NATURAL RESOURCES CONSERVATION AND DEVELOPMENT

Level-II

Learning Guide-62

Unit of Competence: Identify Different Water Sources and Irrigation Methods

Module Title: Identifying Different Water Sources and Irrigation Methods

LG Code: AGR NRC2 M14 L61 L01-LG-61

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LO2: Identify water harvesting Techniques

Instruction Sheet	Learning Guide #62

This learning guide is developed to provide you the necessary information regarding the following **content coverage** and topics:

- Choosing/identifying water harvesting technique
- Recognizing and applying water harvesting techniques
- Identifying and select materials, tools and equipment
- selecting shading & lining materials

This guide will also assist you to attain the learning outcome stated in the cover page. Specifically, **upon completion of this Learning Guide, you will be able to**:

- Choose/identify water harvesting technique
- Recognize and apply water harvesting techniques
- Identify and select materials, tools and equipment
- select shading & lining materials

Learning Instructions:

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described below 3 and 4.
3. Read the information written in the information "Sheet 1, Sheet 2, Sheet 3 and Sheet 4
4. Accomplish the "Self-check 1, Self-check 2, Self-check 3 and Self-check 4," **in page -7, 10, 12 and 20** respectively.

Information Sheet-1	Choose/identify water harvesting technique

1.1 Definitions

Water harvesting in its broadest sense will be defined as the "collection of runoff for its productive use". Runoff may be harvested from roofs and ground surfaces as well as from intermittent or ephemeral watercourses. Instead of runoff being left to cause erosion, it is harvested and utilized. In the semi-arid drought-prone areas where it is already practiced, water harvesting is a directly productive form of soil and water conservation. Both yields and reliability of production can be significantly improved with this method.

Water harvesting (WH) can be considered as a rudimentary form of irrigation. The difference is that with WH the farmer (or more usually, the agro-pastoralist) has no control over timing. Runoff can only be harvested when it rains. In regions where crops are entirely rain fed, a reduction in the seasonal rainfall, for example, may result in a total crop failure. If, however, the available rain can be concentrated on a smaller area, reasonable yields will still be received. Of course in a year of severe drought there may be no runoff to collect, but an efficient water harvesting system will improve plant growth in the majority of years.

The term rainwater harvesting and management for food security is used to encompass all practices of rainwater collection, storage and re-utilization for agriculture, especially crop and livestock production (Rockström et al., 2001; Ngigi et al., 2005; Biazin et al., 2012). Among them, supplemental and off-season small-scale irrigation, spate irrigation, and other practices to increase soil moisture and shallow groundwater recharge.

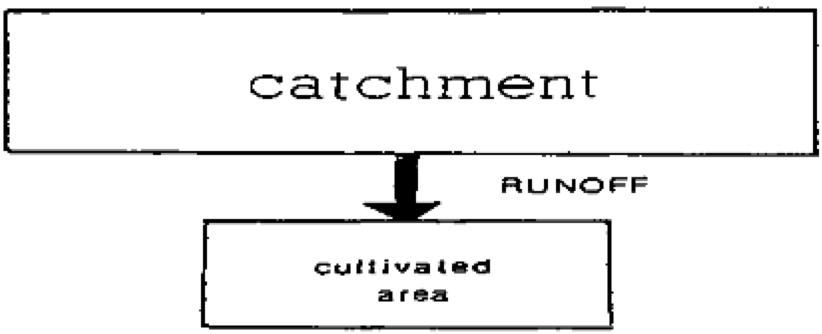


Fig. 1 principle of water harvesting

Why harvest water?

Water resources are limited, and water is becoming a scarce commodity due to increased demand in proportion to a rapidly increasing global population, industrialization, urbanization, and global climate change. Conservation of water resources is necessary, and water harvesting techniques are important conservation tools. Water harvesting refers to all activities used to collect available water resources, to temporarily store excess water for use when required—e.g., in times of drought. Water can be collected from natural water sources, such as rain, fog, runoff, or wastewater. Specifically, rainwater harvesting is the technique of collecting and storing rainwater in surface or sub-surface aquifers before it is lost as surface runoff. This technique is important in areas with significant rainfall but that lack a conventional, centralized supply system.

Rainwater harvesting is particularly important in urban areas, where rapid urbanization has resulted in decreased infiltration of rainwater into the subsoil, reducing groundwater recharging. In this context, rainwater harvesting is essential to meet the demands of water for domestic use, livestock, and groundwater aquifer replenishment. Harvesting from rooftop catchments and groundwater recharging should be made mandatory in urban areas. Areas experiencing extreme rainfalls require good flood protection and diversion structures, while areas prone to extreme drought require significant storage capacity, the securing of alternative water resources, and rationing schemes developed well in advance.

Benefits of water Harvesting:-

- Improvement in the quality of ground water
- Rise in the water levels in wells and bore wells that are drying up
- Mitigation of the effects of drought and attainment of drought proofing
- An ideal solution to water problems in areas having inadequate water resources
- Reduction in the soil erosion as the surface runoff is reduced
- Decrease in the choking of storm water drains and flooding of roads
- Saving of energy, to lift ground water. (One-meter rise in water level saves 0.40-kilowatt hour of electricity)

1.2 Rainwater Harvesting System Components

1.2.1 Catchments surfaces

There are three common systems used to collect water for domestic use:

- ✓ roof catchments,
- ✓ ground catchments and
- ✓ Rock catchments.

1.3 Classification of Rainwater Harvesting Techniques

1.3.1 Micro catchments rainwater harvesting

1.3.2 Macro catchment (External catchment systems) rainwater harvesting

1.3.3 In-situ (Floodwater farming) floodwater harvesting

1.3.1 Micro catchments rainwater harvesting

Collection of surface runoff from small catchment areas with water storage in the soil for rain fed agriculture and/or dry-spell mitigation. According to Biazin et al. (2012), a micro-catchment rainwater harvesting system collects runoff within the farm boundary from relatively small catchment areas from 10 m2 to 500 m2. The most commonly applied micro-catchment rainwater harvesting techniques in sub-Saharan Africa include pitting, contouring, terracing and micro-basins (Motsi et al., 2004; Nyamangara and Nyagumbo, 2010; Biazin et al., 2012; Malesu et al., 2012; Nyamadzawo et al., 2013). These types of technologies are more widely implemented in Ethiopia and Kenya as compared to Zimbabwe and Mozambique. Figure 3 shows two examples of micro catchment systems, i.e. terraces and infiltration trenches. Sometimes referred to as "Within-Field Catchment System"

Main characteristics:

- ✓ Overland flow harvested from short catchment length
- ✓ Catchment length usually between 1 and 30 meters
- ✓ Runoff stored in soil profile
- ✓ Ratio catchment: cultivated area usually 1:1 to 3:1
- ✓ Normally no provision for overflow
- ✓ Plant growth is even

Typical Examples:

- ✓ Negarim Micro catchments (for trees)
- ✓ Contour Bunds (for trees)
- ✓ Contour Ridges (for crops)
- ✓ Semi-Circular Bunds (for range and fodder)

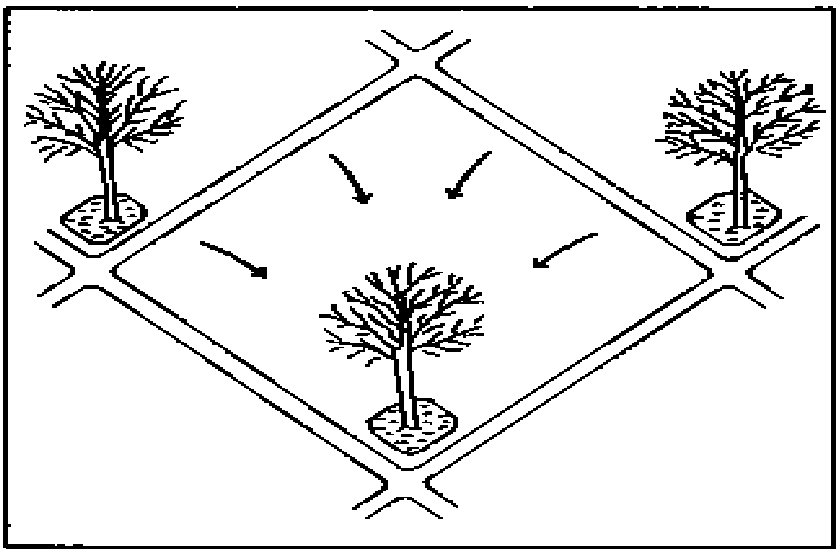


Fig.2 Micro catchment system: Negarim micro catchment for trees
(Source: Critchley and Reij 1989)

Figure 3: Micro-catchment RWH systems (terraces -left- and trenches -right-) that are infiltrating rainwater and higher shallow groundwater levels in Ethiopia. Photo. B. Simane.

1.3.2 Macro catchment (External catchment systems) rainwater harvesting

Collection of surface runoff from large catchment areas with water storage for supplementary and/or off-season irrigation, spate irrigation, and/or livestock watering. This type of technologies collects surface runoff from external catchments and stores it for further use during dry periods (Hatibu et al., 2000; Biazin et al., 2012). Rainwater/ runoff are collected from existing paved surfaces (e.g. roads and/or rooftops) and natural slopes and/or streams and at a lower extent from purpose-built structures (Biazin et al., 2012). The components of the system, the storage volume, and the catchment type and area, depend on the local rainfall pattern and soil types (Studer and Liniger, 2013). Figures 4 and 5 show two examples of macro-catchment systems, a sand storage dam connected to a gravity low-cost irrigation system and an on-farm pond RWH system, respectively. Referred to as Long Slope Catchment Technique.

Main Characteristics:

- ✓ Overland flow or rill flow harvested
- ✓ Runoff stored in soil profile
- ✓ Catchment usually 30 - 200 meters in length
- ✓ Ratio catchment: cultivated area usually 2:1 to 10:1
- ✓ Provision for overflow of excess water
- ✓ Uneven plant growth unless land leveled

Typical Examples:

Trapezoidal Bunds (for crops)

Contour Stone Bunds (for crops)

Fig.4. a sand storage dam connected to a small-Scale irrigation system in Kenya. Photo: J. de Trincheria.

Fig. 5: A RWHI system based on a farm pond is complemented by other micro-catchment and in-situ RWH management technologies in Kenya. Photo: A. Oduor.

Rooftops: If buildings with impervious roofs are already in place, the catchment area is effectively available free of charge and they provide a supply at the point of consumption.

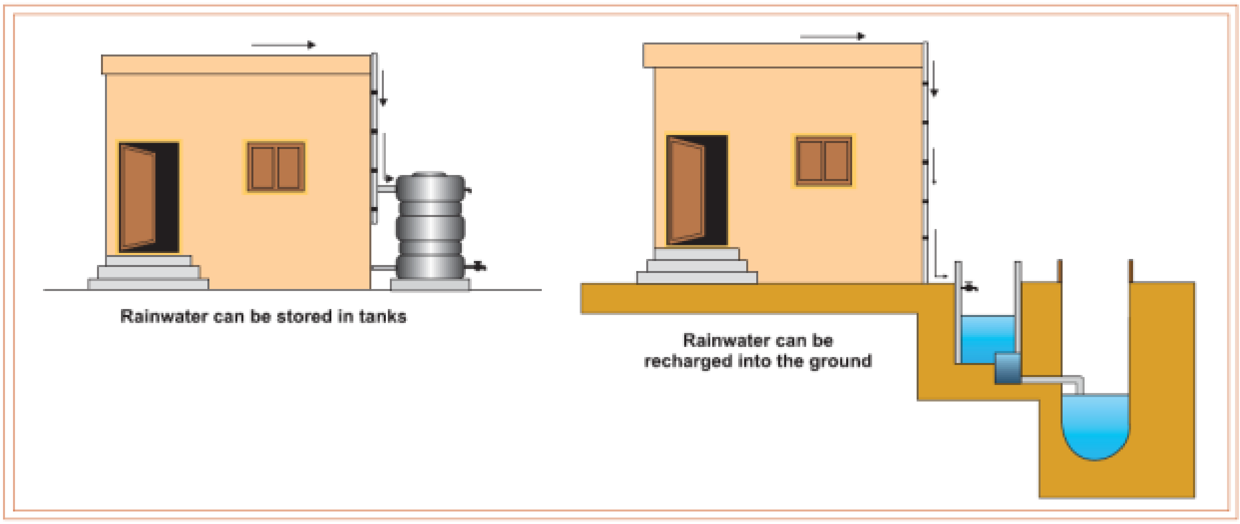


Fig. 8 Rooftops water harvesting

1.3.3 In-situ (Floodwater farming) floodwater harvesting

Techniques applied in the crop area in order to maximize infiltration, reduce surface runoff and soil evaporation, and improve soil fertility and water availability. In-situ systems involve the use of practices that increase infiltration, reduce runoff and evaporation, and improve soil moisture directly in the crop rooting zone by trapping and holding the rain where it falls (Hatibu et al., 2000; Ngigi, 2003; Gebreegziabhert et al., 2009; Nyamangara and Nyagumbo, 2010). These techniques do not generally need at enhancing rainfall infiltration and reducing soil evaporation.

The most commonly applied in-situ rainwater harvesting practices in sub-Saharan Africa include ridging, mulching, various types of furrowing and hoeing, and conservation tillage (Biazin et al., 2012). Figure 6 and 7 shows two examples of in-situ systems. Often referred to as "Water Spreading" and sometimes "Spate Irrigation"

Main Characteristics:

- turbulent channel flow harvested either:-
    - ✓ by diversion or
    - ✓ by spreading within channel bed/valley floor
- Runoff stored in soil profile
- catchment long (may be several kilometers)
- ratio catchment: cultivated area above 10:1
- provision for overflow of excess water

Typical Examples:

- ✓ Permeable Rock Dams (for crops)
- ✓ Water Spreading Bunds (for crops)

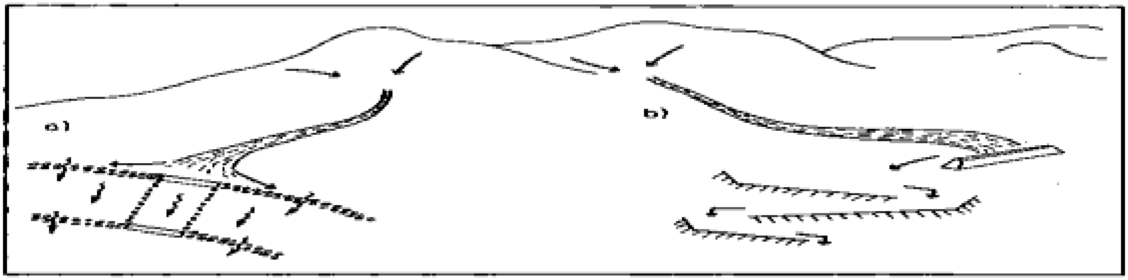


Fig.6. Floodwater farming systems: (a) spreading within channel bed;
(b) diversion system

Figure 7: Mulching (right) and runoff collection with furrows (left). Source: (Studer and Liniger, 2013).

Self-Check -1	Written Test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

1. Define Water harvesting?(5pts)
2. What are the type and characteristics of water harvesting techniques? (10 pts.)

Note: **Satisfactory rating 15 points** **Unsatisfactory - below 15 points**

You can ask you teacher for the copy of the correct answers.

Answer Sheet

Score = ____________

Rating: _____________

Name: ___________________________ Date: ________________

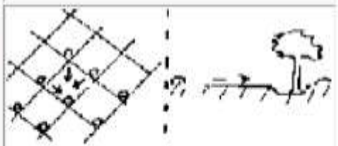
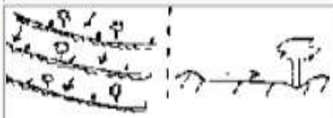
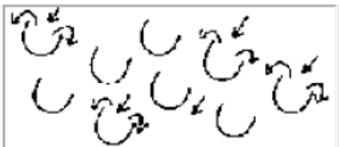
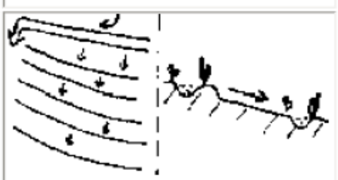
Information Sheet-2	Recognizing and applying appropriate water harvesting techniques

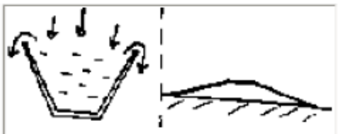
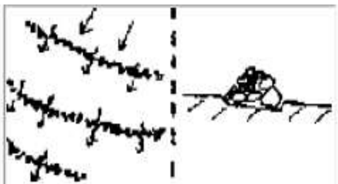
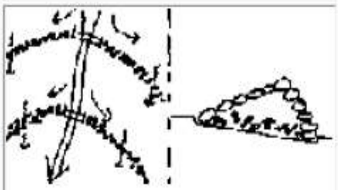
2.1 Overview of main Water Harvesting (WH) systems

Appropriate Water harvesting techniques is recognizing and applying based on applicability and adaptability.

The eight techniques presented and explained in this information sheet are not the only water harvesting systems known which will be applied but they do represent the major range of techniques for different situations and productive uses. In a number of cases, the system which is described here is the most typical example of a technique for which a number of variations exist - trapezoidal bunds are a case in point.

Summary chart of main WH techniques

	Classification	Main Uses	Description	Where Appropriate	Limitations	
negarim microcatchments	microcatchment (short slope catchment) technique	trees & grass	Closed grid of diamond shapes or open-ended "V" s formed by small earth ridges, with infiltration pits	For tree planting in situations where land is uneven or only a few tree are planted	Not easily mechanised therefore limited to small scale. Not easy to cultivate between tree lines	
contour bunds	micro catchment (short slope catchment) technique	trees & grass	Earth bunds on contour spaced at 5-10 metres apart with furrow upslope and cross-ties	For tree planting on a large scale especially when mechanised	Not suitable for uneven terrain	
semi circular bunds	micro catchment (short slope catchment) technique	rangeland & fodder(also trees)	Semi-circular shaped earth bunds with tips on contour. In a series with bunds in staggered formation	Useful for grass reseeding, fodder or tree planting in degraded rangeland	Cannot be mechanised therefore limited to areas with available hand labour	
contour ridges	microcatchment (short slope catchment) technique	crops	Small earth ridges on contour at 1.5m -5m apart with furrow upslope and cross-ties Uncultivated catchment between ridges	For crop production in semi-arid areas especially where soil fertile and easy to work	Requires new technique of land preparation and planting, therefore may be problem with acceptance	

trapezoidal bunds	external catchment (long slope catchment) technique	crops	Trapezoidal shaped earth bunds capturing runoff from external catchment and overflowing around wingtips	Widely suitable (in a variety of designs) for crop production in arid and semi-arid areas	Labour-intensive and uneven depth of runoff within plot.	
contour stone bunds	external catchment (long slope catchment) technique	crops	Small stone bunds constructed on the contour at spacing of 15-35 metres apart slowing and filtering runoff	Versatile system for crop production in a wide variety of situations. Easily constructed by resouce-poor farmers	Only possible where abundant loose stone available	
permeable rock dams	floodwater farming technique	crops	Long low rock dams across valleys slowing and spreading floodwater as well as healing gullies	Suitable for situation where gently sloping valleys are becoming gullies and better water spreading is required	Very site-specific and needs considerable stone as well as provision of transport	
water spreading bunds	floodwater farming technique	crops & rangeland	Earth bunds set at a gradient, with a "dogleg" shape, spreading diverted floodwater	For arid areas where water is diverted from watercourse onto crop or fodder block	Does not impound much water and maintenance high in early stages after construction	

Source: - http://www.fao.org/docrep/U3160E/u3160e03.htm (12 von 13) [15.05.03 10:02:07]

Self-Check -2	Written Test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

1. On what criteria we have to depend to recognize and apply Appropriate Water harvesting techniques? (5pts).

Note: **Satisfactory rating 5 points** **Unsatisfactory - below 5 points**

You can ask you teacher for the copy of the correct answers.

Answer Sheet

Score = ___________

Rating: ____________

Name: _________________________ Date: _______________

Information Sheet-3	Identify materials, tools and equipment

3.1 Materials, tools and equipment for Water harvesting work

There is no universally best material for catchment and storage. The cost of alternative water sources and the importance of the water supply determine the costs which can be justified in a system. Ordinarily, the lowest cost of locally available materials is used. Usually, water-harvesting systems for supplying drinking water are constructed from materials which are more costly than can be economically justified for run off-farming applications. One must balance the cost of materials to the cost of labor. Some materials and installation techniques are labor intensive, but have a relatively low capital cost. Other materials may be higher in initial cost, but require minimum labor for proper construction.

Materials, tools and equipment for Water harvesting work May include, but not limited to:-

- ✓ Tape meter, staff, clinometers, Global positioning system, compass, Auger, core sampler, spatula, oven, pressure apparatus, sensitive balance, sieve, soil grinder, hydro meter, shaker and measuring cylinder, thermometer, stop watch,
- ✓ Line level, chaining pins, ranging pole, flasks, shovel, rakes, spades, rope, plumb bob, hoe, Tracing paper, pencil, graph paper, fixer, topographic map, drawing compass set.

Materials for Rooftop Water harvesting may include:

The different types of materials used to construct tanks include Ferro cement, bricks and blocks, concrete, metal, plastic, wood and fiber glass.

Storage tank materials should prevent or minimize light penetration to reduce algal growth and other biological activity, which helps maintain water quality. For this reason, clear plastic or clear fiberglass tanks are not recommended for use. In hot climates water stored in thinner walled plastic or metal tanks will tend to heat up, particularly if the tanks are not shaded, and for this reason some consumers express a preference for thicker walled Ferro cement or concrete tanks.

Whichever material is chosen, in order to ensure that tanks are durable, good quality, clean construction materials must be used. Poor selection of materials, poor mixing and poor workmanship are all common causes of problems in completed water tanks. A solid foundation is also essential for aboveground rainwater tanks.

Self-Check -3	Written Test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

1. Discuss the Appropriate Materials, tools and equipment for Water harvesting work (10pts).

Note: **Satisfactory rating 5 points** **Unsatisfactory - below 5 points**

You can ask you teacher for the copy of the correct answers.

Answer Sheet

Score = ___________

Rating: ____________

Name: _________________________ Date: _______________

Information Sheet - 4	Identify shading & lining materials

4.1 Shading & Lining Materials

Rain Water harvesting is the artificial collection, storage and use of runoff or rain water. The water harvesting with tanks and ponds is one option to increase water availability and agricultural production at the household level. There are different kind of lining and shading materials that can improve storage efficiency of rainwater harvesting ponds. Some of them are: - Clay soil lining, Soil + cement lining, Table salt treated pond and Geo-membrane. On Luvisols four types of pond lining techniques were tested (clay lining (15cm thick), soil + cement lining (1:5 ratio), Table Salt (at a rate of 2kg/m2) lining, and Geo-membrane). But on the Vertisols only two lining materials were taken (i.e. Clay lining (15cm thick), salt lining (at a rate of 2kg/m2)). In both cases unlined pond was included as a control. Required data on daily variation of storage depth and water temperature was continuously monitored throughout the experimental period. Based on the result of analysis, the variation in storage efficiency was seen only in Luvisols. Application of salt considerably improved storage in these types of soils. But in Vertisols storage efficiency didn't show improvement with application of salt. Regarding the change in temperature, no significant variation was seen between treatments on both types of soils. Geo-membrane was also proved to have not as such significant change in temperature as compared to the other treatments. Furthermore, the cost of labour and salt is by far smaller for salt treated ponds than the other treatments. Application of salt improved storage efficiency of pond from 0.24 to 0.87 on Luvisols. Moreover, the cost of the pond is smaller as compared to other treatments.

The water harvested in the reservoir and farm ponds is a very scarce resource. All care should be taken to prevent any kind of loss of this harvested water.

Two major forms of losses of this water are:-

i. evaporation losses and
ii. Seepage losses.

4.1.1 Techniques for Reduction of Evaporation Loss from Pond

It is observed that the evaporation loss during summer months of May and June is 2-5 times more than that during winter months of December and January. Evaporation is a surface phenomenon and hence, the first step to reduce evaporation loss can be achieved by reducing the surface area of the pond or the reservoir. For example, a pond with greater depth of stored water and lesser surface area would evaporate less as compared to a shallow pond with large surface area subject to both the ponds having same volume of stored water.

- **Vegetative Shade**

An attempt to develop shade on the water surface by growing vegetation over the open surface of the water body is called vegetative shading. In this practice, the open surface of the pond is covered with canopy of creepers like bottle gourd (lagenaria siceraria), pumpkin, bitter gourd and cucumber etc. such that the surface water is shaded and prevented from the direct contact of sun light. The creepers are planted on the embankment and allowed to creep towards the center of the pond on a wooden platform laid across the pond. The platform is made of hardy plants like bamboo tied in a criss-cross manner. When the canopy growth covers the entire open surface of the pond, a shade is formed over the water surface and the sunlight coming onto the water is reflected back due to the albedo effect of the green leaves. Thus, the driving force for causing evaporation i.e. solar radiation is deflected and evaporation loss is reduced. This method of growing creepers on platform over the open surface of the pond is better than the attempt of reducing evaporation loss by growing floating aquatic plants as in case of latter the plants consume a lot of water from the pond to meet their transpiration requirements.

- **Monomolecular Film**

It is a film of one molecule thick also called as monolayer. Chemicals either in the form of powder or solution is spread over the water surface which deflects the energy input of the sun as a result of which evaporation is reduced. Alcohols such as cetyl alcohol [CH3 (CH2)15OH] also called as hexadecanol and stearyl alcohol (octodecanol) are used to form a monomolecular film on contact with water which is sufficiently enduring in field conditions. The invisible film is non-toxic in nature and reduces evaporation by 50-60% at an average wind speed of 16.55 km/hr. The advantage of this film is that it is not opaque and so, does not restrict the path for movement of rainwater, oxygen and sun light through the water surface. However, the limitation of these monomolecular films is that they get diluted in water quickly and then become ineffective to reduce the evaporation of water.

- **Wind Breaks**

Increased turbulence on the water surface is one of the factors to accelerate evaporation loss from the water body. Wind action is solely responsible for such turbulence on water surface. Hence, continuous wind or wind at high speed over the pond or reservoir is likely to increase the evaporation loss. In such cases, developing wind breaks, a physical barrier to oppose the wind blow, by growing tall trees at close spacing around farm pond is expected to minimize the turbulence effect and reduce the evaporation loss. But these wind breaks are useful only for small ponds. It is found out that a reduction of wind velocity by 25% can reduce the pond evaporation loss by only 5%. It indicates that the measure is not very much effective in reduction of evaporation loss.

- **Covering Pond Water with Shading Materials**

Like vegetative shading, many other artificial materials or sheets can be used as effective barriers to prevent the direct sun light coming onto the water surface and thereby, reduce the evaporation loss. Such shading materials may be plastic films, thatches, paddy straw, sugarcane trash etc. When they are used to cover the water surface, the sun light cannot penetrate through and consequently, the evaporation loss is reduced. However, the effectiveness of the shading material in reducing evaporation from the pond depends on its quality and the percentage cover of the open surface area of the pond. Evaporation loss is likely to come down to minimum under complete coverage (100%) of the open surface and thus, partial coverage would have reduced effect on evaporation rate of the pond.

Some other shading materials used for reduction of evaporation loss is dye mixed with pond water, plastic mesh and sheet, polystyrene beads and sheet, white spheres and white butyl sheet etc. Out of these materials, polystyrene raft, plastic sheet and foamed butyl rubber are the best ones since they are reported to reduce the evaporation loss by more than 90%. However, these materials are very expensive and unlikely to make the project cost effective. Therefore, these materials are not applied for reducing evaporation loss from on-farm ponds instead they are used in drinking water projects to reduce evaporation loss.

4.1.2 Methods to Reduce Seepage Losses in Farm Pond

Harvested water in on-farm ponds in water scarce areas is a precious commodity and care should be taken to conserve it for a longer period with minimum loss. Two major means of the loss of harvested water from such ponds are evaporation and seepage. Most of the ponds used for irrigation purpose are unlined and without any measure to reduce evaporation loss. However, the loss due to seepage is more pronounced than that due to evaporation. A study reveals that seepage loss in unlined ponds accounts for about 45% of the total storage and the evaporation loss accounts for only 25% (Guerra et al., 1990). This loss is significant when the pond is underlain by porous strata or when the bed material of the pond consists of coarse textured soil. Small farm ponds constructed in coarse texture soils; especially in arid and semi-arid regions are found to get dry completely just after the withdrawal of monsoon. However ponds constructed in heavy soils are found to have less seepage losses. In general the seepage loss in unlined small farm ponds depends upon the water table position below the ground surface, soil type at the site of excavation and hydraulic gradient available between the pond water level and water level of adjacent areas. It is observed that the seepage loss in newly constructed pond is very high and it decreases gradually with progress of time as silt deposition takes place in the pond.

Seepage loss from farm ponds can be reduced broadly by two ways.

They are:-

(i) Reducing wetted surface area of the pond and

(ii) Using a cost effective sealant.

- **Reducing Wetted Surface Area of Pond**

Seepage from the pond increases with increase in wetted area of a pond. Hence, special considerations must be given to minimize the wetted area per unit of storage capacity during design of the pond. This may be achieved by making the side slopes steep and/or decreasing the depth of the pond. In case of large ponds, division of the pond into two or more compartments also helps in reduction of seepage loss. By doing so the wetted area and top water surface area of the pond are considerably reduced resulting in reduction of seepage and evaporation loss, respectively, to a great extent.

- **Use of Sealants**

A newly constructed pond has self-sealing property by deposition of silt. The runoff of the catchment carries some silt and clay which gets deposited in the side and bottom of the pond and clogs the pore spaces of the soil. Consequently, the flow through the side and bottom of the pond is reduced and seepage loss is checked. Studies conducted at Dehradun and Rajkot of India reveal that seepage from a newly dug out pond reduced to a very low rate due to silting in a period of 8 years. Silting also reduces seepage rate in brick lined pond.

A simple way to reduce water seepage, particularly if the pond bottom is very dry, hard and has open cracks in it, is to break the soil structure of the pond bottom before filling the pond with water. This is common practice is called puddling. It is accomplished through making the pond bottom saturated with water, allowing the water to be soaked into soil just enough to permit working and then, breaking the soil structure by puddling with a plough.

A number of sealants/lining materials are now available to reduce the seepage loss. Lining of the pond, though costly, can reduce the seepage loss and improve the effective storage of the pond.

Different lining materials used to reduce the seepage loss are plastic film, soil cement lining, bitumen lining, clay lining, cow dung lining, brick cement lining etc. Lining with brick masonry or cement mortar lining is most expensive but effective among them. Lining for reduction of seepage losses is feasible only for small pond. Descriptions of a few lining materials used for seepage control in the pond are given below.

- **Clay Lining**

Natural clay can be used for lining with varying degree of efficiency, especially when lower cost is desirable. Clay lining can be applied in two methods:(i) by placing a blanket of relatively impervious clay of 15-30 cm thick over or within the permeable bed and slides of the pond and (ii) by dispersing clay in the water to form clay mud and filter it out to seal off the pores in the permeable sides and bottom of the pond. Alkali soils having poor infiltration rates, if available in the vicinity of the pond can be preferred for lining to control seepage in farm ponds. Burnt clay tiles can also be used as lining material for reducing seepage loss. Percentage of saving of water due to seepage by these tiles is about 98.8% more than the earthen materials. Studies reveal that a lining of soil cement plaster at ratio 5:1 is ideal from the points of cost and efficiency. For good results, the mixture of soil and cement should be mixed well, laid out and compacted. It should be cured for seven days with moist soil cover. The limitation of this lining material is that, it is not weather resistant its life is comparatively short and repair and maintenance cost is relatively higher.

- **Cement Concrete Lining**

Cement concrete lining to reduce seepage loss is stronger and more stable than any other lining material. Though the initial investment for such lining is more, its repair and maintenance cost is very less and it gives long service. Concrete mixture usually recommended for lining is 1:3:4 (cement: sand: gravel) with 4–5 cm thickness. The sides and bottom of the structure should be compacted at suitable moisture content. When concrete hardens, it shrinks resulting in development of cracks. Apart from adequate curing, joints must be provided at a distance of 2 m in order to localize and control the cracks. Cement concrete lining can withstand higher velocity of flow (>2.5 m/sec) because of its greater resistance to erosion and is therefore preferred to any other type of lining.

- **Asphalt Lining**

Asphalt also known as bitumen is sticky, black in colour and highly viscous liquid or semi-solid form of petroleum. It acts as a binding material in road construction. When it is mixed with sand and gravel, it forms asphalt concrete and this is used as a lining material in ponds. Asphalt concrete lining is cheaper than cement concrete lining. Its life span ranges from 10-20 years. There are two types of prefabricated asphalt melts found to be promising in seepage control. They are (i) Gunny (coarse sack cloth made of jute) reinforced asphalt melt and (ii) Synthetic cloth reinforced asphalt melt. Between the two, the former has proved to be a better lining material in terms of reducing seepage loss from ponds.

- **Brick Lining**

In brick lining, the bricks are joined together with soil cement plaster. It requires relatively less investment as compared to cement concrete ling. Brick lining is easier to construct and requires less technical knowledge. It requires less cement as compared to concrete lining and can be laid out without use of any machinery. However, it is not that effective in seepage control as compared to cement concrete lining.

- **Bentonite Lining**

Bentonite is fine textured colloidal clay with as much as 90 per cent of montmorillonite. There are two types of bentonite; high swelling and low swelling. While sodium is the main constituent in high swelling bentonite, calcium makes it for low swelling one. When exposed to water, dried bentonite absorbs several times its own weight of water; at complete saturation, it swells as much as eight to twenty times its original dry volume. The dry bentonite is mixed with the top 15 cm soil layer thoroughly at a rate of 5 – 15 kg/m2. The advantages of bentonite lining are its low cost, easy installation procedure and long lasting solution to excessive seepage. Main disadvantages of this lining are listed below:

- ✓ it is more laborious to apply than a butyl membrane
- ✓ it can be disrupted by cattle or eroded by running water
- ✓ burrowing animals such as crayfish or crabs can make rupture in such lining bentonite treatment is not advisable in highly alkaline soils

- ➢ **Alkali Soil Lining**

Application of alkali soil lining in small ponds is observed to be an effective lining material to reduce seepage loss. In this practice, a layer of alkali soil of about 5 cm thickness is spread on the sides and bottom of the pond for effective seepage control.

- ➢ **Soil Deflocculants**

A deflocculant is a chemical additive to prevent a colloid from coming out of suspension. It is used to reduce viscosity or prevent flocculation and is sometimes called a dispersant. Soil deflocculants like sodium carbonate, sodium chloride, and tetrasodium polyphosphate and sodium tripolyphosphate are used for reducing permeability of pond surfaces. Sodium chloride and sodium polyphosphate perform effectively up to 6 and 8 months, respectively.

- ➢ **Gleization**

When the pond bottom is too permeable, it is required to create an impervious biological plastic layer in the bottom and on the sides of the pond in order to reduce seepage loss. Such an impervious layer is called a gley, and the process of its formation is called gleization. Step by step procedure of gleization is as follows:

The pond bottom is prepared by clearing it of all vegetation, sticks, stones, rocks and filling all cracks, crevices and holes with well-compacted impervious soil.

Cleaned surface is completely covered with moist animal manure spread in an even layer about 10 cm thick.

The manure is covered completely with a layer of vegetal material, preferably broad leaves of banana. Dried grass, rice straw, soaked cardboard or paper, etc. can be used for this purpose.

- ✓ A layer of soil about 10 cm thick is placed over the vegetal cover.
- ✓ All the materials are moistened and compacted properly.
- ✓ Fill up the pond with water slowly.

- **Chemical Sealants**

U.S Bureau of Reclamation studied many chemicals including resins, silicones, linings but none was found suitable in seepage control. Even cationic asphalt emulsion, petroleum emulsion and resinous polymers were tested and found to be short lived and affected by wetting, drying and erosion.

- **Polythene Lining**

Currently, low-density polyethylene (LDPE) sheets, cross laminated plastic tarpaulins of various thicknesses are widely used as lining materials in ponds to reduce seepage loss. Careful placing and burying of the polyethylene sheet under at least 15 cm thick soil layer gives full proof sealing and long expected life. LDPE lining is a cheap and effective measure for reducing seepage loss from unlined water harvesting structures. All India Coordinated Research Project for Dryland Agriculture, Hyderabad, India reported that 91% of seepage loss can be controlled by lining the tanks with LDPE sheets under brick load on the steps (Vijayalakshmi et al., 1982). Another study reveals that with 600 gauge LDPE sheet covered by 20 cm thick soil layer on sides and bottom the seepage loss reduced to 7 L m-2 day-1 (Gajriet al. 1983). Combination of LDPE sheet (800 gauge thickness) at the bottom and 75 mm thick brick cement lining on the sides of the pond can reduce the seepage loss from 520 to 12.71 L m-2 day-1 (Verma and Sarma, 1990).

However, it is important to note that before using any lining materials for seepage control in the pond, the economic analysis relating to the life of the pond and cost of lining materials must be taken into account. At the same time, the amount of irrigation water saved by reduction of seepage loss and use of the same in increasing the crop production and other associated benefits must also be considered to assess the economic feasibility of the technology.

Self-Check - 4	Written Test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

1. Discuss the Appropriate shading and lining for Water harvesting work (10pts).

Note: **Satisfactory rating 10 points** **Unsatisfactory - below 10 points**

You can ask you teacher for the copy of the correct answers.

Answer Sheet

Score = ___________

Rating: ____________

Name: _________________________ Date: _______________

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