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An Analysis of Roof Rainwater Harvesting: A Catalyst to Water Demand Management

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ABSTRACT: Yearly, the rainy season always happens globally, especially in the Asia Pacific. Where water is directly on the soil, roof, plants, etc. without proper harvesting, this water may cause damage in many aspects, such as over watering to the plants, soil, erosion, bacteria, and germs that cause viruses to begin to grow if it has been tainted y dirt and other impurities. So, proper harvesting of roof rainwater is important because it will be utilized for bathrooms, laundry, garden irrigation, etc. The Information and Communication Technology building of Isabela State University – Ilagan Campus was utilized in this study. This paper presents the average rainfall, which represents the monthly average, water availability, water demand, and water storage. As stated, the water demand is 2500 liters per day, which equals about 75000 liters per month. Wherein the amount of water that can be collected from the roof is larger than the water demand. The finding of this paper was extremely beneficial to the campus because they presented the entire details of the roof rainwater harvested in liters which will serve as the basis for utilization.

KEYWORDS: Catalyst, water demand, Rainwater harvesting, water demand, water availability

I. INTRODUCTION

Water is important in different aspects of life, not only for humans but also for other living things that need a supply of water. Considering the day-to-day activities such as washing clothes, watering plants, cooking, etc., water does everything for the satisfaction of every individual when it is considered a source for everything.

Accept the truth. Sometimes, or not all the time, the resources of water are not enough to be distributed in every household, school, and other establishment due to power interruptions and maintenance repairs. It may cause delays in tactics or work. So, harvesting rainwater on the roof may be one of the solutions that could be considered too.

Rainwater harvesting is used to store rainwater for future purposes. By incorporating a smart water management system, Rainwater harvesting will gain the ability to store the excess water in a smarter way by utilizing new technology, which deals with the modules like sensors [1].

The importance of shifting away from traditional storm-and-rainwater management that relies on large-scale, piped infrastructures and more decentralized, natural solutions is frequently emphasized in sustainable urban development in general and in sustainable urban rainwater management in particular [1], [2], [3]. The use of green roofs, artificial wetlands, permeable pavements, and infiltration trenches are just a few of the alternative rainwater harvesting techniques that are thought to be better suited to managing rainfall in densely populated cities, especially considering climate change. They are recognized for offering a variety of advantages, including groundwater replenishment, flood control, aesthetic, and recreational value [1], being more easily adaptable to local conditions [4], and lowering water use [3-5].

Rainwater harvesting systems have long been installed in domestic homes in the Philippines through the traditional once with the sole purpose of supplying a non-potable water supply for use in bathrooms, laundry rooms, and garden irrigation [6].

Yearly always happened especially during the rainy season, water is gathered on the roof and poured through the boundary pipes to flow down. Most often water is wasted by being airlifted to soiled areas. When roadways were composed of mud or sand in the past, rainwater was buried as it began to overflow [7]. However, the roads of today are obviously composed of cement, concrete, wood, etc. But these roads need to be strengthened that will be used for long years that support the weight of the increasing number of vehicles as a result of population growth [9]. Rainwater is now flowing in its own direction and collecting in corners rather than being stored directly in the ground [8]. Many bacteria and gems that cause viruses will begin to grow in the rainwater that has been tainted by dirt and other impurities. As a result, rainfall must be managed for better utilization and stored in a way that allows for absolute harvesting.

The paper presents roof rainwater harvesting wherein it focuses on the average rainfall prediction, water availability, demand, and requirements. Its purpose is to determine the amount of water to be harvested so that the consumer is aware of the estimated value that can be consumed and utilized. So, in this study, water harvested from the roof rainwater will not be useless and can be a great help to schools, universities, households, some other agencies, and establishments.

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II. METHODOLOGY

A. System Architecture

The researcher used the average annual rainfall, roof size, and roof type to determine the total amount of water harvested through the roof rainwater. The formula used is

$$Roof\ Area \times Rainfall \times Runoff\ Coeficient$$

Figure 1. The system architecture represents the flow of roof rainwater harvest.

Also, the average rainfall is predicted, wherein represents the monthly average. Water availability, demand, and required storage are also represented in this study. The information and communication technology building at ISU Ilagan was used as a sample in this paper. The reservoir/tank was already constructed and is located at the back of the ICT building.

B. Water Bill Consumption

The water bill consumption of ISU Ilagan was utilized as one of the tools in analyzing the effectiveness of using the roof rainwater harvester. Water consumption data were obtained at monthly time intervals from Water District in the period from the 1st of January 2020 till the end of October 2022. The data collected is a water bill of the campus. The year 2022 is only until October, to fill in the missing water bill consumption for the month of November and December, the researchers used a data mining predictive model. A feed-forward back-propagation artificial neural network is used in the numerical modeling using a Matlab script. The time series of historical water consumption is used in the model to forecast future demand. Only one data analysis is carried out: The analysis aimed at predicting monthly water consumption and forecasting the demand for the month taking into account a lag of 1 month in order to study the effect of the water consumption of the month before on the actual demand.

III. RESULTS AND DISCUSSIONS

Below is the sample where the roof rainwater harvest was determined as the total amount harvested:

Location:	IT Bldg., ISU Ilagan, Calamagui 2nd, Ilagan, Isabela
Latitude:	17.12930 degrees
Longitude:	121.86868 degrees

Roof size:	529.5 square meters
Roof type:	Metal

Runoff coefficient: 0.9

Water Demand: 2500 liters (2.5 m^3) per day

Figure 2. The map site of the sample building

Based on the Latitude, Longitude, Roof size, and Roof type the optimum size for a storage reservoir for this rainwater harvesting system is 194600 liters (194.6 m^3).

Rainfall

The average rainfall at this location varies between 44.9 mm in the driest month (February) and 353.5 mm in the wettest month (November). The total annual rainfall in an average year is 2112 mm.

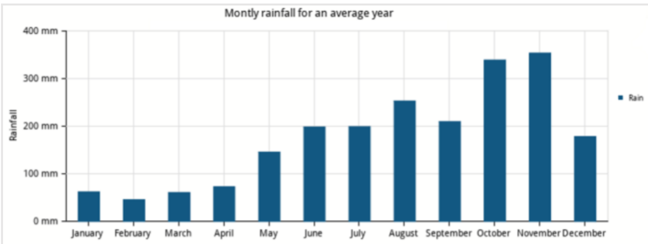

Figure 3. The average monthly rainfall

Water Availability

A metal roof has a runoff coefficient of 0.9 with 4.6% slope, which means that 90% of the rain can be harvested. Based on this runoff coefficient and a roof area of 529.5 square meters a volume of 21397 liters (44.9 mm x 529.5 m^3 x 0.9) of water can be collected in the driest month (February) and 168460 liters (353.5 mm x 30 m^3 x 0.9) in the wettest month (November). The total yearly amount of water that can be collected from the roof is 1006700 liters (1007m^3) in an average year.

Water Demand

The water demand is 2500 liters per day, which equals about 75000 liters per month. The total water demand is 912500 liters (912.5 m^3) per year. During 7 months of the year (June, July, August, September, October, November, and December) the amount of water that can be collected from the roof is larger than the water demand. This excess water can be stored to be used in the months when the water availability is smaller than the demand.

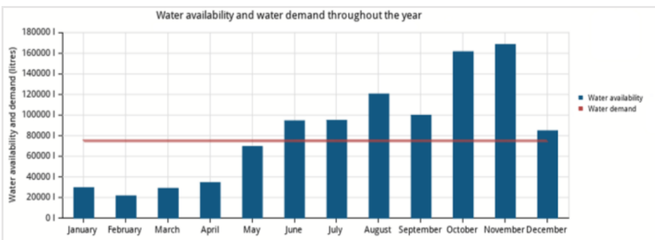

Figure 4. Water availability and demand

Required Storage

A storage reservoir (tank) can be constructed to collect and store the water during the wet months so this water can be used during the dry months. For this location, roof size, and water demand the optimum size of a storage reservoir (tank) is 194600 liters (194.6 m^3).

The storage reservoir will be full in November and December and then slowly drain until it is (almost) empty at the end of May.

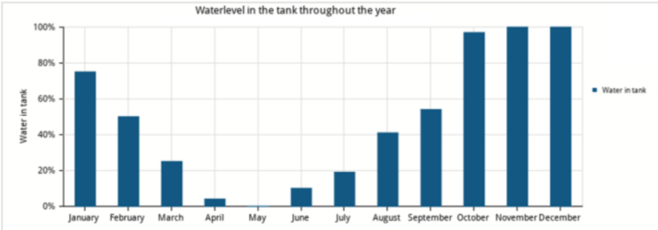

Figure 5. The Water Level in the Tank

Water Bill Consumption

The graph shows that there is an increase in the water bill in 2022 compared to the previous two years (2020 and 2021). This implies that water consumption is related to the number of people using the water facilities on campus due to the pandemic during those years. Further analysis suggests that for a two-month implementation of face-to-face classes in the schools, there is an absolute increase in consumption that shows almost sixty percent (60%) compared to non-contact or work-from-home arrangements as represented in the graph.

The above analysis suggests that a roof-mounted rainwater harvester can significantly reduce the water bill consumption at the ISU Ilagan Campus in a face-to-face setting, up to its average consumption bill.

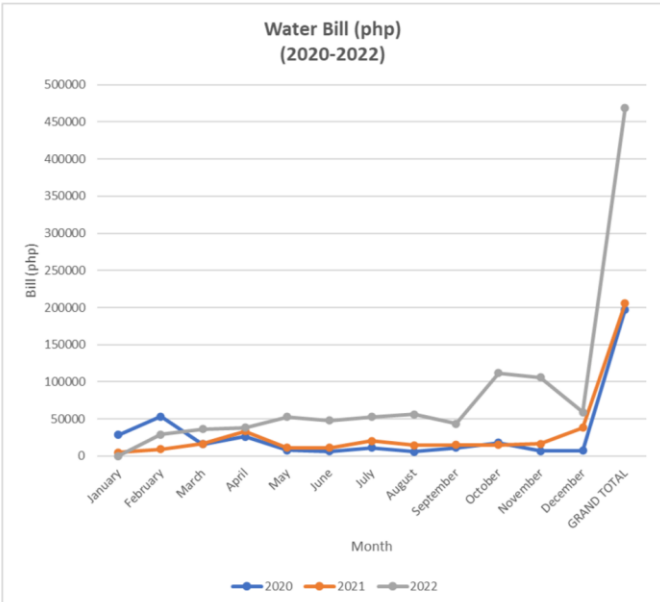

Figure 6. Water bill consumption of ISU-Ilagan for three consecutive years

IV. CONCLUSION AND RECOMMENDATIONS

Based on the findings and analysis of the estimated amount of water harvested from roof rainwater, it is concluded that using those estimation data in the rainfall average, water availability, water demand, and required storage is important. It was already computed that those amounts and averages of the water harvested from roof rainwater are very usable in many ways. It's been observed that the findings can be a great help to the campus because it shows the amount of water available that will cater to how many volumes could be supplied monthly. It is considered a big saving for the campus and as well for other agencies, households, and other establishments that want to implement it. The ICT building on the Ilagan Campus was used as the model and sample for this study. The campus can estimate the amount of water harvested for every building located on the campus. According to the data presented in this study, the campus will be benefited and save on water bills consumed.

Further analysis shows that the predicted water consumption is relative to the consumption during face-to-face setup as water usage is high when faculty, staff, and students are utilizing different water equipment for consumption.

Furthermore, the study also recommends that there be an additional part two of this study; hence, the technological aspect is still needed for the distribution of the harvested roof rainwater. Such things as using some sensors and automatic distribution when the tank has already reached its maximum level to avoid wasting the harvested roof rainwater.

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