MODULE 8

WATER CONSERVATION TECHNIQUES

The topics covered in this module are:

- Rainwater Harvesting (RWH): Need, basics and advantage
- Use of harvested water
- Recommended structures
- Sample estimation of harvested water
- Farm ponds
- Example of design of a farm pond

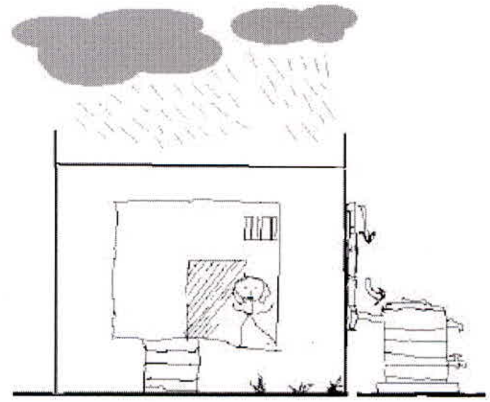
OBJECTIVE (S) OF THE MODULE

The trainer informs the following module objectives to participants:

- Provide a detailed understanding on the overall concept of rainwater harvesting.
- Present the basic required knowledge for undertaking rainwater harvesting.
- Suggest methods of suitable structure in urban as well as rural areas.

RAIN WATER HARVESTING (RWH): NEED, BASICS AND ADVANTAGES

Rain water is the purest form of water available on the earth. Rainwater Harvesting is the process of collecting and storing rain drops and preventing runoff, evaporation and seepage for its efficient utilization and conservation. Rainwater Harvesting is an effective tool option to collect the rain water and store it appropriately. Harvesting of rainwater makes utilization a large quantity of good quality water which would otherwise go to waste creating several problems on the way.


RWH Technique

Rainwater Harvesting is a simple, economical and eco-friendly technique of preserving every drop of water falling on the earth. There is no village in India that cannot meet its basic drinking, cooking and reasonable irrigation needs through Rainwater Harvesting. It is not a new term, rather it is the technology which has also been used by our ancestors, since centuries. Rainwater Harvesting prevents rainwater from going to waste as run-off through conserving it for recharge of groundwater or for storage in tanks. Our ancestors used to harvest the rain directly. From rooftops, they collected water and stored in tankas built beneath the house as in Gujarat and Rajasthan. From open lands, they collected rain and run-off, stored it in kundis and johads as in Rajasthan and in madakas as in parts of Karnataka and Kerala.

NEED

Our country being one of the richest nations in the world in terms of average rainfall (average rainfall is about 119 cm); there is no reason why we should suffer from water crisis. It dosen't matter how much rain you get, rather the question is how much of it you are using for harvesting? The following are the benefits of rainwater harvesting:

- To raise the water levels in wells and bore wells that are drying up
- To improve the water quality of aquifers (groundwater quality)
- To overcome the inadequacy of surface water to meet our demands and to enhance availability of groundwater.
- To increase infiltration of rain water in the subsoil which has decreased drastically in urban areas due to paving of dilution

ADVANTAGES

- Stops water-logging
- Reduces flood hazards
- Direct solution to drinking water crisis
- Mitigates effects of drought
- Rise in groundwater tables
- Reduction in power consumption as one-meter rise in water level saves about 0.40 kilowatt/hour of electricity while pumping groundwater
- Ground water is not directly exposed to evaporation and pollution
- Storing water under ground is environmentally friendly

- Reduces soil erosion

POTENTIAL AREAS

- Areas where groundwater table is falling rapidly
- Areas where availability of groundwater is inadequate
- Areas where rapid urbanization has reduced the recharging of groundwater drastically

DESIGN CONSIDERATIONS

Important aspects for designing a rainwater harvesting system to augment ground water resources are:

- Hydrogeology of the area including nature and extent of aquifer, soil cover, topography, depth to water level and chemical quality
- The availability of source water, the prime requisite for groundwater recharge, assessed in terms of non-committed surplus monsoon runoff
- Area contributing to run off, such as area available, land use pattern, industrial, residential, green belt, paved areas, roof top area etc.
- Hydrometerological characteristics such as rainfall duration, general pattern and intensity of rainfall

SAVING RAIN WATER - SOME METHODS

Urban Areas:

In urban areas, rain water available from roof tops of buildings, paved and unpaved areas goes waste. This water can be recharged to aquifer, collected in tanks and can be utilized gainfully at the time of need. The Rainwater Harvesting system needs to be designed in a way that it does not occupy large space for collection and recharge system.

The method of utilizing the rain that falls on roof is called Roof Water Harvesting. There are two main methods of Roof Water Harvesting. In areas where there is no possibility of getting water in summer, harvested rain can be stored in tanks in advance for direct use. The tank may be above ground or underground. Another method is to use the harvested rain from the roof to recharge groundwater. If you have a dug-well or bore-well in your compound, there is every likelihood that the water level in the well will increase. The basic objective of rain water harvesting in this method is to increase the reducing water table.

Rural areas:

The rural people of this country have a strong tradition of Rainwater Harvesting. The names of the natural water resources structures may differ from state to state but from Laddakh to Kanyakumari, people conserve water. In rural areas, rain water harvesting is undertaken by considering the whole watershed as a unit. Surface spreading techniques are common since plenty of space is available for such systems and quantity of rechargeable water is also large. The traditional rural techniques of water conservation have already been discussed in the sixth module.

PRECAUTIONS

- Develop the recharge well after construction for better recharge.
- Filter material should be used as per recommended size.
- Use PVC pipe for recharge well if ground water is saline.
- Entry of highly turbid water into recharge well should be prevented.
- Periodic removal of fine material deposited on the surface of the filter bed by scraping once in 2-3 years is essential.
- Domestic waste water, sewage water/contaminated water should not be injected to the recharge structure to avoid contamination of ground water.

> If rainwater is used for drinking, it is often filtered first. Filtration (such as reverse osmosis or ultrafiltration) may remove pathogens. While rain water is pure it may become contaminated during collection or by collection of particulate matter in the air as it falls.

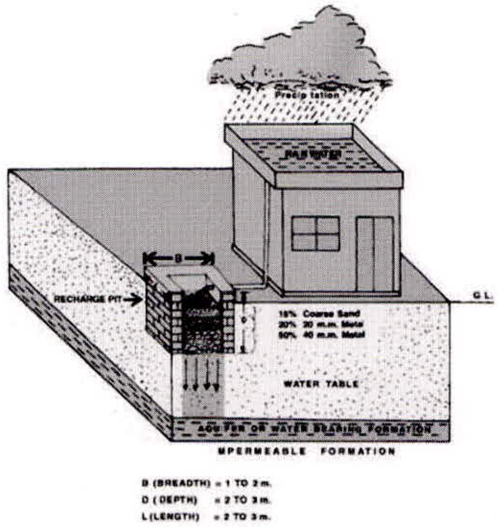
USE OF HARVESTED WATER

DRINKING PURPOSE

- Rainwater stored in a closed tank can be used for drinking purpose.
- First two rain showers should be allowed to run off.
- Once the roof / terrace gets cleaned, thereafter rainwater falling on it can be stored through pipes in the tank.
- Stored water should be well treated before drinking.

AGRICULTURE

- 82% of the agriculture land is rainfed.
- Due to irregular rains, many times water becomes unavailable when required by the crops, especially kharif crops.
- There can be time gap of 15-20 days between 2 rains.
- If we have stored the rainwater then it can be used during this dry period.
- This way proper rainwater management can helpfarmers to take both kharif and rabi crops.



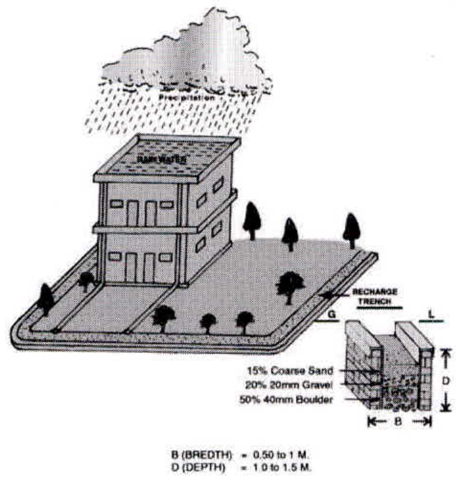
OTHER USES

- Toilet flushing
- Laundry
- Garden irrigation
- Car washing
- General cleaning

RECOMMENDED STRUCTURES

URBAN AREAS

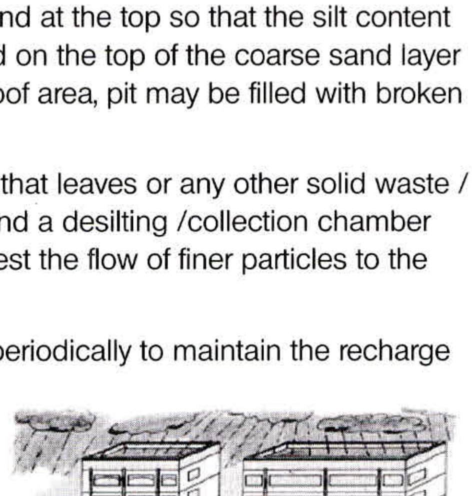
Roof Top Rainwater Harvesting Through Recharge Pit



In alluvial areas where permeable rocks are exposed on the land surface or at very shallow depth, roof top rain water harvesting can be done through recharge pits.

- The technique is suitable for buildings having a roof area of 100 sq m and is constructed for recharging the shallow aquifers.
- Recharge Pits may be of any shape and size and are generally constructed 1 to 2 m wide and 2 to 3 m deep which are back filled with boulders (5-20 cm), gravels (5-10 mm) and coarse sand (1.5-2 mm) in graded form. Bo ulders at the bottom, gravels in between and coarse sand at the top so that the silt content that will come with runoff will be deposited on the top of the coarse sand layer and can easily be removed. For smaller roof area, pit may be filled with broken bricks/ cobbles.
- A mesh should be provided at the roof so that leaves or any other solid waste / debris is prevented from entering the pit and a desilting /collection chamber may also be provided at the ground to arrest the flow of finer particles to the recharge pit.
- The top layer of sand should be cleaned periodically to maintain the recharge rate.

Roof Top Rainwater Harvesting Through Recharge Trench



- Recharge trenches are suitable for buildings having roof area of 200-300 sq m and where permeable strata is available at shallow depths.

- Trench may be 0.5 to 1 m wide, 1 to 1.5m deep and 10 to 20 m long depending upon availability of water to be recharge.
- These are back filled with boulders (5-20 cm), gravel (5-10 mm) and coarse sand (1.5-2 mm) in graded form - boulders at the bottom, gravel in between and coarse sand at the top so that the silt content that will come with runoff will be coarse sand at the top of the sand layer and can easily be removed. A mesh should be provided at the roof so that leaves or any other solid waste/debris is prevented from entering the trenches and a desilting/collection chamber may also be provided on ground to arrest the flow of finer particles to the trench.
- By-pass arrangement be provided before the collection chamber to reject the first showers.
- The top layer of sand should be cleaned periodically to maintain the recharge rate.

Roof Top Rainwater Harvesting Through Existing Tubewells

- In areas where the shallow aquifers have dried up and existing tubewells are tapping deeper aquifer, roof to rain water harvesting through existing tubewell can be adopted to recharge the deeper aquifers.
- PVC pipes of 10 cm dia are connected to roof drains to collect rainwater. The first roof runoff is let off through the bottom of drainpipe. After closing the bottom pipe, the rainwater of subsequent rain showers is taken through a T to an online PVC filter. The filter may be provided before water enters the tubewells. The filter is 1 -1.2 m. in length and is made up of PVC pipe. It's diameter should vary depending on the area of roof, 15 cm if roof area is less than 150 sq m and 20 cm if the roof area is more. The filter is provided with a reducer of 6.25 cm on both the sides. Filter is divided into three chambers by PVC screens so that filter material is not mixed up. The first chamber is filled up with gravel (6-10 mm), middle chamber with pebbles (12-20 mm) and last chamber with bigger pebbles (20-40 mm).
- If the roof area is more, a filter pit may be provided. Rainwater from roofs is taken to collection/desilting chambers located on ground. These collection chambers are interconnected as well as connected to the filter pit through pipes having a slop of 1:15. The filter pit may vary in shape and size depending upon available runoff and are back-filled with graded material, boulder at the bottom, gravel in the middle and sand at the top with varying thickness (0.30-0.50 m) and may be separated by screen. The pit is divided into two chambers, filter material in one chamber and other chamber is kept empty to accommodate excess filtered water and to monitor the quality of filtered water.

A connecting pipe with recharge well is provided at the bottom of the pit for recharging of filtered water through well.

Roof Top Rainwater Harvesting through Trench with Recharge Well

- In areas where the surface soil is impervious and large quantities of roof water or surface runoff is available within a very short period of heavy rainfall, the use of trench/ pits is made to store the water in a filter media and subsequently recharge to ground water through specially constructed recharge wells.
- This techniques is ideally suited for area where permeable horizon is within 3m below ground level.
- Recharge well of 100-300 diameter is constructed to a depth of at least 3 to 5 m below the water level. Based on the lithology of the area well assembly is designed with slotted pipe against the shallow and deeper aquifer.
- A lateral trench of 1.5 to 3 m width and 10 to 30 m length, depending upon the availability of water is constructed with the recharge well in the centre.
- The number of recharge wells in the trench can be decided on the basis of water availability and local vertical permeability of the rocks.
- The trench is backfilled with boulders, gravels and coarse sand to act as a filter media for the recharge wells.
- I f the aquifer is available at greater depth say more than 20 m, a shallow shaft of 2 to 5 m diameter and 3-5 m deep may be constructed depending upon availability of runoff. Inside the shaft a recharge well of 100-300 mm dia is constructed for recharging the available water to the deeper aquifers. At the bottom of the shaft a filter media is provided to avoid choking of recharge well.

RURAL AREAS

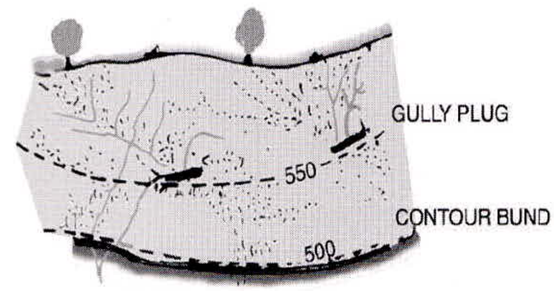
In rural areas, rain water harvesting is taken up considering watershed as a unit. Surface spreading techniques are common since space for such systems is available in plenty and quantity of recharged water is also large. Following techniques may be adopted to save water going waste through slopes, rivers, rivulets and nalas.

Rainwater Harvesting Through Gully Plug

- Gully Plugs are built using local stones, clay and bushes across small gullies and streams running down the hill slopes carrying drainage to tiny catchments during rainy season.
- Gully Plugs help in conservation of soil and moisture.
- The sites for gully plugs may be chosen whenever there is a local break in slope to permit accumulation of adequate water behind the bunds.

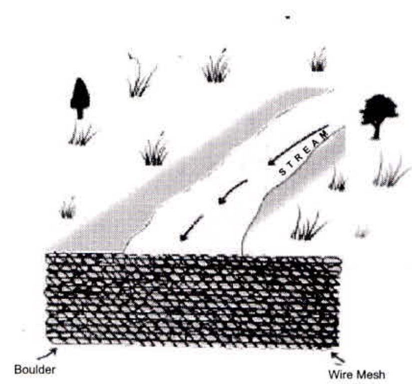
Rainwater Harvesting Through Contour Bund

- Contour Bunds are effective methods to conserve soil moisture in watershed for long duration.



- These are suitable in low rain fall areas where monsoon run off can be impounded by constructing bunds on the sloping ground all along the contour of equal elevation.
- Flowing water is intercepted before it attains the erosive velocity by keeping suitable spacing between bunds.
- Spacing between two contour bunds depends on the slope the area as the permeability of the soil. Lesser the permeability of soil, the close should be spacing of bunds.
- Contour bunding is suitable on lands with moderate slopes without involving terracing.

Rainwater Harvesting through Gabion Structure



- This is a kind of check dam commonly constructed across small streams to conserve stream flows with practically no submergence beyond stream course.
- A small bund across the stream is made by putting locally available boulders in a mesh of steel wires and anchored to the stream banks.
- The height of such structures is around 0.5 m and is normally used in the streams with width of less than 10 m.
- The excess water over flows this structure storing some water to serve as source of recharge. The silt content of stream water in due course is deposited in the interstices of the boulders in due course and with growth of vegetation, the bund becomes quite impermeable and helps in retaining surface water run off for sufficient time after rains to recharge the ground water body.

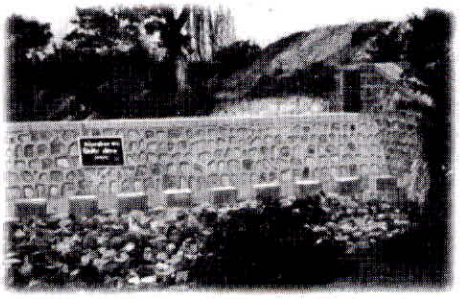
Rainwater Harvesting through Percolation Tank

- Percolation tank is an artificially created surface water body, submerging in its reservoir a highly permeable land so that surface runoff is made to percolate and recharge the ground water storage.
- Percolation tank should be constructed preferably on second to third order steams, located on highly fractured and weathered rocks, which have lateral continuity downstream.
- The recharge area downstream should have sufficient number of wells and

cultivable land to benefit from the augmented ground water.

- The size of percolation tank should be governed by percolation capacity of strata in the tank bed. Normally percolation tanks are designed for storage capacity of 0.1 to 0.5 MCM. It is necessary to design the tank to provide a ponded water column generally between 3 & 4.5 m.
- The percolation tanks are mostly earthen dams with masonry structure only for spillway. The purpose of the percolation tanks is to recharge the ground water storage and hence seepage below the seat of the bed is permissible. For dams upto 4.5 m height, cut off trenches are not necessary and keying and benching between the dam seat and the natural ground is sufficient.

Rainwater Harvesting through Check Dams / Cement Plugs / Nala Bunds



- Check dams are constructed across small streams having gentle slope. The site selected should have sufficient thickness of permeable bed or weathered formation to facilitate recharge of stored water within short span of time.
- The water stored in these structures is mostly confined to stream course and the height is normally less than 2 m and excess water is allowed to flow over the wall. In order to avoid scouring from excess run off, water cushions are provided at downstream side.
- To harness the maximum run off in the stream, series of such check dams can be constructed to have recharge on regional scale.
- Clay filled cement bags arranged as a wall are also being successfully used as a barrier across small nalas. At places, shallow trench is excavated across the nala and asbestos sheets are put on two sides. The space between the rows of asbestos sheets across the nala is backfilled with clay. Thus a low cost check dam is created. On the upstream side clay filled cement bags can be stacked in a slope to provide stability to the structure.

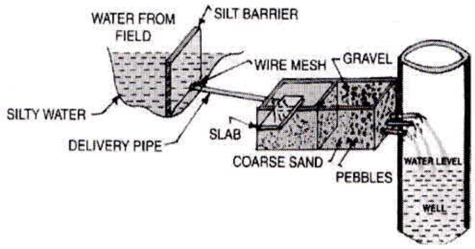
Rainwater Harvesting through Recharge Shaft

- This is the most efficient and cost effective technique to recharge unconfined aquifer overlain by poorly permeable strata.
- Recharge shaft may be dug manually if the strata is of non-caving nature. The diameter of shaft is normally more than 2 m.
- The shaft should end in more permeable strata below the top impermeable strata. It may not touch water table.

- The unlined shaft should be backfilled, initially with boulders/ cobbles followed by gravel and coarse sand.
- In case of lined shaft the recharge water may be fed through a smaller conductor pipe reaching up to the filter pack.
- These recharge structures are very useful for village ponds where shallow clay layer impedes the infiltration of water to the aquifer.
- It is seen that in rainy season village tanks are fully filled up but water from these tanks does not percolate down due to siltation and tubewell and dugwells located nearby remains dried up. The water from village tanks get evaporated and is not available for the beneficial use.
- By constructing recharge shaft in tanks, surplus water can be recharged to ground water. Recharge shafts of 0.5 to 3 m diameter and 10 to 15 m deep are constructed depending upon availability of quantum of water. The top of shaft is kept above the tank bed level preferably at half of full supply level. These are back filled with boulders, gravels and coarse sand.
- In upper portion of 1 or 2 m depth, the brick masonry work is carried out for the stability of the structure.
- Through this technique all the accumulated water in village tank above 50% full supply level would be recharged to ground water. Sufficient water will continue to remain in tank for domestic use after recharge.

Rainwater Harvesting through Dugwell Recharge

- Existing and abandoned dug wells may be utilized as recharge structure after cleaning and desilting the same.
- The recharge water is guided through a pipe from desilting chamber to the bottom of well or below the water level to avoid scouring of bottom and 9entrapment of air bubbles in the aquifer.



- Recharge water should be silt free and for removing the silt contents, the runoff water should pass either through a desilting chamber or filter chamber.
- Periodic chlorination should be done for controlling the bacteriological contaminations.

Ground Water Dams or Sub-surface Dykes

- Sub surface dyke or under-ground dam is a subsurface barrier across stream which retards the base flow and stores water upstream below ground surface.
- By doing so, the water levels in upstream part of ground water dam rises saturating otherwise dry part of aquifer.
- The site where sub-surface dyke is proposed should have shallow impervious

layer with wide valley and narrow out let.

- After selection of suitable site, a trench of 1-2 m wide is dug across the breadth of stream down to impermeable bed. The trench may be filled with clay or brick/ concrete wall upto 0.5 m below the ground level.
- For ensuring total imperviousness, PVC sheets of 3000 PSI tearing strength at 400 to 600 gauge or low-density polythene film of 200 gauges can also be used to cover the cut out dyke faces.
- Since the water is stored within the aquifer, submergence of land can be avoided and land above the reservoir can be utilized even after the construction of the dam. No evaporation loss from the reservoir and no siltation in the reservoir takes place. The potential disaster like collapse of the dams can also be avoided.

SAMPLE ESTIMATION OF HARVESTED RAINWATER

ASSESSMENT OF RUNOFF

The runoff should be assessed accurately for designing the recharge structure and may be assessed by following formula.

*Runoff (m^3/year)= Catchment area (m^2) * Runoff Coefficient * Rainfall (m/year)*

RUNOFF COEFFICIENTS

Runoff coefficient plays an important role in assessing the runoff availability and it depends upon catchment characteristics. It is the factor that accounts for the fact that not all rainfall falling on a catchment can be collected. Some rainfall will be lost from the catchment by evaporation and retention on the surface itself.

General values are tabulated below which may be utilised for assessing the runoff availability -

Type of catchment	Runoff Coefficient
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 percent	0.0 - 0.3
Rocky natural catchments	0.2 - 0.5
Green area	0.05 - 0.10

HOW MUCH WATER CAN BE HARVESTED?

The total amount of water that is received in the form of rainfall over an area is called the rainwater endowment of that area. Out of this, the amount that can be effectively harvested is called the water harvesting potential.

Water harvesting potential = Rainfall (mm) X Collection efficiency

AN EXAMPLE OF POTENTIAL FOR RAINWATER HARVESTING:

Consider a building with a flat terrace area of 100m^2. The average annual rainfall in Delhi is approximately 600 mm (24 inches). In simple terms, this means if the terrace floor is assumed impermeable, and all the rain that falls on it is retained without evaporation, then, in one year, there will be rainwater on the terrace floor to a height of 600 mm.

Area of the plot = 100 m^2

Height of annual rainfall = 0.6 m (600 mm or 24 inches)

Volume of rainfall over the plot = Area of plot X Height of rainfall

= 100 m^2 X 0.6 m = 60 m^3 (60,000 litres)

Assuming that only 60 percent of the total rainfall is effectively harvested,

Volume of water harvested = 36,000 litres

This volume is about twice the annual drinking water requirement of a five member family. The average daily drinking water requirement per person is 10 liters.

FARM POND

A farm pond creates a large hole dug out in the earth, usually square or rectangular in shape, which harvests rainwater and stores it for future use. It has an inlet to regulate inflow and an outlet to discharge excess water. The pond is surrounded by a small bund, which prevents erosion on the banks of the pond. The size and depth depend on the amount of land available, the type of soil, the farmer's water requirements, the cost of excavation, and the possible uses of the excavated earth. Water from the farm pond is conveyed to the fields manually, by pumping, or by both methods.

LOCATION

The selection of a site for a farm pond is critical in maximizing its storage capacity. The pond must be located in a corner of a plot of land so that it does not disturb farm operations like plowing. It must be located at least 3 m away from other farmers' fields common lands. The slope of the land and the slope's direction must also be carefully evaluated.

EXCAVATION

A test pit is dug out before finalizing the location and depth of excavation. The excavation and transportation of earth can be accomplished with a combination of manual labour or with machines like excavators and tractors.

Soil conditions must be carefully considered. Excavation in areas with hard clay soil, such as Ramnad district, is very difficult and expensive using manual labour.

Use of machines for excavation and transportation is the best method in this context, with human labour used for levelling, bund formation, and construction.

ADVANTAGES

- They provide water to start growing crops, without waiting for rain to fall.
- They provide irrigation water during dry spells between rainfalls. This increases the yield, the number of crops in one year, and the diversity of crops that can be grown.
- Bunds can be used to raise vegetables and fruit trees,thus supplying the farm household with an additional source of income and of nutritious food.
- Farmers are able to apply adequate farm inputs and perform farming operations at the appropriate time, thus increasing their productivity and their confidence in farming.
- They check soil erosion and minimizes siltation of waterways and reservoirs.
- They supply water for domestic purposes and livestock
- They promote fish rearing.
- They recharge the ground water.
- They improve drainage.
- The excavated earth has a very high value and can be used to enrich soil in the fields, leveling land, and constructing farm roads.

LIMITATIONS

- They reduce the water flow to other people's tanks and ponds situated in lower-lying areas.
- They occupy a large portion of farmers' lands. However, this can be compensated for by rearing fish in the pond, effectively utilizing the bunds for vegetable and/or tree plantations, etc.

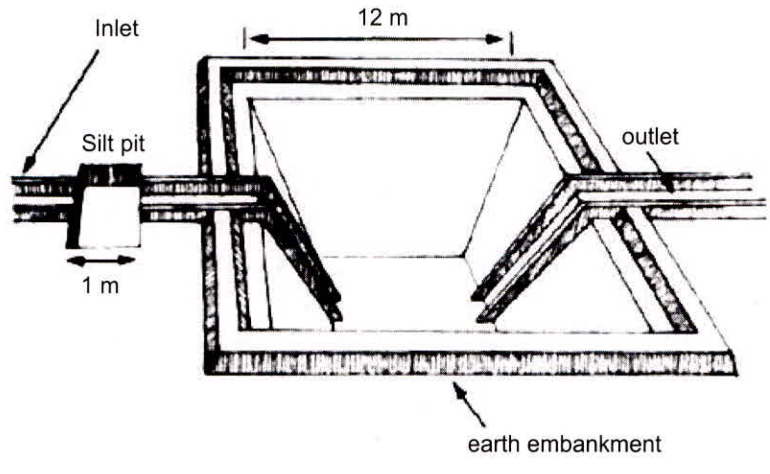
EXAMPLE OF DESIGN OF A FARM POND

The ideal farm pond should be dug into the ground in a naturally low-lying area. Some of the soil that is removed can be used to construct an earthen berm around the pond, which should be planted with trees and grasses for stability. The shade and wind protection provided by the raised mound and vegetation will reduce evaporative losses. Greater depth of the pond and less surface area will also reduce evaporative losses. However, digging deeper than 5 meters will increase the expense of the digging, and increase seepage loss due to increased water pressure on the ground. A pond that is about 10 meters by 10 meters and 3 meters deep is an ideal size. The pond should have an inlet and an outlet (as shown in the picture) lined with rock to prevent erosion. These features will need to be linked into a larger drainage plan which directs water into the pond, and receives any overflow water. A small settling pit at the inlet will help remove silt, and can be more easily cleaned than the whole pond. The sides of the pond should be sloped for stability.

The pond should be sized to hold about 50% of maximum runoff, so that it will fill up even in a dry year. Maximum runoff can be calculated by considering rainfall intensity and duration, watershed area, and slope, soil type, and land-use throughout the watershed. A rough estimate is that a 1 hectare watershed in red soil can yield 250 cubic meters of water, which is enough to fill the pond shown in the picture on the previous page. Individuals with some expertise in hydrology can develop such rules of thumb relevant to the physical characteristics of particular regions.

Another question is whether the pond will be discharging or recharging. If the pond is higher in the watershed and / or the soil is permeable, it may function more as a percolation pit than as a pond. If the pond is lower in the watershed and the water table is high, it may naturally fill with ground-water. It is important to decide whether the goal is to facilitate infiltration of water, or to maintain surface water in the pond, which can be easily accessed for water needs. In the latter case, it may be necessary to line the pond to reduce permeability. Possible linings include: clay, bentonite, stone or brick, cement, rubber, plastic, etc. If a farm pond maintains water for 80 percent of the year it can also be used for raising fish.

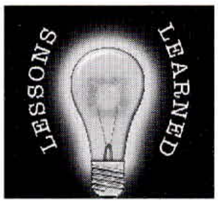
If it is not possible to create a sunken pond because the soil is too shallow, or excavation is too expensive, one can build walls on the surface to create a surface pond.



Dimensions

Bottom width :	6m x 6m	Silt pit depth :	0.5
Top width :	12m x 12m	Inlet width :	2m
Depth :	3m	Capacity :	250 m^3
Side slope :	1:1	Catchment :	1 ha (approx.)

LESSONS LEARNED



- Rain water is the purest form of water available on the earth.
- Rainwater Harvesting is the process of gathering and storing rain drops and preventing runoff, evaporation and seepage for its efficient utilization and conservation.
- The problem of large variations in water availability associated with growing demands leads to the need for Rainwater Harvesting.
- The method of utilizing the rain that falls on roof is called Roof Water Harvesting.
- In rural areas, rain water harvesting is undertaken by considering the whole watershed as a unit.
- Harvested or stored rainwater can be used for drinking, agriculture or other household purposes such as laundry, toilet, car washing and gardening.
- Runoff (m^3/year) = Catchment area (m^2) * Runoff Coefficient * Rainfall (m/year)
- Water harvesting potential = Rainfall (mm) X Collection efficiency
- The ideal farm pond should be dug into the ground in a naturally low-lying area.
- If it is not possible to create a sunken pond because the soil is too shallow, or excavation is too expensive, one can build walls on the surface to create a surface pond.

NOTES

The trainer can note down important notes below and discuss them towards the end of the training programme.