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Full Length Research Papers

Calculation of Rainwater Harvesting Potential by Using Mean Annual Rainfall, Surface Runoff and Catchment area

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Green Clean Guide, India

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Water is essential for the environment, for ensuring agriculture growth and for ensuring food security. Rainwater harvesting is a technique to utilise and store precious water that otherwise would go waste. We estimate the quantity of water that can be harvested by Indira Paryavaran Bhawan which comes out to be 26,37,230 Litres. The research use Mean Annual Rainfall, Catchment area and Rainfall run-off coefficient to calculate the rainwater that can be harvested.

Keywords: Rainwater Harvesting, Catchment Area, Runoff Coefficient.

INTRODUCTION

The next world war may very well be triggered because of water scarcity. Throughout the world, access to water remains the primary concern and many regions are already suffering from water shortages. The increase in demand for water with an increase in population growth has further worsened the situation.

Significance of water availability is directly linked to human settlements; two- fifths of world's population resides in areas with close proximity with interstate river and lake basins (Chellaney, 2013). As per Citigroup Global Markets, water could one day overtake other resources such as oil, copper, iron, and agricultural commodities as a significant asset (Citigroup Global Markets, 2011).

Water scarcity is the situation when demand for water exceeds the rate at which it can be supplied. When access to water is hindered because of lack of resources, it is known as economic scarcity whereas when water is simply not available in a particular region, it is known as physical scarcity (The Water Project, 2014).

If the fresh water supply in a nation is below 1000 m3 per person per year, then the nation may be called a water scare country (Falkanmark, M., & Lundquist, J., & Widstrand, C. 1989).

The usage of water fuelled by India's rapid development and industrialisation is growing manifold. India is the second only to China in terms of population and as per Census 2011, India has a population of 1.2 billion (Census India, 2011).

India gets adequate rainfall with scattered distribution but because of mismanagement, a large part of the country suffers from droughts. Riparian management of India is not up to the mark and inter- state disputes are a common occurrence. The total water availability in the country as per the Central Water Commission is 1869 cu km which includes both surface and groundwater (CWC, 2014).

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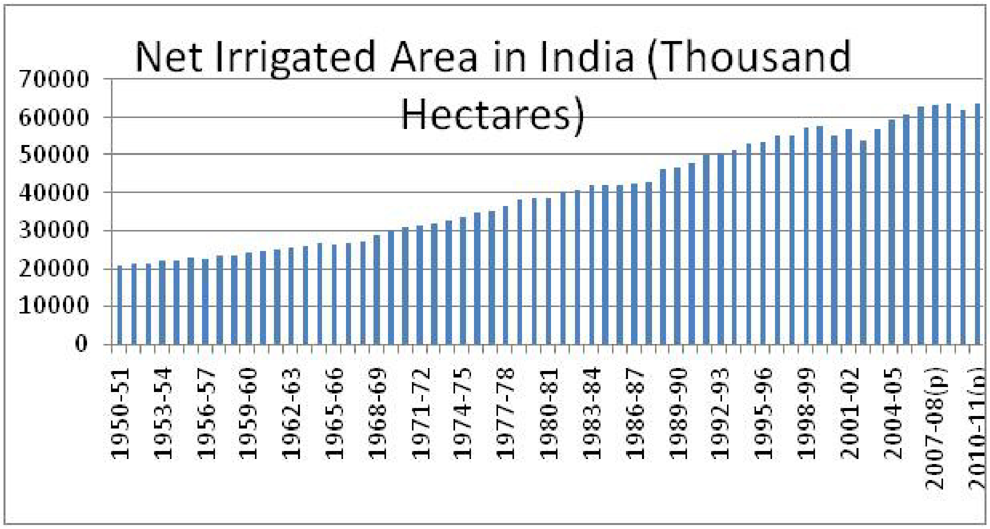

Figure 1. Net Irrigated Area in India (SAPCC, 2014)

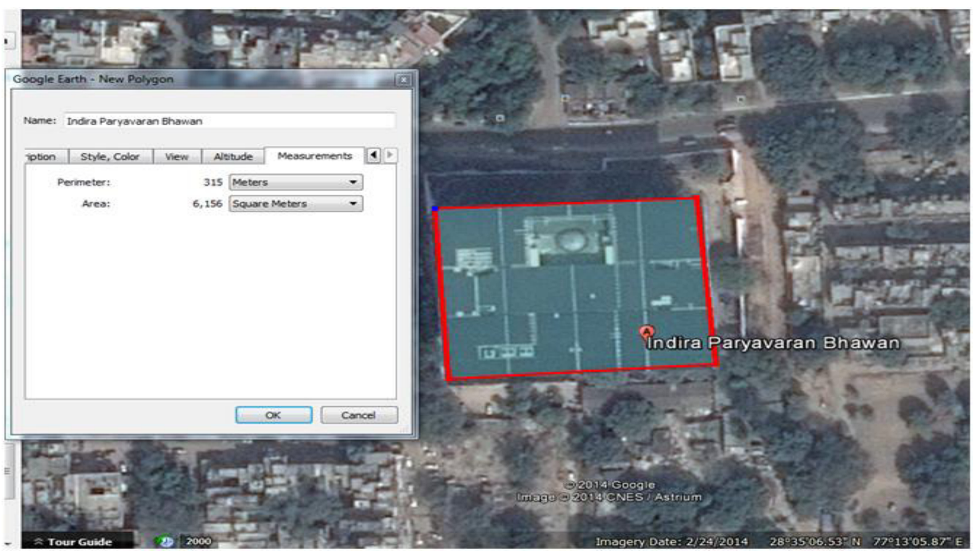

Figure 1. Area of Catchment

Water wastages arise from a number of sources such as household water wastage due to kitchen sinks and bathrooms sinks (leaving tap opened). In Delhi, India, approximately, 30% to 40% of precious drinking water is lost (Kurunthachalam, S.K. 2014).

In addition, India being a developing country with higher rate of population growth is under pressure to produce more food leading to agriculture intensive activities and agriculture consumes a large share of water than any other activity. Figure one shows the net irrigated area in India.

A detailed review has been carried out by (Zakar Zakaria Muhammad, Zakar Rubeena and Fischer Florian, 2012) on the impacts of climate change on water availability. In their study, the authors noted that climate change has the ability to change distribution of water and lead to acute water shortages especially in semi arid areas. The changing pattern of rivers, sea beds and glaciers could also influence the distribution of water resources. All of these factors combined could lead to drastic reduction in fresh water supply.

Water in India is a state subject and is therefore viewed by each state largely through its own narrow prism of demands and what suits it best. Efforts to streamline and make water a centrally managed asset have met with vehement opposition. The government of India has formulated a National Water Mission (Wada, Yoshihide, et

Table 1. Consumption of water in India by different sectors (MNRE, 2014)

Thermal Power Plants	87.87%	Pulp and Paper	2.26%
Engineering and Heavy Industries	5.05%	Steel	1.29%
Textile Industry	2.07%	Sugar	0.49%
Others	0.79%	Fertiliser	0.18%

Table 2. Default Values for the Run-off Coefficient (Pacey, Arnold and Cullis, Adrian, 1989)

Type of Catchment	**Coefficients**
Roof Catchments	
Tiles	0.8 – 0.9
Corrugated metal sheets	0.7- 0.9
Ground surface coverings	
Concrete	0.6 – 0.8
Brick pavement	0.5- 0.6
Untreated ground catchments	
Soil on slopes less than 10 per cent	0.0 – 0.3
Rocky natural catchments	0.2 – 0.5

al. 2010) as part of its commitment to address climate change. Among other things, it envisages increasing water use efficiency by 20%.

Some of the major reasons behind water scarcity in India are population growth and Food production (Agriculture), increasing industrialisation, increased urbanization, climatic change, and lack of implementation of an effective water management system. It may also arise because of depletion of groundwater resources (Padowski J.C. and Jawitz J.W., 2014). Groundwater use in India is dominated by withdrawal at a much faster rate than it can be replenished which has led to groundwater table depletion (Saleth, R. M. 2011).

India's position is a bit unique for it receives bulk of its rainfall from the monsoon winds and the pattern of distribution of rainfall throughout the country is not even. More than half of the annual percentage of rainfall is received during the monsoon season (June to September). As per the Indian Metrological Department, India's annual rainfall is around 1182.8 mm. Out of that, the mean rainfall of south-west monsoon between June to September is around 877.2 mm and contributes 74.2% of annual rainfall. India's solution in combating water scarcity will depend on following the twin approach that deals with water demand and supply management (Arjen Y. Hoekstra, 2014).

The problem mainly arises because not sufficient amount of water is being reused (Evans, A. 2010). The causes of water scarcity are manifold but principally three main reasons often underlined are firstly because of climate change (anthropogenic interference leading to change in climate), secondly due to an increases rate of population growth and thus leading to higher demand of water resources as is valid in case of a growing and developing economy like India and thirdly, and uneven distribution of water resources (Basu Mrittika and Shaw Rajib, 2013). The pattern of water allocation also shows a disparity with priority given to urban areas and industry which further leads to supply hindrance compounded during drought seasons (Gaur A. et al. 2008). In some parts of India, water scarcity is identified as one of the reasons behind migration (Fao, 2013).

Water availability in future will also determine how businesses function and plan their operations because at present India suffers from a lacuna generated due to insufficient clear water policies, regulatory framework and pricing mechanisms. The total cost involved in the transportation of water will ultimately add to the burden of final cost of any product.

There are no water poverty index measures available for India as the country does not aggregate data in this sphere. At the international level, one such index is the one developed by Lawrence et al (Lawrence Peter, Meigh Jeremy and Sullivan Caroline, 2002) that links household welfare with water availability. A similar index can be developed for India given the fact that resource distribution in India (any resource for that matter) is often determined by a complex mix of social hierarchical levels and gender issues.

Simon N. Gosling and Nigel W. Arnell in their study used WCI (Water Crowding Index), and estimated that by 2050 under the A1B scenario, 0.5 to 3.1 billion people will be exposed to an increase in water scarcity arising as a result of climate change (Gosling N. Simon and Arnell W. Nigel, 2013).

Rain water harvesting is a very viable solution for water scarce regions but has not been applied on a large scale in the metro cities of India. Rain water harvesting is the technique of collection and storage of rain water and preventing its losses as surface runoff (Villarreal L. E. and A. Dixon A., 2005).

Rainwater harvesting has numerous advantages such as being freely available and of great use to densely populated cities where availability of water is restricted. It helps in utilising water in a sustainable manner that would otherwise be lost as runoff and also helps in easing the pressure on groundwater table.

METHODOLOGY

To quantify the amount of water that can be harvested and utilised after collection, three values are used. These are: Mean Annual Rainfall, Catchment area and Rainfall run-off coefficient.

Mean Annual Rainfall

The average rainfall intensity over a period of time gives the mean annual rainfall for a particular area. Mean annual is the statistical average calculated on the basis of measured rainfall over many years (usually a time frame of 10 years).

Catchment area

A catchment area is defined as the land area where the surface water from precipitation sources is collected and gets drained towards a common exit and finally leads to formation of other water body such as rivers, streams and lakes. In this study, we carry out the assessment of rainwater harvesting potential of Indira Paryavaran Bhawan, and hence, the catchment area is taken to be the roof. The catchment area measurement is done with the help of Google earth images.

Indira Paryavaran Bhawan is being developed as the new office of the Ministry of Environment and Forests (the nodal agency for Environment in India) and is to be the first of its kind project in India. The building is being made as a net zero energy green building.

Run-off coefficient

Run-off is basically the water flowing away from a catchment area after precipitation. Runoff is dependent on the type of catchment area (surface features) and the size of the area. For example, normal concrete roof has the highest run off value as compared to an area under heavy vegetation. Runoff coefficient is the ratio of runoff to rainfall.

How to calculate run-off coefficient

There are many parts of the hydrologic cycle that affect the runoff coefficient. These include interception, evaporation, infiltration, slope, soil types (not applicable to roof top systems), etc. Therefore to estimate run-off coefficient, following parameters need to be assessed – Roof type; slope; soil type; land use; degree of imperviousness; surface roughness and duration and intensity of rainfall.

Formula Used

Mean rainwater supply in m^3 = Mean annual rainfall in m/year X Surface area of catchment in m^2 X Run-off coefficient
Mean annual rainfall (Economic Survey, Delhi, 2005-2006) = 714 mm/year (0.714m)
Surface area of catchment = 6156 m^2
Run-off coefficient = 0.6
Mean rainwater supply = 2,637.23 m^3 (26,37,230 Litres)

CONCLUSION

Water is essential for the environment, for ensuring agriculture growth and for ensuring food security. Rainwater harvesting is a technique to utilise and store precious water that otherwise would go waste. Freshwater resources are limited and rainwater harvesting helps in utilising precipitation water that can be reused. We estimate the quantity of water that can be harvested by Indira Paryavaran Bhawan which comes out to be 26,36,374 Litres. Coupled with judicious use of water resources, rainwater harvesting can be one of the measures that can come useful in combating water scarcity.

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