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1.1 Rainwater harvesting from rooftop catchments

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The application of an appropriate rainwater harvesting technology can make possible the utilization of rainwater as a valuable and, in many cases, necessary water resource. Rainwater harvesting has been practiced for more than 4, 000 years, and, in most developing countries, is becoming essential owing to the temporal and spatial variability of rainfall. Rainwater harvesting is necessary in areas having significant rainfall but lacking any kind of conventional, centralized government supply system, and also in areas where good quality fresh surface water or groundwater is lacking.

Annual rainfall ranging from less than 500 to more than 1 500 mm can be found in most Latin American countries and the Caribbean. Very frequently most of the rain falls during a few months of the year, with little or no precipitation during the remaining months. There are countries in which the annual and regional distribution of rainfall also differ significantly.

For more than three centuries, rooftop catchments and cistern storage have been the basis of domestic water supply on many small islands in the Caribbean. During World War II, several airfields were also turned into catchments. Although the use of rooftop catchment systems has declined in some countries, it is estimated that more than 500 000 people in the Caribbean islands depend at least in part on such supplies. Further, large areas of some countries in Central and South America, such as Honduras, Brazil, and Paraguay, use rainwater harvesting as an important source of water supply for domestic purposes, especially in rural areas.

Technical Description

A rainwater harvesting system consists of three basic elements: a collection area, a conveyance system, and storage facilities. The collection area in most cases is the roof of a house or a building. The effective roof area and the material used in constructing the roof influence the efficiency of collection and the water quality.

A conveyance system usually consists of gutters or pipes that deliver rainwater falling on the rooftop to cisterns or other storage vessels. Both drainpipes and roof surfaces should be constructed of chemically inert materials such as wood, plastic, aluminum, or fiberglass, in order to avoid adverse effects on water quality.

The water ultimately is stored in a storage tank or cistern, which should also be constructed of an inert material. Reinforced concrete, fiberglass, or stainless steel are suitable materials. Storage tanks may be constructed as part of the building, or may be built as a separate unit located some distance away from the building. Figure 1 shows a schematic of a rooftop catchment system in the Dominican Republic.

· All rainwater tank designs (see Figures 2a and 2b) should include as a minimum requirement:

> *- A solid secure cover*
> *- A coarse inlet filter*
> *- An overflow pipe*
> *- A manhole, sump, and drain to facilitate cleaning*
> *- An extraction system that does not contaminate the water; e.g., a tap or pump*
> *- A soakaway to prevent spilled water from forming puddles near the tank*

Additional features might include:

> *- A device to indicate the amount of water in the tank*
> *- A sediment trap, tipping bucket, or other "foul flush" mechanism*
> *- A lock on the tap*
> *- A second sub-surface tank to provide water for livestock, etc.*

· The following questions need to be considered in areas where a rainwater cistern system project is being considered, to establish whether or not rainwater catchment warrants further investigation:

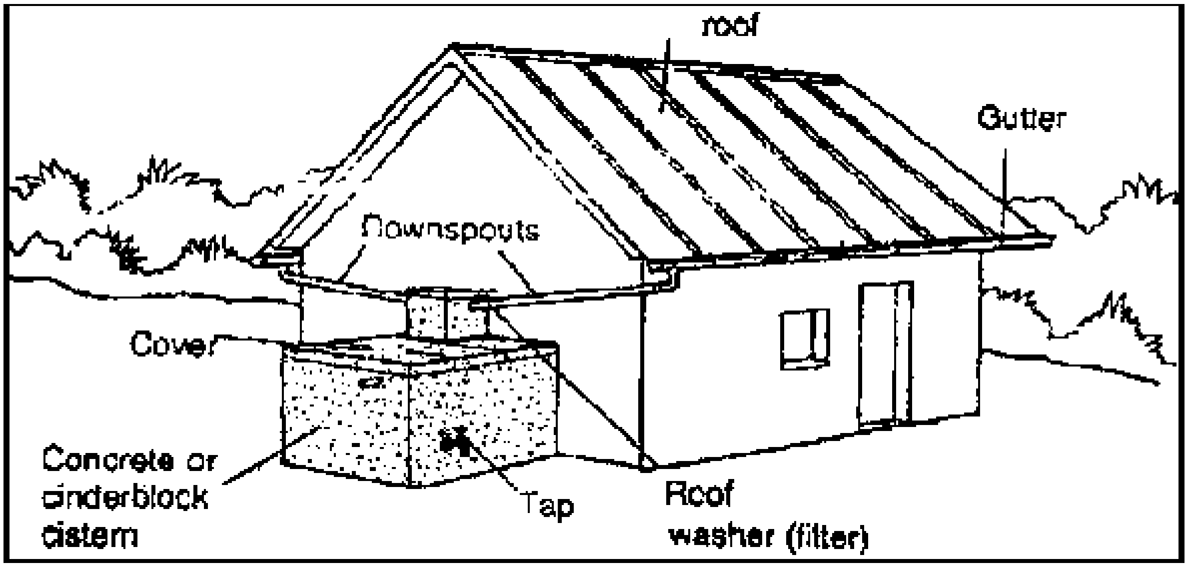
> *- Is there a real need for an improved water supply?*
>
> *- Are present water supplies either distant or contaminated, or both?*
>
> *- Do suitable roofs and/or other catchment surfaces exist in the community?*
>
> *- Does rainfall exceed 400 mm per year?*
>
> *- Does an improved water supply figure prominently in the community's list of development priorities?*

· If the answer to these five questions is yes, it is a clear indication that rainwater collection might be a feasible water supply option. Further questions, however, also need to be considered:

> *- What alternative water sources are available in the community and how do these compare with the rooftop catchment system?*
>
> *- What are the economic, social, and environmental implications of the various water supply alternatives (e.g., how able is the community to pay for water obtained from other sources; what is the potential within the community for income generating activities that can be used to develop alternative water sources; does the project threaten the livelihood of any community members, such as water vendors?)*
>
> *- What efforts have been made, by either the community or an outside agency, to implement an improved water supply system in the past? (Lessons may be learned from the experiences of the previous projects.)*

· All catchment surfaces must be made of nontoxic material. Painted surfaces should be avoided if possible, or, if the use of paint is unavoidable, only nontoxic paint should be used (e.g., no lead-, chromium-, or zinc-based paints). Overhanging vegetation should also be avoided.

Figure 1: Schematic of a Typical Rainwater Catchment System.



> *Source: José Payero, Professor-Researcher, Department of Natural Resources, Higher Institute of Agriculture (ISA), Dominican Republic.*

Extent of Use

Rainwater harvesting is used extensively in Latin America and the Caribbean, mainly for domestic water supply and, in some cases, for agriculture and livestock supplies on a small scale. In Brazil and Argentina, rainwater harvesting is used in semi-arid regions. In Central American countries like Honduras (see case study in Part C, Chapter 5), Costa Rica, Guatemala, and El Salvador, rainwater harvesting using rooftop catchments is used extensively in rural areas.

In Saint Lucia, storage tanks are constructed of a variety of materials, including steel drums (200 l), large polyethylene plastic tanks (1 300 to 2 300 l), and underground concrete cisterns (100 000 to 150 000 l).

The Turks and Caicos Islands have a number of government-built, public rainfall catchment systems. Government regulations make it mandatory that all developers construct a water cistern large enough to store 400 l/m^2 of roof area.

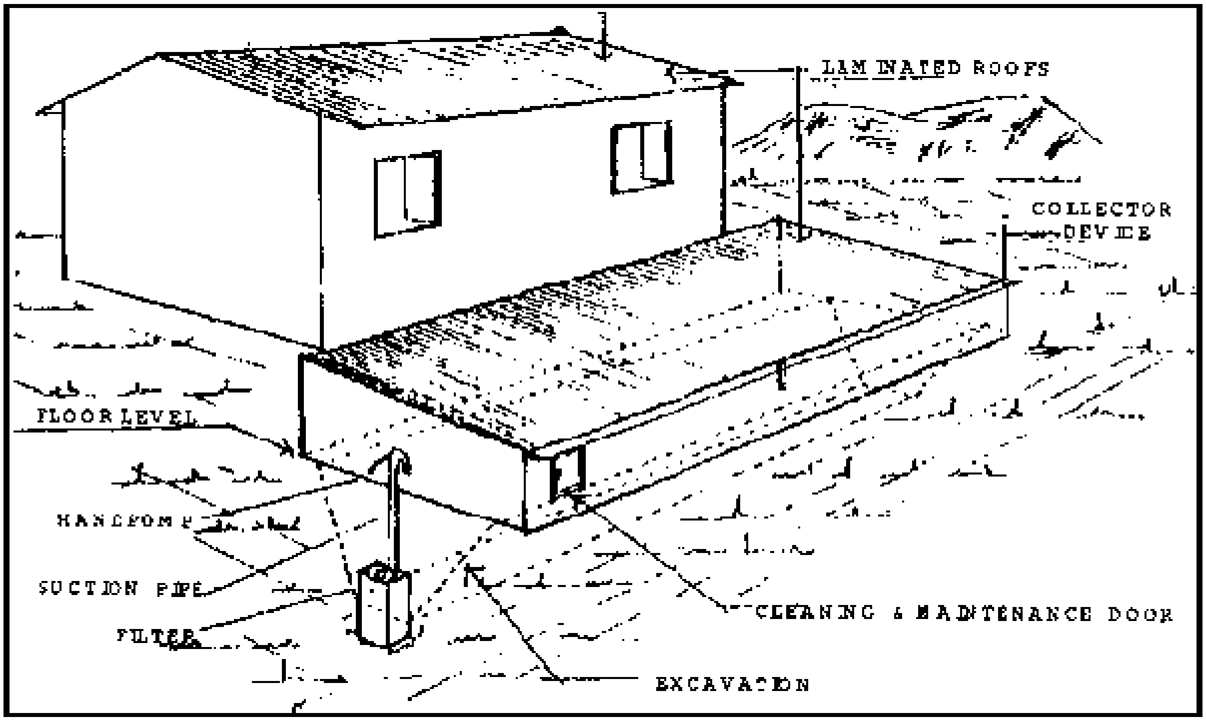
Rooftop and artificially constructed catchments, such as the one at the former United States naval base on Eleuthera, are commonplace in the Bahamas. One settlement (Whale Cay) has a piped distribution system based on water captured from rooftops. On New Providence, most of the older houses collect rainwater from rooftops and store it in cisterns with average capacities of 70 000 l. Industries also use rooftop rainwater, and a preliminary assessment has been made of using Nassau International Airport as a catchment. In multistoried apartment buildings and other areas serving large concentrations of people (such as hotels and restaurants), water supplies are supplemented by water from rooftop catchment cisterns.

The Islas de la Bahía off the shores of Honduras meet a substantial portion of their potable water needs using rainwater from rooftop catchments. Similarly, rooftop catchments and cistern storage provide a significant water supply source for a small group of islands off the northern coast of Venezuela.

In a recent rural water-supply study, the continued use of rooftop and artificially constructed catchments was contemplated for those parts of rural Jamaica lacking access to river, spring, or well water sources. It is thought that more than 100 000 Jamaicans depend to a major extent on rainwater catchments.

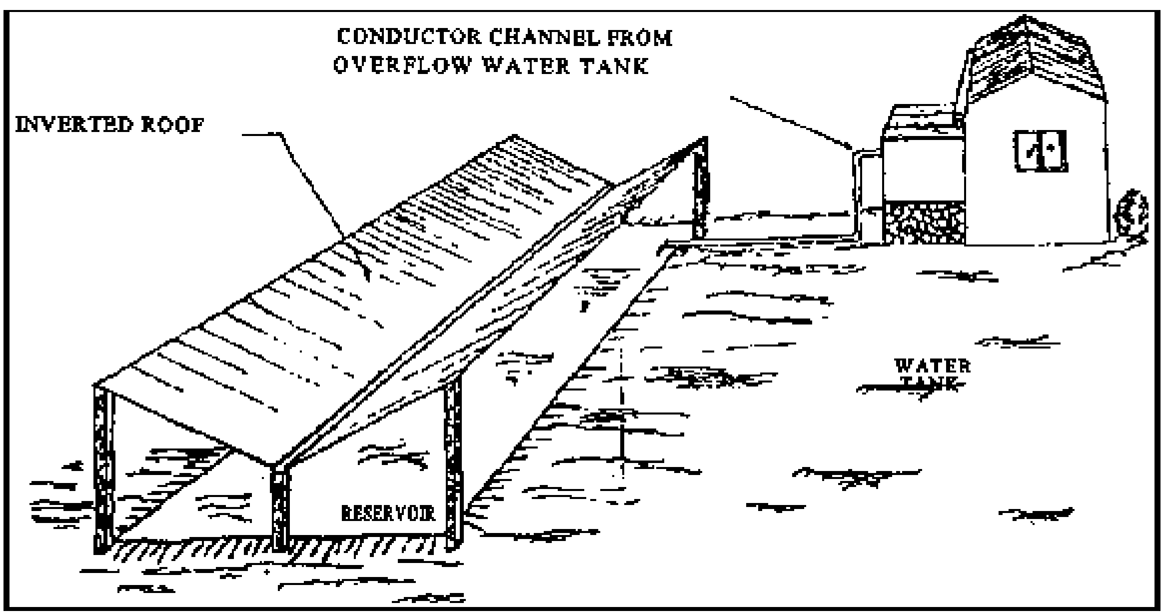
Operation and Maintenance

Figure 2A: Schematic of a Cistern



> *Source: Walter Santos, Center for Training in Agricultural Development, Bureau of Water Resources, Comayagua, Honduras.*

Figure 2B: Schematic of a Storage Tank Reservoir



> *Source: Walter Santos, Center for Training in Agricultural Development, Bureau of Water Resources, Comayagua, Honduras.*

Rainwater harvesting systems require few skills and little supervision to operate. Major concerns are the prevention of contamination of the tank during construction and while it is being replenished during a rainfall. Contamination of the water supply as a result of contact with certain materials can be avoided by the use of proper materials during construction of the system. For example, in Montserrat, where 95% of the houses in the medium to high density areas are roofed with oil-based bitumen shingles, consumers are strongly discouraged from using this source of supply for drinking purposes. Use of alternative roofing materials would have avoided this problem. The main sources of external contamination are pollution from the air, bird and animal droppings, and insects. Bacterial contamination may be minimized by keeping roof surfaces and drains clean but cannot be completely eliminated. If the water is to be used for drinking purposes, filtration and chlorination or disinfection by other means (e.g., boiling) is necessary. The following maintenance guidelines should be considered in the operation of rainwater harvesting systems:

> *· A procedure for eliminating the "foul flush" after a long dry spell deserves particular attention. The first part of each rainfall should be diverted from the storage tank since this is most likely to contain undesirable materials which have accumulated on the roof and other surfaces between rainfalls. Generally, water captured during the first 10 minutes of rainfall during an event of average intensity is unfit for drinking purposes. The quantity of water lost by diverting this runoff is usually about 14l/m^2 of catchment area.*
>
> *· The storage tank should be checked and cleaned periodically. All tanks need cleaning; their designs should allow for this. Cleaning procedures consist of thorough scrubbing of the inner walls and floors. Use of a chlorine solution is recommended for cleaning, followed by thorough rinsing.*
>
> *· Care should be taken to keep rainfall collection surfaces covered, to reduce the likelihood of frogs, lizards, mosquitoes, and other pests using the cistern as a breeding ground. Residents may prefer to take care to prevent such problems rather than have to take corrective actions, such as treating or removing water, at a later time.*
>
> *· Chlorination of the cisterns or storage tanks is necessary if the water is to be used for drinking and domestic uses. The Montserrat Island Water Authority constructed a non-conventional chlorination device with a rubber tube, plywood, a 1.2 m piece of PVC tubing, and a hose clip to chlorinate the water using chlorine tablets.*
>
> *· Gutters and downpipes need to be periodically inspected and cleaned carefully. Periodic maintenance must also be carried out on any pumps used to lift water to selected areas in the house or building. More often than not, maintenance is done only when equipment breaks down.*
>
> *· Community systems require the creation of a community organization to maintain them effectively. Similarly, households must establish a maintenance routine that will be carried out by family members.*

As has been noted, in some cases the rainwater is treated with chlorine tablets. However, in most places it is used without treatment. In such cases, residents are advised to boil the water before drinking. Where cistern users do not treat their water, the quality of the water may be assured through the installation of commercially available in-line charcoal filters or other water treatment devices. Community catchments require additional protections, including:

> *· Fencing of the paved catchment to prevent the entry of animals, primarily livestock such as goats, cows, donkeys, and pigs, that can affect water quality.*
>
> *· Cleaning the paved catchment of leaves and other vegetative matter.*
>
> *· Repairing large cracks in the paved catchment as a result of soil movement, earthquakes, or exposure to the elements.*
>
> *· Maintaining water quality at a level where health risks are minimized. In many systems, this involves chlorination of the supplies at frequent intervals.*

Problems usually encountered in maintaining the system at an efficient level include the lack of availability of chemicals required for appropriate treatment and the lack of adequate funding.

Level of Involvement

The level of governmental participation varies in the countries of Latin America and the Caribbean. In some Caribbean islands, governments regulate the design of rainwater harvesting systems. In the U.S. Virgin Islands, the law requires that provision be made in the construction of all new buildings for the capture and storage of rainfall coming into contact with their roofs. The law requires that roofs be guttered and that cisterns be constructed having a volume that depends on the size of the roof, the intended use of the structure, and the number of floors. For a typical single-level, residential building, the law requires that 400 1 of storage be provided for each m^2 of roof area. Cistern construction is further regulated by the Virgin Islands Building Code to insure the structural integrity of these cisterns, which usually form an integral part of building foundations. As of January 1, 1996, all new residences in Barbados are required to construct water storage facilities if the roof area or living area equals or exceeds 3 000 square feet. They will also be mandatory for all new commercial buildings with a roof area of 1 000 square feet or more. A rebate of $0.50 per gallon of installed tank capacity, up to the equivalent of 25% of the total roof area, will be given as an incentive by the Barbados Water Authority.

Cisterns are likely to continue to be a principal source of water for residences in several Caribbean islands. Even if mandatory requirements are removed, their use will remain widespread, as they provide a water supply that residents consider to be safe, sufficient, and inexpensive.

Costs

The cost of this technology varies considerably depending on location, type of materials used, and degree of implementation. In Brazil, the cost of a 30m^3 cistern in rural areas of the Northeast is around $900 to $1 000, depending on the material used. In the U.S. Virgin Islands, costs as low as $2 to $5/1 000 1 are reported. Construction costs for underground cisterns can vary tremendously, based on the size and the amount of excavation required. In Saint Lucia, the average cost of a 1, 5001 plastic tank is $125.

In the Chaco region of Paraguay, two different types of cisterns have been used for rainwater harvesting: cisterns or storage tanks called *aljibes,* and cutwater cisterns called *tajamares.* The capital cost of a 30 m^3 cistern *(aljibe)* in Paraguay has been reported to be $2 000, while the construction of a 6 000 m^3 *tajamar,* including windmill-driven pumps and distribution piping, has been estimated at $8 400.

Effectiveness of the Technology

Rainfall harvesting technology has proved to be very effective throughout several Latin American countries and most of the Caribbean islands, where cisterns are the principal source of water for residences. Cisterns are capable of providing a sufficient supply for most domestic applications. The use of rainwater is very effective in lessening the demand on the public water supply system in the British Virgin Islands. It also provides a convenient buffer in times of emergency or shortfall in the public water supply. Also, because of the hilly or mountainous nature of the terrain in the majority of the British Virgin Islands, combined with dispersed housing patterns, rainfall harvesting appears to be the most practical way of providing a water supply to some residents. In many countries it is very costly, and in some cases not economically feasible, to extend the public water supply to all areas, where houses are isolated from one another or in mountainous areas.

Steep galvanized iron roofs have been found to be relatively efficient rainwater collectors, while flat concrete roofs, though highly valued as protection from hurricanes, are very inefficient. Rooftop catchment efficiencies range from 70% to 90%. It has been estimated that 1 cm of rain on 100 m^2 of roof yields 10 0001. More commonly, rooftop catchment yield is estimated to be 75% of actual rainfall on the catchment area, after accounting for losses due to evaporation during periods when short, light showers are interspersed with periods of prolonged sunshine. Likewise, at the other extreme, the roof gutters and downpipes generally cannot cope with rainfalls of high intensity, and excess water runs off the roof to waste during these periods.

Suitability

This technology is suitable for use in all areas as a means of augmenting the amount of water available. It is most useful in arid and semi-arid areas where other sources of water are scarce.

Advantages

> *· Rainwater harvesting provides a source of water at the point where it is needed. It is owner operated and managed.*
>
> *· It provides an essential reserve in times of emergency and/or breakdown of public water supply systems, particularly during natural disasters.*
>
> *· The construction of a rooftop rainwater catchment system is simple, and local people can easily be trained to build one, minimizing its cost.*
>
> *· The technology is flexible. The systems can be built to meet almost any requirements. Poor households can start with a single small tank and add more when they can afford them.*
>
> *· It can improve the engineering of building foundations when cisterns are built as part of the substructure of the buildings, as in the case of mandatory cisterns.*
>
> *· The physical and chemical properties of rainwater may be superior to those of groundwater or surface waters that may have been subjected to pollution, sometimes from unknown sources.*
>
> *· Running costs are low.*
>
> *· Construction, operation, and maintenance are not labor-intensive.*

Disadvantages

> *· The success of rainfall harvesting depends upon the frequency and amount of rainfall; therefore, it is not a dependable water source in times of dry weather or prolonged drought.*
>
> *· Low storage capacities will limit rainwater harvesting so that the system may not be able to provide water in a low rainfall period. Increased storage capacities add to construction and operating costs and may make the technology economically unfeasible, unless it is subsidized by government.*
>
> *· Leakage from cisterns can cause the deterioration of load bearing slopes.*
>
> *· Cisterns and storage tanks can be unsafe for small children if proper access protection is not provided.*
>
> *· Possible contamination of water may result from animal wastes and vegetable matter.*
>
> *· Where treatment of the water prior to potable use is infrequent, due to a lack of adequate resources or knowledge, health risks may result; further, cisterns can be a breeding ground for mosquitoes.*
>
> *· Rainfall harvesting systems increase construction costs and may have an adverse effect on home ownership. Systems may add 30% to 40% to the cost of a building.*
>
> *· Rainfall harvesting systems may reduce revenues to public utilities.*

Cultural Acceptability

In Latin America and the Caribbean, it has been found that projects which involved the local community from the outset in the planning, implementation, and maintenance have the best chance of enduring and expanding. Those projects which have been predominantly run by local people have had a much higher rate of success than those operated by people foreign to an area, and those to which the community has contributed ideas, funds, and labor have had a greater rate of success than those externally planned, funded, and built. Successful rainwater harvesting projects are generally associated with communities that consider water supply a priority.

In the Caribbean, attitudes toward the use of rainwater for domestic consumption differ. Some people, who depend on rainwater as their only source of supply, use it for all household purposes, from drinking and cooking to washing and other domestic uses. Other people, who have access to both rainwater and a public water supply, use rainwater selectively, for drinking or gardening or flushing toilets, and use the public water supply for other purposes. These varying attitudes are related to the level of education of the users as well as to their traditional preferences. Different sectors of the society need to be informed about the advantages of harvesting rainwater and the related safety aspects of its use, including the threat of mosquito problems and other public health concerns.

Further Development of the Technology

There is a need for the water quality aspects of rainwater harvesting to be better addressed. This might come about through:

> *· Development of first-flush bypass devices that are more effective and easier to maintain and operate than those currently available.*
>
> *· Greater involvement of the public health department in the monitoring of water quality.*
>
> *· Monitoring the quality of construction at the time of building. Other development needs include:*
>
> *· Provision of assistance from governmental sources to ensure that the appropriate-sized cisterns are built.*
>
> *· Promotion of rainwater harvesting as an alternative to both government- and private-sector-supplied water, with emphasis on the savings to be achieved on water bills.*
>
> *· Provision of assistance to the public in sizing, locating, and selecting materials and constructing cisterns and storage tanks, and development of a standardized plumbing and monitoring code.*
>
> *· Development of new materials to lower the cost of storage.*
>
> *· Preparation of guidance materials (including sizing requirements) for inclusion of rainwater harvesting in a multi-sourced water resources management environment.*

Information Sources

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