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Water Harvesting and Recycling

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Abstract— *As land pressure increases day by day due to population growth, the more marginal lands are being used for agriculture. Especially in arid, semi-arid and sub humid areas where rainfall pattern is irregular, ranges heavy slower to less storm and much of these rainfall is lost as surface run off, results into risk of human being. The irrigation is the most obvious response to the drought which provides more costly. Under such condition water harvesting is suitable and most important.*

Keywords—Water Harvesting, Recycling, contour bund.

I. INTRODUCTION

The water harvesting term was first used in Australia by H. J. Geddes, to denote the collection and storage of any firm water either by run off or creek flow for irrigation use. This nomenclature has since then used very commonly, as the collection of rainfall and all other water harvesting amounted to the same things. Yet in the above definition water harvesting include stream flow in creeks and gullies, not just rainfall at point where it falls.

The source of water that is to be harvested are the roof water, sheet flow or intermittent and even perennial water. These are use for productive use such as domestic water supply, stock water, for irrigation of the fodder crops, trees and also for fish farming.

Water Harvesting Techniques

Water harvesting techniques include a wide range of methods, are based on the following three basic criteria:

1. Source of available water
2. Required storage duration and
3. Intended use of harvested water.

On the basis of above listed criteria, the harvesting techniques are classified as under:

1. Roof harvesting,
2. Run off harvesting
   - i. Short term storage
   - ii. Long term storage
3. Flood water harvesting

Roof water harvesting techniques is applied mainly for domestic purpose. It may be either for short duration or long duration depends upon the availability of water.

Runoff harvesting

In low rainfall areas some time runoff is induced by completely or partially sealing of the soil surface by spraying of chemical like gallatationous material or oily substance which seals the soil pores by artificially compacting the soil surface in the catchment area. Runoff harvesting for short and long term are done by constructing the structures given as under:

Short term water harvesting techniques

By contour bund: This method involves the construction of contour bunds on contour line of the catchment area. This bund holds the flowing of surface runoff, passing through the area of surrounded space of two adjacent bunds. The height of the contour bund generally ranges from 0.03 m to 1.0 m. Similarly the length ranges from 10 m to a few hundred meters. The side slope of the bund is kept within optimum limit. Both the height and slope of the bund determines the storage capacity. The technique is most common and widely adopted in several countries.

By semi-circular hoop: This type of structure consists of earthen embankments, constructed in the shape of semi-circle. The tips of the semi-circle are kept on the contour. The water is collected within the hoof from the area just above it and impounded to a maximum depth equals to the height of the embankment. Excess water is discharged around the tips. In the fields the next lower rows of the semi-circular hoofs are staggered, so that the overflowing water from the upper row can be easily interrupted. The height of the bund ranges from 0.1 to 0.5 m and radius of the hoof varies from 5 to 30 m.

By trapezoidal bunds: Trapezoidal bunds consist of earthen embankments, constructed in the shape of trapezoids. The tip so the bunds wings are placed on the contour. The runoff water yielded from the watershed is collected into the bunded area. The excess runoff water overflows around the tips. In this system the rows of bunds are arranged in staggered from to intercept the overflow from the above adjacent areas. The layout of the trapezoidal bunds on the same principle as those for semi-circular hoops, but they unusually cover a large area. The height of the trapezoidal bunds ranges from 0.3 m to 0.6 m and their widths across the tips varies from 40 m to160 m. Trapezoidal bunds techniques are suitable for that area, where rainfall intensities are too high, causing surface flow at peak rate which may damage to contour bunds.

By graded bunds: Sometimes it is also referred as off contour bund. It consists of earthen or stone embankments, are constructed on the land which has the slope of 0.5 to 2.0%. They vary with the contour bunds and are used to be discharged out through the field, may be intercepted. The excess intercepted or harvested water is diverted to the next field through a channel. The height of the graded bunds ranges from 0.3 to 0.6 m. The bund constructed below, which of a wing which help to intercept the overflowing water from the above bund. This make to the graded bund, just like an open ended trapezoidal bund that is why sometimes it is also known as "Modified Trapezoidal Bund

By rock catchment: The rock catchments are the exposed rock surface which is used for collecting the runoff water. The method behind this is that, when rainfall occurs on the exposed rock, is drained towards the lowest point and is harvested there. Its area may vary from a hundred sq. m to a few thousand sq. m, with corresponding varying dimensions for the storage tank

By ground catchment: In this method, expanse of grounds are used for collecting the water into storage tanks. The ground is clear from vegetation and compacted well. In some countries such as in Australia, the ground is reshaped to create a series of channels leading to the tanks. These channels are again compacted very well and sometimes are covered with gravel. In Lesotho small ground catchment have been used for collecting the runoff water for supplying the water for irrigation of vegetables etc.

Long term harvesting: Long term water harvesting mainly done for building a water stock for the purpose of irrigation, fish farming etc. This is fulfilled by constructing the reservoir and ponds in this area. The design criteria of this structure are given below:

i. Watershed should be contributed the sufficient amount runoff.
ii. There should be some suitable collection site, where water can be safely stored.
iii. There should be suitable methods for minimising the various water losses such as seepage and evaporation during storage and used in the watershed.
iv. There should be some suitable method for efficient utilization of the collected water for maximizing crop yield per unit volume of water.

In designing a runoff system and recycling of runoff the whole watershed must be taken into consideration. In order to get accurate amount of water amount of water yield from the catchment and the water requirement of the command area, proper estimation must be done in the beginning. This will help in arriving the most economical design. Generally too large or too small catchment area with respect to the pondage area should be avoided as it minimises the safety and life of the structure.

It is recommended that for a good design, the storage or water spread area should be from $1/5^{th}$ to $1/8^{th}$ of the catchment area for 1.5 meters average water depth to be stored. However for deciding the accurate size the other consideration like surface condition of the catchment, volume of the water to be stored, pondage site, expected silt load with runoff etc., must be fully assessed.

The most common water harvesting are of two types written as under:

I. Dugout pond and
II. Embankment type reservoirs

I. Dugout pond: Dugout ponds are constructing by excavating the soils from ground surface. These ponds may be fed by ground water or by surface runoff or by both. Constructed of these ponds are limited to those areas which have land slope less than 4% and water table lies within 1.5 m to 2.0 m. depth from the ground surface. This type of ponds involves more construction cost therefore these are generally recommended for construction when embankment type ponds are not commercially feasible. Design of pond is based on the several constrains like desired storage capacity, water table depth, catchment area, amount of runoff yield and its peak rate, subsoil condition, stability of side slopes, suitability of site and economics of the construction.

The dugout pond may also be recommended on the basis of utilizing the maximum runoff water for increasing the crop production. These types of ponds require brick lining with cement plastering to ensuring the storage and reducing the seepage loss.

II. Embankment type reservoir: These types of reservoirs are constructed by constructing a dam on embankment around the valley or depression or creek in which runoff water is collected and used when required.

The designed storage capacity of embankment type reservoir is determine on the basis of requirement and availability of surface runoff. In the condition when heavy usage is expected, the storage capacity must be sufficient so that it can supply more than one years' demand.

Embankment type reservoirs are again classified to the purpose, written as under:

i. **Irrigation dam:** Irrigation dam are mainly meant to store the surface water for irrigating the crops. It may have the provision for gated pipe spillway for taking out the water from the reservoir. Spillway should be located at bottom of dam.
ii. **Silt detention dam:** The basic proposal of silt detention dam is to detain the silt load coming along the runoff from the catchment area. Therefore their location is fixed at the lower

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reaches of the catchment from where water enters into the valley and finally to the streams. In this type of dam a provision of outlet should be made for taking out the water for irrigation purpose. For better safety a series of such dam may be constructed along with the slope in the catchment.

iii. **High level bund:** By the name it is obvious that it is located at the head of the valley. The stored water in the pond is used to irrigate the water lying below it. Usually for best results a series of such bunds may be constructed in such a way that command area of upper tanks forms the catchment area of the lower tank. In this way lower tanks able to collect the excess of water for irrigation from that area.

iv. **Farm pond:** it is constructed for multipurpose use such as for irrigation, livestock, water supply to the cattle field, fish productions etc. It should have the adequate capacity to meet the requirements. The location of the farm pond should be such that all requirements are easily and conveniently met.

v. **Water harvesting pond:** the water harvesting pond either may be dugout or embankment type pond, their constructions depends upon the size of the catchment area. Runoff yield from the catchment area is diverted into these ponds, where it is properly stored. Measures against seepage and evaporation losses should be adopted in this type of pond.

vi. **Percolation dam:** These type of dams are generally constructed in the valley head without the provision of checking the percolation losses. The growing crops on the downstream side of the dam receive the percolated water which helps their growth.

vii. **Flood control reservoir:** The reservoirs which are constructed at suitable sites for controlling the flood are known as flood control reservoir. They are all equipped with self-operating mechanical outlets for empting the flood water into the stream below the structure.

Flood water harvesting

In this wide vallies are reshaped and formed in a series of broad level terrace and flood water is allowed to pass through the terrace. The flood water is spread on the terraces where some amount is absorbed by the soil that is used later on by the crops grown in this area. The following techniques are widely used for flood water harvesting:

By diverting to the Graded Bund: In this method runoff water is diverted to the graded bund by constructing the diversion structure such as diversion dams, which leads to the basin through channels, where crops are irrigated by flooding. Such system has widely been used in several countries such as Pakistan and Afghanistan. This method is valid for harvesting the flood water only for a short duration.

Regarding the long term harvesting, the following structures are constructed:

By Check Dam: In this method the small rock or concrete check dams are constructed across the river or depression to check the velocity of the flow for increasing the infiltration rate into the alluvium under the river bed. It helps the replenishing the aquifers below the stream beds. Water stored in the aquifer is subsequently used by abstracting through the wells or bore holes. This system includes various benefits such as less loss due to evaporation than a surface tank, less problem of siltation, cheaper construction and peak flow are not intercepted, but are allowed to discharge over the check dam.

By Sand Dam: Water harvesting by sand dam consist of constructing a dam across the valley or depression for the purpose to reduce the velocity of surface water mixed with sand, which tends to deposit the sand over the bed. After some time the elevation of the dam is raised and after few flood seasons the space behind the dam is filled with sand known as sand reservoir. Water flowing in the valley fills the pore spaces of the sand reservoir and thus, creating a water body. It has advantages of less surface evaporation.

By Surface Dam: This consists of subsurface vertical barriers like dams which are constructed across the bottom of the valley down to the bed rock. It intercepts the flowing water within the alluvium. The water flow along the surface floods are stored in subsurface reservoir, created by barriers. In this dam the evaporation losses are minimum. The subsurface dam or barriers are generally constructed with clay, stone, masonry, concrete or steel materials etc. The water is stored in the subsurface dam is utilised by gravity or shallow wells or stone by bore holes, later on according to need.

Recycling of Water

For millions of years, water has been constantly recycled and reused. When it rains, the rainwater flows over land into waterways or is absorbed by the ground or plants. Water evaporates from land and water bodies becoming water vapour in the atmosphere. Water is also released from trees and other plants through “transpiration.” The water vapour from evaporation and transpiration forms clouds in the atmosphere which in turn provide

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precipitation (rain, hail, snow, sleet) to start the cycle over again. This process of water recycling, known as the water cycle, repeats itself continuously.

The water cycle is the process by which water is recycled. To many people, recycling seems like a fairly new concept. Actually, water has been recycling itself for thousands of years. This natural water recycling system is highly sophisticated and successful. Let's take a look at an ideal water cycle:

Once rain falls on the earth, it follows one of four paths:

1) It soaks into porous ground surfaces and becomes part of the groundwater, which feeds streams and wetlands and supplies much of our drinking water;
2) It remains in lakes or topsoil and eventually evaporates;
3) It is absorbed by vegetation and then transpires (evaporates from the plant tissues); or
4) It forms streams and rivers that eventually empty to Puget Sound.

Rivers are a sign that the cycle is working, returning water to the oceans where it evaporates, forms clouds and falls again.

Simple methods for recycling of water

There are some methods which can be used for recycling of water. These are as follows:

1) **Percolation pits:** Wherever the surface is paved, dig 4'x4'x4' square pit and fill them same with small pebbles or brick jelly or river sand and covered the perforated concrete slabs.
2) **Percolation pit with bore:** Wherever the depth of the clay soil is more, dig a deep bore well type of pit to the dimension of 30 to 40 cm diameter and 6 to 7 cm deep. The bore can be at the centre of the square pit. Fill the bore and pit with pebbles or brick jelly and cover with sand.
3) **Open ground:** Wherever there is open ground, top soil should be removed and replaced with river sand to allow slow percolation of the rain water.
4) **Storm water drains:** The storm water drains inside the premises should have a 6" boundary to ensure that the rain water, instead of rushing into the drains and going waste, stagnant over the ground for some time and steeps into the soil.
5) **Stopping rain water rushing out of the gate:** The ground level near the gate should be raised to retain as much water as possible inside the compound; alternatively construct a slopping gutter across the gate and direct the rushing water towards a percolation pit. The gutter can be covered by a perforated slab.
6) **Dwarf wall:** Wherever there is a slope construct a dwarf wall to a height of 1 ft. to avoid runoff, as well as to retain the rainwater and allowing for slow percolation.
7) **Regular repair of compound walls:** Regular repair should be carried out to prevent cracks and holes from developing in the compound wall, as otherwise the rain water would flow out through them.
8) **Pits with deep bore:** It is advisable to have numerous percolation pits (pits with deep bore) in agricultural land so that stagnating water percolates slowly and recharging the aquifer, i.e. ground water table.
9) **Tiny check dams:** Construct dikes and small bunds (tiny check dams) on slope area to arrest the runoff water and subsequent water percolation.
10) **Recharging by well in agricultural lands:** dig pits near the well, of 6 ft. cubical in shape and connect them to the wells with pipes at a depth of above 2 ft. from the bottom of the pits, cover both ends with net to prevent clogging, contamination and silting of the wells. Alternatively, construct 6'x6'x6' square filtrating tanks and divide them with perforated slabs. Each portion should be filled with pebbles and brick jelly and connected to the well through a 15 cm PVC pipe. The rain water collected in the farm can be directed to these filtering tanks through a number of channels.

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