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A CASE STUDY ON RAIN WATER HARVESTING TECHNOLOGIES FOR TRIBAL AREA OF MADHYA PRADESH, INDIA

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Abstract

A study was contended under rainfed area of M.P., India. The different types of rain water harvesting structures have constructed in the tribal area of Shahdol, for rainwater storage as the area has no perennial source of water in the vicinity. An effort is to develop different models for rainwater harvesting, *in-situ* soil and moisture conservation and utilization of stored water for tribal area. Three numbers of rain water harvesting structures been constructed at three different locations in the tribal area for different purposes. First one was constructed for storage of rain water for irrigation horticultural plants (Budded Ber) and second and third structures were constructed for rain water harvesting as percolation tank. The capacity of these structures is 72 m^3 (size 6 × 6 × 2 m), 79.2 m^3 (size 6 × 6 × 2.2 m) and 156.8 m^3 (size 7 × 7 × 3.2 m) having catchment area of the 2ha, 2ha and 4ha respectively. Structure-1 was very effective having catchment area 1 to 2 ha for life saving irrigation of the horticultural plants. At least 6 months, it can provide irrigation water to the plants. Structure-2 is suited, especially where ground water depletion is the main problem having moderate land slope. Targeted well was maintained 1.67 meters of water level up to hardy dry period and fulfil the domestic water requirement of the 4 number tribal's family. Structure-3 is most efficient among three and no runoff (0%) generated from the field because of well designed Water Absorption Trenches on catchment area of the structure. 100% rain water have harvested as *in-situ* moisture conservation.

Key words : Water harvesting, rain water harvesting, tribal area, water absorption trenches (WAT), rainfall intensity.

Introduction

Water is considered to be the key input for augmenting agricultural production all over the world. India has been one of the few countries of the world, which showed awareness of the need to conserve and care of the watershed resources of land, water, plants and animals in the integrated manner and the Government has invested heavily in the measures of soil and water conservation on watershed basis and presently number of big or small projects are in operation. After four decades of promotional efforts, the farmer's adoption for recommended soil and water conservation measures installed under special programme have rarely been maintained. On the contrary, there are many cases where farmers lack of interest in soil and water conservation programmes has not been suitable for their small farms. There are wide variations, both temporal and spatial, in the availability of water in the country. Much of the rainfall occurs within a period of a few months during the year, and even during that period the intensity is concentrated within a few weeks. Spatially, there is a wide range in precipitation- from less than 200 mm in parts of Rajasthan to 11000 mm in Cherapunji in the north-east of the country.

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Materials and Methods

Study area is located at Latitude 23^0 17' 375'' N, Longitude 81^0 19' 836'' E and height of the MSL is 466.65 meters. To evaluate the performance three different types rain water harvesting techniques, excavation of the structures on selected sites were completed before the monsoon. The specification of the three rain water harvesting structures (RWH) is given in table 2.

The average annual rainfall, soil type and land slope of these areas were 900 mm, 1 to 2.6% and sandy loam, respectively. Soil depths of catchment area of all structures range in between 30 to 45 cm. The bed and sides of the first structure was levelled by removing rocks, stones or other projections, for the purpose of placing lining material. HDPE 250 µm yellow polythene sheet has been

used as lining material for the structure-1. Two structures were used as percolation tank and therefore, were not lined only removed rocks, stones and other projections from sides.

For the structure-1 and 2, soil erosion has checked by counter bunds and water absorption trenches of the catchment area of the structure. Velocity of runoff has reduced and travelling time of water has increased in the catchment area of the pond. Good vegetative growths have seen of local grass of the catchment area for long time compared to other area of same topography condition in the field. Stored water was available up to April and accessible for life saving irrigation.

Month wise data of water level and amount of stored water used for irrigation were recorded of structure-1. Water level floatation data were recorded of the 2nd and 3rd water harvesting structures on daily basis.

Results and Discussion

Rainfall pattern of study area

Rainfall of the area is erratic and uneven distribution. Annual Rainfall pattern of district Shahdol is presented in fig. 1. Rainfall pattern of the area causes huge amount of soil erosion due to poor *in-situ* soil and moisture conservation measures. The average annual rainfall, soil type and land slope of these areas were 900 mm, 1 to 2.6% and sandy loam, respectively. Soil depths of catchment area of all structures were 30 to 45 cm. The bed and sides of the two structures were levelled by removing rocks, stones or other projections, for the purpose of placing lining material. HDPE 250 µm yellow polythene sheet has been used as lining material for the structure. Two structures were used as percolation tank and therefore were not lined.

The first, second and third structure stored cumulative amount of rainfall respectively 80, 475 and 313 cubic meters. The first water storage structure provided life saving irrigation to 130 Budded Ber and 30 plants of Pomegranate up to March. For the first year per litre cost of rain water harvesting were 0.14, 0.012 and 0.078, respectively.

Second structure was excavated at downstream site of the farm and third arrangement is used for water storage for recharging of open well, which is located 5.5 metres away of the downstream of the structure. First structure was stored 80 cubic meter of rain water and water was used for domestic purposes as well as support irrigation of horticultural plants, second structure was hardly full up to its storage capacity in two times during rainy days because of arrangement of water absorption trenches (WAT) on the catchment area of the structure and third structure was collected and rejuvenated rain water nearly 475 cubic meter during the first rainy season.

Calculation of length of waste weir

The length of the proposed waste weir is calculated by the following formula (Singh, 2000). $L = Q/1.71h^{3/2}$

Where,

L = Length of emergency spillway

Q = Peak discharge of the spillway (m^3/sec)

h = depth of flow over the spillway (m)

Calculation of peak rate of runoff

The peak rate can be computed by the rational formula, which is given below : Q = CIA/36

Where,

Q = Peak rate of runoff (m^3/sec)

C = run off coefficient (dimensionless)

I = Rainfall intensity (cm/hr) for design recurrence interval and for the duration equal to time of concentration of the area.

A = Catchment area (ha)

In the construction of waste weir stone pitching was proposed for controlling soil cutting from both the banks of the pond.

Spacing of the bunds : Spacing of the bunds following principles has adopted :

(1) The seepage zone below the upper bund should meet the saturation zone of the lower bund

(2) The bunds should check the water at a point when the water attains erosive velocity

(3) The bund should not inconvenience agricultural operation.

For determining the spacing of the bunds: V.I. = S/a+b

V.I. = vertical interval between consecutive bunds,

S = land slope (per cent), a and b are constants.

V. I. = 10S + 60, cm

H. I. = V.I/S, Horizontal Interval

Structure 1

Construction of the structure was completed before the rains. It was found; it fills up to 3.5 feet after first precipitation and fills completely up to 6 feet in the month of July in second precipitation. Total 72 m^3 water was stored in the structure for life saving irrigation. Soil erosion has checked by counter bunds and water absorption trenches of the catchment area of the structure. Velocity

Table 1 : Cost of rain water harvesting.

Catchment area (m^2)	Required volume of RWHS Pit (m^3)	Length (m)	Width (m)	Depth (m)	Total cost (Rs)
200	4.0	2	1	2	4000
300	8.0	2	2	2	8000
400	12.0	3	2	2	12000
500	16.0	4	2	2	16000
600	20.0	5	2	2	20000
700	24.0	4	3	2	24000
800	28.0	7	2	2	28000
900	32.0	4	4	2	32000
1000	36.0	6	3	2	36000

Source: www.hydrerabadwater.gov.in

Table 2 : Specification of the three rain harvesting structures.

RWH structure	Size (m)	Capacity (m^3)	Catchment area (ha)	Lining material
1	6 × 6 × 2.0	72.0	2.0	Lined
2	6 × 6 × 2.2	79.2	2.0	Not lined
3	7 × 7 × 3.2	156.8	4.0	Not lined

Table 3 : Hydrological data of the structures.

Particular	Structure-1	Structure-2	Structure-3
Catchment area (ha.)	2	2	4
% of runoff to rainfall as per strange's table	13.9	20.85	13.9
Depth of runoff due to rainfall, mm as per strange's table	111.2	166.8	111.2
Run off generated (m^3)	2224	3336	4448
Runoff water stored in structure (m^3)	72	475	313
Average land slope, %	1.5	1.9	2.6
Depth Water absorption Trench (m)	0.3	Not constructed	0.45
Vertical Interval (m)	0.27	Nil	0.39
Horizontal Interval (m)	18	Nil	15
Soil depth (m)	0.3	0.6	0.5
Depth of pond (m)	2	2.2	3.2
Thickness of lying material	250 µm	Not lined	Not lined
Storage capacity, cum	72	79.2	156.8

of runoff has reduced and travelling time of water has increased in the catchment area of the pond.

Structure 2

Second rain water harvesting structure recharged ground water of the open well. After first day of rainfall water level of structure and open well have recorded on daily basis.

Components of rain water harvesting structure

Inlet pipe : Total catchment area of the rain water structure is 2 ha. During rainfall season, a huge amount of fertile soil travel with runoff. An inlet pipe has fitted on the upstream side of the structure and inserted in earthen bund, to safely release water into the structure. It is a 5 metres long PVC pipe. Diameter of inlet pipe is 152 mm. It is slightly tapper towards water body and water drop on middle of structure.

Sump well : It is a small well of 1.5 metre diameter and 1 meter of depth. Sump well is working water filtration work. It checks soil and other dirt materials. After excavation of Sump well, it fills with big boulders and small stone respectively from bottom to top. Inlet pipe has situated on the bottom of sump well.

Storage area : Total storage area of the structure is 79.2 cubic metres. Shape of the pond is square and a rectangular bund has constructed around the pond to avoid dirt and other foreign materials into the pond through runoff water.

Earthen bunds : Pond is surrounded by earthen bunds around all sides. Shape of earthen bund is

Table 4 : Economical data of the structures.

Particular	Structure-1	Structure-2	Structure-3
Cost of excavation (Rs.)	4800.00	4000.00	9000.00
Cost of lying material (HDPE polythene) (Rs.)	3200.00	NIL	NIL
Cost of water harvesting (Re/litre)	0.14	0.012	0.078
Purpose of construction	Water storage for irrigation and domestic use	Ground water recharging only	Ground water recharging and domestic use
Total no. of plants	160	NA	NA
Plant to plant spacing	8 m	NA	NA
Number irrigations given in first year	11	NA	NA
Plants survival	96%	NA	NA

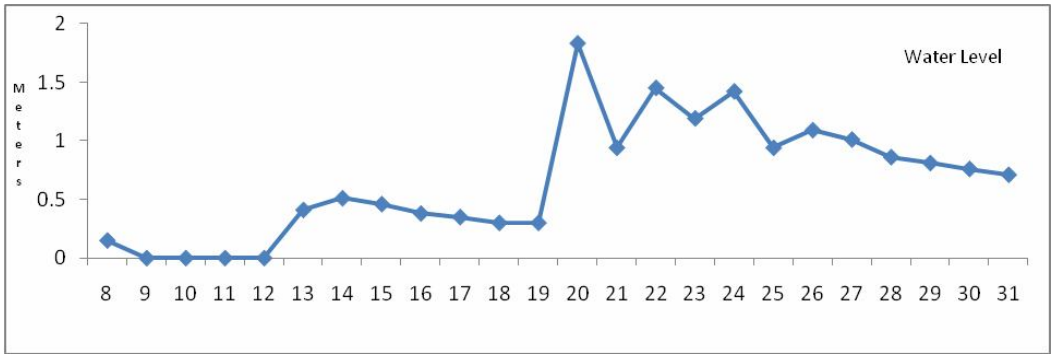

Fig. 1 : Fluctuation of water level in the month of July.

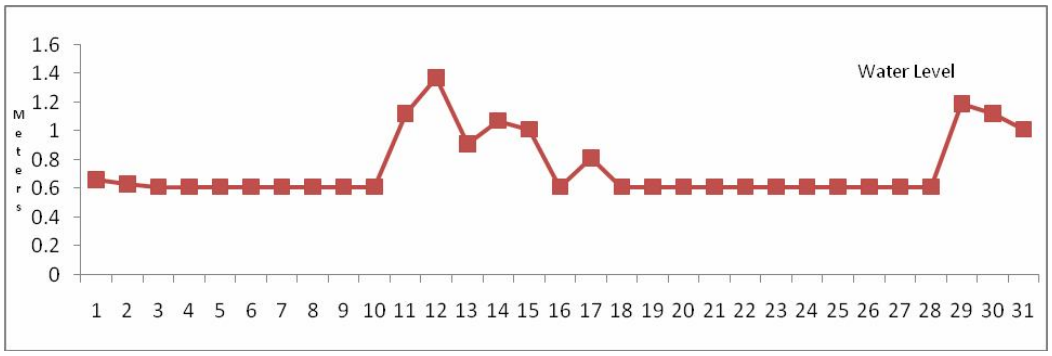

Fig. 2 : Fluctuation of water level in the month of August.

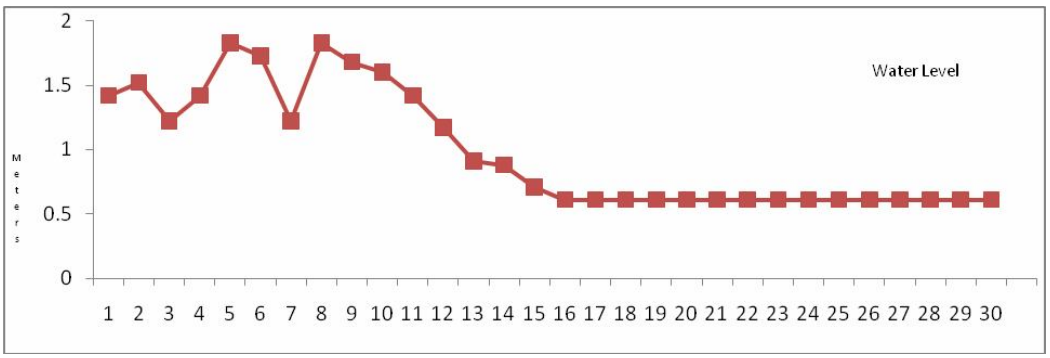

Fig. 3 : Fluctuation of water level in the month of September.

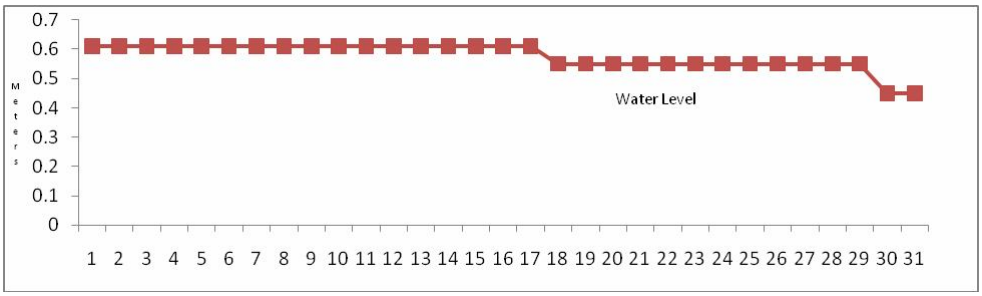

Fig. 4 : Fluctuation of water level in the month of October.

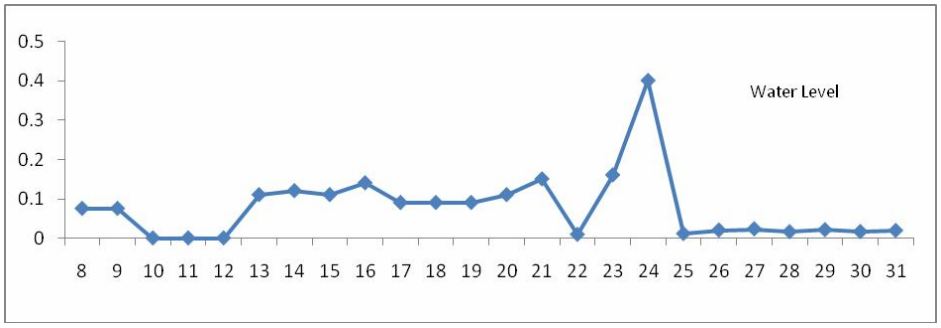

Fig. 5 : Fluctuation of water level (meters) in the month of July.

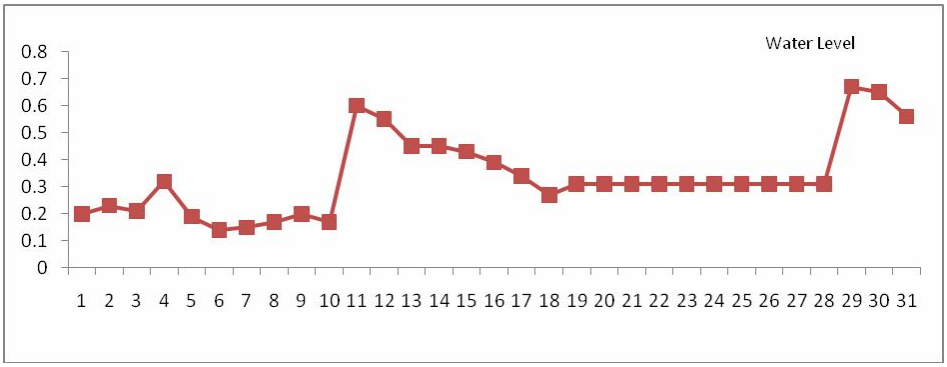

Fig. 6 : Fluctuation of water level (meters) in the month of August.

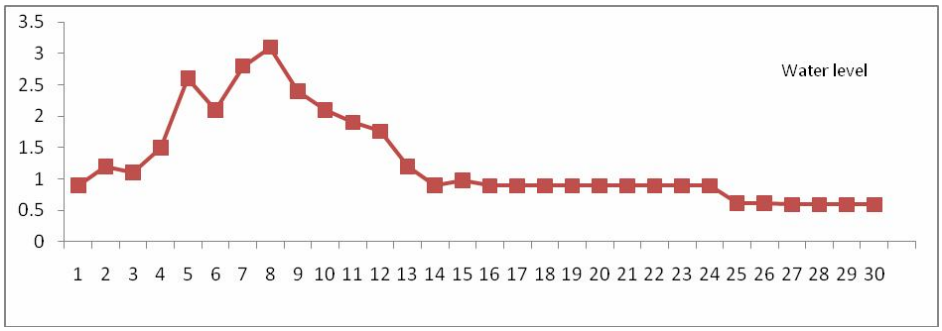

Fig. 7 : Fluctuation of water level (meters) in the month of September.

trapezoidal. Earthen bunds enhance its storage capacity and avoid flow of dirt into the pond with runoff water.

Stone pitching : After compaction of earthen bund, stone pitching work has carried out by locally available stones. Stone pitching gives better strength to earthen bund and reducing soil erosion and soil scouring during heavy and erratic rains.

Out let : On the lower (downstream) side of the pond a pipe out let has provided for safe disposal of excess water during heavy rain. It is a 3 metres long PVC pipe. Diameter of inlet pipe is 100 mm. It is slightly tapper towards outside and it release excess water out of structure.

Plantation : Purpose of horticulture plantation is use

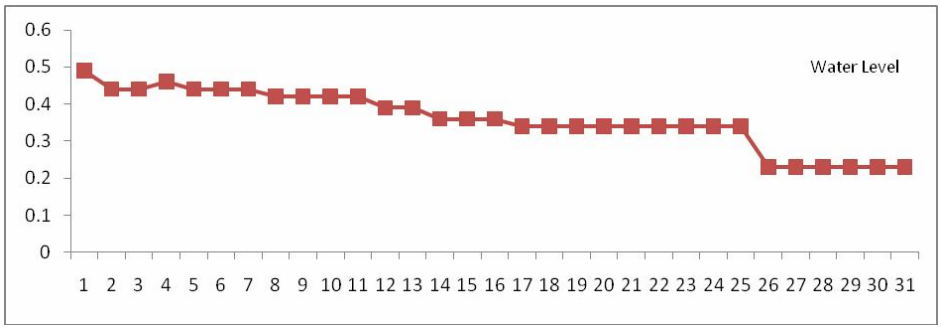

Fig. 8 : Fluctuation of water level (meters) in the month of October.

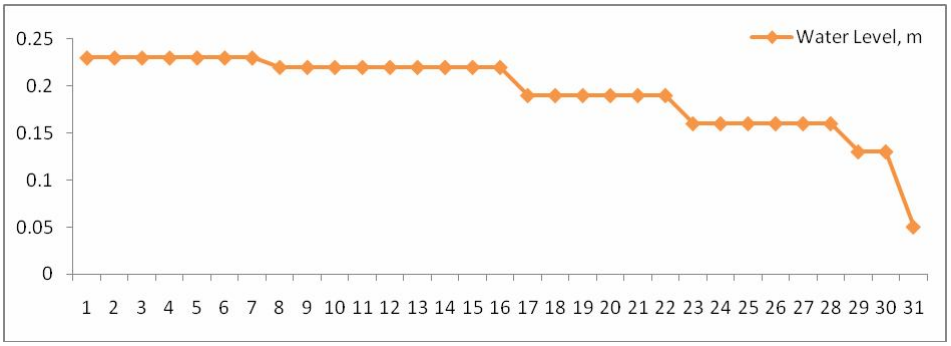

Fig. 9 : Fluctuation of water level (meters) in the month of November.

stored water for life saving irrigation to the plants and enhances extra income. Total 20 numbers of horticulture plants planted near the structure *i.e.* aonla, pomegranate and mango.

Open well : There is an open well on the downstream side of the structure and depth of open well is 10.66 meters. One of the most important objectives of this structure is to recharge the well during rainy season. Diameter of the well is 1.82 metres and distance between structure and well is 4.6 meters.

Structure 3

This structure was most efficient in In-situ soil moisture conservation. Soil type sandy loam and slope of the land is 2.6%. Soil erosion has checked by counter bunds and water absorption trenches of the catchment area of the structure. Velocity of runoff has reduced and travelling time of water has increased in the catchment area of the pond.

Conclusion

All three structures are especially useful for arid and semi arid region for In-situ soil and moisture conservation. After visualizing the success of these cost effective technology, local farmers are interested to construct such structure. Structure-1 was very effective having catchment area 1 to 2 ha for life saving irrigation of the horticultural plants. At least 6 months, it can provide irrigation water to the plants. Structure-2 is suited, especially where ground water depletion is the main problem having moderate land slope. Targeted well was maintained 1.67 meters of water level up to hardy dry period and fulfil the domestic water requirement of the 4 number tribal's family. Structure-3 is most efficient among three and no runoff (0%) generated from the field because of well designed Water Absorption Trenches on catchment area of the structure. 100% rain water have harvested. The impact of the structure on mitigation water stress on horticultural plants in the first year itself has provided very strong demonstrative value amongst tribal's of the district. Seepage loss was completely checked throughout the year.

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