TVET CERTIFICATE III in PLUMBING

RAIN WATER HAVERSTING

Code: CSTRH301 Perform rain water harvesting

Competence

RTQF Level 3

Credits: 7

Learning hours: 70

Sector: Construction

Sub-sector: Domestic Plumbing

Module Note Issue date: June, 2020

Purpose statement

This module describes knowledge and skills required to perform rain water harvesting. It describes the skills, knowledge and attitudes required for the trainee to connect pipes/eave gutter and distribute water.

Table of Contents

Total Number of Pages: 34

Learning Unit 1 – Connect pipes/eave gutter

1. Introduction to rain water harvesting

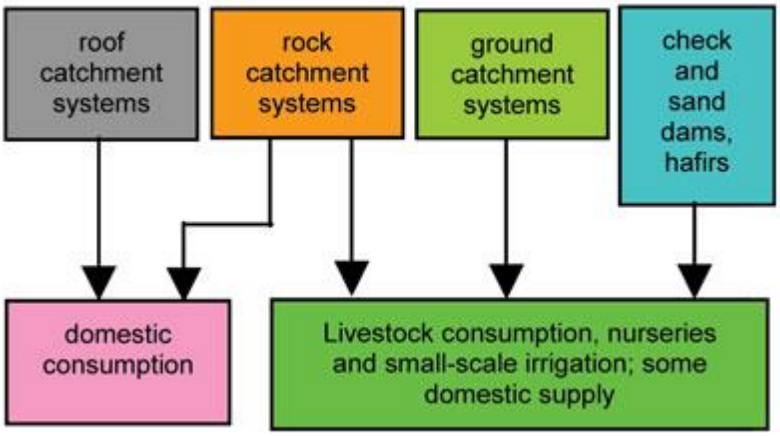
Water is the most essential compound required to the life of animals and plants in order to survive. If there is no water, there is no life. Apart from that, water may be used in different purposes such as irrigation, cooking, washing, cleaning and drinking.

All around the world, there are issues of insufficient water supply but there is rainwater which is not well explored. Rainwater harvesting is an option that has been adopted in many areas of the world where conventional water supply systems have failed to meet people needs like Uganda collecting rainwater from trees, using banana leaves as temporary gutters.

In many African countries this is often as simple as placing a small container under the eaves of the roof to collect falling water during a storm. One 20 litters container of clean water captured from the roof can save a walk of many kilometres, in some cases, to the nearest clean water source. In the industrialized countries of the world, sophisticated rainwater harvesting systems (RWHS) have been developed with the aim of reducing water bills or to meet the needs of remote communities or individual households in arid regions.

The practice of collecting rainwater from rainfall events can be classified into two broad categories: **land-based and roof-based**. Land-based rainwater harvesting occurs when runoff from land surfaces is collected in furrow dikes, ponds, tanks and reservoirs. Roof-based rainwater harvesting refers to collecting rainwater runoff from roof surfaces which usually provides a much cleaner source of water that can be also used for drinking.

Small-scale rainwater harvesting systems and uses



What is Rainwater harvesting?

Rainwater harvesting is the simple process or technology used to conserve Rainwater by collecting, storing, conveying and purifying of Rainwater that runs off from rooftops, parks, roads, open grounds, etc. for later use.

Why rainwater harvesting?

In many regions of the world, clean drinking water is not always available and this is only possible with tremendous investment costs and expenditure. Rainwater is a free source and relatively clean and with proper treatment it can be even used as a potable water source. Rainwater harvesting saves high-quality drinking water sources and relieves the pressure on sewers and the environment by mitigating floods, soil erosions and replenishing groundwater levels. In addition, rainwater harvesting reduces the potable water consumption and consequently, the volume of generated wastewater

Advantages (benefits) of Rainwater Harvesting

The benefits of rainwater harvesting system are listed below.

I. Less cost to install
II. Helps in reducing the water bill
III. Decreases the demand for water.
IV. Rainwater is a relatively clean and free source of water
V. Rainwater harvesting provides a source of water at the point where it is needed

VI. I t is owner-operated and managed

VII. it is socially acceptable and environmentally responsible

VIII. it promotes self-sufficiency and conserves water resources

IX. Rainwater is friendly to landscape plants and gardens

X. It reduces storm water runoff and non-point source pollution

XI. It uses simple, flexible technologies that are easy to maintain

XII. Improves the quality and quantity of groundwater.

XIII. Does not require a filtration system for landscape irrigation.

XIV. provides safe water for human consumption after proper treatment

XV. This technology is relatively simple, easy to install and operate.

XVI. It reduces soil erosion, storm water runoff, flooding, and pollution of surface water with fertilizers, pesticides, metals and other sediments.

XVII. It is an excellent source of water for landscape irrigation with no chemicals and dissolved salts and free from all minerals.

Disadvantages of Rainwater Harvesting

In addition to the great advantages, the rainwater harvesting system has few disadvantages like unpredictable rainfall, unavailability of the proper storage system, etc.

Listed below are few more disadvantages of the rainwater harvesting process.

1. Regular Maintenance is required.

2. Requires some technical skills for installation.

3. Limited and no rainfall can limit the supply of Rainwater.

4. If not installed correctly, it may attract mosquitoes and other waterborne diseases.

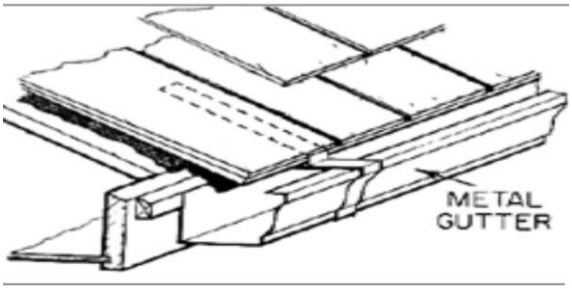
5. One of the significant drawbacks of the rainwater harvesting system is storage limits.

As mentioned above, conveying rainwater is one the processes RWH that why pipes and gutters are more useful in this system.

LO 1.1 – Install eave gutters.

- Content/Topic 1 : Installation of eave gutters

Eave gutter is a shallow channel of metal or wood set immediately below and along the eaves of a building to catch and carry off rainwater from the roof



1. Materials and tools required to install eave gutter

1. Gutters: channel fixed along the edge of roof to receive rain water to the downspouts

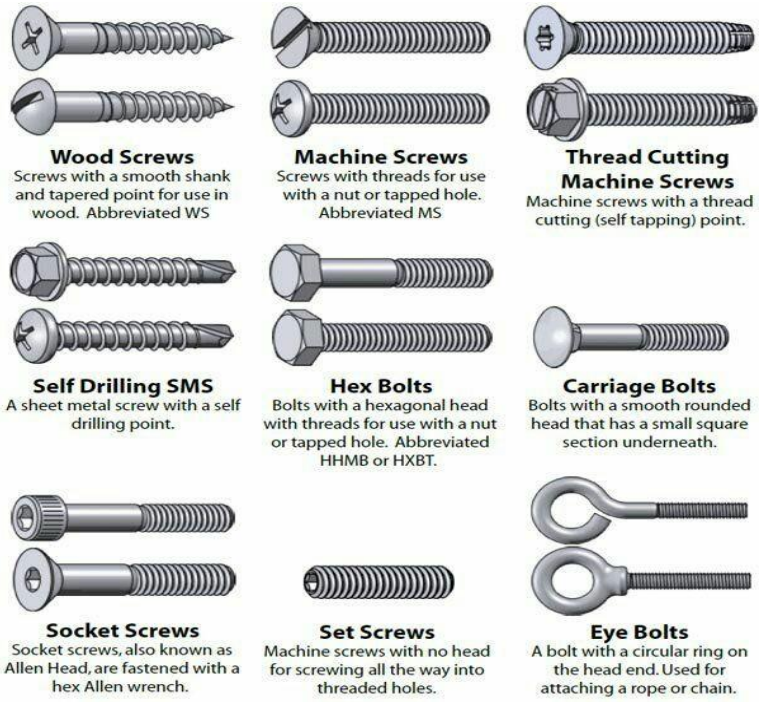
2. Clips and screws : Large Corr-a-Clip Shelf Support The first bracket piece is inserted through the side wall and then the shelf wraps around the second piece and simply slides

3. Welding plant: electrical portable tool used to connect (weld) two pieces of gutter

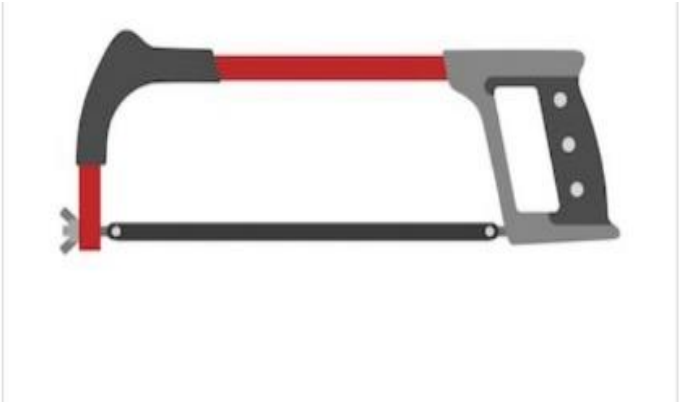
4. Brackets: Gutter hangers are essential in attaching your gutters to your roof. They're basically responsible for providing stability, support and protection for the entire gutter system. Without these hangers, your gutter system won't be able to function properly, making your roof and your home vulnerable to water damage.

5. Screw drivers: tool used to drive screw into the wall

6. Screw and bolts: materials used to fix brackets into the wall in order to increase the stability of gutter



7. Hack saws: needed to cut metals



8. Hammers: hammer is a tool consisting of a weighted "head" fixed to a long handle that is swung to deliver an impact to a small area of an object. This can be, for example, to drive nails into wood, to shape metal, or to crush rock. Hammers are used for a wide range of driving, shaping, and breaking applications

9. Tape measures: used to measure length (distance) of gutter needed

10. Spirit level is a device for determining true horizontal or vertical directions by the centering of a bubble in a slightly curved glass tube or tubes filled with alcohol or ether.

Why do they call it a spirit level?

A Spirit Level is a tool used to indicate how parallel (level) or perpendicular (plumb) a surface is relative to the earth. A spirit level gets its name from the mineral spirit solution inside the levels.

11. Scribers or pens: used to mark where to cut or where to fix bracket

2. Processes of installing eave gutter

I. First analyze the direction of rain water by checking gradient of gutters
II. Measuring lengths of gutters
III. Estimating materials required
IV. Fixing gutter box
V. Fixing the outlet piece pipe
VI. Fixing brackets or welding gutters

3. Proper installation of eave gutter

As gutter used to collect and drain water from the rooftop of building, gutter must fulfil these below:

1. Should have little slope to direct water to the down pipes

2. Should be water tight (no leakage)
3. Should be held by brackets to the rooftop
4. Should have down pipe to serve

4. Guttering design

Many gutters are formed in rectangular shape

- Flow capacity (Q) = $100*A*R^{0.66}*S^{0.5}$
- Gutter slope vary between 1 % - 2 %
- Area = length x width
- R = $\frac{Area\ of\ rectangle}{Perimeter\ of\ rectanle}$

5. Components of a rooftop rainwater harvesting system

Rainwater harvesting systems generally consist of six basic elements:

1. A collection (catchment) area: Used to collect and store the captured Rainwater.

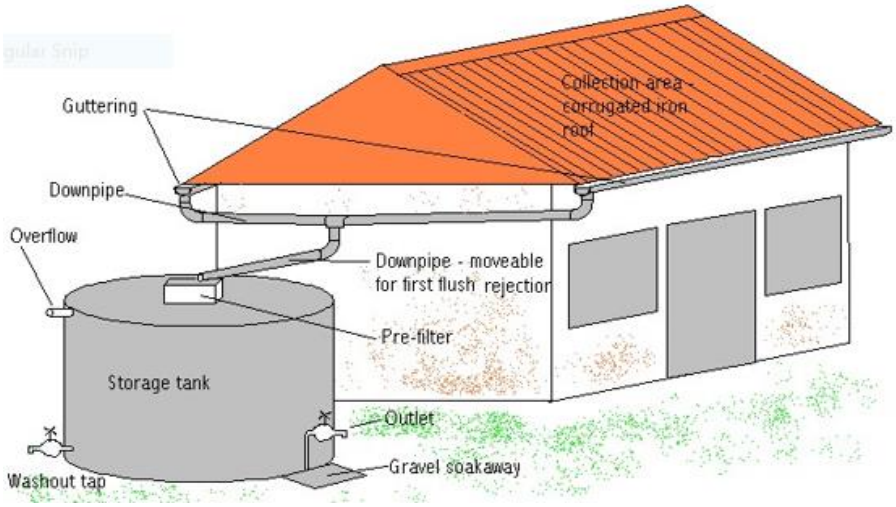
2. A conveyance system consisting of pipes and gutters: It is used to transport the harvested water from the catchment to the recharge zone.

3. Flush- It is used to flush out the first spell of rain.

4. Filter – Used for filtering the collected Rainwater and remove pollutants.

5. A storage facility: Used to store the filtered water which is ready to use.

6. A delivery system consisting of a tap or pump.

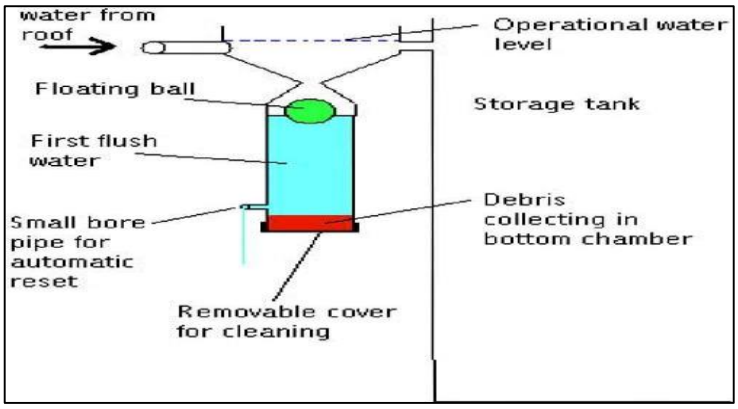


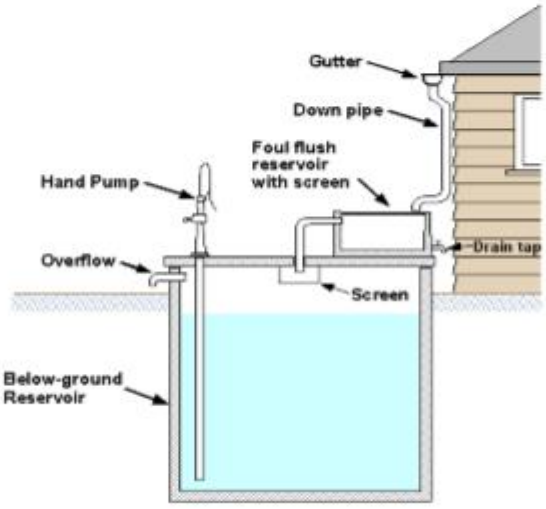
- *Content/Topic 2 : First flush and filter screens*

1. First flush and filter screens

The first rain drains the dust, bird droppings, leaves, etc. which are found on the roof surface. To prevent these pollutants from entering the storage tank, the first rainwater containing the debris should be diverted or flushed. Automatic devices that prevent the first 20-25 liters of runoff from being collected in the storage tank are recommended.

Screens to retain larger debris such as leaves can be installed in the down-pipe or at the tank inlet. The same applies to the collection of rain runoff from a hard ground surface. In this case, simple gravel-sand filters can be installed at the entrance of the storage tank to filter the first rain.





ig. 2: A schematic diagram of a rooftop rainwater harvesting system.

Estimation of amount of water harvested on catchment area.

To estimate of amount of water available, you have to determine the total catchment area and total annual rainfall. These determine the potential value for rain water harvesting.

Calculating potential rainwater supply by estimating run-off.

The amount of available rain water depends on **the amount of rainfall**, **the area of catchment** and **its run-off coefficient according to the type of roof material**.

The annual run-off from a given catchment can be obtained by using the following equation:

$Q=R * A * C$

Q: Rain water supply (m^3)

R: Average annual rainfall (mm)

A: Catchment area (m^2)

C: Run-off coefficient

2. Runoff Coefficients for Various Catchment Surfaces "C"

Types of catchment	Coefficients
Roof Catchments	
Tiles	0.8-0.9
Corrugated metal sheets	0.7-0.9
Ground Surface Coverings	
Concrete	0.6 - 0.8
Brick pavement	0.5 - 0.6
Untreated Ground Catchments	
Soil on slopes less than 10 per cent	0.0 - 0.3
Rocky natural catchments	0.2 - 0.5
Green area	0.05 - 0.10

Example: calculate the quantity of rainwater harvested from roofs of 4650.7m^2 and the average rainfall intensity is equal to 824.95 mm/year. Remember that the roof material is corrugated metal sheet

Solution

Total rooftop area (A) =4650.7m^2

Average rainfall (R) = 824.95mm/year = 0.82495m/year

Runoff coefficient (C), C calculated basing on rooftop materials, C = 0.9

Quantity of rainwater harvested

Q = R*A*C (m^3)

Q = 0.9*0.82495*4650.7

= 3452.93m^3/year=287.744m^3/month.

3. In summary: Installation of eave gutters

Site visits where the following works are carried out:

- ✓ Checking the gradient of gutters
- ✓ Measuring lengths of pipes/gutters
- ✓ Estimating materials required
- ✓ Fixing gutter box
- ✓ Fixing the outlet piece pipe
- ✓ Fixing brackets or welding gutters

LO 1.2 – Install rain water pipes

Content/Topic 1: Components of a rooftop rain water harvesting system

Although rainwater can be harvested from many surfaces, rooftop harvesting systems are most commonly used as the quality of harvested rainwater is usually clean following proper installation and maintenance. The effective roof area and the material used in constructing the roof largely influence the efficiency of collection and the water quality.

1. Rainwater harvesting systems generally consist of four basic elements:

(1) A collection (catchment) area

(2) A conveyance system consisting of pipes and gutters

(3) A storage facility, and

(4) A delivery system consisting of a tap or pump.

Figure 2 shows a simple schematic diagram of a rooftop rainwater harvesting system including conveyance and storage facilities.

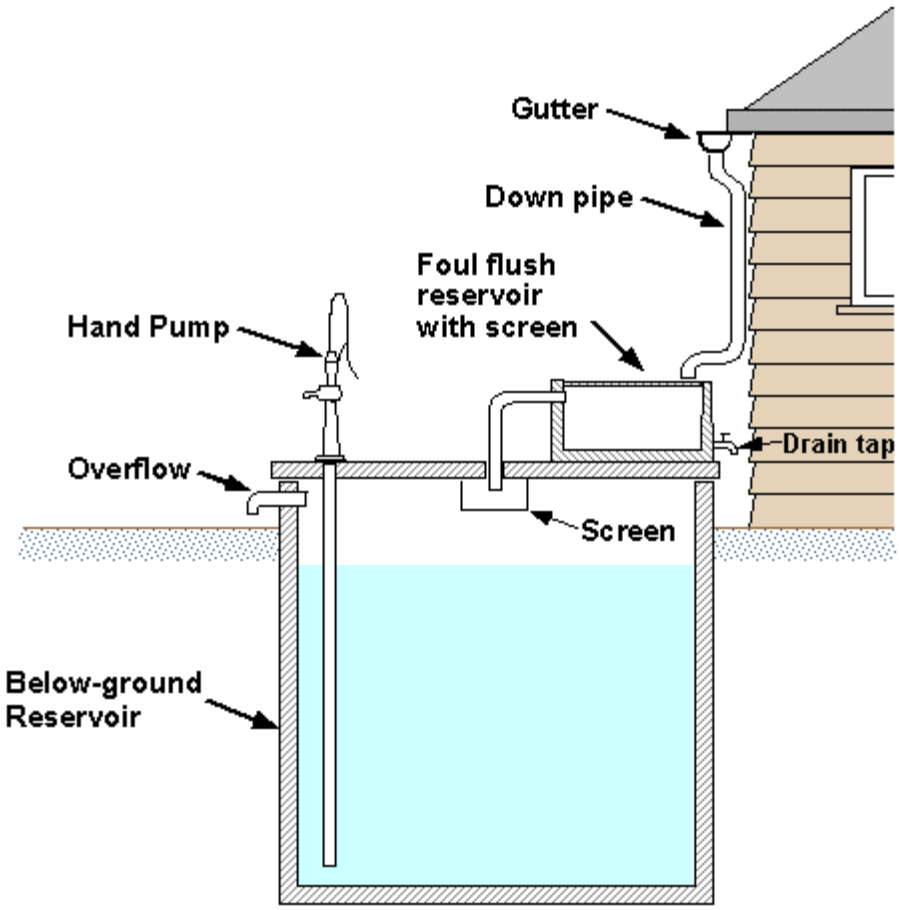


Fig. 2: A schematic diagram of a rooftop rainwater harvesting system.

(1) **A collection or catchment** system is generally a simple structure such as roofs and/or gutters that direct rainwater into the storage facility. Roofs are ideal as catchment areas as they easily collect large volumes of rainwater.

The amount and quality of rainwater collected from a catchment area depends upon the rain intensity, roof surface area, type of roofing material and the surrounding environment. Roofs should be constructed of chemically inert materials such as wood, plastic, aluminium, or fibreglass. Roofing materials that are well suited include slates, clay tiles and concrete tiles. Galvanised corrugated iron and thatched roofs made from palm leaves are also suitable. Generally, unpainted and uncoated surface areas are most suitable. If paint is used, it should be non-toxic (no lead-based paints).

(2) **A conveyance system** is required to transfer the rainwater from the roof catchment area to the storage system by connecting roof drains (drain pipes) and piping from the roof top to one or more downspouts that transport the rainwater through a filter system to the storage tanks. Materials suitable for the pipe work include polyethylene (PE), polypropylene (PP) or stainless steel.

(3) **Storage tank or cistern** to store harvested rainwater for use when needed. Depending on the space available these tanks can be constructed above grade, partly underground, or below grade. They may be constructed as part of the building, or may be built as a separate unit located some distance away from the building.

(4) **Delivery system** which delivers rainwater and it usually includes a small pump, a pressure tank and a tap, if delivery by means of simple gravity on site is not feasible.

Disinfection of the harvested rainwater, which includes filtration and/or ozone or UV disinfection, is necessary if rainwater is to be used as a potable water source.

2. Storage tanks or reservoirs

The storage reservoir is usually the most expensive part of the rainwater harvesting system such that a careful design and construction is needed. The reservoir must be constructed in such a way that it is durable and watertight and the collected water does not become contaminated.

All rainwater tank designs 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.

3. Storage reservoirs for domestic rainwater harvesting are classified in two categories:

1. Surface or above-ground tanks, most common for roof collection, and

2. Sub-surface or underground tanks, common for ground catchment systems.

Materials and design for the walls of sub-surface tanks or cisterns must be able to resist the soil and soil water pressures from outside when the tank is empty. Tree roots can also damage the structure below ground.

Underground water tank

The size of the storage tank needed for a particular application is mainly determined by the amount of water available for storage (a function of roof size and local average rainfall), the amount of water likely to be used (a function of occupancy and use purpose) and the projected length of time without rain (drought period).

- Content/Topic 2 : Installation of rain water pipes

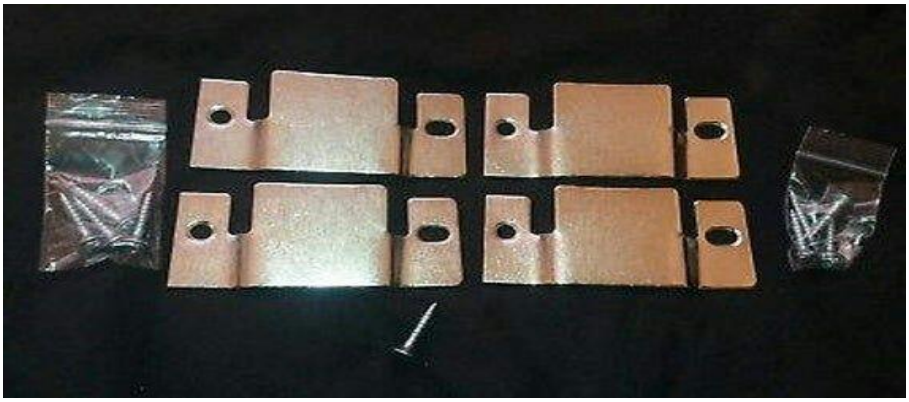
1. Definition: Rainwater pipe: known as downspout used for conveying rain water from a roof of building or gutter to the ground or storage tank

The diameter of rain water pipe varies between 50 cm and 150 cm

Dimensions of rainwater pipes (diameter)	**Max length of the roof gutter per connected rain water downpipes**
70 mm	**10 m**
80 mm	**20 m**
100 mm	**20 m**
120 mm	**20 m**

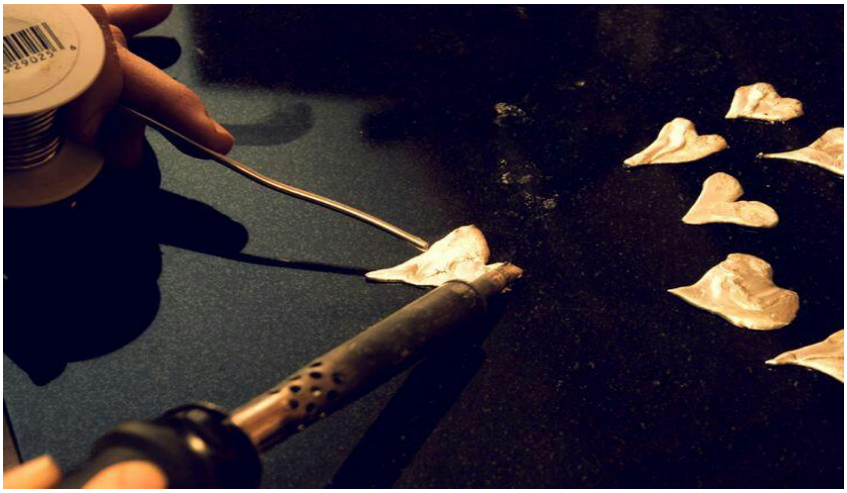
2. Materials and tools used to perform rain water pipe

1. Clips and screws



2. Wall plugs: are good for receiving screws and fixing pipe battens to masonry. ...

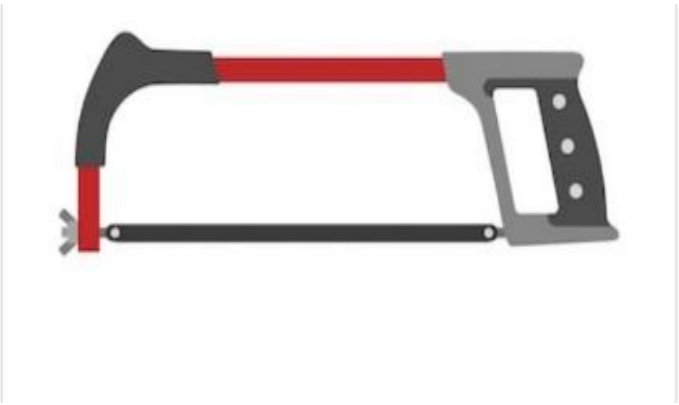
3. Solder: is melted steel stick which is used to bind (join) two pieces of gutter. This solder seal the empty space between two pieces are going to be joined by burning it highly to the level of liquification



4. Hammers: tools which is more likely to be used in plumbing works including rain water harvesting for purpose of drive nails into wood, to shape metal, or to crush rock. Hammers are used for a wide range of driving, shaping, and breaking applications

5. Screw drivers: used to press (pressurize) screw into the wall for purpose of fix tightly pipe against the wall

6. Hack saws: Many hacksaws have a two-part adjustable frame and a pistol grip handle. Hacksaws are used by plumbers to cut pipes and occasionally by electricians to cut conduit. The hacksaw got its name because historically these saws did not cut smoothly.



7. Drills: used to drill where wall plugs are going to be placed

8. Tape measures: used to measure needed length of pipe

9. Solvent cement: is chemical substance applied on the surface of plastic pipe to allow two pieces of plastic bind each other. It strengthens the joint of PVC pipe

3. Processes of how to install rain water pipes

1. Mark the position for the rain water pipe
2. Fix clips
3. Join pipes
4. Connect pipes to gutters
5. Connect the rain water pipe to the reservoir /storage tank

4. Proper installation of rain water pipes

Proper installed rain water pipes must:

- Have enough diameter to call all from the rooftop
- Have slope to carry rainwater
- Made from proper materials
- Carry water with no sound
- Resist to rust
- Resist to external weather

5. Design of down pipe

Down pipe are used for conveying water and connecting to the rainwater tank. Gutter and down pipes must be properly sized, sloped and installed to maximize the quantity of rainwater collected. Now the following formula must be used for calculating size of down pipe $Q=V*A$, $A=\frac{\pi}{4}D^2$

Then, $Q=V*\frac{\pi}{4}D^2$

$D^2=\frac{4\,Q}{V\pi}$

Topic 6. Rainwater harvesting technique

Rainwater harvesting is a technique of collection, storage of rainwater into a nature reservoir or tanks or infiltration of surface water into a sub-surface aquifer (before it is lost as surface runoff).

6. The practice of collecting rainwater from rainfall event can be classified into two broad categories:

- land based
- roof based

Land-based rainwater harvesting occurs when runoff from land surfaces is collected in furrow dikes, ponds, tanks and reservoirs. **Roof-based** rainwater harvesting refers to collecting rainwater runoff from roof surfaces which usually provides a much cleaner source of water that can be also used for drinking

Determine the total amount required and available rain water

7. Estimating domestic water demand

The first step in designing a rain water harvesting system is to consider the annual water demand. Water demand is estimated by differentiate all days of year and days water stored can be used.

To estimate the water demand, the following formula can be used:

Water demand = water/cap/day*number of users*days of year

Example: Department of 30 rooms is occupied by 60 tourists for 1 year, 1 tourist consumer 25 litres per day. Calculate the water demand to comfort all tourists accommodate in this department

Solution

Given data

Water /cap/day = 20 l = 0.02 m^3

Number of users = 60 tourists

Number of days = 365days

Unknown: water demand

WD= 0.02 * 60 * 365 = 438 m^3/year

Learning Unit 2 – Distribute water

1. Introduction to the Distribute water

In this chapter, learners will understand both theoretically and practically performance how to distribute rain water harvested to the customers.

- ✓ **Tools and materials to give a help to the implementation of distribution**

- Pipes

- Clips and screws

- Water taps

- Foat valves

- Non return valves

✓ **Criteria for selection of rainwater harvesting technologies**

Several factors should be considered when selecting rainwater harvesting systems for domestic use:

- type and size of catchment area
- local rainfall data and weather patterns
- family size
- length of the drought period and alternative water source

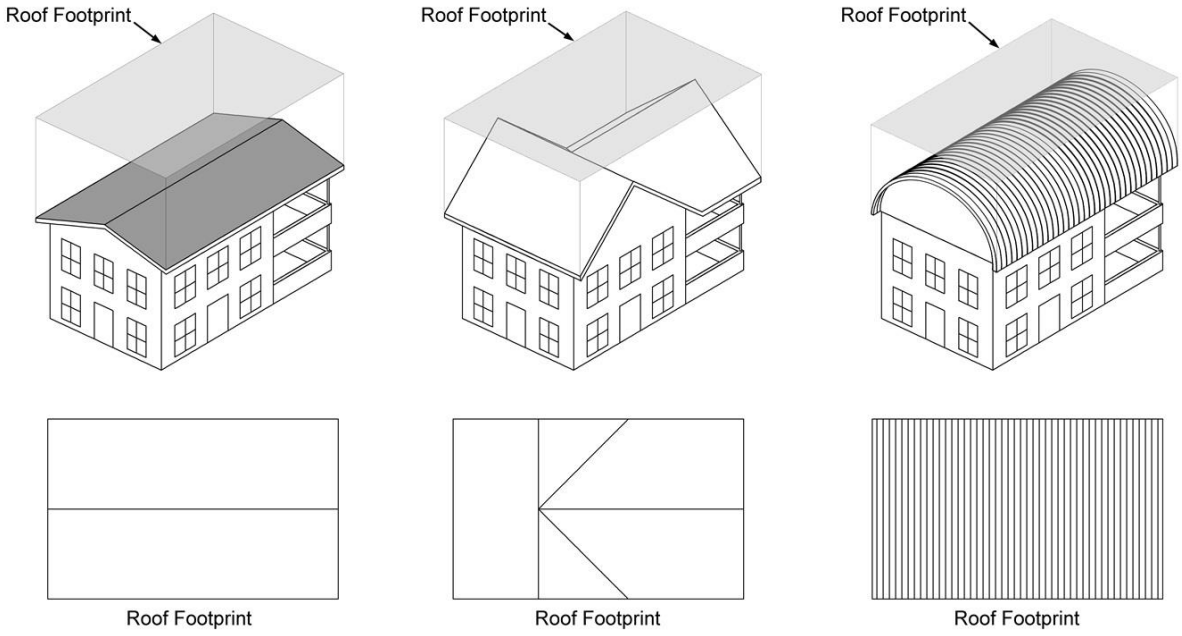
LO 2.1 – Use gravitation system

- Content/Topic 1 : Roof gradient

The slope of the roof affects how quickly water will runoff during a rain event. A steep roof will shed runoff quickly and more easily clean the roof of contamination. A less-steep, flatter roof will cause the water to move more slowly, raising the potential for contamination to remain on the catchment surface. The roof on the right has a steep slope followed by a more gradual slope.

Sizing a Catchment Area

The size of the catchment area or roof will determine how much rainwater that you can harvest. The area is based on the "footprint" of the roof, which can be calculated by finding the area of the building and adding the area of the roof's overhang. The image below shows how differences in roof slope do not change this building's catchment area.



✓ **Storage reservoirs for domestic rainwater harvesting are classified in two categories:**

1**. Surface or above-ground tanks,** most common for roof collection, and

2. **Sub-surface or underground tanks,** common for ground catchment systems

- Content/Topic 2 : Types of gutter

Rain gutters are one of your home's most important protections against the elements. Gathering the runoff from your roof caused by rain and melting snow and diverting it away from your siding and foundation to where it will do the least amount of harm. Because rain gutters are such an important aspect in maintaining the integrity of any home, it's important that you make an educated and informed decision as you look at available styles and materials so that you can make the best choice for your home and budget.

- rectangular gutter
- semi-circle or U-shaped gutter
- polygonal gutter

A conveyance system

The conveyance system is a fancy term for the gutters and downspouts. These are basically the networks of pipes that move the water from the roof surface to the storage containers. When selecting gutters and downspouts, it's important to consider three factors: sizing, proper installation, and aesthetics.

Below is a list of the most common gutter materials, as well as their benefits and drawbacks, so that you can move ahead with your next rain gutter purchase with confidence.

1. Vinyl Gutters

Vinyl gutters have quickly become a homeowner favourite because of their ease of installation, the fact that they never rust or corrode, and due to their cheap purchase price. Because they are so lightweight and sections easily snap together, they are very easy for the do-it-yourself to manage and install.

Furthermore, when used in milder climates they function just as well other materials, especially when installed correctly. Poor installation can result in sagging sections, however, and vinyl gutters do have a reputation for growing brittle and cracking over time and in extreme cold. These home gutters are a good solution if you're in need of new gutters while on a tight budget.

2. Aluminium Gutters

Next on the list of cost efficiency are aluminium rain gutters. Like vinyl gutters, aluminium house gutters also have the advantages of being lightweight, rust-proof, and relatively easy to work with. Unlike vinyl, however, they are weather-resistant across the board and maintain their integrity in cold climates. Add to that the fact that they hold paint well (again something that vinyl gutters can't claim) and can be manufactured in seamless models (we'll talk more about this later), and it's clear why many homeowners and gutter contractors prefer aluminium home gutters over all other materials.

3. Steel and Copper Gutters

As with aluminium gutter products, steel gutters come in a few different varieties. Galvanized steel rain gutters are by the far most popular as they are very competitive cost-wise and are sturdier than their aluminium counterparts when it comes to damage incurred by falling branches and ladders. The main drawback of galvanized steel is the rust factor. Eventually rust will take its toll with this brand of steel and they will rust through, though with proper maintenance they can still last for a very long time.

4. Stainless Steel

These puppies are virtually indestructible, shine for years on end, won't rust, and are pretty well accepted as one of, if not the, strongest materials in the industry. The one drawback is price. These gutters will run two-to-four times as much as gutters manufactured from lesser materials, so be prepared to shell out a few more peanuts if you go this route. Finally, copper gutters are perhaps the most beautiful rain gutters on the market, and like stainless steel are virtually indestructible. The only barrier here is price as well, as copper would easily win first place if there was a "most expensive gutter material" category at the county fair.

5. Wood Gutters

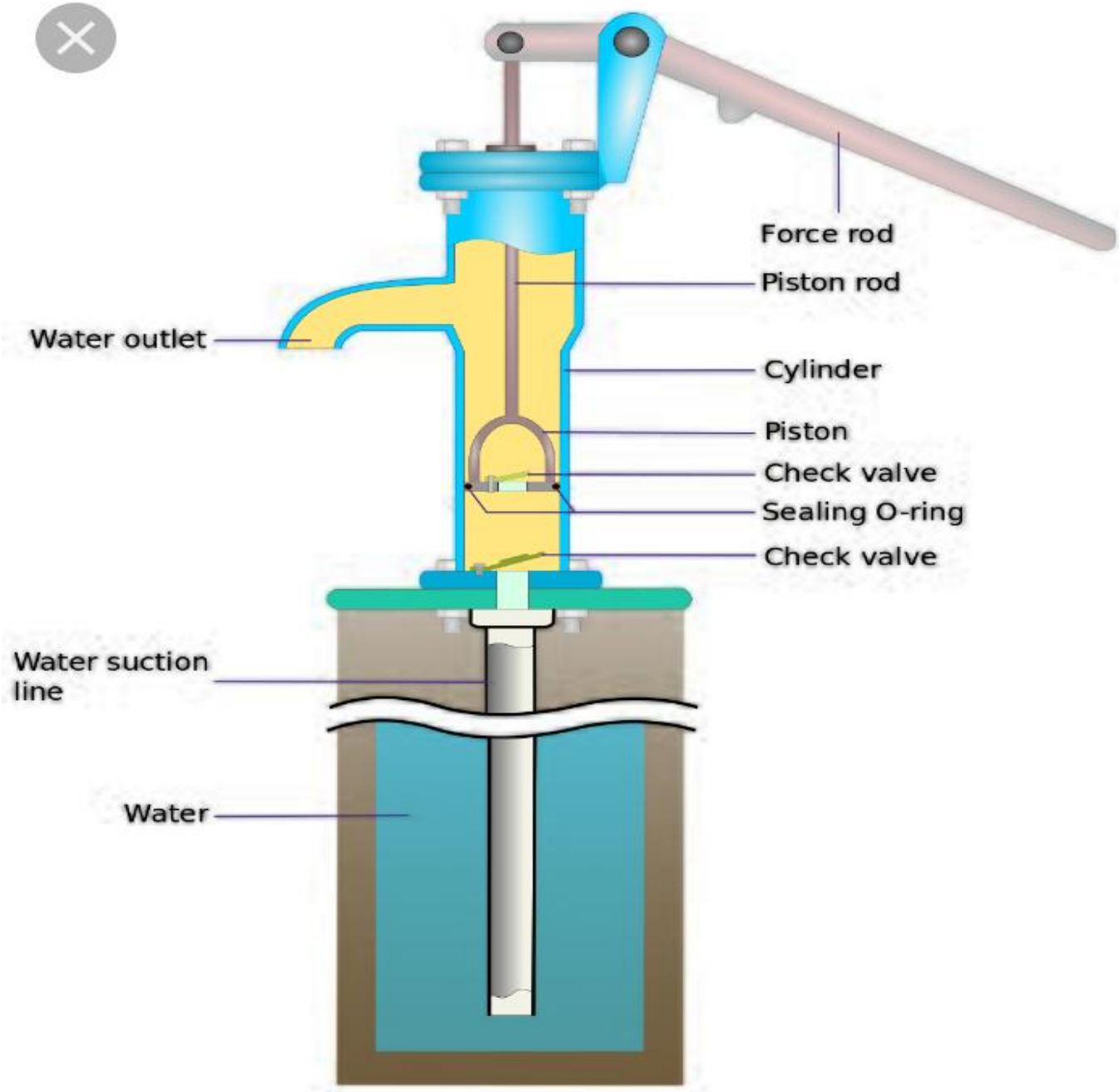
Wood gutters used to be the norm a hundred years past, though with the advent of cheaper, mass-produced materials that are more weather resistant, this home gutter material has mostly dropped out of favor. Wood rain gutters made of cedar, redwood, and fir are still available however, and are most often used in renovations of older, historic houses, where staying true to the original building materials takes precedence over longevity. Be prepared to spend a bundle as well if you choose this classic house gutter material.

LO 2.2 – Use a manual water pump

- Content/Topic 1 : Manual water pump

- Hand pumps are manually operated pumps; they use human power and mechanical advantage to move fluids or air from one place to another. They are widely used in every country in the world for a variety of industrial, marine, irrigation and leisure activities. There are many different types of hand pump available, mainly operating on a piston, diaphragm or rotary vane principle with a check valve on the entry and exit ports to the chamber operating in opposing directions. Most hand pumps are either piston pumps or plunger pumps, and are positive displacement.

- **Cross section and details of a pitcher pump**



- Animation of a suction hand pump. On the up stroke of the piston the foot valve opens and suction brings water into the pump head. On the following down stroke of the piston the valve on the piston opens up and allows water to flow above the piston. On the successive up stroke of the piston water is pushed out of the outlet.
- Hand-powered force pump, with an air chamber to smooth out variations in flow rate
- Hand pumps are commonly used in developing countries for both community supply and self-supply of water and can be installed on boreholes or hand-dug wells.
- Modern hand-operated community pumps are considered the most sustainable low-cost option for safe water supply in resource-poor settings, often in rural areas in developing countries. A hand pump opens access to deeper groundwater that is often not polluted and also improves the safety of a well

by protecting the water source from contaminated buckets. Pumps such as the Afridev pump are designed to be cheap to build and install, and easy to maintain with simple parts. However, scarcity of spare parts for these type of pumps in some regions of Africa has diminished their utility for these areas.

- Types
- **Suction and lift hand pumps**
  Suction and lift are important considerations when pumping fluids. Suction is the vertical distance between the fluid to be pumped and the centre of the pump, while lift is the vertical distance between the pump and the delivery point. [4] The depth from which a hand pump will suck is limited by atmospheric pressure to an operating depth of less than 7 meters. [5] The height to which a hand pump will lift is governed by the ability of the pump and the operator to lift the weight in the delivery pipe. Thus the same pump and operator will be able to achieve a greater lift with a smaller diameter pipe than they could with a larger diameter pipe.
- In addition to their use in drawing water from shallow groundwater sources for water supplies, another version of the hand-powered suction pump, with low lift and high delivery, was developed in the later 19th century for use as a ship's bilge pump (for smaller coastal vessels) and as a building site contractor's pump. It was known as a deluge pump. [6] One manufacturer who illustrated this product from the late 1880s onwards into the early 20th century was Gould’s Manufacturing Co. [7]
- **Force Pump**
  Where it is necessary to raise water to a height above that to which a suction or lift pump will operate effectively (about 7 meters), or to raise the pressure so that it will exit a nozzle with a strong force, such as through a fire hose, a force pump may be used. As with a suction pump, in its manual form it relies on an operator to pump a handle. The difference is however that after the water is sucked through the lower valve (as a result of raising the piston that is attached to the handle), its means of exit is via a pipe or nozzle in the side of the main cylinder. The water, once it has been drawn up above the lower valve and trapped there, is forced out the exit when the piston or plunger is pushed down again on the next stroke. [8]
- **Siphon**
  A siphon (or siphon) at its simplest is a bent tube, with one end placed in the water to be moved, and the other end into the vessel to receive the water. The receiving vessel must be at a lower level than the supplying vessel. [9] Water will always try to find its lowest level. Using this principle, very simple pumps with plastic or rubber bulb with flap valve at each end are used for emptying fuel or water cans into tanks. Once the bulb is full, the fluid will flow without further effort from the higher to the lower container. Many hand pumps will allow the passage of fluid through them in the direction of flow and diaphragm pumps are particularly good at this. Thus where the levels are correct large volumes of liquid such as swimming pools can be emptied with very little effort and no expensive energy use.
- **Chain pump**
  A chain pump is made of an endless chain carrying a series of discs that descend into the water, and then ascend inside a tube, carrying with them a large quantity of water. They are a simply made, old hand-powered pumping technology in the 18th century they were used as ship's bilge pumps.
- **Direct action**
  Direct action hand pumps have a pumping rod that is moved up and down, directly by the user, discharging water. Direct action hand pumps are easy to install and maintain but are limited to the maximum column of water a person can physically lift of up to 15 m. Examples of direct action pumps include the canzee pump and the EMAS pump.
- **Deep wells**

- Deep well hand pumps are used for high lifts of more than 15 m. The weight of the column of water is too great to be lifted directly and some form of mechanical advantage system such as a lever or flywheel is used. High lift pumps need to be stronger and sturdier to cope with the extra stresses. The installation, maintenance and repair of deep well hand pumps is more complicated than with other hand pumps.
- A deep well hand pump theoretically has no limit to which it can extract water. In practice, the depth is limited by the physical power a human being can exert in lifting the column of water, which is around 30 m
- **Diaphragm**
- Diaphragm pumps have the advantage that they pump relatively lightly due to the lack of pulling rods and are corrosion resistant. Their disadvantage is that they need a specific length of tubing and high quality rubber diaphragms, which are costly and are relatively inefficient due to the extra work needed to deform the diaphragm.
- Rubber diaphragms will eventually leak and need to be replaced. Because this is usually complicated and costly, diaphragm pumps operating in poor rural areas are often abandoned once the diaphragm wears out.
- **Progressive cavity**
- Progressive cavity pumps consist of a single helix rotor inserted into a double helix stator. As the rotor is turned, the voids in the stator are screwed upwards along the axis of rotation. Progressive cavity pumps can have complicated gearing mechanisms and are difficult for local pump technicians to maintain and repair.
- A rope and washer pump is a type of progressive cavity hand pump.
- Range of lift
- The range of lift of different types of hand pumps is given below: [14][15]
- **Type Range**
- Suction pumps 0 – 7 meters
- Low lift pumps 0 – 15 meters
- Direct action pumps 0 – 15 meters
- Intermediate lift pumps 0 – 25 meters
- High lift pumps 0 – 45 meters

- Content/Topic 2 : Types of rain water use

- Rainwater systems can be classified according to their reliability, yielding four types of user regimes:
- • Occasional - water is stored for only a few days in a small container. This is suitable when there is a uniform rainfall pattern with very few days without rain and when a reliable alternative water source is available.
- • Intermittent - in situations with one long rainy season when all water demands are met by rainwater. During the dry season, water is collected from other sources.
- • Partial - rainwater is used throughout the year but the 'harvest' is not sufficient for all domestic demands. For example, rainwater is used for drinking and cooking, while for other domestic uses (e.g. bathing and laundry) water from other sources is used.
- • Full - for the whole year, all water for all domestic purposes comes from rainwater. In such cases, there is usually no alternative water source other than rainwater, and the available water should be well managed, with enough storage to bridge the dry period.
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- Which of the user regimes to be followed depends on many variables including rainfall quantity and pattern, available surface area and storage capacity, daily consumption rate, number of users, cost and affordability, and the presence of alternative water sources.
- **1. Benefits 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. In homes and buildings, collected rainwater can be used for irrigation, toilet flushing and laundry. With proper filtration and treatment, harvested rainwater can also be used for showering, bathing, or drinking. 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 promotes self-sufficiency and conserves water resources
  • Rainwater is friendly to landscape plants and gardens
  • It reduces storm water runoff and non-point source pollution
  • It uses simple, flexible technologies that are easy to maintain
  • offers potential cost savings especially with rising water costs
  • provides safe water for human consumption after proper treatment
  • Low running costs
  • Construction, operation and maintenance are not labor-intensive.

2. Disadvantages

The main disadvantages of rainwater harvesting technologies are the limited supply and uncertainty of rainfall. Rainwater is not a reliable water source in times of dry periods or prolonged drought. Other disadvantages include:

• low storage capacity which will limit rainwater harvesting, whereas, increasing the storage capacity will add to the construction and operating costs making the technology less economically feasible
• Possible contamination of the rainwater with animal wastes and organic matter which may result in health risks if rainwater is not treated prior to consumption as a drinking water source
• 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.

3. Sustainability

Rainwater harvesting is one of the most promising alternatives for supplying water in the face of increasing water scarcity and escalating demand. The pressure on water supplies, increased environmental impact from large projects and deteriorating water quality, constrain the ability to meet the demand for freshwater from traditional sources. Rainwater harvesting presents an opportunity for the augmentation of water supplies allowing t the same time for self-reliance and sustainability.

- **4. Cultural acceptability**
- Rainwater harvesting is an accepted freshwater augmentation technology in many parts of the world. While the bacteriological quality of rainwater collected from ground catchments is poor, rainwater from properly maintained rooftop catchment systems, which are equipped with tight storage tanks and taps, is generally suitable for drinking and often meets the WHO drinking water standards. This water is generally of higher quality than most traditional water sources found in the developing world. Rooftop catchment of rainwater can provide a good quality water which is clean enough for drinking, as long as the rooftop is clean, impervious and made from non-toxic materials and located away from over-hanging trees.
- **5. Maintenance**
- Maintenance is generally limited to the annual cleaning of the tank and regular inspection and cleaning of gutters and down-pipes. Maintenance typically consists of the removal of dirt, leaves and other accumulated material. Cleaning should take place annually before the start of the major rainfall season. Filters in the inlet should be inspected every about three months. Cracks in storage tanks can create major problems and should be repaired immediately.
- **6. Regulations and technical standards**
- The most important aspect during the construction of a rainwater harvesting system is to completely separate the rainwater and drinking water networks. All rainwater pipe work and tapping points should be clearly designated and secured against unauthorized use.
- In Germany, the construction of a rainwater harvesting system does not require a building approval but it is advisable to report it to the local public health office as well as the local water supplier. Some regulations and standards (especially DIN 1989) should be taken into consideration during construction and maintenance of a rainwater harvesting system.
- **7. Effectiveness of technology**
- The feasibility of rainwater harvesting in a particular locality is highly dependent on the amount and intensity of rainfall. As rainfall is usually unevenly distributed throughout the year, rainwater harvesting can usually only serve as a supplementary source of household water. The viability of rainwater harvesting systems is also a function of the quantity and quality of water available from other sources, household size, per capita water requirements and available budget.
- Accounts of serious illness linked to rainwater supplies are few, suggesting that rainwater harvesting technologies are effective sources of water supply. It would appear that the potential for slight contamination of roof runoff from occasional bird droppings does not represent a major health risk. Nevertheless, placing taps at about 10 cm above the base of the rainwater storage tanks allows any

debris entering the tank to settle on the bottom, where it will not affect the quality of the stored water, provided it remains undisturbed.

- Finally, effective water harvesting schemes require community participation which is enhanced by:
  • Sensitivity to people's needs
  • Indigenous knowledge and local expertise
  • Full participation and consideration of gender issues, and
  • taking consideration of prevailing farming systems as well as national policies and community by-laws.

8. Economic efficiency

Valid data on the economic efficiency of rainwater harvesting systems is not possible. Dependent on the regional conditions (water and wastewater prices, available subsidies), the amortization period may vary between 10 and 20 years. However, it should be taken into consideration that for the major investment (storage and pipe work) a period of use of several decades is expected.

- **Costs**

  The associated costs of a rainwater harvesting system are for installation, operation and maintenance. Of the costs for installation, the storage tank represents the largest investment which can vary between 30 and 45% of the total cost of the system dependent on system size. A pump, a pressure controller and fittings in addition to plumber's labor represent other major costs of the investment.

  In general, a rainwater harvesting system designed as an integrated element of a new construction project is more cost-effective than retrofitting a system. This can be explained by the fact that many of the shared costs (such as for roofs and gutters) can be designed to optimize system performance and the investment can be spread over time.

9. Rainwater quality standards

The quality of rainwater used for domestic supply is of vital importance because, in most cases, it is used for drinking. Rainwater does not always meet drinking water standards especially with respect to bacteriological water quality. However, just because water quality does not meet some arbitrary national or international standards, it does not automatically mean that the water is harmful to drink. Compared with most unprotected traditional water resources, drinking rainwater from well-maintained roof catchments is usually safe, even if it is untreated. The official policy of the Australian Government towards the question "Is rainwater safe to drink?" is as follows: "Providing the rainwater is clear, has little taste or smell and is from a well-maintained system, it is probably safe and unlikely to cause any illness for most users". For immune-compromised persons, however, it is recommended that rainwater is disinfected through boiling prior to consumption.

- **10. Drinking water from rainwater**

  In many countries of the world where water resources are not available at a sufficient quality fit for human consumption, rainwater acts as a substitute for drinking water and other domestic uses. In some remote islands around the globe, rainwater may even act as the major potable water source for their population.

  The most important issue in collecting rainwater is keeping it free of dirt such as leaves, bird droppings and dead animals, and avoiding contamination with pollutants like heavy metals and dust. Rainwater can be also treated for use as a potable water source. The use of slow sand filtration has proved to be a simple and effective treatment technology for the elimination of most of the organic and inorganic pollutants that may be present in rainwater, as well as producing a virtually pathogen-free water for drinking.

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