Effective Utilization of Rain Water Harvesting Technique To Reduce Scarcity of Water for Nimshirgaon Village, Kolhapur District, Maharashtra, India

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***Abstract*: Water is key of life. One of the major sources of water is rainwater. Water is the basic element of social & economic infrastructure and it is essential for sustainable development. It is necessary to harvest water immediately after raining; therefore proper planning & harvesting necessary to obtain healthy society. In this paper we have designed rain water harvesting for Nimshirgaon village.**

***Index Terms*: Components, Design of Rain water harvesting (RWH) system, Ground water table (GWT)**

I. INTRODUCTION

Water availability is the most important consideration for all areas. As the population increases the demand increases for various purpose. Rain water harvesting is technology where surface runoff is effectively collecting of rain water which can be stored for direct use or can be recharged into the ground water. RWH is essential and economical in construction compare to other sources. Now a day this aspect is mandatory for every construction of building. For design purpose we have collected information about rainfall intensity, runoff, soil data, population trend, water demand etc. then analyzing, forecasting of data for the selected village site.

II. OBJECTIVES OF STUDY

1. To study rain water harvesting technique.
2. To collect data based on various parameters like rainfall intensity, soil data, population, requirement of water.
3. Designing of water storage tank at various locations for selected village site.
4. Bore well recharge through excess availability of water for increase in G.W.T.
5. To suggest RWH system and its implementation to minimize scarcity of water for selected village site.

III. METHODOLOGY OF WORK

1. To study the present status of RWH systems through different research papers & make literature review.
2. Fixing the location for work & then collecting all the information about that area.
3. To conduct various tests on soil sample like Specific gravity, water content, permeability etc.
4. Calculation of catchment area for existing roof structures of each house in a selected village.
5. Designing of rain water harvesting system to minimize scarcity of water for selected village.

IV. METHODS OF RAIN WATER HARVESTING

There are two methods of rain water harvesting,

1. Surface runoff water harvesting. e.g. Dam, Lake, Percolation tank etc.
2. Roof top rain water harvesting. e.g. Inclined or flat roof of building.

In this paper we mainly focus on roof top rainwater harvesting system for design purpose. It is a system of catching rainwater where it falls. In roof top rainwater harvesting, the roof becomes the catchment & rainwater is collected from the roof of a building. It can be either store in tank or diverted to recharging system.

a. Storage of rainwater in tanks above grounds or below grounds.
b. Recharge into well for withdrawal later by ground water recharging basis.

V. COMPONENTS OF ROOF TOP RAIN WATER HARVESTING SYSTEM

1. Catchment- The catchment is the area or surface, which receives rainfall directly. It can be any surface such as paved area like a terrace or courtyard of building or an unpaved area, like lawn or open ground. Temporary structures like sloping sheds can also act as catchment. Run-off factor determines the quantity of water which will be available from the catchment run-off factors for wooded or grassy land is very less say 10% rest is absorbed by percolation, whereas run-off factor for paved or terraced area is 70% to 80% as most of the rainwater is available for recharge or storage except for water lost due to evaporation.

2. Transportation- Rain water from roof top should be carried through down take water pipes or drain to storage/recharging system. Water pipes should be UV resistant (HDPE/PVC) of required capacity. Water from sloping roof could be caught through rain water gutters & down take pipe. At terrace, mouth of each drain should have wire mesh to restrict floating materials.

3. First flush- It is a device used to flush off the water received in first shower of rain. The first shower of rain needs to be flushed off to avoid contaminating storable/rechargeable water by the probable contaminants of the atmosphere & the catchment roof. It will also help in cleaning of silt & other material deposited on roof in dry seasons. Provision of first rain separator should be made at outlet of each drain pipe.

4. Filter- The filter unit is a container or chamber filled with filter media such as coarse sand, charcoal, coconut fiber, pebbles and gravels to remove the debris and dirt from water that enters the tank. The container is provided with a perforated bottom to allow the passage of water. The filter unit is placed over the storage tank. Commonly used filters are of two types. One is a ferrocement filter unit, which is comparatively heavy and the other is made of either Aluminum or plastic bucket. The latter is readily available in market and has the advantage of ease in removing, cleaning and replacing. Another simple way of filtering the debris and dust particles that came from the roof along with rainwater is to use a fine cloth as filter media. The cloth, in 2 or 3 layers, can be tied to the top of a bucket or vessel with perforations at the bottom.

5. Storage- Storage tank is used to store the water that is collected from the rooftops. Common vessels used for small scale water storage are buckets, jerry cans, clay or ceramic jars, cement jars, old oil drums etc. For storing larger quantities of water the system will usually require a bigger tank with sufficient strength and durability. There are unlimited number of options for the construction of these tanks with respect to the shape (circular or rectangular), the size (Capacity from 1000 liters to 15000 liters or even higher) and the material of construction (brickwork, stonework, cement bricks, ferrocement, PCC, RCC).

6. Recharging- There are various methods of recharging rain water. Most commonly used methods are percolation pit method, recharge trench method, bore well with settlement tank, open well method with filter bed sump, etc.

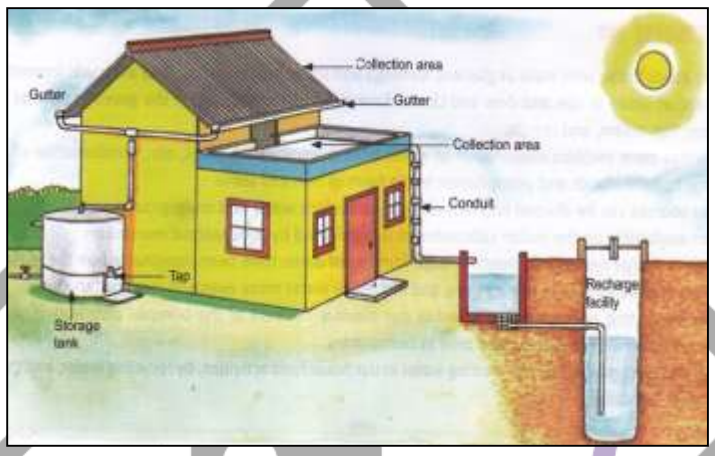

Fig. 1 Rooftop Rainwater Harvesting Systems

VI. DATA COLLECTION

The rain water falls in Nimshirgaon village merges to some natural stream. This rain water should be collected and conveyed to recharge wells from where the rain water percolates into ground and thereby increases the ground water table. This work will helps to improving the water scarcity problem in the summer season.

Nimshirgaon village is located at 16˚47’07”N latitude and 74˚30’43”E longitudinal in Kolhapur district of Maharashtra at an elevation of about 550 meters above mean sea level. It has a tropical climate and receives high rainfall during monsoon (June-September). Average annual rainfall ranges about 735.4mm. The monthly rainfall data of the Nimshirgaon village is given below.

Table 1 Monthly Rainfall data of Nimshirgaon Village

Month	**Rainfall (mm)**
January	0
February	0
March	0
April	0
May	2
June	59.8
July	91.2
August	176.2
September	363.8
October	40.4
November	1.8
December	0.2
Total	**735.4**

For design purpose we collect information about rainfall intensity, runoff, soil data, population, water demand etc. for the selected village site.

Total population of village = 4851

Number of Buildings in village = 1081.

The soil sample is taken from site & tested in laboratory is taken at the depth of 1 meter from plane surface ground.

1. Specific gravity of soil = 2.62
2. Water content of the soil sample = 25.79%
3. Maximum Dry Density (MDD) = 2.20 gm/cc
4. Optimum Moisture Content (OMC) = 23.30%
5. Coefficient of Permeability = 4.7475 X 10^{-7} m/s

Fig. 2 Collection of soil sample

Fig. 3 Map of Nimshirgaon village

VII. RAIN WATER HARVESTING METHODOLOGY

1. Hydrological Analysis- On the basis of experimental evidence, H. Darcy, a French scientist enunciated in 1865, a law governing the rate of flow (i.e. the discharge) through the soils. According to him, this discharge is directly proportional to head loss (H) and the area of cross-section (A) of the soil, and inversely proportional to the length of the soil sample (L). In other words,

$$Q \propto (H/L).A$$ where, Q =Runoff

Here, H/L represents the head loss or hydraulic gradient (I), 'K' is the co-efficient of permeability. Hence,

$$Q = K.I.A$$

Similarly, based on the above principle, water harvesting potential of the catchment area is calculated.
The total amount of water that is received from rainfall over an area is called the rainwater legacy of that area. And the amount that can be effectively harvested is called the water harvesting potential. The formula for calculation for harvesting potential or volume of water received or runoff produced or harvesting capacity is given as,

Harvesting potential or Volume of water received = Area of catchment X Amount of rainfall X Runoff coefficient

Runoff coefficient for any catchment is the ratio of the volume of water that runs off a surface to the volume of rainfall that falls on the surface. Runoff coefficient accounts for losses due to spillage, leakage, infiltration, catchment surface wetting and evaporation, which will all contribute to reducing the amount of runoff. Runoff coefficient varies from 0.5 to 1.0. In present problem statement, runoff coefficient is equal to 1 as the rooftop area is totally impervious. Eco-climatic condition (i.e. Rainfall quantity & Rainfall pattern) and the catchment characteristics are considered to be most important factors affecting rainwater potential. Table 2 given below showing the value of runoff coefficient with respect to types of surface areas.

Table 2 Value of Runoff coefficient (K)

Sr. no.	Types of area	Value of 'K'		
		Flat land 0%-5% slope	Rolling land 5%-10% slope	Hilly land 10%-30% slope
1	Urban areas	0.85	0.65	-
2	Single family residence	0.30	0.30	0.30
3	Cultivated Areas	0.50	0.60	0.72
4	Pastures	0.30	0.36	0.42
5	Wooden land or forested areas	0.30	0.35	0.50

2. Reduce Level (RL) Analysis- The analysis of RLs at different regions in Nimshirgaon is necessary for having idea about surface elevation and surface topology of the ground which is one of the most important parts for fixing the position of recharge point. For this we have used the contour map of Nimshirgaon area which gives detail distinct information on the variation in the elevation of different regions of surface giving clear idea on the surface topology.

3. Methods for storage of harvested rainwater in tank- We need to store the water which is obtained from the rooftop areas of the different buildings. The volume of tank to store the harvested water will be directly proportional to the total volume of water harvested. Technically, there are two types of methods for distributing the harvested rainwater.

a. Rapid Depletion Method (RDM) - In Rapid Depletion method, there is no restriction on the use of harvested rainwater by consumer. Consumer is allowed to use the preserved rain water up to their maximum requirement, resulting in less number of days of utilization of preserved water. The rainwater tank in this method is considered to be only source of water for the consumer and alternate source of water has to be used till next rains, if it runs dries. The standard requirement of water supplied at the rate of 135 lit/day per capita water demands.

b. Rationing Method (RM) - The Rationing method distributes stored rainwater to target public in such a way that the rainwater tank is able to service water requirement to maximum period of time. This can be done by limiting the amount of use of water demand per person.

4. Design of Water tank-

According to Nimshirgaon village map shown in fig. no. 3, total area of village is divided into 5 main parts having 33 sub parts. Catchment area (roof top area) for these 33 sub parts calculated using this map. Storage tank designed of required capacity & shape (circular or rectangular) according to site conditions for each area. Table 3 & 4 given below showing design of circular & rectangular water tank respectively. Sample calculations for water tank design are as follows,

VIII. Circular water tank

For catchment area = 429.67 m^2 (for Block no. M1-4)

IX. Rainwater potential = Area X Runoff coefficient X Rainfall intensity

= 429.37 X 0.8 X 0.735

= 252.64 m^3

2. Water requirement: Maximum population = 48 Peoples

Rate of consumptions = 135 lit/capita/day = 0.135 m^3/day

Total amount of water consumption = 48 X 0.135 = 6.48 m^3/day

3. For recharging bore wells & wells = 126.32 m^3

Remaining water stored in tank = 126.32 m^3

4. Number of days it can be utilized = Stored water / Water demand

= 126.32 / 6.48

= 20 days

5. Optimum dimensions of tank

Total amount of water stored in tank = 126.32 m^3

Height of water tank = 4 m

Area of base = 126.32/4 = 31.58 m^2

Provide circular water tank of diameter = 6.34 m = 6.5 m

b. Rectangular water tank

For catchment area = 805.68 m^2 (for Block no. M4-1)

X. Rainwater Potential = Area X Runoff coefficient X Rainfall intensity

= 805.68 X 0.8 X 0.735

= 473.74 m^3

2. Water requirement: Maximum population = 84 Peoples

Rate of consumption = 135 lit/capita/day = 0.135 m^3/day

Total amount of water consumption = 84 X 0.135 = 11.34 m^3/day

3. For recharging bore wells & wells = 235 m^3

Remaining water stored in tank = 238.74 m^3

4. Number of days it can be utilized = Stored water / Water demand

= 238.74 / 11.34

= 21 days

5. Optimum dimensions of tank

Total amount of water stored in tank = 238.74 m^3

Height of water tank = 4 m
Area of base = 238.74/4 = 59.68 m^2
Provide rectangular water tank of size (6 m X 10 m)

Table 3 Tabular format of design calculations for Circular type water tank

Sr. No.	No. of Block	Catchment Area (m^2)	Harvested Potential (m^3)	Recharge of Bore wells (m^3)	Diameter of water tank (m)	Height (m)
1	M1-1	642.59	377.84	188.92	7.75	4
2	M1-2	413.38	243.06	121.53	7	3
3	M1-3	612.73	360.28	180.14	6.5	4
4	M1-4	429.67	252.64	126.32	6.34	3
5	M2-1	619.212	364.09	182.04	7.17	4.5
6	M2-2	380.56	223.76	111.88	5.62	4.5
7	M2-3	474.75	279.15	139.58	6.66	4
8	M2-4	334.33	196.58	98.29	6.45	3
9	M2-5	253.44	149.02	74.51	4.86	4
10	M2-6	408.64	240.28	120.14	6.18	4
11	M2-7	265.004	155.82	77.91	4.78	4
12	M2-8	332.38	195.43	97.71	5.57	4
13	M2-9	779.54	458.36	229.18	7.63	5
14	M2-10	677.98	398.65	199.32	7.12	5
15	M2-11	527.64	310.25	155.12	6.42	4.5
16	M2-12	607.69	357.32	178.66	6.74	5
17	M2-13	271.16	159.44	79.72	4.96	4
18	M3-1	618	363.384	181.692	7.60	4
19	M3-2	363.90	213.97	106.985	7.38	2.5
20	M3-3	429.67	252.64	126.32	6.34	3
21	M3-4	389.64	229.11	114.55	6.03	4
22	M3-5	585.94	344.54	172.27	7.40	4

Table 4 Tabular format of design calculations for Rectangular type water tank

Sr. No.	No. of Block	Catchment Area (m^2)	Harvested Potential (m^3)	Recharge of Bore wells (m^3)	Dimensions of water tank (m)	Height (m)
23	M4-1	805.68	473.74	235	6 X 10	4
24	M4-2	949.13	558.08	280	6 X 12	4
25	M4-3	972.89	572.05	330	6 X 10	4
26	M4-4	800.42	470.64	200	7 X 10	4
27	M4-5	880.32	517.62	300	6 X 9	4
28	M5-1	914.72	537.85	300	6 X 10	4
29	M5-2	1053.74	619.59	380	6 X 10	4
30	M5-3	660.63	388.45	150	6 X 10	4
31	M5-4	1070.74	629.59	370	6 X 11	4
32	M5-5	548.65	322.60	100	6 X 10	4
33	M5-6	935.41	550.02	300	6 X 11	4

XI. **Conclusion**

Water is the major source for social, agricultural and industrial development. Now a day's for economic infrastructure, the self sustainable approach for water management is absolutely essential for reducing the scarcity of water. Rain Water Harvesting technique is key aspect which is to be considered while planning for every construction of building. To meet the challenges like increase in population, water scarcity, ground water depletion the effective utilization of rain water harvesting technology aspect in the planning phase of structure is to be considered.

This work is concerned about storage of rain water as well as increasing the ground water table in Nimshirgaon village. For RWH system design we have collected and analyzed data based on various parameters like rainfall intensity, soil data, population, requirement of water. Then designing of water storage tank at various locations for selected site is to be carried out. To minimize scarcity of water we have suggested RWH system for its implementation. Also the excess water available can be used to increase ground water table through recharging wells.

Therefore from the above study it is concluded the aspect of Rain Water Harvesting technique must be considered while planning for any type building construction.

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