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Introduction of Road Runoff Water Harvesting in India

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ABSTRACT

Road runoff water harvesting is a process in which the water flowing in the road side drains along the hills or plains can be transported and stored in a reservoir and can be used subsequently for agricultural or domestic use. Road runoff harvesting can solve water shortage problems of various hamlets and villages located adjacent to hills and Highways with side drains. This paper focuses on introduction of this system in India and its viability in Indian scenario.

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Introduction

In India agriculture contributes 40% to our country's GNP and gives subsistence to 70% of our population. And yet 1/3 of our total geographical area is drought prone because we are dependent upon the monsoons which can be erratic. Drought-prone areas have to be provided water not only for human and cattle consumption but also for irrigation. Whereas, even after good monsoons water is not available only because of lack of proper management and storage.

Rainwater harvesting

In areas that have regular rainfall, the most appropriate alternative source of water is the collection of rainwater, called 'rainwater harvesting'. Falling rain can provide some of the cleanest naturally occurring water that is available anywhere. Most modern technologies for obtaining drinking water are related to the exploitation of surface water from rivers, streams and lakes, and groundwater from wells and boreholes. However, these sources account for only 40% of total precipitation. It is evident, therefore, that there is considerable scope for the collection of rainwater when it falls, before huge losses occur due to evaporation and transpiration and before it becomes contaminated by natural means or man-made activities. The term 'rainwater harvesting' is usually taken to mean the immediate collection of rainwater running off surfaces upon which it has fallen directly.

Road Runoff harvesting is an innovative approach towards water conservation and management, where the runoff water is diverted from the road side drains into inlet channels and distribution into basins/water reservoir for domestic or agricultural use.

The Road Runoff Water Harvesting System:

The RRH system includes basic components:

- Catchment area
- Inlet channel
- Silt trap
- spillway
- Water storage

Catchment Area:

The catchment area for RRH system is roadside drains and culverts where the rainwater flowing on the road is directed. These drains and culverts also collect rainwater from areas at higher level with inclined slopes towards the roadways.

Inlet channel (Collection of water from roadside drains):

The water flowing from the roadside drains needs to be directed to the reservoir with minimum spillage or seepage. The water from the road side drains will pass through culverts at irregular intervals and from culverts it can be carried by a variety of drains.

Types of drains to carry water to the reservoir:

1. Trenches dug in mud.
2. Construction of concrete drains.
3. R.C.C Hume pipes or PVC pipes.
4. Trenches with plastic lining.

The traditional method to divert water to reservoirs is to dig trenches in soil till the reservoir. This is a traditional method to divert water to reservoirs. There are various limitations associated with this practice. The water flowing through such drains carry lot of silt along with it and the water will turn hard water. Water flowing in trenches is subjected to various losses and seepage. The water also gets contaminated.

Another innovative method can be trenches with HDPE lining can also be used as it can overcome the limitations of trenches like seepage is very less about 95% less than without lined trenches, less silt and less contamination. Trenches with HDPE lining is most economical and can cost around Rs.50/m.

Also there are concrete drains which overcome all the limitations as stated above in case of trenches. Concrete drains carry less silt; therefore the water carrying capacity remains the same and decreases maintenance. The probability of contamination is also very less. These drains are costly and the rate can be as costly as Rs. 1000/m (Dimension of drain= 50cm x 50cm)

RCC Hume pipes have various advantages like there is no seepage, no silt and no contamination. But the cost can be as high as Rs.500/m for 300mm pipe. PVC pipes are also available and have many favorable properties like no seepage, no silt and no contamination but the cost is very high.

Depending upon the fund available the type of drains can be selected. In the case of Indian scenario, Trenches with HDPE

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lining can be ideal to minimize silting, seepage and contamination and is also economical.

Water inlet to reservoir via silt traps:

Since the water is collected from road side drains the water contains large quantities of suspended impurities. These impurities if let in the reservoir can make water unfit to use also the silt continuously depositing in the reservoir can reduce the capacity of water storage. Hence, road runoff harvesting system needs a silt trap to prevent suspended sediments from adding to the water reserve.

Silt trap:

Suspended sediments travel a long distance in water flowing with high velocity. In order to prevent the sediment entering the water reserve the velocity of the water has to be reduced. Silt traps work effectively for this purpose.

Silt trap is an arrangement to prevent suspended sediments from entering the water reserve. Arrangement consists of two small shallow tanks connected to each other, all the inlets from water source are connected to the first tank and the second tank is connected to the water reserve. The first tank retards the velocity of the water which give time for sediments to settle at the bottom of the tank after the tank is completely filled the water flows to the other tank, the second tank further retards the water velocity and most of the silt is deposited at the bottom of the tank and clean water is transferred to the water reservoir.

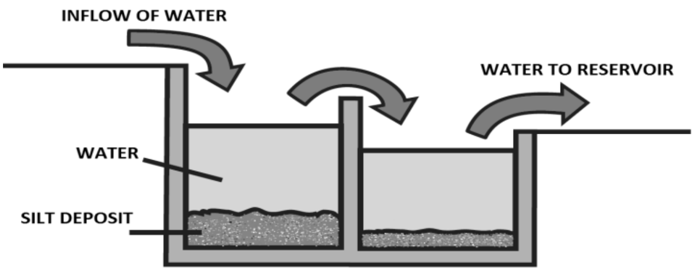

Figure 1. Silt Trap

Construction of silt trap :

Silt trap tanks are brickwork construction. To prevent the seepage of water from the tank it need to be plastered with cement and waterproofing agents. The dimension of the tank depends on the inflow of the water and the retard time needed based on the suspended sediments in the water. Also the depth of the tanks should be accessible in order to remove silts periodically.

Spillway:

At times when it rains excessively the volume of water flowing through the inlet channel increases and water enters the reservoir directly bypassing the silt traps. It is necessary to ensure water flows from silt traps before entering the reservoir in order to maintain the quality of water. Spillway acts as a barrier which prevents overflow water from entering directly to the water reservoir. It is a bund wall build by soil it extends both sides of the silt traps which directs the overflow water away from the reservoirs. No extra efforts are needed in building such barriers the soil excavated from the reservoir is deposited along the sides of the silt traps creating a spillway.

Storage of water:

Water cannot be used as and when available and has to be stored for future use. It has to be protected against seepage, evaporation and contamination.

Ideal storage type for such system can be '**Water Reservoirs**'. Water reservoirs are reservoirs with bund walls surrounding it. The reservoir is egg shaped with the tapering end connected to the silt trap. Thus, water can enter the reservoir only from one point.

Also the construction of such reservoirs is very simple can requires minimum skills. These reservoirs can be built in stages in dry seasons and is very economical. At every stage, the water reservoir can be made deeper and the dam wall higher from soil excavated from the reservoir. This process can be continued until the dam can hold enough water throughout the year. Hence, this will also help to make the system more economical and can be developed by locals without help from outside.

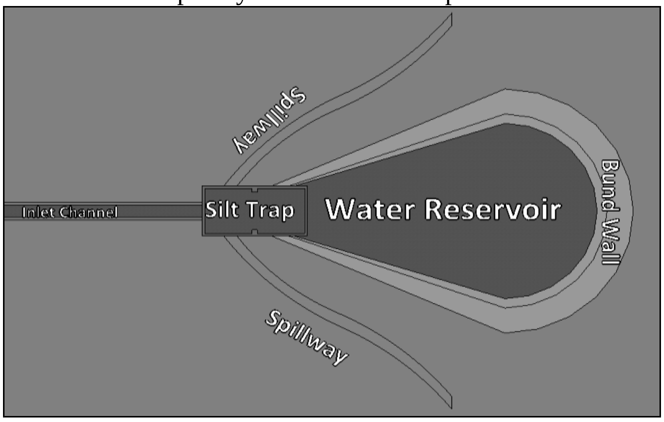

Figure 2. Diagrammatic representation of Water Reservoir

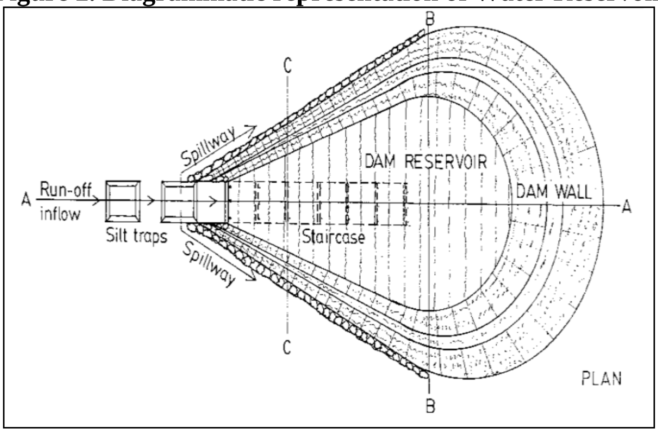

Figure 3. Water Reservoir Top View

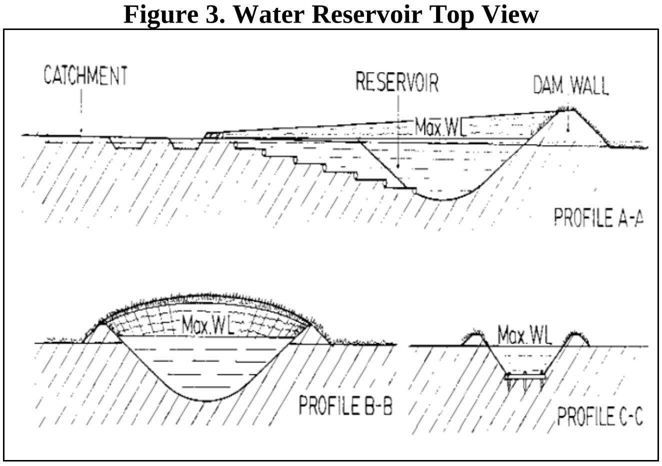

Figure 4. Profile Views of Water Reservoir

Seepage and Evaporation Losses:

The RRH system can be effective only if the water stored during rains is preserved till the dry season. The losses of water stored in the reservoir are mainly due to the seepage of water in the soil below and due to evaporation. In dry season the loss per day can be tremendous. It is vital to minimize such losses in the RRH system.

One of the most effective techniques used to prevent seepage in India is plastic lining of the reservoir. This system is very effective can greatly minimize losses due to seepage. The government of India has provided subsidy under Nation Horticulture Mission (NHM) - a centrally sponsored schemes on construction of plastic line tanks or reservoirs in all states of India to mitigate the scarcity of water.

To prevent evaporation losses is a difficult task since the water storage is open reservoir it is hard to control such losses. Certain traditional techniques can be helpful to minimize evaporation. Plantation along the reservoir is one of the effective techniques in such case. Tress acts as barriers to the hot air winds flowing in dry season which accelerate the process of evaporation. Also vegetation helps maintain low temperature which can further help to minimize the loss. Covering the open water reserves with polystyrene particles is experimented in other countries and is very effective method to prevent losses; though it is not used in India it can be experimented.

Operation and maintenance in RRH

There are various precautions and steps that should be taken for maintenance of RRH to increase its efficiency and durability as stated below.

- Sediment removal from inlet channels to maintain capacity.
- Repair of broken sections of the channels and embankment.
- Replanting of fruit trees or grass along the embankment.
- Rebuilding/repairing basin embankments and spillways.

Costs in Road Runoff harvesting (RRH)

Cost is the prime parameter in design and execution of such projects as funds are very limited in such projects. The RRH system is designed in such a way that material cost is very low and main expenditure is on labor requirement for inlet channels excavation. If this system is setup in small settlements/villages, local self-help groups can efficiently get the job done since the system is going to help them harness the precious water for their own need.

Benefits of Road Runoff Harvesting (RRH)

1. This system can provide water for domestic use.
2. Farmers/land users can increase their produce as more water would be available
3. Fodder production can be increased and soil loss reduced, as some farmers/land users normally harvest soil in addition to runoff. The results have been improved food security and farm income resulting from improved yields/production and consequently improved livelihoods.
4. It can helps in increasing the groundwater.
5. It can also help in drip irrigation in the region.
6. The conserved water can be used by the livestock.
7. It reduces the dependency on the city water works.

Farmers/land users in Kenya who have used this have more than doubled their banana/pawpaw production and doubled their maize/beans yields.

Runoff rainwater harvesting for Sample Model (Aatekar Vasti, Pune):

In order to check the viability of RRH in India a sample model is designed and calculated.

A small settlement near Pune city, in Maharashtra state, India is considered for the purpose.

- The Name of the locality: Aatekar vasti.
- Location: Pune District, Maharashtra State, India.
- Population: 300.
- Average rainfall in rainy season: 600 mm.

This locality is surrounded by hilly region on 3 sides. These hills have roads reaching the Sinhagad Fort these roads are recently constructed with roadside drains and thus can be ideal site for RRH.

Various calculations are to be done to calculate various parameters required for the design of RRH. The total capacity of water pan is to be calculated based on the volume of water flowing in the drains along the ridge. A stretch of 3.6 KM is selected where the volume of water flowing in the drain is calculated

Volume of rainwater running off roads

The volume of rainwater running off from a 1 km long Tarmac road from a rain shower of 30 mm, can be estimated as follows:

Road area: 1,000 m long and 4 m wide
Road surface: Tarmac
Run-off efficiency: 80%
Rainfall: 30 millimetres
Volume of Water = Road area x Runoff efficiency x rainfall
1,000 m x 4 m x 80 x 30 mm = 96,000 litres
= 96 cubic meters, from 1 km road.

Annual volume of runoff

Bearing in mind that the average annual rainfall is more than 600mm in this area, the total annual volume of run-off water from a 3.6 km long road is:

3,600 m x 4 m x 80 x 600 mm = **6,912,000 litres** = 6,912 cubic meters

Since it's the hilly route water from additional catchment area will also flow on the roads.

From a general survey it has been observed that additional catchment area is minimum 5000sq, m.

Volume of this additional water:
5000 x 80 x 600 = **2,400,000 litres** = 2,400 cubic meters.
Adding this to annual volume of runoff
Total annual volume of runoff
6,912,000 litres + 2,400,000 litres = **9,312,000 litres**

Total Water requirement

Say the population of the Aatekar Vasti is 300

And the average water use per person per day for such settlement is 117 liters (Central Ground Water Board)

Therefore, total water requirement of entire Aatekar Vasti for 1 year = 300 x 117 x 365 = 12,811,500 liters.

If we compare the water requirement of the village and the potential volume of water that can be collected from RRH, more than half of the water requirement of this settlement can be fulfilled by the project.

This example shows clearly that roads can supply huge volumes of water for domestic use, livestock, irrigation, forestry, construction works, etc., provided the harvested water can be stored until it can be used in the following dry season.

Road Runoff Harvesting (RRH) is becoming increasingly important in arid and semi-arid lands in countries Kenya for crop production, due to increased benefits and farm income resulting from high yields.

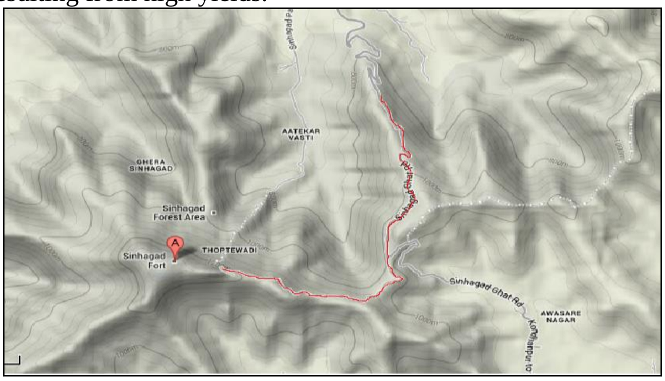

Figure 5. Contour map of the region; Red line showing the stretch of 3.6 KM which is contributing water for Aatekar Vasti

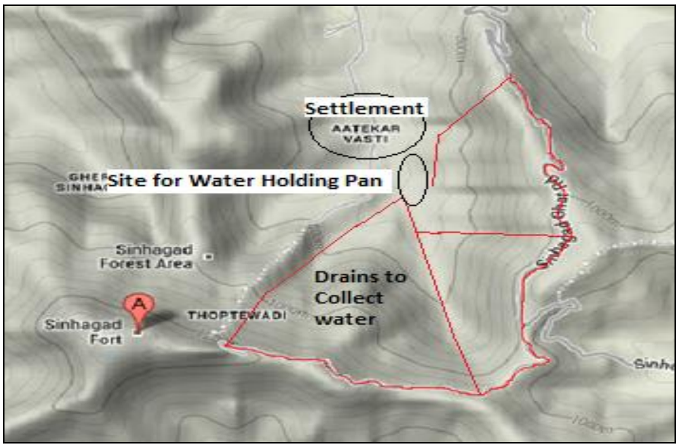

Figure 6. Layout for RRH system near Aatekar Vasti on a Topographical Map

Conclusion:

The Road Runoff water Harvesting is designed in such a way that it can be easily implemented with very less economical support and the locals can be largely benefited from it. In Indian state of Rajasthan, Rain Water Harvesting is done since ancient times and it has helped people survive the Thar Desert but in the semi-arid and arid areas of central India people are not aware of such techniques and RRH can prove to be a great help for such areas.

The varying frequencies monsoon rains has made it more necessary to conserve water and harvest the rain as much as possible.

In some regions eastern Maharashtra the local governments have provided water to villages via water tankers which have costs government a large sum of money this can be prevented if government takes the initiatives in such projects and provide primary help to the locals for building such systems. RRH can also provide water for irrigation and livestock which will helps people to sustain their food and livelihood requirements.

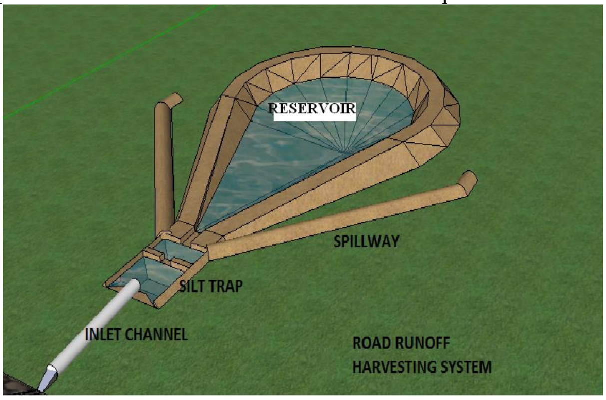

Figure 7. Water Collection System

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