GIS BASED SURFACE RUNOFF RAIN WATER HARVESTING IN HILLY TOWNSHIP DARJEELING: WEST BENGAL

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ABSTRACT

Remote sensing was joined with GIS environment for land and water assets evaluation. A geographical database was stored as attributes. Demonstrating Modelling are intense apparatuses for basic leadership in the study zone. The present investigation goes for setting up suggestions for surface water development as far as best sites choice and surface overflow. GIS and multi-criteria examination were connected to find a rain fall, rain water stream area in consider territory of Darjeeling, to get the advantage for agricultural development. Simply, rainwater harvesting is the act of gathering and putting away rainwater for later utilize. Rain water harvesting (RWH) frameworks go from the extremely basic a rain barrel put under the downspout of a building's drains to more mind boggling alternatives that connect to a building's pipes framework. The training is prominent over an extensive variety of socioeconomics, from rustic plant specialists to individuals living in urban focuses. Based GIS report and land overview can execute three unique kinds of Geography. That is Farm lake development with shade balls, Storage tank and Surface spill over harvesting. This study quickly examined about finding most noteworthy rainfall territory through GIS and starting environmental arranged way to deal with construct water tank utilizing by light weight and cost cutting froth concrete tanks. Darjeeling was chosen as catchment zone to this examination and topography conditions, climates, rain fall, land study are gathered from Indian Meteorological Department.

Keywords: Water sources, Water demand management, Water conservation, Environmental friendly technologies, Irrigation, Water smart construction

1. INTRODUCTION

Information and Geo database about the land and water assets is urgent for any planned task to fulfil the environmental conditions. Land and water assets information are spatial in nature and they could be effectively handled and investigated utilizing Remote Sensing and Geographic Information Systems. Henceforth the advantages of utilizing multi phantom information in handling land and water assets information would be exhibited in the momentum work have a place the Northern coast. For those whose groups enable them to gather rainwater, the training offers various environmental and economic advantages. First of all, harvesting rainwater enables control to storm water overflow, which decreases the danger of disintegration in gardens and around downspouts, limits the effect on neighbourhood storm water framework and joined sewer frameworks and diminishes the risk of flooding. Not exclusively does rainwater harvesting enable environmental and human infrastructure to adapt to a lot of rain, however it likewise puts that water to great usage. Stored rainwater can be utilized for both open air and indoor uses, including landscape water system, watering plants or gardens, latrine flushing, clothing, washing vehicles or patio furniture, and notwithstanding showering or drinking. Another awesome advantage of rainwater harvesting is it decentralizes the water supply. That implies as opposed to being totally subject to civil sources, customers who collect rainwater have more control over how their water is sourced, treated, and put to utilize. Truth be told, a few people are roused to introduce rainwater-harvesting frameworks for the sole reason for having a private, ensured wellspring of water if there should be an occurrence of crisis or if the civil water supply wind up debased.

Objectives

- To study the water conservation management and to discuss the hydrology of water saving in hilly area
- To determine rain water harvesting in Darjeeling
- To analyse GIS mapping for rain water harvesting

Problem Statement

- The water crisis in dry season
  The drainage problem
- The submergence problem in city area
- Reduction in flood level in rivers

2. RELATED RESEARCH

Remote detecting strategies and more detailed climatologically and process models now accessible give new conceivable outcomes to point by point displaying of little repositories in order to capture catch their surface zones for evaluating their capacity abilities to have a reasonable picture of accessible water assets. Geospatial techniques such as geographical information system (GIS) and remote sensing (RS) have pulled out significant attention for locating the suitable water recharging/ harvesting sites in the recent history Ahmed AS (2012). Remote sensing technique gives us directly the water spread area of the reservoir at a particular elevation on the date of pass of the satellite Rashash A (2010). Al-Suhaili and Hassan studied of GIS to investigate the potential of having enough runoff in the five selected sites to establish water harvesting dams based on rainfall, evaporation data and catchments' areas for the selected sites. The point of this study was to create spatial GIS modelling for appropriate site determination for Dam and situating of repositories water supply in dry channel in view of the joining between remote detecting and GIS.

3. GEOLOGY OF REMOTE SENSING AND GIS

Location of the study area

Darjeeling is a beautiful small city in Lesser Himalayas, in northern West Bengal, right near the border between Nepal and India. The area is an example of the finest forest covered zone in northern India, with a small national park Singalila located slightly to the west of the town. The latitude of Darjeeling, West Bengal, India is 27.036007 and the longitude is 88.262672.Darjeeling, West Bengal, India is located at *India* country in the *Cities* place category with the GPS coordinates of 27° 2' 9.6252" N and 88° 15' 45.6192" E.

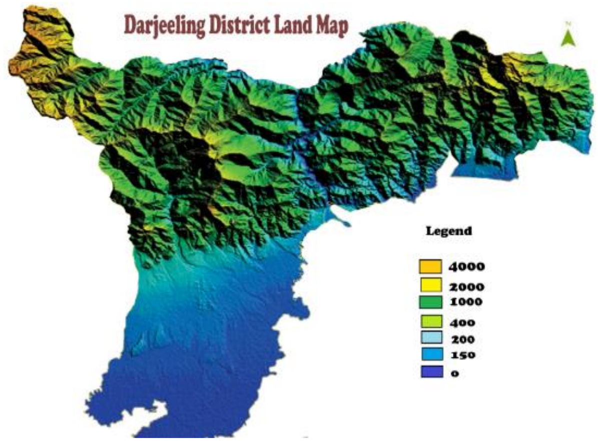
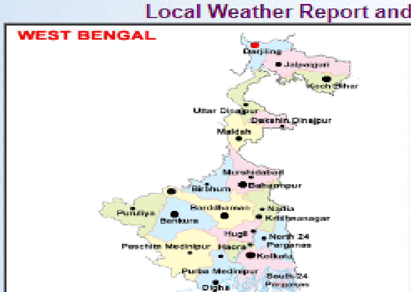


Figure 1: Darjeeling District Land Map

Digital elevation model by GIS: The quickly expanding accessibility of digital elevation model (DEM) information and release of programming devices for GIS hydrological modeling offer an extensive variety of chances for inspecting water system, farming improvement and water asset zone. Advanced rise models (DEMs) are progressively utilized for visual and scientific investigation of geology, landscapes and landforms, and also demonstrating of surface procedures. The studied area has elevations from 0^o to 280^o above the land surface. Exact residential zones, maximum available rainy.

Surface water: The zone is constrained in magnitude as it starts from the rainfall of the winter season. In the extreme southern bit of the region, where the landscape is raised however level in geology, water of the rainfall is incompletely lost through vanishing and the rest invades into the shallow soil where it might along these lines either be lost by dissipation or used by some local vegetation. Ongoing northward, the landscape shows some wadis catchments areas. Runoff is possible after rather heavy rains, and a considerable amount of water may percolate to deeper soil layers.

Local Weather Report and Forecast For: Darjeeling Dated :Apr 07, 2018



Past 24 Hours Weather Data	
Maximum Temp(^oC) (Recorded. on 07/04/18)	NA
Departure from Normal(^oC)	NA
Minimum Temp (^oC) (Recorded. on 07/04/18)	10.0
Departure from Normal(^oC)	2
24 Hours Rainfall (mm) (Recorded from 0830 hrs IST of yesterday to 0830 hrs IST of today)	5.3
Relative Humidity at 0830 hrs (%)	98
Relative Humidity at 1730 hrs (%) (Recorded. on 07/04/18)	NA
Todays Sunset (IST)	17-57
Tommorows Sunrise (IST)	05-21
Moonset (IST)	10-14
Moonrise (IST)	xx-xx

7 Day's Forecast

Date	Min Temp	Max Temp	Weather	
07-Apr	9.0	16.0		Partly cloudy sky with possibility of moderate rain or Thunderstorm
08-Apr	8.0	17.0		Partly cloudy sky with possibility of moderate rain or Thunderstorm
09-Apr	10.0	17.0		Generally cloudy sky with one or two spells of rain or thundershowers
10-Apr	9.0	16.0		Generally cloudy sky with one or two spells of rain or thundershowers
11-Apr	9.0	17.0		Thunderstorm with rain
12-Apr	10.0	17.0		Partly cloudy sky with possibility of rain or Thunderstorm
13-Apr	10.0	16.0		Partly cloudy sky

Figure 2: Report fromhttp://www.imd.gov.in/pages/city_weather_show.php

STATE	STATION NAME	RAINFALL (mm) (07-04-2018)
UTTARAKHAND	THARALI	0.0
UTTARAKHAND	UKHIMATH	0.0
WEST BENGAL	ALIPORE	0.0
WEST BENGAL	CHAKDAH	0.0
WEST BENGAL	CHENGMARI TEA GARDEN	0.0
WEST BENGAL	CHOPRA	0.0
WEST BENGAL	DARJEELING	7.0
WEST BENGAL	DHANIAKHALI	0.0
WEST BENGAL	DINHATA	0.0
WEST BENGAL	GANAGRAMPUR	0.0
WEST BENGAL	JAGATBALLAVPUR	0.0

Figure 3: Report fromhttp://hydro.imd.gov.in/hydrometweb/(S(imcd2brwqqlkf155qd2exdms))/landing.aspx

How to harvest rainwater at home

- For what purpose(s) for use rainwater? The way intend to utilize rainwater will decide how much rainwater will have to gather, the framework you'll have to utilize, and the costs, hardware, and support included. For instance, gathering rainwater for watering plants will require an immensely unexpected framework in comparison to utilizing rainwater for in-home exercises, for example, flushing in the wash rooms, showering, or doing laundry.
- What are the laws in your area concerning rainwater harvesting? A few states consider rainwater the property of the state and disallow its accumulation, while different districts urge mortgage holders to take part in rainwater harvesting. Counsel with your nearby government (attempt the wellbeing division or environmental quality office) before setting up any harvesting frameworks.

When decided the responses to the inquiries over, it is an ideal opportunity to pick a rainwater harvesting framework. While they differ in size, intricacy, and capacity, all frameworks share a similar fundamental parts:

- **Catchment area:** This is the area that first captures the rainfall; it is most commonly the roof of a building or house.
- **Conveyance system:** This refers to whatever moves the water from the roof to its storage areafor example, gutters, downspouts, and piping.
- **Storage system:** Typically a barrel, cistern, or tank, this is what collects the rainwater for later use.
- **Distribution system:** This refers to whatever is used to move the water from the storage system to wherever it's being usedwhether that's a watering can or an underground irrigation system.

4. CASES IN WATER CONSERVATION

Darjeeling faces an intense water deficiency because of parched atmosphere and nonappearance of lakes and rivers. The demand for water is developing generously and that is being met through the accessible rare and decreasing water assets. Regularly expanding lopsided characteristics are normally met by expanding water supplies, though the ideas of water-demand administration have not been given due significance and weightage. Taking care of the quickly rising demand with rare and draining assets remains the critical issue. This study places emphasizes on the urgency of adopting conservation and water-demand management initiatives to maintain demand supply relationship and achieve an acceptable balance between water needs and availability. The kingdom places emphasis on the shift from supply development to demand management to use of critical and non-renewable water resources efficiently. The article suggests that the water useefficiency (WUE) in various sectors can be enhanced and improved in the kingdom.

The study presents an overview of the country's water resources and issues related to water. Some possible conservation and remedial measures particularly in the agricultural sector - the largest and most inefficient user of water have been suggested. The aim of this study is to protect and conserve this valuable normal asset through environmental friendly technologies for the future ages to come. It is assumed that water assets can be overseen on maintainable premise by conceiving and utilizing environmental neighbourly advances including water preservation measures. The helpfulness of these measures can be supplemented through the lively and feasible expansion and instruction activities and limit building programs.

Different factors of recharge rates

- Infiltration capacity of soil: It is the capacity of soil to allow water inside it. If infiltration rate of soil is high then maximum amount of water can be recharged.
- The location of recharge zone: The recharge zone should be in such a place that the maximum water gets collected to the place i.e. it has good catchment area.
- Ground Water Table: If the ground water table is so high, water will rise upward instead of recharging. So, GWT should be sufficiently low.

5. WATER DEMAND MANAGEMENT

At present the concept of Water Demand Management (WDM) is slowly gaining recognition and popularity as an essential complement to supply management if fresh water is to be used in a sustainable manner (Brooks, 2009). While WDM showed many economic benefits by increasing efficiency and in many cases, greater equity, reduced environmental damage, and helped increasing greater public participation. Water demand management can be defined as any method whether technical, economic, administrative, financial or social is capable of accomplishing one (or more) of the following five components:

- Reduce the quantity or quality of water required to accomplish a certain and specific task
- Adjust the nature of the task or the way it is undertaken so that it can be accomplished with less water or with lower quality water
- Reduce the loss in quantity or quality of water as it flows from source through use to disposal; Shift the timing of use from peak to off peak periods
- Increase the ability of the water system to continue to serve the communities when water availability is low and at times of shortage of water

Approach: The plan outlined five water conservation programs

- Water pricing reform
- Indoor residential water conservation
- Industrial and commercial water conservation
- Plant and turf irrigation efficiency
- Water-efficient landscaping

Water conservation and demand management (WC/DM) holds tremendous potential to help the region to meet its water needs. Urban and agricultural water use in southern Africa is highly inefficient (no capability).

- Darjeeling faces a serious water supply challenge driven by scarce and unevenly distributed water resources, rapid population growth and urbanisation, and imperatives of development and social equity.
- Water use in the urban and agricultural sectors is generally highly inefficient, with waste/inefficiencies of up to 50 percent and 60 percent respectively.
- Although the policy and legal framework for implementing WC/DM has been established in many southern African countries, very few measures have been put in place.
- Less than one third of all urban water users are encouraged to conserve water by any measure other than escalating block tariffs, and only two cities in the entire region have implemented comprehensive

WC/DM programmes (the population of these two cities represents less than one percent of the regional urban population).

- Flood irrigation, which achieves only 55 percent efficiency, is used on more than half of all irrigated land in the region.
- An increase in efficiency of only 20 percent in urban and agricultural water use would save 9000 million m^3 each year – more than the combined use of Namibia, Botswana,
- Swaziland and Zimbabwe, and more than 10 times the combined yield of Katse and Mohale dams of the LHWP.
- Water "produced" through WC/DM can be 65 to 80 percent less expensive than water developed through new infrastructure.
- Water providers in Gauteng could delay the construction of the next water supply dam by 12 years through an effective WC/DM programme, and save R2 billion/US$325 million each year.

Recommendations

- WC/DM principles should be integrated fully into water supply planning, *i.e.*, water potentially produced through increased efficiency and decreased losses should be considered alongside other options at the beginning of supply planning processes.
- Water management entities should establish specific targets/standards for water use efficiency and allowable loss for each water sector and develop strategies to achieve those targets.
- Mechanisms for financing WC/DM approaches should be developed, including traditional methods enjoyed by the dam building industry as well as new innovative mechanisms.

6. THE POTENTIAL FOR WATER CONSERVATION IN SOUTHERN AFRICA INTERNATIONAL RIVERS

Integrated water resource management (IWRM) for comprehensive and sustainable management of river and lake basins is a recent phenomenon, although the idea has been present in academia for at least half a century. The notion of IWRM and its successful implementation is worth studying for its potential benefits in both the scientific and political arenas.

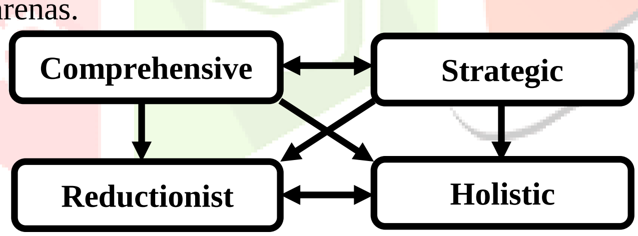


Figure 4: The four problem modules with IWRM

Figure 5: Environment as affected by people's economic activities

Table: Comparison with other methods

Water Source	Setup Cost	Running Cost	Yield	Applicable in
Tubewells	Medium	Medium	Medium	Places with deep aquifers
Hand dug wells	Low	Medium	Low Medium	Places where water tableis not lower than six metres
Reverse	High	High	High	Only in Urban regions

Osmosis				
Rainwater Harvesting	Low Medium	Low Medium	High	Only in regions which receive moderate high rainfall once a year

7. FOAM CONCRETE BASED TANKS

Rain water harvesting can handle in various streams, yet that ought to be with less support. In this exploration have broke down the harvesting technique. In light of GIS report the rainy are and rain water stream was watched. In view of the reports can assemble the less maintenance tanks for capacity, the water flow streams likewise would extern be able to next up and coming tanks. Low early and 28 day's quality protein based froth bond has genuine froth crumple and similarity issues when it is figured into high quality bond and concrete with low water/bond proportions and super plasticizers. Such drawbacks significantly limited such foam agents for use in the high performance cement and concrete industries. Foam collapse and loss of air entrainment in high fly ash containing cement & concrete: It is known that the carbon content in fly ash will adsorb most of the surfactant foam agents and causes foam collapse and reduces the air entrainment efficiency of such air entraining additives. Different hardware and devices must be utilized to screen the expansion of froth specialist dose when such issues occur in the bond and concrete slurries. The vast majority of the surfactant and protein based froth bond have coarser surfaces and poor handling highlights caused by the constrained froth dependability in the composites. Such inadequacies turn out to be more genuine at low densities where expanded froth content is required. Such shortcomings will keep their utilization in top of the line building materials, for example, enriching stones and roof/wall panels.

Insulated concrete forms (ICFS)

If you're looking to construct an insulated pond wall with excellent structural integrity, my favourite choice has come to be Insulated Concrete Forms, or ICFs. Think giant Lego blocks made of foam with hollow centers. These are perfect for wall construction in buildings, coming in a variety of shapes and sizes from a multitude of manufacturers to fit every aspect of construction. Even curves and circles are available. If I ever build another home from scratch, it will be with ICFs. After stacking and positioning the blocks, make sure to clip the rebar in place with mounts made into the blocks, and then pour concrete into the centers. This creates a double-foam, concrete wall with a very high level of insulation, or R-value. Flanged penetrations, such as skimmers, midwater drains and returns, are treated just as they would in any other pond. The floor is typically concrete, yet can utilize an earth fixate with squares set on an establishment ring too. The floor does not really need to be protected if it is underneath the frost line. Contingent upon the profundity of the lake, the hotter earth beneath the frost line can transmit the important warmth into the water through the liner in a chilly atmosphere, while having a contrary cooling impact in a hot atmosphere.

Construction is Simple: Once the floor or establishment ring shape has been framed and poured and rebar has been set up along the edge, the main course of squares can be set. Resulting courses can be stacked and bolted together with the interlocking square structures. Wherever a penetration is necessary, a pipe and flanged connector can be installed as stack. Insert the skimmer into the top row, just for a block wall, shot Crete or gunite pond. The rebar should be clipped in place for each row as stack.

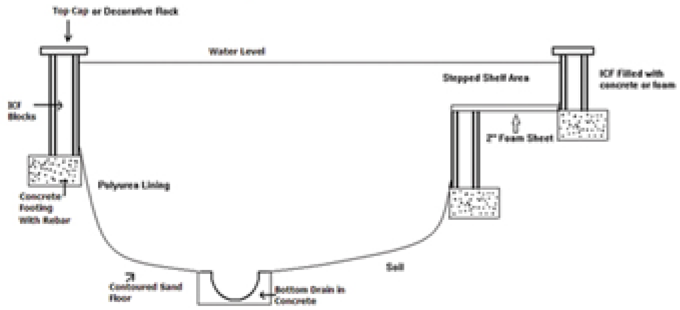


Figure 6: Foam block construction mimic block wall construction

Once the blocks are stacked and the walls are up, pour the center space with a concrete slurry, just as when filling block walls. However, depending on the surrounding soil type and structure, do not necessarily have to pour the center with concrete. This is not building a structure that has to support a roof or second-story floor, which is what these blocks are made for. A few alternatives incorporate filling the centers with pourable foam, pea rock or sand. Pourable foam makes for an exceptionally solid structure and incredibly builds the insulation factor. Whenever the wall will not totally loaded with concrete, it is vital to delicately cover the base column to bolt it against the floor. After the divider is filled to inside a foot of the best, pour about a foot or so underneath the best edge to make an upper concrete neckline, expanding the structural integrity and filling in as a stage for following the best top in whatever shape it takes. The upper blocks can also be offset, creating an upper ledge for placement of plant material, boulders or rock.

8. GET CREATIVE WITH ICFS

Working with foam blocks are simple and enable to accomplish for all intents and purposes any shape to be needed. For instance, a few pieces are made with a calculated shoulder, which can be put as a change from the floor to the divider. A bit of froth cut on a 45-degree edge can be stuck in to make the floor-to-divider change, accordingly taking out the hard corner. Once the structure is finished and ready for liner, use spray foam or urethane sealant to clean up any joints or connections that might show through the liner in an unsightly manner. A thin sheet of one-half-inch foam can be glued to an entire surface if the curves leave a blocky appearance.

Figure 7: Foam concrete water tank construction

In this method of collecting rainwater for irrigation, water flowing along the ground during the rains will be collected to a tank below the surface of the ground. The tank is constructed using bricks, which are coated with cement. During storage, it is important to incorporate efficient and effective water conservation methods – by reducing evaporation and also by adopting efficient irrigation techniques. It is a very 'easy to adopt' technology proven with many communities in the country that if used properly can be very profitable.

Selecting a location for the construction of a rainwater harvesting tank

- Observe the direction of the surface flow of rainwater in the land.
- Even though some believe that such tanks should be constructed in the lowest lying area of the land, this is not essentially so. Due to the seasonal patterns of rainfall and the high intensity of rains received in Sri Lanka, it is possible to fill a 12,000 litre capacity tank without much difficulty.
- The tank may be subjected to cracks due to the root zone activities (i.e. ramification), therefore, it is advisable not to construct the tank in close proximity to large trees.
- The tank should be close to the area of cultivation to ensure ease of irrigation.
- The tank should not be in close proximity to the house or to paths /roadways as it is possible for children and even negligent adults to fall in. As an additional security measure, construct a fence around the tank.
- The opening of the tank should be to the direction of the flow of rainfall. It is not advisable to obstruct patterns of natural flow of water as there is a possibility of mud and other waste getting into the tank. (The mud filters function only when the water flows directly through them).

Rooftop and paved surface rainwater harvesting is not sufficient for entire year. So it is exceptionally important to present the manufactured energize techniques for rainwater harvesting. In this technique the rainwater is collected in a little contracted region like pits, wells, trenches, shafts and so forth and penetrated under the dirt through them. This is the indirect method of rainwater harvesting so there is no direct gain but in long-term this is the best method of making water available sufficient under the ground. This method of rainwater harvesting is also called recharging ground water aquifer. There are different methods of recharging ground water aquifers. Some of them are:

1. Recharging of bore holes
2. Recharging through wells
3. Recharging through pits
4. Recharging through trenches
5. Recharging through shafts
6. Recharging making percolation tanks

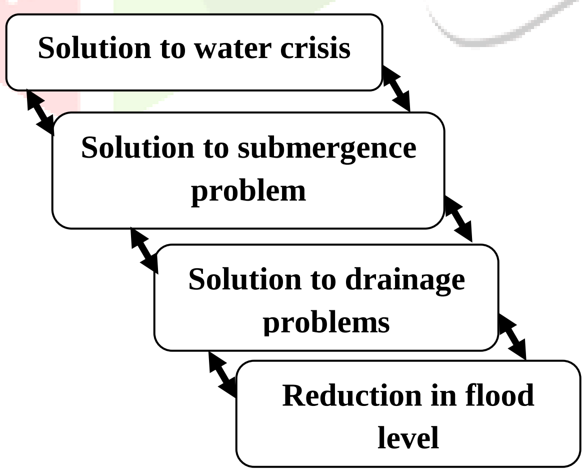


Figure 8: Surface Runoff Rainwater Harvesting

9. CONSTRUCTING THE RAINWATER HARVESTING TANK

- Clear the selected land thoroughly. Flattening the land is important for ease of taking measurements.
- It is advisable to construct a circular tank as it will withstand greater pressures.

- Determine the quantity of water required for irrigation purposes.

In such instances, the following factors should be considered

1. The rainfall pattern of the area. (If the area experiences regular rainfall throughout the year, a small tank of 4000-5000 litres would suffice, whereas in particularly dry areas which experience dry spells for about 6 months of the year, it would be beneficial to store as much water as possible).
2. The extent of land, which is proposed to be cultivated.
3. The amount of investment that can be made. The tank should not be more than 1.75 m in depth in order to withstand the pressure of the water. Low depth makes cleaning and use of the tank easier. The chart given below can be used as a guide to determine the radius of the tank.

Take a length of rope as long as the radius and tie it to a wedge. Plant the wedge at the place where want to be the centre of the tank and draw a circle. Now dig-out the soil within this circle. The tank should have a slope of about one foot from the periphery to the middle of the tank. Figure 11 will give a side view of the tank. Now dig-out the soil within this circle. The tank should have a slope of about one foot from the periphery to the middle of the tank. Figure 11 will give a side view of the tank. After the soil has been removed, a 10 cm slab of concrete has to be laid at the bottom of the tank. The ratio of sand, cement and metal stone in the concrete mixture should be 1: 2: 4 after the slab of concrete is hardened and has completely dried, construct the walls one foot in height from the inlet with a width of one brick. It is important to use bricks with dimensions of: 5cm x 10cm x 23cm for this purpose. The cement mixture should have a ratio of cement to sand of 4:1. As the water inlet is connected to the tank at the ground level, hence, the water inlet wall should not be raised above the surface level. The mud filters are attached to the water inlet. Hence the door has to be sturdy. As depicted in the picture below, a concrete slab measuring in metres 0.75m X 1m (height and length) should be laid near the door. While developing the water channel, it is important to confront it toward the normal water-stream of the garden. As the mud channels ought to be put around this entryway, a drain ought to be built near the bay of 0.5 meters (close to the entryway) and 1 meter width. The aggregate length of this drain ought to be 1 meter.

Capacity of tank (Litres)	Radius of tank (Meters)
5000	0.9
6000	1
7000	1.125
8000	1.2
9000	1.275
10000	1.35
11000	1.425
12000	1.5

Table 2: Capacity according to the radius of the tank

Figure 9: Measurement taken for radius of the tank

Figure 10: Pit for the tank construction

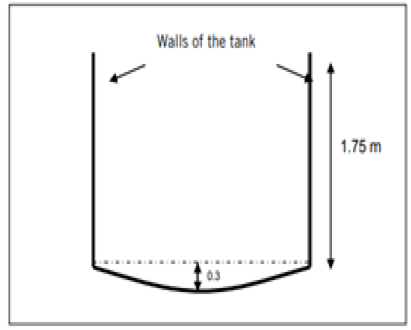


Figure 11: Cross section of a tank

Mud filters: Various waste items are present in flowing water. Mud, sand and gravel deposits in the tank will lessen the quantity of water that can be stored in the tank. Therefore mud- filters are used as a simple method of reducing the flow of waste items into the tank. Construct 2 brick bunds in the shape of a 'V' on either side of the drain, which is constructed near the inlet. Two other small bunds of about one brick (10 cm) high should be constructed across the 'V' shaped bunds. They should be placed in 45 cm and 85 cm from the inlet. From these 2 small bunds, the one closer to the tank should be a 0.75 cm lower than the inlet bund. The external bund should be constructed 0.75 cm lower than the internal bund.

10. CONCLUSION

Geographic Information Systems is a system based tool that breaks down, stores, controls and pictures geographic data, for the most part in a map. The strategies to gather, store, utilize and reuse rainwater are anything but difficult to apply. However, to utilize these techniques in an economical and powerful way, it is critical to understand precisely where rainwater harvesting can be connected to make full utilization of its potential. GIS (Geographic Information Systems) can enable to distinguish the rainwater harvesting potential and achievability in a particular zone. All the more particularly, it can bolster with:

- Identifying potential project sites for rainwater harvesting.
- Sharing information easily on the rainwater harvesting potential of a specific area by making it visual.
- Making informed decisions about time and budget investments during project implementation.
- Informing donors, governments and other partners about the potential of rainwater harvesting. GIS maps are strong lobby & advocacy tools.

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