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Rainwater Harvesting an Alternative Water Resource in Airports: A Case Study in Raipur

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ABSTRACT

The immense and growing scarcity of fresh water across the globe arises as a troubling issue for both developed and developing countries. Groundwater is the only source of water of the Swami Vivekananda Airport Raipur, and it faces water crisis when the groundwater level decreases. In this scenario, Rain Water Harvesting (RWH) can contribute considerably to tackle these problems. Rainwater treatment systems can be installed at different potential locations in study area based on their physical site conditions such as slope, elevation etc. The airport has a total area of 2.108 Square Kilometres (sq. Kms), through the properly designed drainage system storm water is collected and separated into three potential zones. Zone I, II and III having area 0.2393, 0.4307 and 1.4382 sq. Kms respectively, which produce different runoff amount based on maximum daily rainfall. The airport has 38955.62 Square meters rooftop area, water collected from the rooftop will fulfil approximately 30% of the total daily demand of the airport. Storm water is treated by Slow Sand Filter (SSF) of rate of 200 litres per hour per square meter and stored under design capacity, size and number of treatment unit depend on the maximum discharge at their respective zones. Excess water of storage tank is used for groundwater recharge, recharge well is provided at different depths according to fracture available below the ground.

KEYWORDS

Rainwater harvesting, Hydrological Modeling, Rainwater treatment, Drainage design.

INTRODUCTION

Water is crucial and it has always been considered throughout history as a natural resource for survival of humanity. Worldwide the important issue is the shortage of water either by quantity or quality. In highly populated area like urban area, the availability of fresh water even for daily use is not within reach and need external processes to get the water to the inhabitants of the area. Assessing and managing justified of water resources can help for preservation and sustainable use becomes a vital issue in people life, mainly in an area where the ground water level is very low and very low rainfall. In this sequence to complete the freshwater demand of inhabitants, use of rainwater is becoming an extensively influential instrument. For harvested water to remove microbial contamination and other chemical substances, rainwater needs some treatment system prior utilize that water. The type of treatment to be provided depends on the purpose of intended use and characteristics of collected water from the ground surfaces or roofs. Low-cost traditional treatment method like slow sand filter and disinfection by chlorination can be used for the region like an airport where treatment should be done only for rainy days and SSF is a highly efficient filter that removes 98 to 99% of bacterial contamination from water.

The location such as airport required water at the significant amount to manage their operational routine and infrastructural demand. The main purpose of this study is to reduce flash flood and use rainwater for the non-potable demand of airport. Proper drainage system also required for collection of storm water at different potential zones where water gets treated. Problem-related to this is must be taken for granted in India because in scarcity this will become a most treasured resource. After knowing all the significance of fresh water to our growing inhabitants and thriving industries, to compensate these highly increasing demands RWH techniques can be adopted.

METHODOLOGY

STUDY AREA

Raipur, the capital city of Chhattisgarh and Swami Vivekananda Airport is near to the city and its boundaries spread in the range between 21˚10′15″ to 21˚12′00″ North latitudes and 81˚43′27″ to 81˚46′20″East longitudes. Airport bounds are limited to toposheet no. 64G/12 and 64G/11 which is provided by Survey of India (SOI). The total plot area of the airport is approximately 520.89 acre (2.108 sq.Kms.). Semi-arid tropical climatic conditions prevail in Raipur urban area. The area experiences a very warm summer of longer duration of March to the middle of June and after this monsoon season will be started, which lasts for almost four months from the middle of June to September. December to the end of february study area faces the winter season. Temperature varying from 10°C to 46°C, humidity ranges from 30% to 85% and it receives 1185 mm an average rainfall.

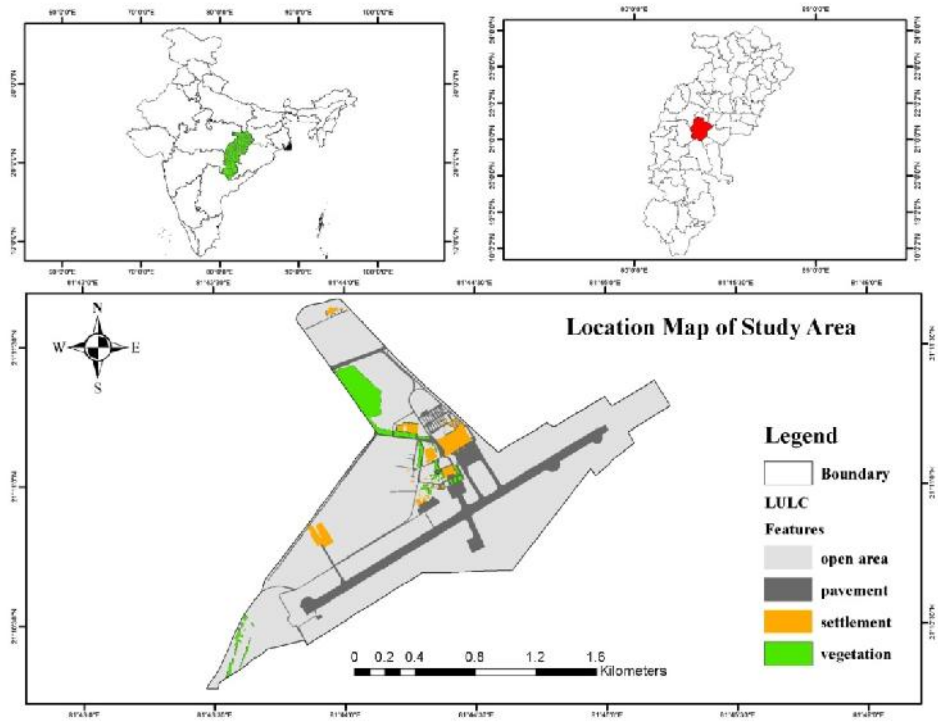

Figure 1: Location map of the study area

Physiographically study area is situated in the South-Central part of Chhattisgarh basin having gentle undulating topography. Raipur is situated on Proterozoic Chandi Formation of Raipur group (Chhattisgarh Super Group), comprising of limestone, shale and sandstone. In the airport area, there is the occurrence of limestone and shale.

RAINFALL RUNOFF MODELLING

The model was created using ArcGIS extension known as HEC-GeoHMS, which includes various steps in series collectively term called as terrain preprocessing. The data needed for modeling such as DEM, LULC, soil map are imported and merged with the proper projection system. Hydrologic Engineering Center's Hydrologic Modeling System (HEC-HMS) of version 4.1 is used for rainfall-runoff modeling. The HMS model allowed parameterization of various infiltration loss could choose by the modeler. For spatially

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dispensed calculation of infiltration enables by the Soil Conservation Service (SCS) curve number (CN) method. The SCS-CN method is used for quantifying storm runoff of particular area on the basis of their soil, land use land cover type and hydrological soil group. The ability of infiltration of any soil to decide that soil fall under which hydrological soil group. To differentiate the infiltration and runoff from the rainfall some important equation are used which are empirical and derived by the infiltration loss method.

$$Q = \frac{(P - I_a)^2}{(P - I_a + S)}$$

Where P is effective rainfall depth, Q is event discharge or Surface runoff (mm), S is the potential maximum soil retention, and I_a is Initial abstraction.

$$I_a = \lambda S$$

$$S = \frac{2}{c} - 254$$

Where value of λ vary according to soil type and Antecedent Moisture Content (AMC) and CN also varies in the range of 0 (no runoff produce) to 100 (produce all rain as runoff) which depend on LULC and soil condition.

$$Q = \frac{(P - I_a)^2}{(P - I_a + S)} \quad \text{if } P > I_a\text{; Produce runoff}$$

$$Q = 0 \quad \text{if } P < I_a\text{; No runoff}$$

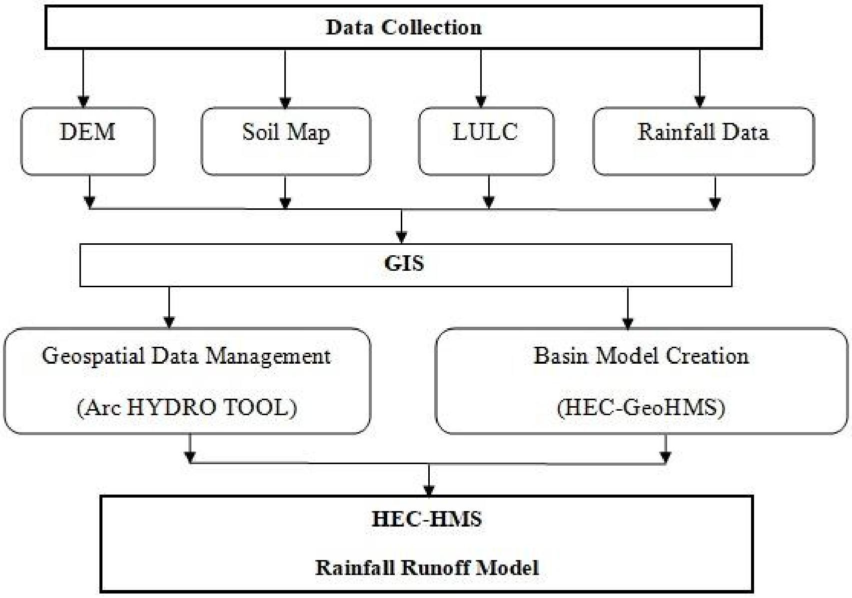


Figure 2: Flow chart of Rainfall Runoff model

DRAINAGE DESIGN

The Storm Water Management Model (SWMM) is developed by EPA, which is extensively used for urban runoff simulation. The SWMM is widely operating for analysis, design, and planning related to the urban drainage system. SWMM of version 5.1 is used for designing of the drainage network, input data editing, simulation run and showing the results in the suitable form of tables, thematic maps, graphs and reports in statistical format. IDF curve has generated to determine the intensity of the rainfall event at various time durations for different return periods. These curves have generated for the return periods of 2,5,10,20,25,30,50 and 100 years. The cross-section of the barrel is taken as a rectangle and size (depth & width) of barrel is depending on the water accumulated at a particular point. The study area has 14 sub-catchments, 27 junctions which collect and divert storm water towards the outfall. The outfall is located at the lowest elevated point of respective zones, and water is forwarded to the treatment unit where it get treated and stored.

RAINWATER TREATMENT AND STORAGE

Storm water contains sediment particle, to remove the sediment settling tank can be constructed so that filter will not be chocked during filtration. Size of the settling tank and SSF is based on the maximum discharge at the outlet point. SSF should be installed parallel near the settling tank and minimum 2 filters must be provided as per guidelines. The rate of filtration (ROF) is taken as 200 litres per hour per square meter and to meet this filtration rate thickness of layers in the filter will be specified. After filtration clear water forwarded

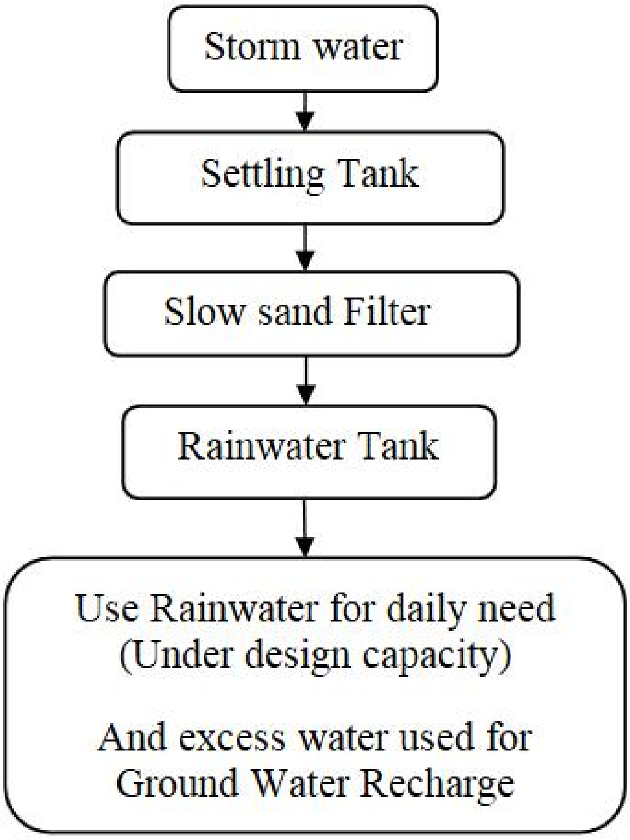
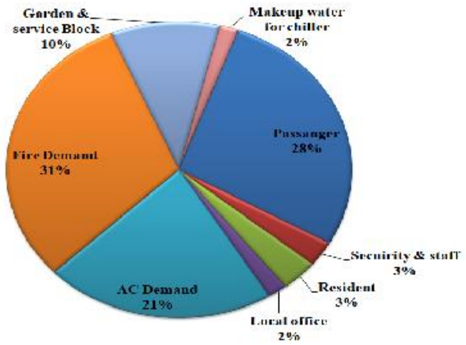


Figure 3: Flow Chart of Rainwater treatment

the rainwater tank, water can be stored in the tank under its design capacity and excess water used for groundwater recharge when it reaches to recharge structure. In recharge pit, 2 perforated borewells are installed to recharge ground water because of the geological formation in the form of limestone and shale available in the study area. Therefore some fractures are present in the ground which can utilize for water recharge and the depth of the borewells is depends on the availability of fracture below the recharge structure.

RESULT AND DISCUSSION

To estimate the maximum daily water demand of the airport is essential to know the consumption profile of the premises and terminal building, because to find the duration of service provided with the utilization of harvested water. The data was collected from airport authority of Raipur which shows the consumption profile of the area. The rooftop water has enough to serve approximately 30 % of the total daily demand of the airport.



Category	Final (Kl/d)
Passanger	135
Secuirity & staff	13.5
Resident	16.875
Local office	9
AC Demand	105
Fire Demand	150
Garden & service Block	50
Makeup water for chiller	8.571

Figure 4: Water Consumption Profile of Study Area

MODELS CALIBRATION

Rainfall runoff of relation in monthly wise is calibrated through the HEC-HMS modelling. These relation is essential for manage the drainage design and dimensions of barrel and junctions are provided for 20 year return periods.

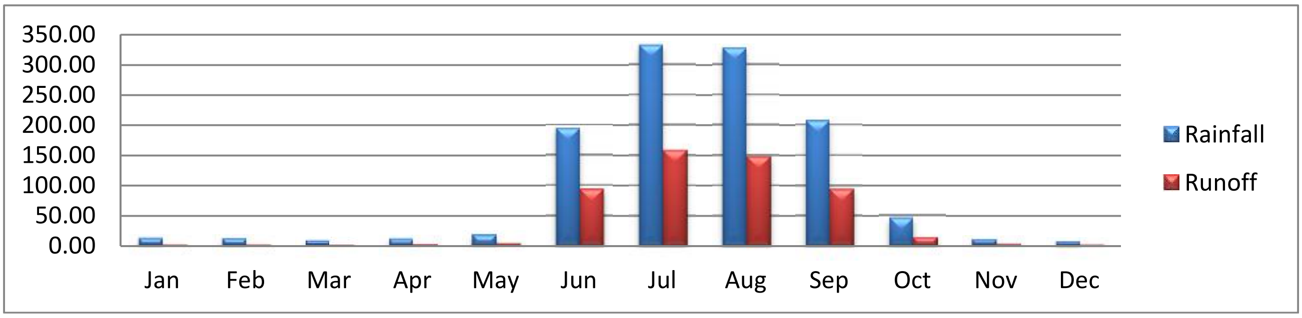


Figure 5: Monthly Rainfall - Runoff relation

Drainage system is design using SWMM, a detailed network system is given below figure throught this barrels stormwater passes and goes to the treatment unit. Necessary flow checks may be provided within the storm water drains to retain the debris.

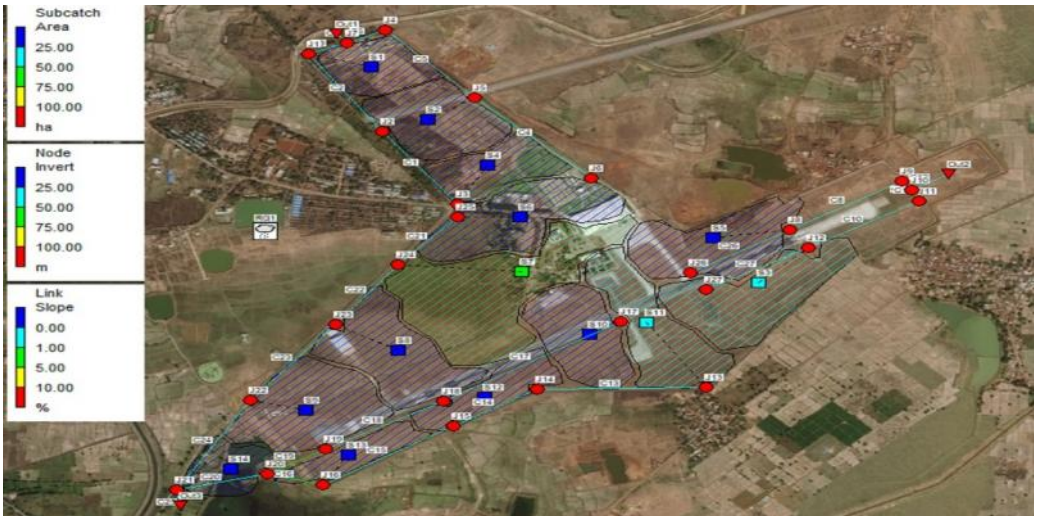


Figure 6: Drainage map of the study area

4. CONCLUSION

In Swami Vivekananda Airport application of rainwater harvesting is needed to meet increasing water consumption demand such as cooling, domestic etc. The water supply at the airport depends on groundwater delivered through five borewells located within the study area. The water is mostly used for domestic activities and as cooling water for air conditioning unit for the airport terminal building. The wastewater from the terminal building is treated at the sewage treatment plant and treated wastewater is used for irrigation of gardens. Similarly, the effort of water conservation has been made by installing waterless urinals in the terminal building. The airport has a large open area and by judicious collection and retention of stormwater in strategically located at different zone can save about 282.42×10^3 m^3 of water and excess water is used for groundwater recharge. There further scope for conservation of groundwater by collecting and using the subsurface seepage water.

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