



# Training Module on Roof Rain Water Harvesting Techniques

Prepared by SMIS project

November, 2016

Bahirdar





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## **1. General Descriptions**

This training manual is prepared by SMIS Project National office to enhance the efficiency and effectiveness of planning, design, development and operation of Rain Water Harvesting(RWH) for small scale & household micro irrigation. Through the adoption of efficient strategic approach to usewater in general and RWH in particular forplanning, responsible institutions will be able to: better manage water resources in a sustainable way; better plan, develop, maintain and operate supply systems and optimize the use ofexistingRain water resource. In doing so, this training manual consists of some training topicswhich will be conducted in a minimum of 3-day periods including practical field visit and observations. At the end of the program, participants will have developed a preliminary strategic plan for their organization. The plan may need to be later revisited as part of the normal annual work and annual review process. Each training topics contains a brief introduction to each segment outlining the basic concepts needed to include in the Roof Water Harvesting techniques.

## **2. The Rainwater Harvesting Context& Potentials in Ethiopia**

The history of rainwater harvesting practices in Ethiopia dates back as early as 560 BC, during the AxumiteKingdom. In those days, rainwater was harvested and stored in ponds for agriculture and water supply purposes, which are evidenced with documented literature and visual observations on the remains of ponds that were once used for irrigation during that period. Even these days, there are several traditional rainwater-harvesting technologies in Ethiopia, which have been used by communities in areas of water shortage. For many traditional communities in rural areas where natural sources of water are lacking, collectionof rainwater from pits on rock outcrops and excavated ponds are common practices. In many semi-arid lowland areas of Ethiopia, where rainfall is not adequate for crop growth, farmers use runoff irrigation as a source of life-saving irrigation supplies.

Despite the enormous potential of its natural resource bases and the development efforts being made by the various actors in the country, Ethiopia's chronic food shortages and drought-induced famines have continued to be common phenomena during the past few decades (Asmare 1998).

In line with this, the Ministry of Agriculture (MOA) has been making some efforts towards the development and promotion of rainwater-harvesting technologies as part of its



extensionprogramme. The above facts strongly support the need to focus on development and promotion of rainwater harvesting technologies as one of the alternatives to enhance water availability for different uses including domestic water supply, sanitation and food production/agricultural Development. This is therefore; Ethiopia has to feed itself by enhancing its agricultural production, yet it's predominantly rain fed agriculture has been constrained by the unpredictable variability of the rainfall pattern. Obviously, this situation brings about the need to maximize the use of existing or unexploited sources of freshwater. Given the good potential of Ethiopia's agro climatic resources, the prevailing limitations in terms of rainfall distribution and amount could be effectively addressed if rainwater harvesting is seriously taken. Applications of rainwater-harvesting techniques, however, are constrained by the limited availability of information on the technologies and relevant traditional practices, lack of resources to conduct local specific research on the performance of available techniques and inadequate attention to avail and promote suitable extension packages to the end users. For effective and efficient use of rainwater harvesting to address domestic supply and food production, all concerned should give timely and adequate attention.



### 3. Roof Catchment Rain Water Harvesting Techniques

#### 3.1 Introduction

This training module is part of the other HHMI capacity enhancement modules prepared for zonal and district staff which will be cascaded down to majority of the community in a manner that suits to the needs of woreda's experts and technicians in the field.

As well known, Rainwater harvesting is a broad subject covering RWH from roofs, ground surfaces, and rock outcrops, through the construction of RWH systems that include various types of storage reservoirs such as surface and subsurface tanks, ponds and various kinds of dams. The water harvested is used for various purposes, both domestic and agricultural. RWH also includes soil and water conservation activities that protect water from running off and stored in the soil and ground aquifers. For this reason, it is necessary to be selective and to focus on certain aspects of RWH. Therefore, this part of module focuses mainly on harvesting water from Roof catchments, storing it in storage tanks, for use in domestic & Agricultural purposes. The manual will encompass both the conceptual and practical aspects of Roof RWH. It is complemented by annexes, drawings and pictures that are relevant and useful.

Training Objectives: - After this training the participants will be able to:

- ✚ Define the Purpose & Rationale for Rainwater Harvesting
- ✚ Identify types and components of Roof rainwater harvesting systems
- ✚ Describe Roof rainwater demand and supply for domestic use
- ✚ Design Roof rainwater harvesting systems
- ✚ Describe the Management of Roof Rainwater Harvesting Systems
- ✚ Identify technical Description for reservoir
- ✚ Integrate Roof RWH with other opportunities/requirements
- ✚ Identify Institutional responsibility and implementation arrangements
- ✚ Provide technical support for the treatment of Stored Rainwater

**Materials:** Flip Chart, Markers, meter, PPT, handout, Gutters, Iron sheet etc.

**Time required:** three days (one day for class presentation, and two days for field work)



**Methods of facilitations:** - PPT presentations, Group work, Gallery walk presentation, field observations, feedback from field observations, Identification of performance tasks, Action plan preparations etc.

### **3.2 Learning Outcomes**

The general learning outcomes of this training module is to provide skill based capacity building training for zonal & woreda experts and private sectors who are engaged in the Rain water harvesting from their roof and sub catchment. However; the specific objectives are as follows:

- To provide zonal experts, Districts experts and private trainees with a working skills & knowledge of Roof Rain water harvesting and its operations, and proper maintenance procedures used for water reservoir to provide adequate timely support on the maintenance as well.
- To provide trainees with a working knowledge of the different types of the Roof Rain water harvesting and their basic operations.
- Enhanced skills and knowledge, Strengthened administration and management of the Rain water harvesting.
- Improved coordination, collaboration and synergy among implementers, & Support for all stakeholders will be strengthened

### **3.3 Purpose & Rationale for Roof Rainwater Harvesting**

The Roof RWH option has certain merits over surface and ground sources that can make it play a real role in providing total or complementary water supply for domestic and agricultural purposes. It is available nearly everywhere, is relatively clean needing only simple treatment, and depending upon situations and the technology used it can also be cheaper. Harvested rain water, in most cases, does not need pumping; also, it does not need to be transported unless the user is located far away from the collection point. Roof RWH schemes are simple and render themselves easily to individual ownership, managed by households or decentralized communities. From the domestic water supply point of view, most consumers provided with improved water supplies are in many cases inadequately served, they also encounter frequent supply interruptions; the water may sometimes be contaminated. Many poorer segments of

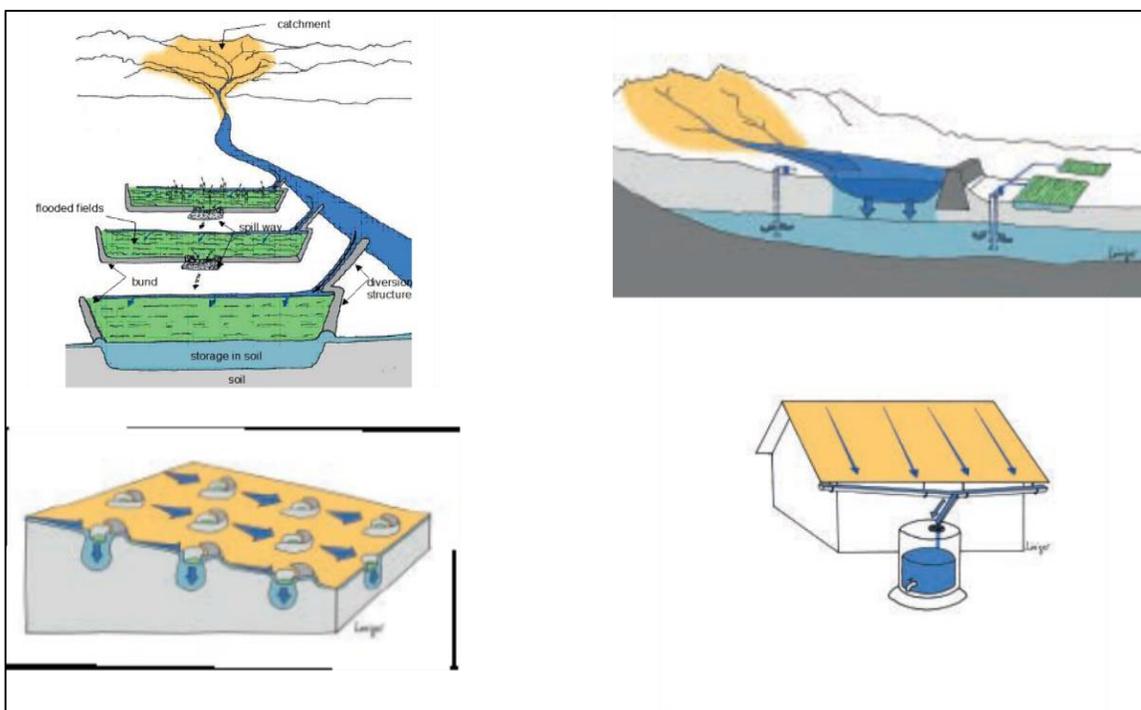


the communities collect water from communal water points located at some distance are common.

The operation and maintenance of domestic RWH systems is also relatively simple. The real limitation of domestic RWH systems is that the unit costs of water storage tanks per user or per unit volume of water they produce per unit time. Traditional communal rainwater storage ponds from ground catchments are common, particularly in areas where there are no nearby surface or groundwater sources for domestic use. There are more and more people building their houses with roofs made from corrugated iron sheets; this creates an ideal situation for the wider promotion of domestic roof water harvesting both in urban and rural areas. It is now clear that rainwater has an important place and role to play in providing the water needed for various purposes; and to contribute to the attainment of the community needs.

### 3.4 Types and components of Roof Rainwater Harvesting systems

The application of an appropriate Roof rainwater harvesting technology can make possible the utilization of rainwater as a valuable and, in many cases, necessary water resource. There are many types of RWH Based on the catchment type and size such as Floodwater harvesting, macro catchment systems, Micro catchment systems, and rooftop / courtyard water harvesting. But this module is only prepared for the domestic water harvesting from roofs and small catchments.





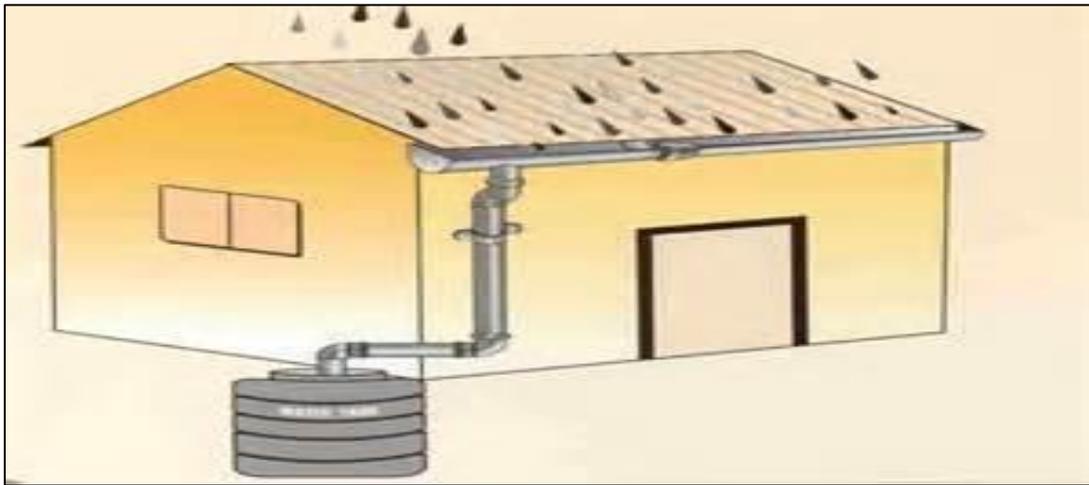
**The basic components of Roof RWH systems are;**

- Roof catchment surface from which rainwater is collected;
- conveyance system to collect and transport them to storage facilities;
- Storage facilities or reservoir, and storage related inflow and outflow devices/facilities.

### **3.5 Types of Catchment Surfaces**

#### **Roof Catchments**

The roof of a building or house is the obvious first choice for catchment. Roof catchments are the most commonly used for domestic RWH. Roofs have to be impervious, durable and clean and types of roofing material used for domestic RWH are such as corrugated iron sheets, corrugated plastics and tiles. All are suitable to serve as Roof catchment surfaces; however, corrugated iron sheets are the most ideal and the most rapidly expanding as they are smoother. If painted roofs are to be used, it is necessary to make sure that the paints are free from lead contents, if the water is to be used for drinking.

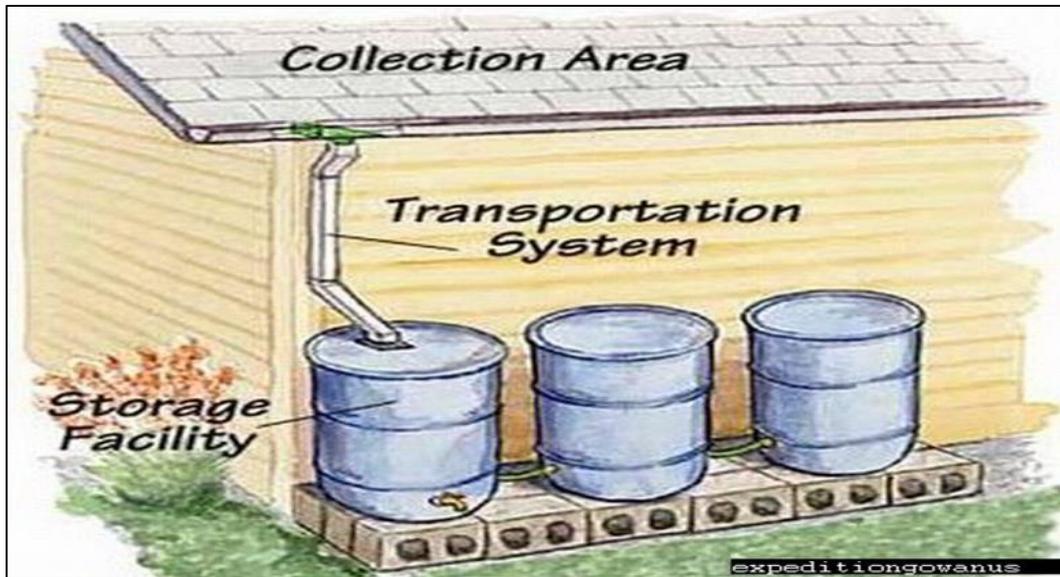


#### **3.6 Roof catchment Rainwater Conveyance Systems**

Rainwater conveyance systems are components of a RWH system that collect water from catchment surfaces and transport it to the inlets of storage facilities such as Roof Catchment Conveyance Systems, Ground Catchment Conveyance Systems, & Rock Catchment Conveyance Systems. Each type of rainwater catchment has a conveyance system that is appropriate to the specific type of RWH system. In Roof Catchment Conveyance Systems Gutters and down pipes are the most common roof catchment conveyance systems. They are fixed on roofs, even



without RWH systems, to protect walls and to safely dispose of water without causing erosion on the ground next to buildings. When used in RWH systems, gutters and down pipes must be able to intercept runoff water from roofs and convey it to storage tanks.



Roof conveyance systems consist of gutters suspended along the lower edges of roofs that project over the walls, sloping towards down pipes leading rainwater to storage tanks. Gutters are normally fixed to fascia boards. Appropriate gutter slopes are necessary to keep their sizes and costs of installation to a minimum.

Examples of other types of roof conveyance systems are;

- Surface drains/cement channels on the surface of courtyards used to divert water to sub-surface tanks. They may be a cheaper option but need to be cleaned regularly.
- Stone or cement glides built as slanting ridges on the roof itself, to divert runoff sideways towards a receiving inlet to the tank. These work well in flat surfaced roofs rather than the ridged or corrugated.
- The most common materials used for making gutters and down pipes are metals and PVC. They are much more durable when compared to other traditional material such as wood and bamboo; and they cost effective.





### 3.7 Rainwater Storage Facilities

The most expensive component of a RWH system is the water storage facilities which sometimes lead to direct use of rainwater. It is therefore necessary to pay due attention to the selection, design and construction of reservoirs, always keeping in mind cost aspects along with other considerations.

There are three broad categories of rainwater storage facilities;

- Surface tanks or above ground tanks;
- Sub-surface tanks or underground tanks; and
- Dammed reservoirs and ponds. Once water is stored it can be used for any purposes as discussed.

#### Surface Tanks

Surface tanks are used for harvesting water from elevated catchment surfaces, e.g. large roofs. The materials used for construction are ferrocement, blocks (of concrete, brick and rubble stone), concrete in situ, plastic, metals and wood. The tanks should be watertight, durable, affordable, and non-contaminant.

The selection of the material depends on local situations; e.g. metals are not suited to saline areas, plastic to strong light areas, and wood to termite areas. Other factors include construction costs, and availability of material. Surface tanks vary in size; for household use between oil drum size (200 liters or even lower) to 40 m<sup>3</sup>. For communal tanks built in large blocks such as schools, the size can go even beyond 100 m<sup>3</sup>. The selection of an actual size depends on various factors such as the amount and distribution of rainfall over the year, available roof area, household demand, and the presence of other supply sources.

#### **The advantages of surface tanks over sub-surface tanks are that:**

- Water can easily be abstracted by gravity;
- Allow for easy inspection of cracks and leakages; and
- Smaller sizes render themselves for central production and transportation, which is good for the quality control of certain tank types such as plastic or ferrocement.

#### **The disadvantages are however that:**

- They are relatively expensive when compared with subsurface storage tanks; and



- They require space, generally a problem in urban areas.



### **Sub-surface Tanks**

Subsurface tanks are mostly associated with the purpose built ground catchment surfaces; they are however used for roof catchments as well. They share much of the features of surface tanks regarding construction material and methods. Sub-surface tanks are built in excavated ground where the soil is backfilled upon completion. Where the soil is firm, excavated holes can be lined with ferrocement chicken wire mesh and barbed wire for reinforcement, and cement directly plastered onto it this type saves costs significantly and the need for formwork. In places where the soils are clay, and impervious, it is possible to build unlined sub-surface tanks, but they suffer from seepage, evaporation and poor water quality.



The advantages of sub-surface tanks include the following;

- The costs are cheaper than surface tanks. This is due to cheaper designs resulting from tanks benefited by the support of the surrounding ground;
- They are appropriate in places where space above ground is limited; and



- The water is cooler.

#### **The disadvantages are;**

- Pump or some kind of abstraction device (such as rope and bucket) is required to access water. An alternative to this is to construct steps to a tap stand from where the water can be abstracted by gravity.
- When they use ground catchments, they suffer from contamination and sediment inflow.
- Leakages and failure is difficult to detect; and
- They cannot be easily drained for cleaning.

#### **Dammed Reservoirs and Ponds**

These are reservoirs that make use of larger natural catchments purposely built for RWH. They are used at community level rather than owned individually by a household. The reservoirs can be created by constructing rock catchment dams, sub-surface/sand dams, earth dams or ponds. Dams are built across natural water courses at the downstream side of natural depressions. Ponds can however be constructed at any convenient site outside natural waterways.

The water from these sources may be used for domestic and livestock water supply and/or for irrigation purposes. When used for domestic purpose they need some form of treatment to make them safer and potable. The selection of site for dam or pond construction should follow certain criteria that are suitable for the particular type selected for construction. The catchments ideally need to be protected from pollution and erosion to protect the water from contamination, and the reservoirs from silt deposition. Sediments should be removed from small reservoirs to maintain their capacity.

The advantage of dammed reservoirs and ponds is that relatively large volumes of rainwater can be stored when compared to that of surface or sub-surface tanks. The main disadvantage of such reservoirs is that the water is liable to pollution and contamination due to unprotected catchments. Seepage and evaporation losses are also problems owing to the fact that the reservoirs are built on natural ground and that they are mostly too wide to provide cover.

Examples of dammed reservoirs are;

- Rock Catchment dams
- Sand River Storage



- Earth dams
- Ponds

### **Rainwater Supply**

The volume of rainwater supply over a given period depends upon the amount of rainfall in that period, the catchment area and the runoff coefficient. The formula relating these variables is straight forward; it would though be necessary to be watchful of the units.

$$\text{Volume of rainwater supply} = \text{rainfall amount} \times \text{catchment/roof area} \times \text{runoff}$$

Therefore, rainfall amount and pattern should be analyzed and compared with demand distribution to help come up with the most appropriate and economical storage tank size. If rainfall is uniformly distributed over the year, then, storage requirement/tank size is smaller; if it is highly seasonal, the storage required would be bigger for the same amount of rainfall.

### **3.8 RAINWATER HARVESTING SYSTEMS AND DESIGN CONSIDERATIONS**

This part will mainly look into considerations for the planning and design of surface tanks (i.e. plastic tanks, concrete rings tanks, ferrocement tanks) and for storing water from roofs, as this is the most important type of RWH systems for domestic supply used.

#### **Roof Gutters and Downpipes**

##### **Gutters**

A well designed, installed and maintained gutter system is necessary for a roof RWH system to operate efficiently and effectively. A good gutter is expected to perform well in intercepting and conveying water to the downpipe/gutter or the tank; it should also be reasonably cheap as well as durable. As indicated earlier however, it is in practice the most poorly performing component, and thus the commonest source of failure of the whole RWH system. The usual problems include gutters clogged with debris and not cleaned, not properly sloping, not intercepting runoff properly, overflowing, making use of only part of the roof area, twisted, leaking, broken and not repaired. Gutters should neither be too small nor too large; if too large they become expensive; if too small they cannot be able to accommodate heavy storms and cause overflow. Gutters are governed by the principles of open channel hydraulics, and thus



their water conveyance capacity depends on gutter cross sectional area, shape, roughness and slope.

Rainfall intensity and roof area also need to be considered in determining appropriate gutter sizes. In general cases (by Gould and Petersen, 1999 and Hasse, 1989) it is suggested to make use of at least  $1\text{cm}^2$  gutter cross sectional area for every  $1\text{m}^2$  roof area. For example a  $100\text{cm}^2$  cross sectional area gutter can be used for a  $100\text{m}^2$  ( $20\text{m} \times 5\text{m}$ ) roof area.

It would be safe to install gutters at a gradient of 1:100 (1%). This slope increases the carrying capacity of gutters, owing to the high velocity of water, thus water will not be wasted due to overflow. The high velocity also enables the transportation of debris to sieves on tank inlets without clogging gutters. Gutters normally have uniform slopes along horizontal roof edges. For long roofs with no splash-guards, considering a lower gradient at the upper stretch and increasing it down the gutter towards the outlet may be useful. This helps avoid spill over at the lower edges of the roof, due to reduced gap between the roof and the gutter. Semi-circular gutters are the most efficient at conveying water, as they have the largest cross sectional area for a given perimeter. Trapezium gutters with all three sides equal, although lower than the semicircular, also have higher cross sectional area when compared with other gutter shapes. Square shaped gutters are also used to convey runoff water. As indicated earlier, for large roofs such as those of schools V-shaped gutters, with splash-guard and steeper than 1% gradient, can cope with heavy down pours without large losses due to overflow. There are various material used for gutters. These include galvanized metal sheets, aluminum and plastic. However, the use of galvanized metals is recommended due to strength and or cost reasons, but for the coastal zones it is preferable to use plastic materials to avoid rusting. When installing gutters, they must be placed 3 cm inward from the roof edge in order to catch the back drop of water from light showers. Placing tanks at the end of long roofed buildings such as schools, requires large gutters. If instead, they are placed in the middle, they allow smaller gutters which can be easily and cheaply installed. Gutter brackets must be strong enough so as not to bend under the added weight of water, and pressure from wind.

### **Down pipes**

In gutters that are not used for RWH, down pipes are normally vertical and may have smaller cross sectional area as the water flows faster downward. In roof RWH systems however, they



often are not vertical; and usually the gutter channels themselves are extended to convey water to the tanks. For this reason, they are called down gutters. This arrangement avoids water wastage, because it does not reduce the speed of the water, and debris are easily flushed away at the sloping screen cover of the tank without causing blockage. Both the gutters and down gutters should have similar shapes and dimensions, although the down gutters have steeper slopes.

Downpipes can also be used to receive water from gutters and convey it to tanks. In the first case where down gutters are used, one of the following two arrangements can be made.

- In the first arrangement, a tank is built with its center in line with the gutter. In this case, the gutter is simply extended with same size and shape to the tank inlet. The slope of the down gutter will be 2% (1:50); and needs to be supported at both ends.
- In the second arrangement, the discharging end of the roof gutter is provided with a hole at the bottom.

The water flowing through the hole is received by a down gutter (with same size and shape as the gutter and at 2% slope) and conveyed in any direction to a tank inlet. The advantage of the second arrangement is that it is possible to feed a single tank from two gutters installed particularly on the front and back roofs of a building. Downpipes may receive water from a funnel below the gutter, and convey it to the tank inlet. As long as the required head is provided, pipes can follow any route to the tank, along walls, above or below ground, etc. Whichever of the three arrangements is used, it is not advisable to place tanks too far from a building, for the sake of shorter down pipes. A downpipe should normally enter a tank at the highest point of the tank to maximize volume. To exclude leaves and debris from entering tanks, a coarse 5mm or smaller wire mesh may be placed over the top of a downpipe inlet, at the end of the gutter. This should be inspected regularly so that it is not blocked. A better alternative is however, the use of a self-cleaning tank inlet or guttersnipe.

### **Splash-guards**

There are two common problems associated with installing gutters on long roofs of large buildings, and on houses with irregular roof edge slopes (which were supposed to be horizontal), which may also be without fascia boards to nail in gutter brackets.



- In the first case, long roof means that the gap between the edge and the gutter widens along the slope, and the gutters are hung many cm below the roof. This causes the roof runoff to overshoot and miss the gutter totally or partially wasting rainwater. The gutter cannot be raised, because that will reduce or reverse its gradient.
- In the second case, the uneven roof edges pose problems while trying to provide the correct uniform slope to gutters, this results with irregular slopes of the gutters themselves and causes water to overflow and spillover the gutters. Houses without fascia boards also mean that there is no provision for the gutter brackets to be fitted on.

A splash-guard consists of a long strip of sheet metal 30cm long, bent at an angle and hung over the edge of the roof by 2-3cm to ensure that all runoff enters the gutter. The vertical leap of the splash guard intercepts the overshooting runoff and directs it straight into the gutter. This solves the problems of houses without fascia boards. The gutter hangers are made by bending 3mm GI wire into a triangular or any gutter shape; the gutter can then be mounted onto these hangers. The triangular shaped gutter, though not as efficient hydraulically as the other shapes, it has the advantage that it is more stable, owing to the fact that it is fitted into the triangular shaped 3 mm wires that do not buckle easily under the weight of water to which it is subjected. The adjustable wires enable an even gradient (1:100), by keeping the gutter suspended in the correct position under the eave.

### **3.9 The Management of Rainwater Harvesting Systems**

Once a Roof catchment rainwater harvesting system is planned and designed properly, and built with good construction material and workmanship, it is ready to provide the services expected and aimed at meeting the objectives set for it in a sustainable manner. This however requires certain arrangement in terms of putting in place a management system/mechanism that is capable of ensuring the proper operation, maintenance and repair of the RWH system.

It is necessary that the management of Roof RWH systems is done by the users themselves, unlike design and construction which in many cases are initiated and implemented by experts. The users of Roof RWH systems could be individual households, institutions such as schools, or communities for whom the RWH systems are built for communal use.

The management of RWH systems needs to lay out clear duties and responsibilities in respect of the following items.



- The management arrangement/system and responsibilities;
- Physical safety and protection of the RWH system;
- Maintenance and control of water quality;
- Operation, maintenance and repair of the system; and

Like any other water supply system, it is important that communities should aware of/educated on matters related to hygiene and sanitation. In any case, proper maintenance is an important aspect in the management of RWH systems and needs to include, among others, the following activities;

- Inspection, regular cleaning and minor repair of the whole RWH system; the catchment, the conveyance, the tank and the various tank components such as tap.
- Removal of branches of trees over hanging on roofs. Not only leaves and debris, but also the droppings of birds and small animals contaminate rainwater. Dust and other such dirt also need to be cleaned regularly from the catchment/roof.
- Cleaning and minor repair of the conveyance system (gutters and downpipes/gutters) at least once a year;
- Inspection of water quality in the tank, testing from time to time and treating/disinfecting regularly.
- There should be no opening that allows small animals to enter into the tank; it is therefore necessary to inspect, clean and repair/replace screens and filters. Screens and filters unless cleaned regularly can themselves be a source of water contamination.
- Clean/wash-out accumulated sediment and sludge when necessary; take the opportunity to clean the tank when it is empty.
- There should be no tree growing within 10 m from the tank to protect the foundation from damage/crack by roots searching for moisture underneath.
- Inspect regularly the amount of water in the tank, and compare with demand and abstraction rates.

### **Repair of Rainwater Tanks**

The repair of RWH tanks, unlike maintenance, is not a regular activity; nevertheless, it is one of the most important tasks in the management of RWH systems. The repair of tanks normally



involves locating leakage points and making them water tight. Most of the following remedies are suggested to repair tank leakages:

**(a) Leakage between wall and foundation:** -Many tanks built of masonry leak water through the joint where the wall joins the foundation. The reasons could be insufficient reinforcement, poor mixture of mortar, or lack of cleanlines when the joint was made. The joint can be made watertight by cleaning the joint, adding more reinforcement and making strong in both sides of the joint. The procedure for this is as follows.

- Drain all water out of the tank and clean the floor and the foundation on the outer side of the tank.
- Chisel a groove (on the wall), about 3cm x 3cm, all around the joint on both the interior and external sides of the tank.
- Roughen a 15cm wide stretch of the foundation on both sides of the joint. Clean the joint and the roughened surface with plenty of water.
- Wrap 5 rounds of barbed wire tightly around the tank in the external groove.
- Compact mortar 1:3 into the external and internal grooves with a piece of timber.
- Compact a 15cm wide and 10cm high apron over the external and internal grooves.

**(b) Leakage through a cracked foundation:** -Water may leak through cracks in the foundation. The reasons for this could be soft soil under the foundation, insufficient reinforcement, and poor mixture of concrete or improper curing. The leakage can be sealed by constructing a new foundation onto the old cracked foundation. The procedure is as follows.

- Drain all water out of the tank and clean the floor.
- Fill all cracks with some strong paste.
- Cut sheets of weld mesh to fit the foundation. All overlaps must be at least 20cm and tied together with binding wire for every 10cm.
- Mix concrete (1:3:3). Compact a 7cm thick layer of concrete onto the old foundation.
- Lay the weld mesh on the concrete in the tank.
- Compact a second layer of 7cm concrete onto the weld mesh in the tank.
- Compact a 1cm thick layer of mortar 1:3 onto the concrete.
- The next day, compact a rounded apron into the joint between the new foundation and the wall.



- Keep the foundation moist and under shade for 3 weeks.

**(c) Leakage through walls without cracks:** -Water may leak through the wall of a water tank, although the wall has no cracks. This is due to porosity caused by mortar mixture with insufficient cement, insufficient curing or poor workmanship. The wall can be sealed by replacing the porous parts with mortar. The procedure is as follows;

- Drain all water out of the tank and clean its interior.
- Chisel away the porous parts of the interior wall.
- Clean the chiseled parts with water & throw dry cement onto the watered parts of the wall.
- Mortar of 1:3 and throw a thin layer of it onto the watered parts of the wall.
- Next day, fill up the coated parts with mortar 1:3 and apply with a square steel trowel.
- Should the tank still leak, its internal side has to be painted with a water proofer, such as swimming pool paint, non-toxic bitumen, oil paint or 1 part of cement with 10 parts of lime mixed with water.

**(d) Leakage through cracked walls:** -Water may leak through cracks and fissures in the wall of a water tank. The reason for this could be vertical cracks that are caused by insufficient horizontal reinforcement and/or incorrect joining of bricks and blocks; or horizontal cracks due to incorrect joining between the horizontal courses between bricks and blocks. The remedy for this is to build a new wall on the outside of the cracked tank by wrapping reinforcement mesh or wire around the tank and plastering it. The procedure for this is as follows;

- Drain all water out of the tank and clean it.
- Chisel off any loose part on the external side of the tank wall.
- Tie sheets of weld mesh together with binding wire and wrap them tightly around the tank and plaster the outside of the tank.

**(e) Repair of leaking ferrocement tank walls:** -The repair of ferrocement tanks is relatively easy and involves the following steps;

- Chisel out the damaged area around the leak;
- Wet the whole area to make it really moist;
- Apply new mortar with the same cement to sand ratio as the original;
- Apply a coat of Nil the next day; and



- Cover the patch with plastic sheet and cure for at least for 3 weeks

The key points to remember here are:

- The quality and mix ratio of the material (cement, sand and water) used should be the same as that used for the initial construction; and
- If a different mix ratio or sand type is used, then, there will be differential expansion stresses, and thus a new leak.
- Small leaks in ferrocement tanks are much easier to repair in rainwater tanks.

**(f) Plastic and metal tanks:** -Plastics and metals are harder to repair. It may however be possible to use water tight plastic or rubber liners. Plastic jerry cans are repaired by sealing the leaking points with melted plastic material. Corrugated iron tanks can be lined with cement or ferrocement.

- Mix cement with coarse river sand at a ratio of 1:3
- Smear the mixture onto the inside in 1 cm thick layer and let it dry for a day
- Next day, apply a 2cm thick 1:3 mixture on to the previous layer and smoothen it
- Within the same day, apply Nil (cement slurry) and press it with a trowel onto the plaster
- Keep the oil drum under shade and sprinkle the plaster 3 times a day for a week, then fill up with water

### **3.10 Siting of Roof Catchment Rain Water Harvesting Technologies**

The catchment area is the first point of contact for rainfall. For the vast majority of tank-based rainwater harvesting systems, the catchment area is the roof surface. There are some important factors about the roof to consider when planning for a RWH system:

**Roof Material** – It's important to avoid wood shingles or metal flashing that contains lead.

**Slope** – 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.



**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.

### **3.11 Period/phases for implementation**

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. As the main objectives of harvesting Roof Rainwater is to use the water during the dry seasons and/or during the rain seasons for both domestic and agricultural purposes, the establishments of the system should be as early of the rainy time. Accordingly, it is recommended once during the dry season, & should be finished before the rainy season commences.

### **3.12 Suitability, agro-ecology and adaptability based upon local knowledge**

- More suitable in high rainfall areas for frequent filling of storage reservoirs;
- Suitable for arid and semi-arid areas where rainwater is the most accessible water source

### **3.13 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 is 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.



### **3.14 Potential to increase/sustain productivity and environmental protection**

- . Allows safe disposal of rain water from roofs for direct use
- . Reduce workload of women by availing water at home
- . No effect on environment

#### **Minimum surveying and tools requirements**

- . Pipes
- . Cement
- . Gutters

#### **Min. technical standards**

- Calculate the area of your roof in  $m^2$
- Calculate the average yearly rainfall in mm
- Calculate the cubic meter of roof water (area of roof,  $m^2$  x yearly rainfall, m)
- Establish the size of water tanker, which is equal to the annual volume of water from roof.

### **3.15 Work norm**

It requires skilled manpower in constructing the gutters, pipes and storage tanks.

### **3.16 Integration opportunities/requirements**

This system could be integrated with vegetable gardening and livestock rearing (small scale poultry production).

### **3.17 Institutional responsibility and implementation arrangements**

Individual household are responsible for planning and implementation of the activity. It requires skilled manpower for installation of this system. Responsibility is at household level with support provided by water harvesting experts and Development Agents.

### **3.18 Treatment of Stored Rainwater**

The aim of water treatment is to make water safe (from harmful substances/chemicals and organisms); to make it good in appearance and attractive for human consumption. There are various methods and stages of water treatment which include screening, sedimentation, filtration (with fine granular materials such as sand and gravel), disinfection, and miscellaneous



other treatments to reduce chemical levels, improve taste, hardness etc. The treatment of rainwater is done in the tank itself or after it is drawn and taken home. There is however various newly emerging treatment methods mentioned as follows:-

**(a) Chlorination:** -Chlorination is done either in the tank or after the water is collected and taken home. Chlorine is very effective in killing micro-organisms, but requires care because it can affect the taste of water and over application may cause certain problems.

**(b) Use of filters:** - Sand filters are simple to use and cheap to acquire. They can as well be used at home, but require proper operation and maintenance. They filter fine suspended material and also much of the bacteria, and improve physical qualities such as color, taste and odour.

**(c) Boiling:** -Boiling for two to three minutes makes water free from any harmful bacteria. But it is not always a practical option as it requires of fuel, and needs waiting for the water to cool.

**(d) Sunlight:** -Putting water in clear glass or plastic bottles, and placing it in direct sunlight for several hours kills both bacteria and other microorganisms.



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