JOURNAL OF INTERDISCIPLINARY PERSPECTIVES

ISSN Print: 2984-8288, ISSN Online: 2984-8385
Vol. 3 No. 9, pp. 374-382, September 2025

Design and Evaluation of a Rooftop Rainwater Harvesting System for Rural Household Use

Mary Joy B. Mabbin*[1], Rissa N. Reyes[2]
[1]Nueva Vizcaya Irrigation Management Office, Bayombong, Nueva Vizcaya, Philippines
[2]Nueva Vizcaya State University, Bayombong, Nueva Vizcaya, Philippines

*Corresponding Author Email: rnevada30@gmail.com

Date received: June 25, 2025
Date revised: July 29, 2025
Date accepted: August 19, 2025

Originality: 94%
Grammarly Score: 99%
Similarity: 6%

Recommended citation:
Mabbin, M. J., & Reyes, R. (2025). Design and evaluation of a rooftop rainwater harvesting system for rural household use. *Journal of Interdisciplinary Perspectives*, *3*(9), 374-382. https://doi.org/10.69569/jip.2025.533

Abstract. Water scarcity in rural Philippine communities often undermines household and irrigation needs, yet empirical assessments of rooftop rainwater harvesting system (RWHS) performance under actual rural conditions remain scarce. This study aimed to design, construct, and evaluate a rooftop rainwater harvesting system (RWHS) for a rural household in Cabuluan, Villaverde, Nueva Vizcaya. It examined the volume of actual rainwater collected from January to May 2022 and evaluated the system's cost-effectiveness in meeting domestic and irrigation demands. Results revealed that a total rainfall volume of 69.53 m^3 could be harvested annually by the household, with a roof area of 36.25 m^2 and a roof slope of 12.33°, made of corrugated GI sheet roofing. Average rainfall amounts were based on 20-year rainfall data (1999–2018) obtained from the NVSU-PAGASA agrometeorological station 21.1 km from the study site. A storage requirement of 3 m^3 was determined using the supply-side approach, which considers both rainfall patterns and household water demand. From January to May 2022, the system collected 0.81 m^3, 2.19 m^3, 0.66 m^3, 0.69 m^3, and 0.82 m^3, respectively. These values excluded overflows from the storage system and rainwater during rainfall events. Variations in collected rainwater volumes and historical rainfall data were attributed to spatial differences in rainfall distribution. The findings indicated that the RWHS is a reliable water supply option for domestic and irrigation use at the household level. The total cost of constructing the rooftop rainwater harvesting system was approximately ₱60,000. The system offers convenient water access while contributing to environmental benefits, such as erosion control and stormwater management. By presenting actual collection data alongside long-term climatic records, this study fills a critical gap in RWHS performance evaluation under real-world rural household conditions, offering actionable insights supporting more sustainable and locally adapted water scarcity solutions.

Keywords: Irrigation system; Rainwater harvester; Rainwater utilization; Sustainability; Water supply

1.0 Introduction

The Philippines receives between 965 and 4,064 millimeters of rain annually (PAGASA, 2025), underscoring its potential for sustainable water collection; yet countless rural households still struggle with access. In this context, rooftops become untapped reservoirs of resilience. The country experiences a tropical and maritime climate, with rainfall as its most significant climatic element. Annual rainfall varies widely across regions due to prevailing winds and mountain systems, creating uneven water availability (PAGASA DOST, 2021). Despite having an estimated 130 km^3 of internal water resources annually, the country continues to suffer from limited freshwater availability per capita and increasing water-related challenges (Lapong & Fujihara, 2008; Icamina, 2017). These problems are expected to worsen due to climate change, which is projected to cause decreased rainfall during dry months and heavier rains during wet seasons, alongside a growing population and expanding urban areas (British Geological Survey, 2021). These trends further stress water resources, particularly at the household level.

Strategies such as on-site water storage and conservation are increasingly vital in addressing water stress, especially in regions facing erratic rainfall and declining groundwater levels. Recent empirical studies emphasize that rainwater harvesting (RWH) is not merely a supplemental solution but a strategic intervention that enhances water security, climate resilience, and community autonomy (Khanal et al., 2020; Munirah et al., 2021). RWH systems collect and store rainwater from rooftops or land surfaces, offering a decentralized alternative to conventional water infrastructure. Their effectiveness spans domestic, agricultural, and even potable applications, depending on system design, filtration, and maintenance. In regions with limited access to surface or groundwater, RWH has proven to be a cost-effective and environmentally sustainable solution (Umapathi et al., 2019; Suki et al., 2022). Beyond technical feasibility, RWH systems contribute to urban flood mitigation, groundwater recharge, and reduced energy demand for water transport. Studies show that when integrated with intelligent monitoring and life cycle costing models, RWH systems can be optimized for yield, reliability, and affordability (Umapathi et al., 2019).

Moreover, their success hinges on community engagement, policy support, and adaptive design, especially in climate-vulnerable areas (Raimondi et al., 2023). Recent studies also recognize rainwater harvesting as a practical and sustainable water management strategy, especially under water scarcity and climate variability (Velasco Muñoz et al., 2019). For instance, McCarton et al. (2021) highlight that RWHS not only enhance climate resilience but also support the circular economy of water by reducing dependence on centralized supply systems. Bañas et al. (2023) highlight the efficiency and sustainability of rooftop catchment systems in tropical regions. Similarly, de Sá Silva et al. (2021) emphasize the environmental, economic, and social benefits of RWHS, particularly in low- and middle-income regions. In the Philippine context, Juele and Lapong (2024) underscore the potential of RWHS to address both water scarcity and flooding, provided that institutional and technical barriers are addressed. Despite growing interest in RWHS, there remains a lack of empirical evaluation of system performance under actual rural household conditions in the Philippines.

This study aims to design and evaluate a rooftop rainwater harvesting system for a household in Cabuluan, Villaverde, Nueva Vizcaya. It assesses the system's potential to meet irrigation and domestic water needs and estimates its construction cost. The results aim to support future adoption of similar systems to enhance water access and resilience at the household level.

2.0 Methodology

2.1 Research Design

This study utilized an experimental research design to assess the effectiveness of a rooftop rainwater harvesting system (RWHS) for domestic and irrigation use. The system was installed in a selected household in Cabuluan, Villaverde, Nueva Vizcaya. Rainwater collection volumes from January to May 2022 were measured and analyzed in comparison with historical rainfall data. The design also applied the supply-side approach to determine storage requirements, integrating rainfall trends and estimated water demand. This practical setup allowed evaluation under real-world conditions to determine cost-efficiency and system reliability.

2.2 Research Locale

The study was conducted in Barangay Cabuluan, Villaverde, Nueva Vizcaya, at coordinates 16.5891N and 121.1346E. Elevation at these coordinates was estimated to be 609 m above sea level. Its population, as determined by the 2020 Census, was 1,859. This represented 9.24% of the total population of Villaverde. Based on the 2015 Census, the household population of Cabuluan was 375 households, or an average of 4.42 members per household (PhilAtlas, 2020).

2.3 Research Instrument

The study employed complementary instruments to support the design and evaluation of the rooftop rainwater harvesting system. First, a semi-structured household interview was conducted to gather demographic profiles, quantify domestic and irrigation water-use patterns, and identify roof catchment characteristics pertinent to rainwater collection. Second, a 20-year rainfall dataset (1999–2018) obtained from the Philippine Atmospheric, Geophysical, and Astronomical Services Administration (PAGASA) station at the Nueva Vizcaya State University compound was utilized to inform the system's design parameters. From this dataset, 1-day, 3-day, and 5-day rainfall durations were analyzed to estimate peak rainfall events, which guided the sizing of the conveyance components, distribution infrastructure, and storage tank. Third, a performance log was maintained from January to May 2022, documenting daily rainfall occurrences and the actual volume of rainwater harvested. These empirical records provided a basis for assessing the system's operational efficiency under varying weather conditions.

2.4 Data Gathering Procedure and Analysis

The construction of the rooftop rainwater harvesting system used accessible and affordable materials, including three 1000L IBC tanks, rain gutters, PVC pipes and fittings, sealants, and support structures like fascia boards and steel bars. Tools such as welding machines and grinders were utilized for assembly. A 20-year rainfall dataset (1999–2018) from the NVSU-PAGASA station was used to estimate rainfall patterns and calculate 1-day, 3-day, and 5-day rainfall durations, which informed the sizing of the conveyance and storage systems. The potential volume of harvested rainwater was determined using a formula that considers rainfall intensity, roof area, and runoff coefficient, based on the corrugated GI sheet roof of the study site.

Designing the system involved estimating the household's monthly water demand through interviews, covering irrigation (for flowers and a planned tomato garden) and domestic uses such as toilet flushing, washing, and food preparation. The total estimated monthly demand was 6.14 m^3. The delivery system, made of PVC and aluminum for cost and durability, was sized based on maximum rainfall intensity and roof area, resulting in a recommended 90 mm-wide gutter. Storage sizing used the supply-side approach, comparing roof runoff with monthly demand. Results showed that roof runoff exceeded demand in peak months (July–October), justifying a tank capacity of 3 m^3, including a 5 m^3 residual storage. The system also accounted for overflow to manage excess rainwater, ensuring the system's reliability for both irrigation and domestic needs.

2.5 Ethical Considerations

This study did not involve human or animal subjects. All experimental procedures were conducted, ensuring environmental responsibility, data integrity, and safe implementation. The design and operation of the rooftop rainwater harvesting system adhered to relevant safety and environmental protocols. Additionally, interviews were conducted with local participants to gather contextual insights. These were carried out with informed consent and in a manner that respected participant confidentiality and ethical research practices.

3.0 Results and Discussion

3.1 Potential Rooftop Rainwater Volume Collected

The potential amount of rooftop rainwater volume was calculated based on the 20-year rainfall data (1999-2018) obtained at the NVSU-PAGASA Agromet Station. The average monthly rainfall (mm) is shown in Table 1, column 2. The calculated average monthly roof run-off using the equation, Water Harvesting Potential (WHP) = Rainfall (mm) x Catchment Area (mm^2) x Runoff Coefficient, with the roof area of the household model of 36.25 m^2 inclined at 12.33°, utilizing a run-off coefficient of 0.9 for galvanized iron sheet, is also presented.

Table 1. *Average Monthly Roof Run-off*

Month	Average Monthly Rainfall (mm)	Average Monthly Roof Run-off (cu.m.)
January	90.23	2.62
February	68.79	1.99
March	69.42	2.01
April	117.43	3.41
May	183.88	5.33
June	180.71	5.24
July	265.16	7.69
August	370.96	10.76
September	416.57	12.08
October	296.38	8.60
November	194.28	5.63
December	143.68	4.17
Average Total	**2397.49**	**69.53**

The highest average monthly roof run-off of 12.08 m³ was calculated in September, followed by August (10.76 m³) and October (8.60 m³). These months were included in the area's rainy season, which starts from June and continues through November. The least runoff of 1.99 m³ was from February, which was included in the dry season. There could be an expected amount of rainfall of about 2,397.49 m³ in a year based on the 20-year rainfall data, while the average total roof run-off volume of the household model for a year was estimated to be about 69.53 m³.

This highly supports the possibility of rooftop rainwater collection in the area, especially in the household, as affirmed by Bañas et al. (2023), who emphasized that roof catchment systems in tropical climates can yield substantial runoff volumes when designed with seasonal rainfall patterns in mind. Xie et al. (2023) further demonstrated that optimizing roof coverage and tank sizing significantly enhances water reliability in rainwater harvesting systems. Sousa et al. (2025) also noted that even small-scale systems can achieve meaningful water savings and retention when aligned with local rainfall dynamics. Additionally, Lepcha et al. (2024) highlighted that long-term rainfall data is essential in assessing the feasibility and sustainability of RWHS, particularly in rural settings. Finally, Prabha et al. (2025) confirmed that household-level systems can be tailored to maximize runoff capture during peak months, ensuring year-round utility despite seasonal variability.

3.2 The Rooftop Rainwater Harvesting System

The study considered literature reviews, face-to-face interviews, field investigations, the availability of local materials, and the cost of construction in designing the different components of the rooftop rainwater harvesting model. After analyzing the potential amount of rainwater that can be collected from the household's roof and designing the rooftop rainwater harvesting facility model, the constructed rainwater harvesting model was implemented.

The rainwater storage comprises three plastic tanks with a 1000 L capacity, each covered with a protective hood to protect the tanks from the sun and prevent algae from growing inside them. The storage tanks were elevated from the ground and supported by a steel frame, which created pressure for the water to be delivered by gravity without water pumps. Two water taps were provided to access water from the storage for use. A coarse stainless steel filtration screen was placed at the entrance to the downpipe from the gutter to prevent leaves and other materials from entering the storage tank. A simple first flush device made of PVC pipe was also installed at the end of the downpipe, where the rainwater received during the first shower after a dry period was collected. The water stored in it could be manually cleared with a clean-out mechanism.

3.3 Rainwater Collection

From the observations in the average monthly roof run-off based on the 20-year rainfall data (1999-2018), which agrees with PAG-ASA, DOST (2021), the months of February to May belong to the dry season in the area. Hence, the researcher decided to collect rainwater and fill the storage tanks in the first two months of collection in preparation for the hot, dry season of March to May. This also allowed the rainwater collected by the rooftop rainwater harvesting model during a rainfall event to be recorded accurately. The inflow and outflow cannot be recorded simultaneously during continuous rainfall unless the outflow is measured at the point of delivery before its specific use.

Volume of Rainwater Collected in January

Rainwater collection was done after the rooftop rainwater harvesting model was constructed, beginning on the fourth week of January 2022, specifically on the 22nd day of the month. Rainfall data from January to May 2022 were collected at the NVSU PAG-ASA Agrometeorological station. These data were used to estimate the amount of rainwater the rainwater harvesting system could collect. Figure 1 shows the estimated daily volumes of rainwater collected by the rooftop rainwater harvesting system in January. Estimates based on the 20-year rainfall data (1999–2018) and 2022 rainfall data showed the highest daily volumes of rainwater collected, with nearly identical values of 0.30 m³ and 0.29 m³, respectively. The actual rainwater collection recorded a maximum daily volume of 0.24 m³ for the month. Some of the rainwater during the collection was deposited in the first flush system, while some may have been lost due to wind or absorption by surrounding vegetation.

There is an inherent variation between the volume of rainwater collected and the recorded rainfall days. This could be attributed to spatial differences between the study area and the weather station where the rainfall data used for estimation were obtained. According to map data from Google Maps (2022), there is a distance of approximately 21.1 km between Cabuluan, the project site, and the nearest agrometeorological station located in Bayombong, Nueva Vizcaya, where the rainfall data were collected.

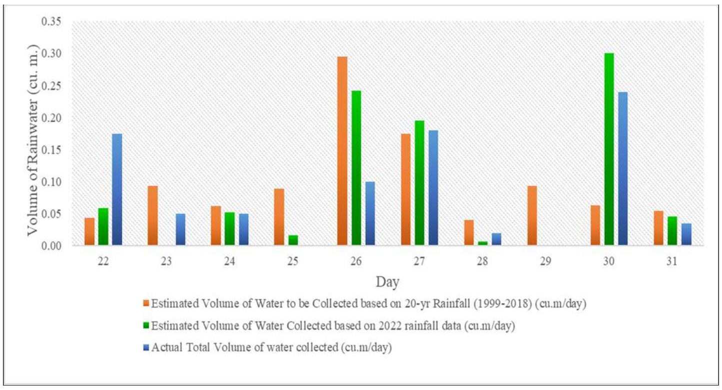

Figure 1. *Estimated and Actual Daily Volume of Rainwater Collected in January*

Volume of Rainwater Collected in February

The second month of daily rainwater collection for the rooftop rainwater harvesting model was done in February 2022, where the estimated and actual daily volume of rainwater collection is shown in Figure 2.

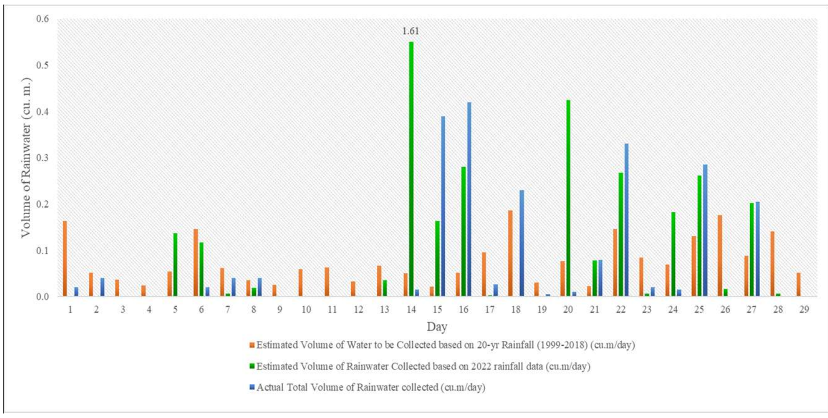

Figure 2. *Estimated and Actual Daily Volume of Rainwater Collected in February*

The highest volume of estimated rainwater collected was about 1.61 m³ based on the 2022 rainfall data, followed by the actual collection and the estimates based on the 20-year rainfall data (1999–2018), with volumes of 0.42 m³ and 0.19 m³, respectively. From the 1st to the 13th day of the month, zero to moderate rainwater volumes ranging from 0–0.12 m³ were collected based on the 2022 rainfall data and actual collection. However, from the 15th to the 27th day, the actual collection and the 2022 estimates exceeded the estimated volume based on the 20-year rainfall data. Overall, the total volumes of rainwater collected were 3.81 m³ from the 2022 rainfall data, 2.24 m³ from the 20-year rainfall data, and 2.19 m³ from the actual collection. The rainwater collected during actual conditions was 57% lower than the estimated volume based on the 2022 data and slightly lower than the 20-year estimate, with only a 0.05 m³ difference. Some portions of the rainfall may have been lost due to wind, conveyance losses, or interception by vegetation.

Volume of Rainwater Collected in March

Figure 3 shows the estimated daily volume of rainwater collected for March. It can be observed from the figure that there was a small amount of rainfall expected for the month based on the 20-year rainfall data estimates, where the highest volume of rainwater is 0.31 m³. On the 2022 rainfall data, high amounts of rainfall were observed, with the highest volume of rainwater estimated to be 1.61 m³.

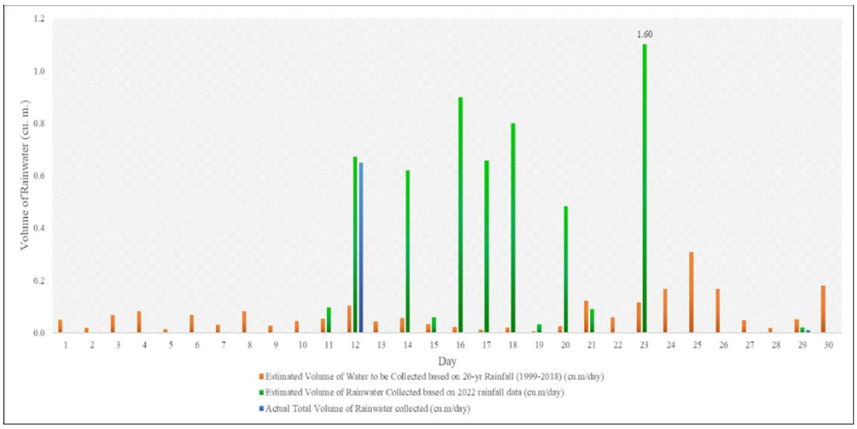

Figure 3. *Estimated and Actual Daily Volume of Rainwater Collected in March*

Though a dry period was anticipated during the first week of the month due to the absence of rainfall, heavy and continuous rainfall was experienced in the middle weeks. This may be attributed to the impact of climate change on the area. As stated by PAGASA-DOST (2022), there is growing global concern over climate change due to its adverse effects, which are now being observed globally and at regional, national, and local levels. Manton et al. (2001) also noted that in Southeast Asia, including the Philippines, changes in rainfall patterns have been observed, particularly in the performance of the monsoon.

The unexpectedly high rainfall amounts in the month caused the rooftop rainwater harvesting system (RWHS) storage tanks to overflow during actual collection. The highest volume of rainwater collected in actual conditions was 0.65 m³, more than twice the volume estimated based on the 20-year rainfall data (1999–2018). The estimated rainwater collected in March was 2.26 m³ based on the 20-year data and 6.62 m³ based on 2022 rainfall data. In contrast, the actual volume collected was 0.66 m³, excluding overflow and water usage during rainfall events. The total outflow from the RWHS was approximately 0.95 m³, with a remaining volume of 2.73 m³ stored in the tanks at the end of the month.

Volume of Rainwater Collected in April

Figure 4 shows the estimated daily rainwater collected in the RWHS for April. Continuous rainfall occurred on the second day of the month, and the system collected some rainwater. However, there was an overflow in the storage as only a little of the rainwater stored from the previous month was used, and the water level in the storage tanks was nearly at full capacity at the start of the month.

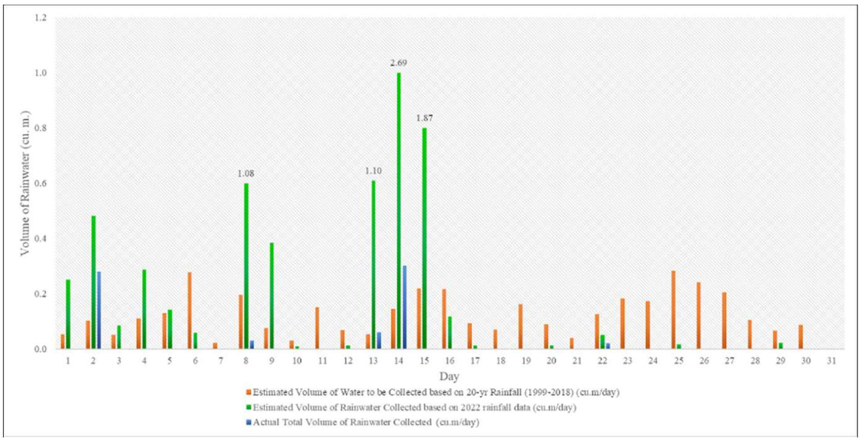

Figure 4. *Estimated and Actual Daily Volume of Rainwater Collected in April*

Storage overflows continued for about two weeks; nevertheless, the RWHS could still collect some rainwater, replenishing the amount that had been used. Based on the 20-year data, only a small amount of rainfall is typically expected in April, with the highest estimated rainwater volume of about 0.28 m^3. This is lower than the collected volume and the 2022 rainfall data, which recorded 0.30 m^3 and 2.69 m^3, respectively. It can also be observed from the figure that little to no rainfall occurred during the last two weeks of April, aligning with historical data trends. The estimated rainwater collected for April was 3.83 m^3 based on the 20-year data and 8.70 m^3 based on the 2022 rainfall data. Due to storage overflows, the total volume of rainwater collected during actual conditions was only 0.69 m^3. The total water usage from the RWHS during the month was approximately 1.77 m^3, with the highest recorded outflow of 0.67 m^3.

Volume of Rainwater Collected in May

Figure 5 shows the estimated and actual daily rainwater collected in May. Based on the 2022 rainfall data, the figure shows that there were high amounts of rainfall at the beginning of the month.

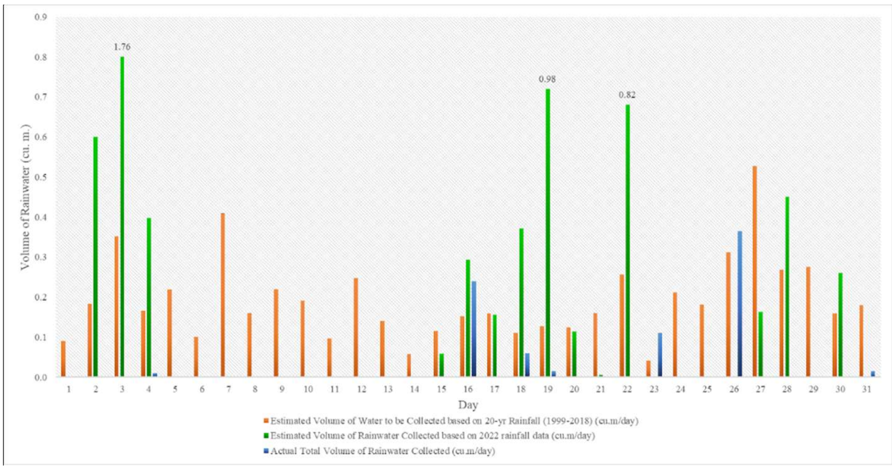

Figure 5. *Estimated and Actual Daily Volume of Rainwater Collected in May*

This exceeded the estimated rainwater volume based on the 20-year rainfall data, even though little to no rainfall occurred in the study area, as shown in the figure. It is important to note that the nearest agrometeorological station, where the rainfall data were sourced, is located 21.1 km away from the study area, which may explain the variation in recorded rainfall amounts. The highest estimated rainwater volume collected was 1.76 m^3 based on the 2022 rainfall data, while the 20-year rainfall data recorded a maximum of 0.53 m^3. The highest recorded volume in the rainwater collection was 0.37 m^3, excluding rainfall days when storage overflow occurred.

The total estimated rainwater collected for May was 6.42 m^3 based on the 2022 data and 6.0 m^3 based on the 20-

year rainfall data. In contrast, the rainwater collected was 0.82 m^3, excluding overflows and water used during rainfall events. As shown in Appendix Table 8, the rainwater harvesting system recorded a total outflow of 1.44 m^3 for the month, with the highest outflow of 0.35 m^3 at the end of May. From January to May 2022, a total of approximately 5.21 m^3 of rainwater was collected by the rooftop RWHS. During the three months of March to May 2022, the system recorded a total outflow of approximately 4.13 m^3, representing the volume of rainwater the household uses for various domestic and irrigation activities.

3.4 Potential Uses of the Collected Rainwater from the RWHS

The daily uses of the rainwater collected in the rainwater harvesting system (RWHS) modeled by a household include toilet flushing, comfort room cleaning, washing kitchen utensils, washing rags, motorcycle washing, irrigation of flower plants, irrigation of a small vegetable garden, herbicide application on the farm, and spraying insecticides. It could be observed that rainwater was often used to flush toilets. The highest outflow of 0.67 m^3 in April was mainly used for herbicide application and insecticide spraying on the citrus farm. In May, an outflow of about 0.35 m^3 was used mainly to irrigate the small vegetable garden of tomatoes that the farmer transplanted in the last week of the month. It could also be noticed that higher outflows were expected for longer dry periods, as water would be needed for more applications.

These findings are consistent with the observations of Sousa et al. (2025), who emphasized that small-scale RWHS implementations in rural areas effectively supplement domestic and agricultural water needs. Similarly, Juele and Lapong (2024) found that rainwater harvesting systems contributed significantly to behavioral shifts in resource conservation and reduced dependence on centralized water supplies in rural Philippine communities. By storing runoffs in three 1,000 L IBC tanks, families buffer against dry-season shortages, smoothing supply between rainfall events. This decentralized approach aligns with rural Koronadal studies, where rooftop systems reduced peak-season groundwater withdrawal by up to 30 percent and mitigated stormwater runoff during heavy rains (de Sá Silva et al., 2021). The system's modular design—gravity-fed delivery, minimal maintenance, and reliance on locally available materials—further underscores its replicability in similar rural landscapes (Juele & Lapong, 2024).

3.5 Cost of Construction of the Rooftop Rainwater Harvesting System

The cost of constructing the rooftop rainwater harvesting system (RWHS) was approximately ₱60,000. An amount of ₱20,400, which accounted for 34% of the total cost, was allocated for the three storage tanks. Meanwhile, ₱11,230 was used for the steel bars needed for the frame support, ₱2,729 for PVC materials, and ₱7,231 for other necessary materials. Labor cost was estimated at 30% of the material cost, amounting to ₱12,545, and a miscellaneous cost of ₱5,000 was also allotted.

Although the capital investment required for constructing the rooftop RWHS may be considered expensive for the farmer, using locally available materials is recommended to reduce expenses. For instance, replacing G.I. gutters with bamboo and combining bamboo and wood for the tank frame support could reduce the overall cost by 22%. While this alternative would result in a less durable frame requiring more frequent inspection and maintenance, it would make the project more affordable. Another advantage of using wood is that it is easier to install and does not rust like metal. This aligns with the findings of Khanal et al. (2020), who emphasized that RWHS becomes economically viable when cost-reduction strategies and risk assessments are integrated into the design. Moreover, Amos et al. (2016) concluded that life cycle cost analysis reveals that RWHS can yield long-term savings when properly maintained and scaled to local needs.

It should also be noted that, despite its cost, the rooftop RWHS can provide numerous benefits and even additional profit for the farmer. The system serves as a reliable water source for irrigation, allowing the farm to support a wider variety of crops. It also offers easy access to water for domestic use and various farm activities such as irrigation, spraying insecticides, and weed control. As Steffen et al. (2013) pointed out, an additional environmental benefit of such systems is the reduction of soil erosion caused by runoff, as well as improved stormwater management and increased resiliency in potable water systems due to reductions in both stormwater volume and potable water demand.

4.0 Conclusion

This study demonstrated that a 36.25 m^2 corrugated GI-sheet rooftop catchment can yield an average annual runoff of 69.53 m³ under local rainfall patterns. A 3 m³ storage capacity, determined via the supply-side approach, efficiently balances peak-season surpluses and dry-season demands. The constructed RWHS -comprising PVC gutters and downpipes, a coarse filtration screen, a first-flush diverter, and an overflow outlet - harvested 5.21 m³ of rainwater from January to May 2022. The captured rainwater met the household's domestic needs and irrigated a small garden, demonstrating practical reliability under real-world conditions. At a total construction cost of approximately ₱60,000, the system proved to be a cost-effective intervention. Beyond improved water access, it contributed to reduced soil erosion and more effective stormwater management.

Beyond its technical performance, the RWHS model offers a transformative framework for local water management. At the household level, it promotes proactive water budgeting, routine maintenance habits, and heightened water literacy as families monitor storage levels, optimize catchment efficiency, and schedule clean-up before dry spells. Finally, this household-scale RWHS dovetails with broader sustainability initiatives - it curbs runoff. It recharges groundwater, lowers household water expenses, generates local fabrication and maintenance jobs, strengthens community self-reliance, and buffers against climate-driven dry-season shortages and extreme rainfall events. Future research should assess long-term system performance across multiple seasons, explore cost-reduction through alternative or locally sourced materials, and investigate scalable models for community-level water management networks. These next steps will further validate and amplify rooftop rainwater harvesting as a resilient, sustainable water-security solution for rural households.

5.0 Contributions of Authors

Author 1: conceptualization, data gathering, data analysis
Author 2: data gathering, data analysis, editing

6.0 Funding

This research received no external funding.

7.0 Conflict of Interests

The authors declare no conflict of interest.

8.0 Acknowledgment

The authors extend their deepest appreciation and gratitude to the Department of Science and Technology – Science Education Institute (DOST-SEI) for the generous support provided through the STRAND Scholarship Program, which has been instrumental in advancing their academic and research pursuits. They also wish to convey sincere gratitude to all those who have offered guidance and encouragement throughout this journey, especially to their academic advisers, families, and friends. Above all, they offer their highest praise and profound thanks to God Almighty for His unending guidance and provision.

9.0 References

Amos, C. C., Rahman, A., & Gathenya, J. M. (2016). Economic analysis and feasibility of rainwater harvesting systems in urban and peri-urban environments. Resources, Conservation and Recycling, 113, 1–10.

Bañas, K., Robles, M. E., & Maniquiz-Redillas, M. (2023). Stormwater harvesting from roof catchments: A review of design, efficiency, and sustainability. Water, 15(9), 1774. https://doi.org/10.3390/w15091774

British Geological Survey. (2021). Improving water security in the Philippines. https://tinyurl.com/yzyt2d6j

Department of Science and Technology - Philippine Atmospheric, Geophysical and Astronomical Services Administration. (2022). Climate of the Philippines. https://tinyurl.com/4vvhj5fw

De Sá Silva, A. C. R., Bimbato, A. M., Balestieri, J. A. P., & Vilanova, M. R. N. (2021). Exploring environmental, economic and social aspects of rainwater harvesting systems: A review. Sustainable Cities and Society, 76, 103475. https://doi.org/10.1016/j.scs.2021.103475

Google. (2022). Cabuluan to Bayombong distance [Map]. Google Maps. https://www.google.com/maps

Icamina, P. (2017). Water crisis in Ph: Scarcity amid abundance. Malaya.

Juele, I. B., & Lapong, E. R. (2024). Rainwater harvesting systems (RWHS): The multi-level perspective towards sustainability transition. Journal of Interdisciplinary Perspectives, 2(8), 1–1. https://ejournals.ph/article.php?id=24109

Khanal, G., Thapa, A., Devkota, N., & Paudel, U. R. (2020). A review on harvesting and harnessing rainwater: An alternative strategy to cope with drinking water scarcity. Water Supply, 20(8), 2951–2963. https://doi.org/10.2166/ws.2020.264

Lapong, E., & Fujihara, M. (2008). Water resources in the Philippines: An overview of its uses, management, problems and prospects. Journal of Rainwater Catchment Systems, 14(1), 57–67. https://www.researchgate.net/publication/30804442

Lepcha, R., Patra, S. K., Ray, R., & Kumar, A. (2024). Rooftop rainwater harvesting: A solution to water scarcity—A review. Groundwater for Sustainable Development, 26, 101305. https://doi.org/10.1016/j.gsd.2024.101305

McCarton, L., O'Hogain, S., & Reid, A. (2021). The worth of water: Designing climate resilient rainwater harvesting systems. Springer International Publishing. https://doi.org/10.1007/978-3-030-50605-6

Munirah, A. M., Rahmat, S. N., Madun, A., & Mustapa, M. S. (2021). Issues and challenges in rainwater harvesting for potential potable and non-potable water production. iTECH MAG, 3, 55–58. https://itechmag.org/paper/volume3/55-58.pdf

PAGASA. (2021). Climate of the Philippines. Philippine Atmospheric, Geophysical and Astronomical Services Administration. https://tinyurl.com/2eajpmrz

Philippine Atmospheric, Geophysical and Astronomical Services Administration. (2025). Climate of the Philippines. https://tinyurl.com/s97875w4

PhilAtlas. (2020). Cabuluan, Villaverde, Nueva Vizcaya. https://tinyurl.com/uuvtkppm

Prabha, D., Anitha, V., Kumar, C. S., Prabagaran, S. R., & Lakshmanaperumalsamy, P. (2025). Rooftop rainwater harvesting potential at Bharathiar University. Lingkar: Journal of Environmental Engineering, 5(2), 32–48. https://doi.org/10.22373/ljee.v5i2.6897

Raimondi, A., Quinn, R., Abhijith, G. R., Becciu, G., & Ostfeld, A. (2023). Rainwater harvesting and treatment: State of the art and perspectives. Water, 15(8), 1518. https://www.mdpi.com/2073-4441/15/8/1518

Sousa, V., Carollo, M., Butera, I., & Meireles, I. (2025). The combined performance of green roof and rainwater harvesting: Retention capacity and water saving. Blue-Green Systems, 7(1), 238–257. https://doi.org/10.2166/bgs.2025.041

Steffen, J., Jensen, M., Pomeroy, C. A., & Burian, S. J. (2013). Water supply and stormwater management benefits of residential rainwater harvesting in U.S. cities. Journal of the American Water Resources Association, 49(4), 810–824.

Suki, N. M., Latif, H. M., & Zainol, H. (2022). A systematic literature review on rainwater harvesting implementation fidelity. IOP Conference Series: Earth and Environmental Science, 1067, 012022. https://tinyurl.com/4vab8wrh

Umapathi, S., Pezzaniti, D., Beecham, S., Whaley, D., & Sharma, A. (2019). Sizing of domestic rainwater harvesting systems using economic performance indicators to support water supply systems. Water, 11(4), 783. https://www.mdpi.com/2073-4441/11/4/783
Velasco Muñoz, J., Aznar-Sánchez, J. A., Batlles de la Fuente, A., & Fidelibus, M. (2019). Rainwater harvesting for agricultural irrigation: An analysis of global research. Water, 11(7), 1320. https://doi.org/10.3390/w11071320
Xie, H., Randall, M., & dos Santos, S. M. (2023). Optimization of roof coverage and tank size for integrated green roof rainwater harvesting systems: A case study. Water Resources Management, 37, 4663–4678. https://doi.org/10.1007/s11269-023-03568-z