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# A CASE STUDY ON PROVISION OF RAIN WATER HARVESTING FOR INCUBATION CENTRE BUILDING UNDER GREEN BUILDING PROVISIONS

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**Abstract:** This research paper deals with the proposal study of rain water harvesting for an incubation centre building under Bhopal smarty city development corporation limited present in Bhopal (M.P.) location. This study comprises of detailed methodology used for setting up the complete rain water harvesting setup to conserve the rain fall water for further use. In this study, a pilot project on rooftop rainwater harvesting (RWH) was under taken in Bhopal Smarty city Development Corporation limited. For completing this study under smart city development a detailed case study was performed to conclude the significance of rain water harvesting setup in betterment of green buildings.

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**Keywords:** *Green Buildings, Rain Water Harvesting (RWH), Water conservation.*

## INTRODUCTION

India, as it relies upon on Monsoon for its rainfall, has a notably seasonal pattern of precipitation, with 50% of precipitation falling in only 15 days and over ninety percent of river flows in only four months. Additionally, India is presently in the early ranges of a profound demographic, social and economic transition. The share of the population that is city has doubled over the last thirty years (and is now about 30%); agriculture now a day only comprise of about 25% of GDP. Urbanization has led to concretization of large land. The paved pathways, roads and roofs all are impervious surfaces that don't permit the water to percolate in to the floor and additionally result in huge amount of typhoon water to waft and go to waste. If this water is stored and treated it may cater to half the demand of the metropolis. If this water is directed to the ground it can increase the water table and supply plenty of water in the summer time. The other vital factor is that loss of environmental considerations in city planning and production has caused blockading of herbal drainage system of the towns. This has especially occurred in our case instance i.e. Bhopal region in Madhya Pradesh of the Central India.

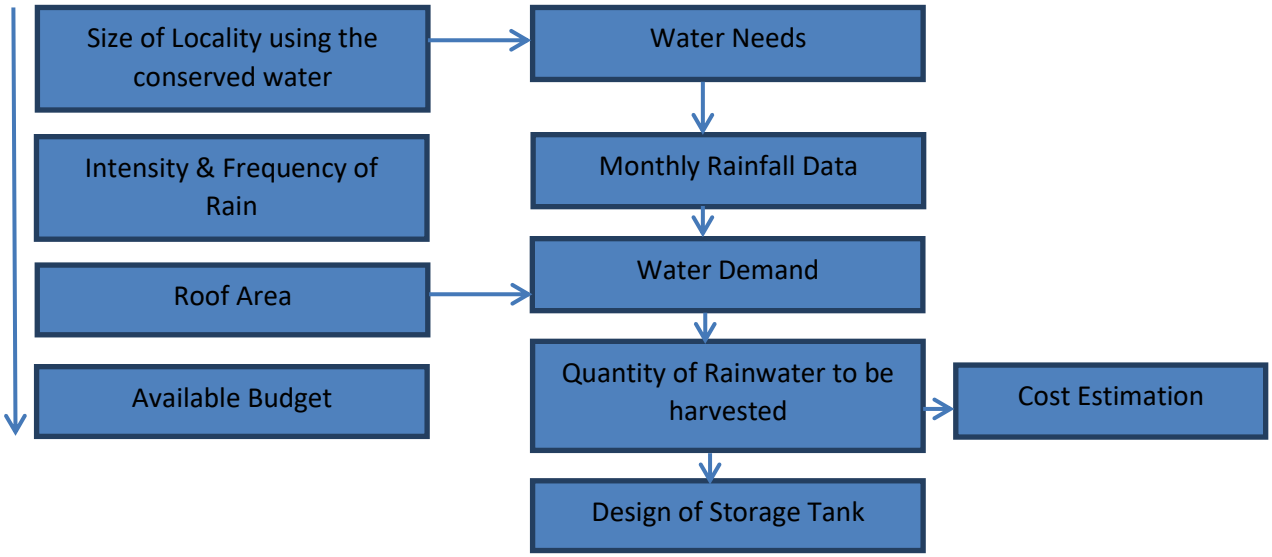
In the face of increasing scarcity of water resources, there is a need for communities to come up with solutions for the rain water conservation. In the scenario prevailing these days green building technology is advancing at a much faster rate which provides various advantages of conserving various natural resources. Rain water harvesting is also a concept followed in the construction of buildings with green technology fundamentals. For defining the correct scope of green technology buildings with rain water harvesting in this study an estimate is proposed for the conservation of rain water.

**Aim of study:** To present a rain water harvesting setup in the incubation centre, under Bhopal smarty city development corporation limited an estimate was prepared to conserve the rain water in the existing Tube Well bore by discharging it at site location and further treating it for drinking and other uses.

**METHODOLOGY**

The methodology of this study starts with the water needs for the community on which the rainwater harvesting system is applied is needed to be estimated. This process was followed by the design of storage option which depends on the intensity and frequency of rain, size of the roof surface, available budget and available material and labour. Finally the total cost of whole rainwater harvesting system is determined.

Flow chart of the research strategy is given below:



**Steps of Methodology for Case study of a pilot project:**

## Basic Data

1. Plot Size-1200 sq. m
2. Roof top Area- 1100 sq. m (assume)
3. Height of Building -16m
4. Annual Rainfall of Bhopal – 1126.7 mm (Indian Metrological Department)
5. Number of Boring – One (1)

## Calculations

*Runoff - It is the term applied to the water that flows away from a surface after falling on the surface in the form of rain.

*Runoff Coefficient - the term applied to the water that flows away from a surface after falling on the surface in the form of Rain.

* Another coefficient for evaporation, spillage and first flush wastage can be considered as **0.80 (CPWD Manual)**

***** Average drinking water is required per person per day is 10 litres.

| Type of Catchment | Runoff coefficient |
|---|---|
| Roof Catchment<br>• Tiles<br>• Corrugated Metal Sheets | <br>0.8-0.9<br>0.7-0.9 |
| Ground Surface covering<br>• Concrete<br>• Brick pavement | <br>0.6-0.8<br>0.5—0.6 |
| Untreated Ground surface<br>• Soil on slopes less than 10 percent<br>• Rocky natural catchment<br>• Green area | <br>0.0-0.3<br>0.2-0.5<br>0.05-0.10 |

- Amount of water can be collected = Catchment Area X Annual Rainfall

  = 1100 X 1126.7

  = 1100 $m^2$ X 1.12 m

  = 1232 cu. m

  = 1232000 litres

- Runoff Coefficient - 0.9 (as per concrete surface {CPWD Manual})

  = Amount of water X Runoff Coefficient X 0.80

  = 1232000 X 0.9 X 0.80

  = 887040 Litres

  = 73920 Litres rainy season.

**Suggestions**

The quantity of water obtained can be stored by constructing an underground tank.

***"OR"***

Either the quantity of water obtained can be discharged in the existing Tube Well bore by constructing a Filtration tank above/aside of bore well.

*As per CPWD Manual for RWH for 1200 cu. m volume of water recharge of dug wells are recommended.

**DETAILS OF WELL AND TUBE WELL AVAILABLE FOR RECHARGING**

| S.No. | Location Details |
|---|---|
| 1 | Tube well near connecting bridge of the building |

**Selection of Recharging Method**

Roof top rain water Harvesting System comprised of 6 component as described below-

- Catchment Area/Roof Surface- surface upon which rai falls.
- Gutters and Downpouts- Transport channels from catchment to storage,
- Leaf screens and Roof Washers- System that remove contamination and debris.
- Cistern or Storage tnks- Where collected rain water is stored.

- Conveying- The delievering system for treated rain water either by gravity or pump.
- Water Treatment- Filters and equipment and additives to settle filter and disinfect.
- Ground Water recharge structure like pit, trench, tubewell or combination of structures.

The basic purpose of artificial recharge of ground water is to restore supplies from aquifer depleted due excessive ground water development and usage. Detailed knowledge of geological and hydrological features of the area is necessary for adequately selecting the site and type of recharge structure. Building Site Area comprises alluvial formation with 10-15 m groundwater level in post-monsoon period. Alluvial formation have good transmissivity.

Since the catchment area and runoff volume is very large, so need to distribute the runoff and recharge centers along the gravitational flow of the campus. Building site Campus have one running and one abandoned tube well located

**First method suggested is use of existing/abandoned Tube well as recharge structure.**

- Rainwater collected from PVC pipes.
- Rainwater from roof is taken to collection desilting chamber located on ground. These collection chambers are interconnected as well as connected to the filter pit through pipe.
- A connection pipe with recharge well is provided at the bottom of the pit for recharging of filtered water through well.
- Wire mesh filter should be provided just before the inlet to avoid entry of any foreign material, tree leaves etc. into the system.

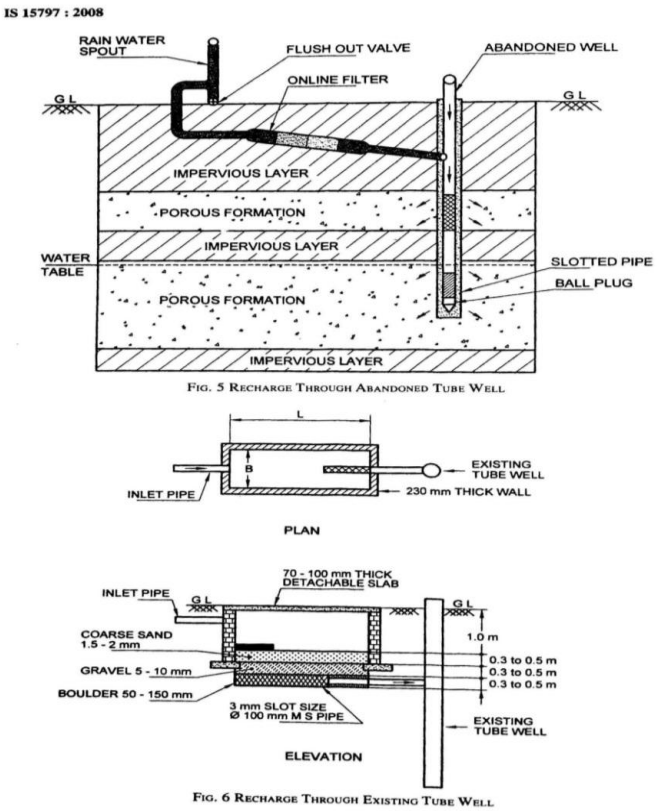



FIG. 5 RECHARGE THROUGH ABANDONED TUBE WELL

FIG. 6 RECHARGE THROUGH EXISTING TUBE WELL

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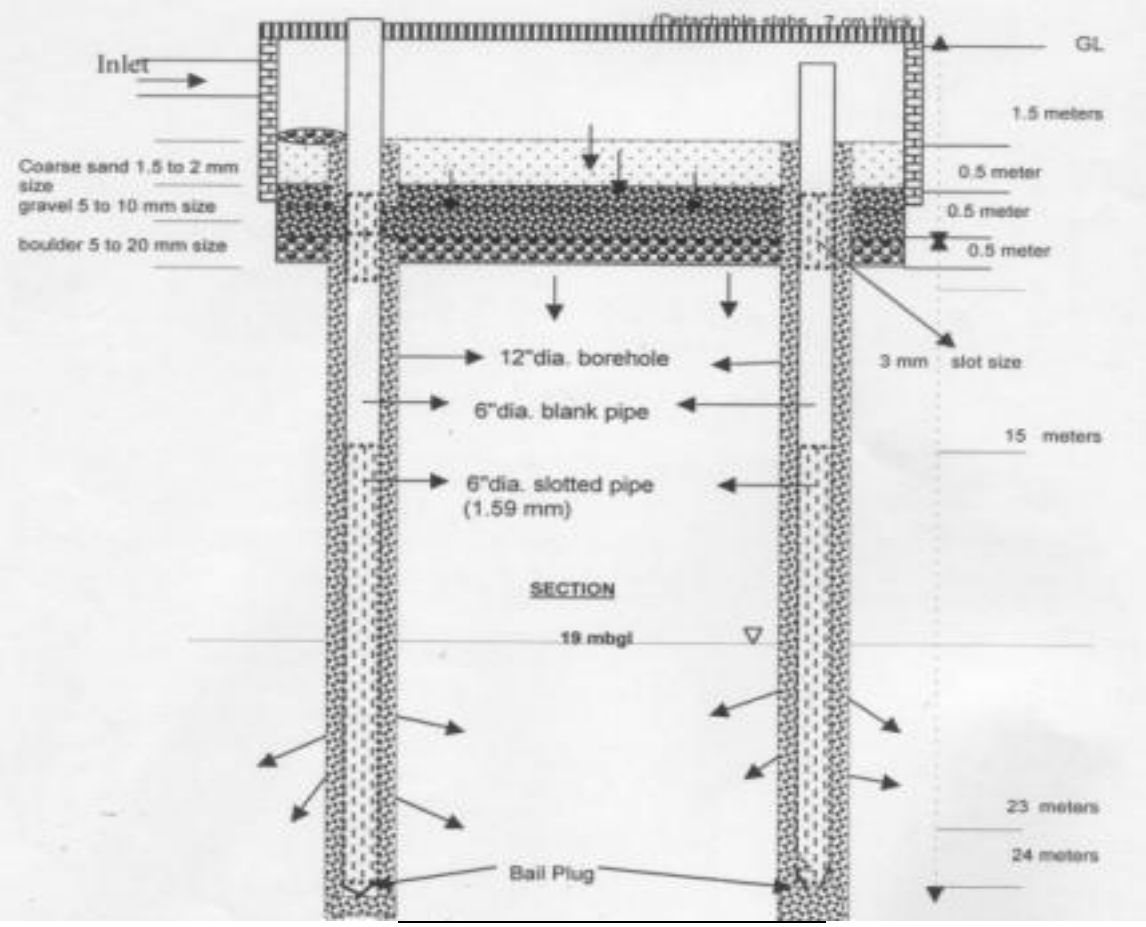
**Second Method suggested for rainwater harvesting is Lateral trench with bore-wells.**

For recharging the upper as well as deeper aquifers lateral trench of 1.5-3 m wide and 10-30m long depending upon the availability of water with one or more bore well may be constructed. The lateral trench is back filled with boulders grounds and coarse sand.

Depth of the tube-well also varies from place to place and is normally taken down to the first granular saturated sandy formation.




- The filter material recommended is coarse sand of 1.5 to 2 m size at the top. Followed by gravel of 5 to 10 mm size. and boulders of 5 to 20 m at bottom. The thickness of each layer should be about 0.5 m. Coarse sand should be placed at the top so that the silt content that comes with runoff will be deposited on the top of the coarse sand/pea gravel

and can easily be removed. For smaller roof area the pit may be filled with over burnt broken bricks/cobbles.

- After excavation of filter chamber, Boulders and gravel should be filled up first to the foundation of wall of the structure.
- After filling of boulder and gravel, filter material should be covered with polythene/jute bags to avoid spilling of construction material, which may damage the filter bed. After the construction of walls, the polythene/jure bags should be removed and the sand/pea gravels filled up to the recommended depth as per the design.
- Filter media should be free from silt and any other foreign material. Before putting the filter material into the chamber, filter material should be sieved and washed to remove all the finer material. During operation the scouring effect of flow of water into the structure should be checked upon and if flow is disturbing the filter media, the water can be released near the filter media. This can be done by providing an 'I ' shape joint in the inlet pipe in trench.
- Regular inspection of filter material is essential in recharge structures. Silt deposited on the filter media should be cleaned regularly. Once in a year the top 5-10 sand/pea gravel layer should also be scraped to maintain a constant recharge rate through filter material.
- Growth of grass or bushes hampers the filtration rate of the chamber. The grass and bushes should be cleared regularly.

**Maintenance of Catchment Area, Water drains and Recharge structure.**

- The catchments should beneath and clean. The roof top/terrace of the building spaces around the buildings should not be used for dumping of unwanted item s and scrap material.
- The washing machine water having heavy dose of detergents should not be allowed to enter into the water drains which are connected with recharge structures.
- Open water drains covered with perforated detachable RCC slabs are best as the maintenance of these drains is easy and pollution, especially bacteriological pollution, can be avoided. If the storm water drainage is through pipe system, provide manholes

and chambers at regular intervals as well as close to the suspected silt and waste accumulation places within the channel.

- Protect the drainage system from tree leaves, polythene bags, plastic bottles and pouches of eatables.
- Put up sign boards mentioning that the campus of building is equipped with rainwater harvesting system which is being recharged to the ground water system. Mention the ill effects and health impacts if the storm water drains are not properly maintained. Educate the Staff maintaining the storm water drains to keep the drains neat and clean.
- Provide wire mesh filter just before the inlet. Provide silt check wall with in the drain bed at a convenient place. If more silt is expected provide check wall at regular intervals in the storm water drains.
- The periodic removal of the material deposited on the surface be done by scraping the silt accumulated on top of the filter bed regularly.
- Precaution should be taken to avoid domestic waste water entering into the recharge structures.
- Recharge tube wells should be developed periodically by hand bailers to avoid clogging of the slots.
- Before the arrival of monsoon, the roof tops well as drains should be properly cleaned.
- Length and placement of the slotted pipe should be finalized after drilling of pilot hole for tube well.
- Recharge water should be introduced into the structure at its lowest point to prevent erosion and disturbance of filter material.
- A wire mesh should be placed at the entrance of recharge structures.
- Periodic cleaning of collection chambers should be carried out to remove the plastic bags, leaves, etc. which may choke the entry of water recharge structures.

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## TABLE NO.3

## AVAILABILITY OF RAIN WATER THROUGH ROOF TOP RAIN WATER HARVESTING

| Rainfall(mm) Roof top area (Sqm) | 100 | 200 | 300 | 400 | 500 | 600 | 800 | 1000 | 1200 | 1400 | 1600 | 1800 | 2000 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Harvested Water from Roof Top (cum) | | | | | | | | | | | | |
| 20 | 1.6 | 3.2 | 4.8 | 6.4 | 8 | 9.6 | 12.8 | 16 | 19.2 | 22.4 | 25.6 | 28.8 | 32 |
| 30 | 2.4 | 4.8 | 7.2 | 9.6 | 12 | 14.4 | 19.2 | 24 | 28.8 | 33.6 | 38.4 | 43.2 | 48 |
| 40 | 3.2 | 6.4 | 9.6 | 12.8 | 16 | 19.2 | 25.6 | 32 | 38.4 | 44.8 | 51.2 | 57.6 | 64 |
| 50 | 4 | 8 | 12 | 16 | 20 | 24 | 32 | 40 | 48 | 56 | 64 | 72 | 80 |
| 60 | 4.8 | 9.6 | 14.4 | 19.2 | 24 | 28.8 | 38.4 | 48 | 57.6 | 67.2 | 76.8 | 86.4 | 96 |
| 70 | 5.6 | 11.2 | 16.8 | 22.4 | 28 | 33.6 | 44.8 | 56 | 67.2 | 78.4 | 89.6 | 100.8 | 112 |
| 80 | 6.4 | 12.8 | 19.2 | 25.6 | 32 | 38.4 | 51.2 | 64 | 76.8 | 89.6 | 102.4 | 115.2 | 128 |
| 90 | 7.2 | 14.4 | 21.6 | 28.8 | 36 | 43.2 | 57.6 | 72 | 86.4 | 100.8 | 115.2 | 129.6 | 144 |
| 100 | 8 | 16 | 24 | 32 | 40 | 48 | 64 | 80 | 96 | 112 | 128 | 144 | 160 |
| 150 | 12 | 24 | 36 | 48 | 60 | 72 | 96 | 120 | 144 | 168 | 192 | 216 | 240 |
| 200 | 16 | 32 | 48 | 64 | 80 | 96 | 128 | 160 | 192 | 224 | 256 | 288 | 320 |
| 250 | 20 | 40 | 60 | 80 | 100 | 120 | 160 | 200 | 240 | 280 | 320 | 360 | 400 |
| 300 | 24 | 48 | 72 | 96 | 120 | 144 | 192 | 240 | 288 | 336 | 384 | 432 | 480 |
| 400 | 32 | 64 | 96 | 128 | 160 | 192 | 256 | 320 | 384 | 448 | 512 | 576 | 640 |
| 500 | 40 | 80 | 120 | 160 | 200 | 240 | 320 | 400 | 480 | 560 | 640 | 720 | 800 |
| 1000 | 80 | 160 | 240 | 320 | 400 | 480 | 640 | 800 | 960 | 1120 | 1280 | 1440 | 1600 |
| 2000 | 160 | 320 | 480 | 640 | 800 | 960 | 1280 | 1600 | 1920 | 2240 | 2560 | 2880 | 3200 |
| 3000 | 240 | 480 | 720 | 960 | 1200 | 1440 | 1920 | 2400 | 2880 | 3360 | 3840 | 4320 | 4800 |

(Extract from CGWB Guide) Central Ground Water Board

3.5 The broad idea about the particular dia of pipe which will be required to cater the certain roof surface area for given average rate of rain fall in millimeter per hour is shown in Table No. 4 is on page -

## TABLE NO.4

## SIZING OF RAIN WATER PIPES FOR ROOF DRAINAGE

| S.No. | Diameter of pipe (mm) | Average rate of Rain Fall (mm per hour) | | | | | |
|---|---|---|---|---|---|---|---|
| | | 50 | 75 | 100 | 125 | 150 | 200 |
| | | Roof Area (Sqm) | | | | | |
| (i) | 50 | 13.4 | 8.9 | 6.6 | 5.3 | 4.4 | 3.3 |
| (ii) | 65 | 24.1 | 16.0 | 12.0 | 9.6 | 8.0 | 6.0 |
| (iii) | 75 | 40.8 | 27.0 | 20.4 | 16.3 | 13.6 | 10.2 |
| (iv) | 100 | 85.4 | 57.0 | 42.7 | 34.2 | 28.5 | 21.3 |
| (v) | 125 | - | - | 80.5 | 64.3 | 53.5 | 40.0 |
| (vi) | 150 | - | - | - | - | 83.6 | 62.7 |

(Extract from SP-35)

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## Project Cost

For making 6" Dia rain water harvesting system at a single existing bore well will be as following:

| S.no | Description | Quantity | Rate | Per | Amount Rs. |
|---|---|---|---|---|---|
| 1 | A. Providing and fixing in position Johnson make V wire SS screen pipe 6" dia. Of 0.75 mm slot size inner screen and 12 " dia of 1.00 mm slot size= outer screen in length of 100 meter for filtration | 1 | Unit | 65000/- | 65000/- |
| | B. Coarse Sand | | | | |
| | C. Providing and installation of 1.5 meter dia. X 2.35 meter height two layer RCC precast structure including Filter media | | | | |
| | D. Providing and Fixing of Air vent cap and MS top Cover | | | | |
| | | | | Total | 65000/- |

| PVC Pipes for collecting water to the filter bed | | | | | |
|---|---|---|---|---|---|
| S.no | UADD SOR | Description | Rate | Quantity | Amount |
| 1 | | ROOF TOP RAIN WATER HARVESTING | | | |
| | | Providing & laying of P.V.C. pipe for roof top harvesting from roof slab to Ground floor including all fittings, jointing material with bypass arrangement with suitable valves. | | | |
| | 22.1.1 | P.V.C. pipe 6kg/sqm (90 mm) | 1282 | 251.1 | 321910.2 |

## RESULTS

It is found that the potential rainwater supply would be accomplished for the drinking water demand during June to September and there have a lack of water during October to May. This surplus water can be stored to supplement the shortage during dry periods or can be discharged in the existing bore well to recharge it.73920Litres of water will obtain in rainy season from the roof top of the building. The overall estimated cost was found to be 65000/- for construction and all arrangements. Other cost and estimate of 321910/- was provided for the PVC pipes to collect the water to the filter bed.

Implementation of such water harvesting setup can be a beneficial setup for the water conservation during rainy seasons to supply the demand of water problems in the locality. Thus Green building technologies with RWH setup can benefit the society in various ways and is the best possible implementation for conserving various natural resources in present time.

## CONCLUSION

It is expected that the study results, if implemented would shape up the water scenario of site location in an eco-friendly direction and scale down the overall exploitation thereby maintaining the equilibrium between the recharge and discharge.

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