RAINWATER HARVESTING SYSTEMS FOR SMALLHOLDER PRODUCERS

A guide for designing and selecting rainwater harvesting technologies.

Developed by Tanzania Organic Agriculture Movement (TOAM).

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INTRODUCTION

What is Rainwater Harvesting?

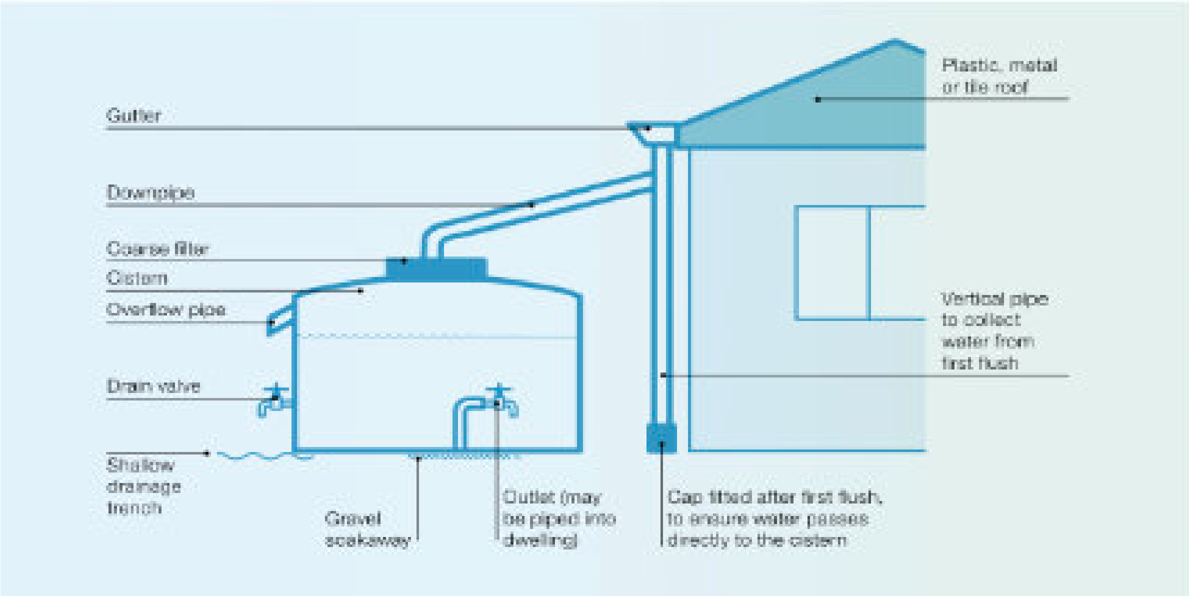
Is defined by Wikipedia as “the accumulation and deposition of rainwater for reuse on-site, rather than allowing it to run off.”

However, it can also be simply defined as the collection of rainwater from a surface that allows for the rainwater to be stored and used at a later time. In a typical rainwater harvesting situation, rainwater is collected from an impervious surface such as the roof of a building, land surfaces and others then stored inside of a tank or cistern.

The rainwater harvested is mostly clean and suitable for drinking and domestic use after treatment, and can be used directly for crop irrigation, livestock and poultry, and post harvest activities that add value to crops and energy production.

Water harvesting has been widely applied in different socio-ecological contexts and has proven to be a valuable approach for sustainable intensification of agriculture; the literature indicates that water harvesting in cultivated areas can significantly boost agricultural production.

This guideline is intended to raise awareness on the existing harvesting systems and provide tips on designing water harvesting systems.



A typical water harvesting system, contain four main components:

1. **Collection / catchment area:** This is the section where rain, directly or in the form of run-off, is harvested for example cultivated or uncultivated land, hillsides, impermeable sheets, rooftops, courtyards and paved roads.

2. **Conveying system:** This is the section where run-off is conveyed through channels or pipes (e.g. in the case of rooftop water harvesting) and either diverted to storage structures, or near cultivated fields or to target users (houses, industry, etc.) or infiltrated into groundwater through pits or trenches.

3. **Storage system:** This is the section where the harvested water is stored in the soil profile as soil moisture, as groundwater in aquifers or in specifically designed storage facilities such as ponds, reservoirs, tanks, cisterns and barrels.

4. **Distribution system:** This is the section where the harvested water is used for domestic purposes consumption by livestock, fish farming, agriculture (including supplemental irrigation), industry, ecosystem conservation, etc.

Note: In each of these parts, there are a variety of methods, materials, and technical issues that can allow the system to be individualized for the particular site.

What are the designing factors to consider before setting up a water harvesting system?

In terms of system design, these systems can be implemented without much thought or they can employ feasibility studies that take into account many different factors for the site. Usually what guides the kind of water harvesting system to be installed is the purpose of the harvested water.

If you want to harvest rainwater just to use it for your garden/farm plants, then a simple rain barrel will work for this situation. However, for the efficient water harvesting system for wider use, may required you to install a bit complex system by taking into account the following steps:

1. Amount of water needed:

As a first step, it is essential to identify the need that water harvesting could fill. This entails estimating the needed volume per period, type of use and the required quality, while also accounting for dry and rainy seasons, as this will help assess the amount of water that needs to be harvested and the type of storage. It is also important to take into account the current and future water demand.

Box 1: Example of a water demand estimate for a small family farm

Knowing that water requirements vary widely with climate, breed of livestock, type of soil, type of crops and many other factors, an example of the water requirements of a small family farm in an arid climate is presented here. Water demand for livestock and small animals also varies widely, depending on feed intake, type and quality of the feed and increases with growth and increasing production processes such as milking, spawning and other factors. Our small family farm has six members and therefore has an estimated AQ based on the MQHH assumption of 14,600 liters (AQ = (10 + 6 people x 5 litres) x 365 days =14,600 litres/year).

The family cultivates a 12 m2 vegetable garden in a mulch basin, which has an estimated water demand of 31,000 litres/year (see FAO CROPWAT 8.0). Other crops and fodders are cultivated in a rain-fed system. We can also estimate the water demand for livestock and poultry at 5 litres/day per sheep, 27 litres/day per cow, 4 litres/day per 10 chickens and 16 litres/day per donkey (see FAO. 2019. Water use in livestock production systems and supply chains. Guidelines for assessment),which comes to 41,619 litres/year if the property has 8 sheep, 2 cows, 10 chickens and a donkey. Our example of a family farm will therefore need 87,219 litres/year of good-quality water. The project design should now assess the annual availability of water for different needs and plan to fill the gap through water harvesting.

2. Amount of water that can be harvested

In this second step, you have to calculate the amount of water that can be harvested for that particular year cumulatively. Consider the current climate and predicted climate change scenarios in the region and locally, if available. Climate change has direct implications for temperature and the amount and timing of precipitation; hence, the design of the water harvesting components. Also is important to consider the water loss factors such as evaporations, infiltration etc, such that the estimations made are relevant.

3. Maintaining the required water quality

Required water quality depends on its intended use: high-quality drinking water is needed for human consumption, while the quality of water for other uses such as domestic use, livestock and inland fisheries, horticulture and crop irrigation and different industrial processes does not have to meet these standards and can often be used without further treatment.

For domestic use, closed storage, such as cisterns, is recommended. For agricultural purposes, which normally require larger volumes and lower quality standards than domestic use, open storage, such as ponds or reservoirs, is more cost-effective. The least expensive storage means is infiltration into the soil in the form of soil moisture or possibly in the form of groundwater recharge if volumes, topography and geology are adequate. The type, size, location, available space and material of the storage structure should be planned along with the water harvesting system. Regular maintenance should be considered beforehand in terms of labour and material costs – e.g. for cleaning ponds and repairing and replacing plastic liners or pumping systems.

Harvested rainwater does not always meet drinking water standards, especially in terms of bacteriological values. However, this does not necessarily imply that the water is harmful to drink; this becomes more obvious when its quality is compared with that of the most unprotected traditional drinking water supply

4. Selection of a suitable water harvesting technique

When designing a suitable water harvesting system, the most essential starting point is to consider the needs and socio-economic conditions of key stakeholders in the project area, as well as the natural conditions of the surrounding watershed. When poor scattered rural households are targeted, water harvesting measures, such as roof water harvesting or microcatchment water harvesting, should be preferred. If entire villages or producer organizations are targeted, more onerous macrocatchment water harvesting works or road water harvesting may be more convenient.

TABLE 1: Overview of intended water use and recommended water harvesting technique

	Water use	Water harvesting technique
Domestic	Human consumption (drinking, cooking, personal hygiene)	Roof water harvesting
	Other domestic uses	Roof water harvesting or water harvested from other impermeable surfaces (e.g. rocks)
Livestock	Drinking water & cleaning	Roof water harvesting; macrocatchment water harvesting, especially from impermeable surfaces
Cropping	Vegetables and garden	Water harvesting from roof, yard or other impermeable surfaces, Microcatchment water harvesting, macrocatchment water harvesting, fog water harvesting
	Crop irrigation	Microcatchment water harvesting, macrocatchment water harvesting, road water harvesting

5. Costs estimates for water harvesting system

The economic analyses of the costs of alternative water supply, in comparison with the costs of the current water available to the community, including costs in the form of women’s time, labour and poor health due to water collection, need to be done to select the suitable technology to be implemented (UN Water, 2020).

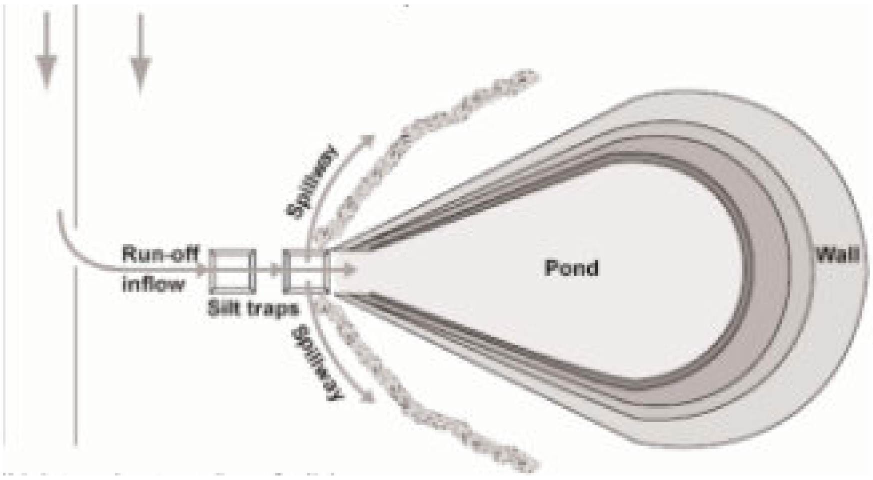
The Costs are very country- and site-specific and are highly dependent on the components of the water harvesting system and the material and labour used.

For learning purposes, this document will explain the steps towards establishing a water pan for rainwater harvesting in the next section.

WATER PANS.

What is a water pan?

It is a hole or pond dug in the ground, used to collect and store surface runoff from uncultivated grounds, roads or laggas. It can be square, rectangular or round. Construction of a water pan needs a flat and level location that is easily accessible to the farm and animals.



How much water can a water pan hold?

The capacity is variable and depends on site conditions and how much one wants to invest. Common ones are 400 to 1,000m 3. By changing the shape of the pan, a water pan capacity can be increased with time to hold more water.

How to choose where to make a water pan?

- Consider soil texture of the place: Clay soil tends to retain water, avoid areas with sand soils.
- A natural depression or small valley so you don't have to dig too deep.
- A road or lagga (dry streambed of a river that flows only in the rainy season) nearby to act as a source of runoff water.
- The area from which water flows into the water pan should be covered in trees or shrubs, so that the water collected is not full of soil

How do you build a water pan?

Step 1: Site the water pan and mark the embankment, inlet and spillway.

Step 2: Excavate the reservoir section and use the soil to build the embankment wall, with side slopes of 1:2.5 for shallow pans to 1:3 for deep pans. To minimize water losses, compact the embankment wall by rolling with drums filled with water or with roller machinery. Line the beds and walls of the water pan with clay soil. On soils that are not water-tight, line the pan with a polythene sheet.

Step 3: Construct spillway to discharge excess runoff water when the pan is full.

Step 4: Construct silt trap(s) along the inlet channel to filter excess sediment load.

Step 5: Close off the water pan with live fence to keep livestock out

Step 6: Provide livestock watering trough outside the fenced area.

Note: In order to minimize water loss in a pan, it is recommended to plant trees/cuttings such as commiphora around the edges of the pan. Plant shrubs and grasses on the embankment wall while placing the stones on the walls to stabilize the walls of the pan.

PLASTIC LINED UNDERGROUND

Tanks, ponds, dams and reservoirs all need to be lined to stop water from seeping out. If the water stored does not leak away, there will be more available for use in the home and on the farm. Materials used for lining include clay, rubber, plastic, bricks, stones, concrete etc

Design of the tank shape depends on the soil type, which dictates the maximum possible slope that will stay in place without falling in. For easy roofing, the tank should be rectangular, long and narrow.

How do you built it?

- Excavate the tank site to required shape and depth. Provide for water inlet and outlet (in case of over-flow)
- Smooth the walls and floors of the tank to ensure that the lining walls and floors to ensure that the plastic lining will not be damaged. You could plaster with mortar or soil/cement mixture to make it smooth.
- Order enough lining material from the manufacturer so that some sticks out at the top for use in anchoring down the lining.
- Place the lining in the tank after ensuring that there are no stones or sharp objects. Anchor lining edges to ensure that the lining lies smoothly on the walls of pit and is firmly held. Make sure that the plastic lining fits the pond loosely so it doesn't break when it is anchored.
- Cover the top of the tank using any roofing materials to minimize loss of water by evaporation and protect the plastic from the sun. Build in a manhole to help with maintenance. Make sure manhole is closed or fence off the whole area as a safety measure

How do you maintain a plastic-lined underground tank?

Regularly inspect inlets, channel and collecting area. Clean the silt traps and sieve. Periodically clean tank and remove any accumulated silt. Clean with great care to make sure that the plastic is not cut/pricked. Don't use rough tools or equipment to clean. After cleaning, check the pond for perforations and have them repaired.

Plastic lining anchored with brick wall:

Plastic lining anchored with sand-bags

Advantages of rainwater harvesting

Rainwater harvesting in urban and rural areas offers several benefits including provision of supplemental water, increasing soil moisture levels for urban greenery, increasing the groundwater table via artificial recharge, mitigating urban flooding and improving the quality of groundwater.

The major benefits of rainwater harvesting are summarized below:

- Rainwater is a relatively clean and free source of water.
- Rainwater harvesting provides a source of water at the point where it is needed
- It is owner-operated and managed
- It is socially acceptable and environmentally responsible.
- It reduces stormwater runoff and non-point source pollution
- It uses simple, flexible technologies that are easy to maintain and cost effective.