showing the predicted cumulative inflow and outflow from the tank. The maximum storage requirement occurs in April at 50.45 cubic metres. All this water will have to be stored to cover the shortfall during the dry period.

In this case the solution was a 50 cubic metre ferrocement tank.

Figure 12: Ferrocement tank in Ruganzu Village ©DTU

Method 3 – computer model
There are several computer-based programmes for calculating tank size quite accurately. One such programme, known as SimTanka, has been written by an Indian organisation and is available free of charge on the World Wide Web. The Ajit Foundation is a registered non-profit voluntary organisation with its main office in Jaipur, India and its community resource centre in Bikaner, India.

SimTanka is a software programme for simulating performance of rainwater harvesting systems with covered water storage tank. Such systems are called Tanka in western parts of the state of Rajasthan in India. The idea of this computer simulation is to predict the performance of a rainwater harvesting system based on the mathematical model of the actual system. In particular SimTanka simulates the fluctuating rainfall on which the rainwater harvesting system is dependent.

SimTanka requires at least 15 years of monthly rainfall records for the place at which the rainwater harvesting system is located. If you do not have the rainfall record for the place then the rainfall record from the nearest place which has the same pattern of rainfall can be used. The software will then calculate optimum storage size or catchment size depending on the requirements of the user. SimTanka also calculates the reliability of the system based on the rainfall data of the previous 15 years. See the resources section for the Web Site address.

Further comments

The methods outlined above can be further refined, where necessary, to use daily rainfall data. This is particularly important in areas where rainfall is more evenly distributed and more sensitive calculations are necessary.

Rainfall data can be obtained from a variety of sources. The first point of call should be the national meteorological organisation for the country in question. In some developing countries, however, statistics are limited due to lack of resources and other sources are often worth seeking. Local Water Departments or local organisations, local hospitals or schools are all possible sources of information.

In reality the cost of the tank materials will often govern the choice of tank size. In other cases, such as large RWH programmes, standard sizes of tank are used regardless of consumption patterns, roof size or number of individual users (although the tank size will, hopefully, be based on local averages).

User behaviour patterns with domestic RWH

Styles of RWH – system, climate and geographical variables

Rainwater that has been harvested is used in many different ways. In some parts of the world it is used merely to capture enough water during a storm to save a trip or two to the main water source. Here, only small storage capacity is required, maybe just a few small pots to store enough water for a day or half a day. At the other end of the spectrum we see, in arid areas of the world, systems which have sufficient collection surface area and storage capacity to provide enough water to meet the full needs of the user. Between these two extremes exists a wide variety of different user patterns or regimes. There are many variables that determine these patterns of usage for RWH. Some of these are listed below:

Figure 13: small jars used in Cambodia as part of a multi-sourced water supply ©DTU

- *Rainfall quantity (mm/year)*
- *Rainfall pattern* - The type of rainfall pattern, as well as the total rainfall, which prevails will often determine the feasibility of a RWHS. A climate where rain falls regularly throughout the year will mean that the storage requirement is low and hence the system cost will be correspondingly low and vice versa. More detailed rainfall data is required to ascertain the rainfall pattern. The more detailed the data available, the more accurately the system parameters can be defined.
- *Collection surface area (m^2)*
- *Available storage capacity (m^3)*
- *Daily consumption rate (litres/capita /day or lpcd)* - this varies enormously – from 10 – 15 lpcd a day in some parts of Africa to several hundred lpcd in some industrialised countries. This will have obvious impacts on system specification.
- *Number of users* - again this will greatly influence the requirements.
- *Cost* – a major factor in any scheme.
- *Alternative water sources* – where alternative water sources are available, this can make a significant difference to the usage pattern. If there is a groundwater source within walking distance of the dwelling (say within a kilometre or so), then a RWHS that can provide a reliable supply of water at the homestead for the majority of the year, will have a significant impact to lifestyle of the user. Obviously, the user will still have to cart water for the remainder of the year, but for the months when water is available at the dwelling there is a great saving in time and energy. Another possible scenario is where rainwater is stored and used only for drinking and cooking, the higher quality water demands, and a poorer quality water source, which may be near the dwelling, is used for other activities.
- *Water management strategy* – whatever the conditions, a careful water management strategy is always a prudent measure. In situations where there is a strong reliance on stored rainwater, there is a need to control or manage the amount of water being used so that it does not dry up before expected.

We can simply classify most systems by the amount of ‘water security’ or ‘reliability’ afforded by the system. There are four types of user regimes listed below:

Occasional - water is collected occasionally with a small storage capacity, which allows the user to store enough water for a maximum of, say, one or two days. This type of system is ideally suited to a climate where there is a uniform, or bimodal, rainfall pattern with very few dry days during the year and where an alternative water source is available nearby.

Intermittent – this type of pattern is one where the requirements of the user are met for a part of the year. A typical scenario is where there is a single long rainy season and, during this time, most or all of the users’ needs are met. During the dry season, an alternative water source has to be used or, as we see in the Sri Lankan case, water is carted/ bowsered in from a nearby river and stored in the RWH tank. Usually, a small or medium size storage vessel is required to bridge the days when there is no rain.

Partial – this type of pattern provides for partial coverage of the water requirements of the user during the whole of the year. An example of this type of system would be where a family gather rainwater to meet only the high-quality needs, such as drinking or cooking, while other needs, such as bathing and clothes washing, are met by a water source with a lower quality.

Full – with this type of system the total water demand of the user is met for the whole of the year by rainwater only. This is sometimes the only option available in areas where other sources are unavailable. A careful feasibility study must be carried out before hand to ensure that conditions are suitable. A strict water management strategy is required when such a system is used to ensure that the water is used carefully and will last until the following wet season.

Rainwater quality and health

Rainwater is often used for drinking and cooking and so it is vital that the highest possible standards are met. Rainwater, unfortunately, often does not meet the World Health Organisation (WHO) water quality guidelines. This does not mean that the water is unsafe to drink. Gould and Nissen-Peterson(1999), in their recent book, point out that the Australian government have given the all clear for the consumption of rainwater 'provided the rainwater is clear, has little taste or smell, and is from a well-maintained system'. It has been found that a favourable user perception of rainwater quality (not necessarily perfect water quality) makes an enormous difference to the acceptance of RWH as a water supply option.

Generally the chemical quality of rainwater will fall within the WHO guidelines and rarely presents problems. There are two main issues when looking at the quality and health aspects of DRWH:
Firstly, there is the issue of *bacteriological water quality*. Rainwater can become contaminated by faeces entering the tank from the catchment area. It is advised that the catchment surface always be kept clean. Rainwater tanks should be designed to protect the water from contamination by leaves, dust, insects, vermin, and other industrial or agricultural pollutants. Tanks should be sited away from trees, with good fitting lids and kept in good condition. Incoming water should be filtered or screened, or allowed to settle to take out foreign matter (as described in a previous section). Water which is relatively clean on entry to the tank will usually improve in quality if allowed to sit for some time inside the tank. Bacteria entering the tank will die off rapidly if the water is relatively clean. Algae will grow inside a tank if sufficient sunlight is available for photosynthesis. Keeping a tank dark and sited in a shady spot will prevent algae growth and also keep the water cool. As mentioned in a previous section, there are a number of ways of diverting the dirty 'first flush' water away from the storage tank. The area surrounding a RWH should be kept in good sanitary condition, fenced off to prevent animals fouling the area or children playing around the tank. Any pools of water gathering around the tank should be drained and filled.

Gould points out that in a study carried out in north-east Thailand 90 per cent of in-house storage jars were contaminated whilst only 40% of the RWH jars were contaminated. This suggests secondary contamination (through poor hygiene) is a major cause of concern.

Secondly, there is a need to prevent insect vectors from breeding inside the tank. In areas where malaria is present, providing water tanks without any care for preventing insect breeding, can cause more problems than it solves. All tanks should be sealed to prevent insects from entering. Mosquito proof screens should be fitted to all openings. Some practitioners recommend the use of 1 to 2 teaspoons of household kerosene in a tank of water which provides a film to prevent mosquitoes settling on the water.

There are several simple methods of treatment for water before drinking.

- Boiling water will kill any harmful bacteria which may be present
- Adding chlorine in the right quantity (35ml of sodium hypochlorite per 1000 litres of water) will disinfect the water
- Slow sand filtration will remove any harmful organisms when carried out properly
- A recently developed technique called SODIS (SOlar DISinfection) utilises plastic bottles which are filled with water and placed in the sun for one full day. The back of the bottle is painted black. More information can be found through the Resource Section at the end of this document.

Rainwater harvesting resources

References and further reading

- *Runoff Rainwater Harvesting* Practical Action Technical Brief
- *The Sri Lankan 'Pumkin' Eater Tank ~ Case Study* Practical Action Technical Brief
- *The Underground Brick Dome Water Tank ~ Case Study* Practical Action Technical Brief
- *The Cement Mortar Jar ~ Case Study* Practical Action Technical Brief
- *Rainwater Catchment Systems for Domestic Supply*, by John Gould and Erik Nissen-Petersen, IT Publications Ltd., 1999. Summarises the state of the art at the moment. *Ferrocement Water tanks and their Construction*, S. B. Watt. 1978 The classic text on construction of ferrocement tanks.
- *Rainwater Harvesting: The Collection of Rainfall and Runoff in Rural Areas*, Arnold Pacey and Adrian Cullis – a wider focus including the capture of runoff for agricultural use. IT Publications.
- *Water Harvesting – A Guide for Planners and Project Managers*, Lee, Michael D. and Visscher, Jan Teun, IRC International Water and Sanitation Centre, 1992
- *Water Harvesting in five African Countries*, Lee, Michael D. and Visscher, Jan Teun, IRC / UNICEF, 1990. As snapshot of the status of RWH in five African countries.
- Waterlines Journal Vol. 18, No 3, January 2000 and Vol. 14, No.2, October 1995 Both issues are dedicated to rainwater harvesting, available through ITDG Publishing,
- Photo-manuals by Eric Nissen-Petersen. A range of manuals on how to build a number of tank types including: cylindrical water tanks with dome, an underground tank, smaller water tanks and jars, installation gutters and splash-guards, available from the author at: P.O. Box 38, Kibwezi, Kenya.
- Rainwater Catchment Systems – Reflections and Prospects, John Gould, Waterlines Vol.18 No. 3, January 2000.
- Domestic Water Supply Using Rainwater Harvesting, by T.H.Thomas, Director of the Development Technology Unit (DTU), University of Warwick. The article is available on DTU's Website (see below).
- Waterlines back issues containing rainwater harvesting articles: Vols 17(3), 16(4), 15(3), 14(2), 11(4), 8(3), 7(4), 5(4), 5(3), 4(4), 4(3), 3(3), 3(2), 3(1), 2(4), 2(1), 1(1).

Video

- *Mvua ni Maji – Rain is Water, Rainwater Harvesting* by Women's Groups in Kenya, FAKT, 1996. 27 min VHS/PAL. A Kenyan film team documented this success story on the occasion of the visit of a delegation of Ugandan women who came to learn the skills of rainwater harvesting from their Kenyan sisters. Available through FAKT (see address section)
- *A Gift from the Sky – An Overview of Roofwater Harvesting in Sri Lanka*. Available from the Lanka Rainwater Harvesting Forum (see address section).
- *Construction of Water Tanks for Rainwater Harvesting* – a video manual prepared by Eric Nissen-Petersen (see above).
- *Rock Catchments*. Several designs of rock catchment system looked at in detail. Again by Erik Niseen-Petersen.

Useful contacts

Development Technology Unit,
School of Engineering,
University of Warwick,
Coventry CV4 7AL, UK.
Email dtu@eng.warwick.ac.uk
http://www.eng.warwick.ac.uk/DTU/rainwaterharvesting/index.htm - a number of case studies from around the world, with good descriptions.
Contact Dr Terry Thomas. Also the co-ordinators of the Rainwater Harvesting Research Group (RHRG)

International Rainwater Catchment Systems Association (IRCSA)
Dept. of Natural Resources, Chinese Cultural University, Hwa Kang, Yang Min Shan, Taipei, Taiwan.
E-mail: ufab0043@ms5hinet.net
Website: http://www.ircsa.org/
IRCSA Fact sheets http://www.ircsa.org/factsheets.htm

Lanka Rainwater Harvesting Forum (LRWF)
c/o Practical Action South Asia,
5 Lionel Eridisinghe Mawatha, Colombo 5, Sri Lanka
E-mail: rwhf@itdg.lanka.net
Website: http://www.rainwaterharvesting.com

Centre for Science and Environment (CSE)
41 Tughlakabad Institutional Area, New Delhi 110062, India
E-mail: cse@cseindia.org

People for promoting Rainwater Utilisation
1-8-1 Higashi-Mukojima, Sumida City, Tokyo, Japan
E-mail murase-m@tc4.so-net.ne.jp

IRC (The International Water and Sanitation Centre)
PO Box 93190, 2509 AD
The Hague, Netherlands
E-mail: general@irc.nl
Website: http://www.irc.nl

Uganda Rain Water Association (URA),
P. O. Box 20026, Kampala, Uganda.
E-mail: wesacc.dwd@imul.com

Kenya Rainwater Association
P O Box 72387, Nairobi, Kenya
E-mail: kra@net2000ke.com

United Kingdom Rainwater Harvesting Association
Website: http://www.rainharvesting.co.uk/

The Pelican Tank Rainwater Collection System - a packaged RWH collection system developed in Australia for use in developing countries
http://www.pastornet.net.au/worldview/ac.htm

SimTanka
http://www.geocities.com/RainForest/Canopy/4805/
software for sizing reliable rainwater harvesting systems with covered storage tanks – SimTanka, is freely available.

JRCSA (Japan Rainwater Catchment Association)
http://takeyam.life.shimane-u.ac.jp/jircsa/homepage.html

SA WATER (South Australian Water Corporation)
http://www.sacentral.sa.gov.au/agencies/saw

Centre for Science and the Environment (CSE)
http://oneworld.org/cse/html/cmp/cmp43.htm -
Rainwater harvesting page - a very active Indian Group

Sunstove
http://www.sungravity.com/index.html
The Sunstove Organization's web site provides free instructions, photos, drawings and specifications to build a roof catchment system, sand filter, cement water tank, and spring capping systems

Global Applied Research Network (GARNET)
http://info.lut.ac.uk/departments/cv/wedc/garnet/tncrain.html
Site of the Global Applied Research Network (GARNET) Rainwater Harvesting Page –

http://www.unep.or.jp/ietc/Publications/TechPublications/TechPub-8d/index.html#1 - link to a recent UNEP publication titled 'Sourcebook of Alternative Technologies for Freshwater Augumentation in Small Island Developing States' that includes some useful information on RWH

http://www.unep.or.jp/ietc/Publications/TechPublications/TechPub-8e/index.html
Sourcebook of Alternative Technologies for Freshwater Augumentation in Some Countries in Asia - another in this series of UNEP publications

World Meteorological Organisation (WMO)
http://www.wmo.ch/

http://www.ufrpe.br/~debarros/APED/RWCpres/index.htm - Rainwater Harvesting in the Loess Plateau of Gansu, China - a paper presented at the 9th IRCSA Conference in Brazil

http://www.greenbuilder.com/sourcebook/Rainwater.html#CSI - Sustainable Building Sourcebook Website

Information Centers
Center for Library and Information Resources (CLAIR)
International Ferrocement Information Center (IFIC)
Asian Institute of Technology (AIT)
P.O. Box 4
Khlong Luang Pathumthani 12120, THAILAND
Tel: (66-2) 529-0900-13; Direct Line: (66-2) 524-5864
Fax: (66-2) 516-2126 or (66-2) 524-5870
E-mail: geoferro@ait.ac.th
Website: http://www.ait.ac.th/clair/centers/ific

WELL
http://www.lboro.ac.uk/well/resources/technical-briefs/36-ferrocement-water-tanks.pdf
A technical brief on how to make a ferrocement water tank

Roofwater harvesting discussion forum
http://www.jiscmail.ac.uk/lists/rwh.html