e-ISSN: 2745-9535
No. 105/E/KPT/2022
Jurnal Pengabdian Masyarakat
Member of: AJEBI
Editorial Office: Jl. Soekarno-Hatta, Rembuksari No. 1A, Malang, East Java, Indonesia, 65113
Contact: Phone: +62 (341) 478494 e-mail: jpm@asia.ac.id
The journal is published by Institut Teknologi dan Bisnis Asia Malang
Website: https://jurnal.stie.asia.ac.id/index.php/jpm
Indexed in: Google Crossref neliti GARUDA Journal Dimensions

Design and Implementation of an Integrated Rainwater Harvesting System in the Hargosari Village Rest Area

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Volume
7
Issue
2
Edition
November
Page
410-420
Year
2026

Article History

Submission: 28-06-2026
Review: 01-07-2026
Accepted: 03-09-2026

Keyword

Rainwater Harvesting;
Rest Area;
Water Treatment;

How to cite

Pratiwi, D. M., & Kuncoro, H. B. B. (2026). Design and Implementation of an Integrated Rainwater Harvesting System in the Hargosari Village Rest Area. Jurnal Pengabdian Masyarakat, 7(2), 410-420. https://doi.org/10.32815/jpm.v7i2.3029

Abstract

Purpose: The aim of this activity is to design and implement a rainwater harvesting system that is effective, efficient, and appropriate to local conditions, as well as to increase community capacity in independent and sustainable water management.

Method: Implementation methods include:survey and analysis of water needs and potential rainfall, planning the design of an integrated rainwater harvesting system participatory system development.

Practical Applications: After the Rainwater Harvesting system was completed, the Rest Area now has an alternative water source derived from rainwater utilization. This condition indirectly has the potential to improve the image of the tourist area and support the economic activities of the community around the location.

Conclusion: The Rainwater Harvesting system also has a positive impact on improving the quality of public facilities. The availability of water reserves ensures the operation of toilets and sanitation facilities, thereby enhancing the comfort of rest area visitors.

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Introduction

Water availability has become a major challenge in achieving sustainable development, particularly in areas with limited freshwater resources. Increasing demand for clean water due to population growth, tourism development, and public service facilities has increased pressure on conventional water supply systems. Consequently, alternative water resource management strategies are needed to improve water security while supporting environmental sustainability (Pratiwi, 2025)

Hargosari Village, located in Gunungkidul Regency, Yogyakarta Special Region, Indonesia, is located in a karst landscape that experiences seasonal water shortages. Although the area receives an annual rainfall of approximately 1,500 to 2,000 mm, rainwater has not been optimally utilized as an alternative water resource. Rest areas in the Hargosari area serve as essential facilities supporting tourism activities and local economic development. However, these facilities are almost entirely dependent on the municipal water supply (PDAM) to meet water needs for sanitation, ablution facilities, toilet flushing, and cleaning activities. This dependence increases operational costs for the village government and creates vulnerability during the dry season.

Field observations conducted prior to the implementation of this community engagement program identified several critical issues. First, there is no integrated rainwater harvesting (RWH) system installed in the rest area. Furthermore, the local community and facility managers have limited knowledge of rainwater harvesting technology and sustainable water management practices. Furthermore, the existing water supply system relies solely on conventional sources without considering locally available alternative resources. Finally, despite the significant rainfall potential, rooftop rainwater harvesting areas remain underutilized for water conservation purposes. This situation not only impacts operational efficiency but also the quality of public services provided to visitors.

Rainwater harvesting has been widely recognized as an effective and environmentally sustainable approach to supplement conventional water supplies, particularly in water-stressed areas. According to the United Nations Environment Programme(Stockholm Environment Institute & United Nations Environment Programme, 2009), rainwater harvesting contributes to improved water security, climate resilience, and sustainable resource management. Similarly, the Food and Agriculture Organization (Mekdaschi Studer, 2013),highlights rainwater harvesting as an appropriate technology for increasing water availability in arid and semi-arid regions through decentralized storage systems. Gould and Nissen-Petersen (1999) further emphasized that rooftop rainwater harvesting systems are relatively easy to construct, economically feasible, and suitable for rural communities due to their low maintenance requirements and adaptability to local environmental conditions. The monthly PDAM (municipal water utility) cost for Hargosari Village reaches Rp 500,000.

Several previous studies have demonstrated the effectiveness of rainwater harvesting systems in reducing dependence on groundwater and centralized water supply networks while improving environmental sustainability. Integrated rainwater harvesting systems equipped with filtration and pre-storage facilities can significantly increase the availability of non-potable water for sanitation and domestic applications. Furthermore, community participation during the planning, construction, and maintenance stages has been identified as a key factor influencing the long-term sustainability of such systems.(Pratiwi, 2025)

de Sá Silva et al. (2022) state that rainwater harvesting systems can provide multidimensional benefits encompassing environmental, economic, and social aspects. From an environmental perspective, this technology can reduce pressure on groundwater resources and lower the volume of surface runoff entering drainage networks. Economically, utilizing rainwater for non-potable needs—such as irrigation, washing, and sanitation—can reduce water consumption from the main supply network.

This community engagement program aims to design and implement an integrated rainwater harvesting system in the Hargosari Rest Area while enhancing the knowledge and

technical capacity of local stakeholders in operating and maintaining the installed system. The intervention includes field surveys, assessments of water needs and potential rainfall, engineering design, construction of the harvesting system, system operation, and community training.

Method

This study used a community engagement approach with participatory action methods to design, implement, and evaluate an integrated Rainwater Harvesting (RWH) system in the Hargosari Rest Area, Gunungkidul Regency, Indonesia. This approach combines engineering design with community empowerment to ensure that the developed technology is technically feasible, socially acceptable, and sustainable. The overall methodology consisted of four sequential stages: (1) initial assessment, (2) engineering design, (3) system construction, and (4) system testing.

Community engagement activities were conducted in the public rest area of Hargosari Village, Gunungkidul Regency, Yogyakarta Special Region, Indonesia. The study location was chosen due to its strategic function as a tourism support facility and its dependence on municipal water supply despite receiving relatively high annual rainfall.

Participants in this program included village government representatives, local community members, community service implementers, and university students. Community participation was emphasized throughout the project, particularly during construction, system operation training, and maintenance planning. In addition, ten respondents representing the management team and community members participated in a post-implementation satisfaction survey. Qualitative and quantitative data were collected throughout the implementation process.

A field survey was conducted to identify the condition of the existing water supply system and evaluate the feasibility of implementing a rainwater harvesting system. The survey included direct observation of sanitation facilities, roof conditions, available installation space, the existing water distribution network, and potential locations for storage tanks and filtration units. Photographic documentation was collected before, during, and after construction to document the implementation process and verify project completion. Engineering drawings, material specifications, and construction records were also documented throughout the project.The program evaluation was conducted using a structured questionnaire distributed to ten respondents after the project's completion. The questionnaire consisted of nine evaluation indicators covering infrastructure quality, functionality, usability, community engagement, implementation process, and overall satisfaction. Responses were measured using a four-point Likert scale consisting of Strongly Agree (SA), Agree (A), Disagree (D), and Strongly Disagree (SD).

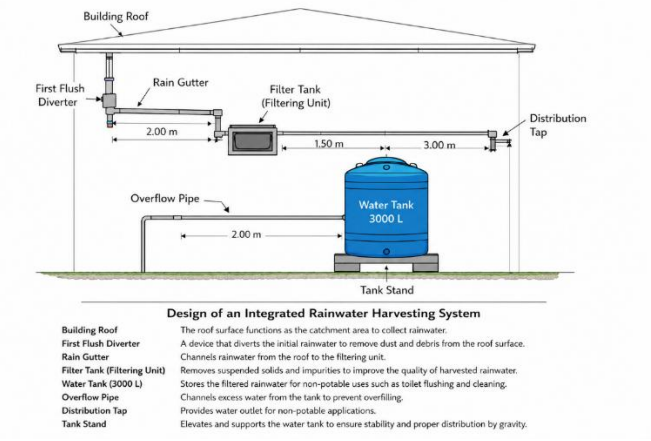

Figure 1. Instalation Design RWH

Source: Author's Work, 2026

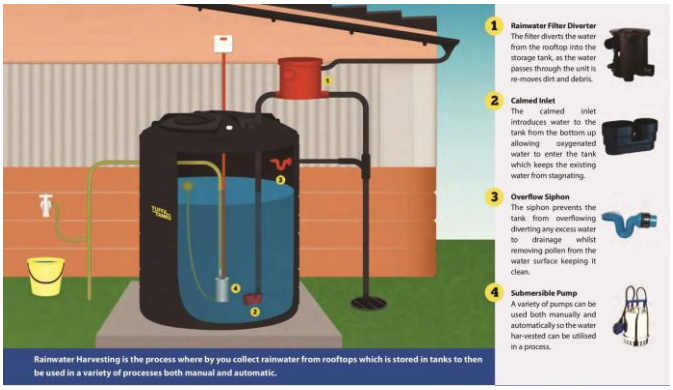

Figure 2. Design RWH

Source: Author's Work, 2026

The engineering design of the Rainwater Harvesting system followed a systematic design process consisting of several stages.Initially, potential rainfall and rooftop catchment areas were analyzed to estimate the amount of rainwater that could be harvested. Next, a detailed engineering design (DED) was prepared, including storage tank capacity, gutter configuration, filtration units, support structures, and distribution piping. Material specifications and construction cost estimates were also developed to ensure compatibility with local conditions and available funding.Construction activities were carried out collaboratively between the university team and local community members. Implementation included the installation of roof gutters, PVC conveyor pipes, filtration units, storage tanks, support tower structures, and distribution pipes connected to restroom and shower facilities. (Kementerian PUPR, 2016) Finally, technical training and an awareness session were conducted for the restroom management team. The training covered system operation, routine maintenance procedures, and gutter cleaning schedules.

Result

A community engagement program was implemented at the Hargosari Rest Area in Gunungkidul Regency, Yogyakarta Special Region. This location was chosen because it serves as a strategic tourism support area and is highly dependent on PDAM water supplies despite its significant rainfall potential. The program involved researchers from the Jakarta State Polytechnic, village government officials, rest area managers, local community members, and university students who participated throughout the planning and implementation stages.



Figure 3. Use of PDAM for Water Distribution

Source: Author's Work, 2026



Figure 4. Existing condition of the Hargosari Rest Area before program implementation.
Source: Author's Work, 2026

Based on field assessments, a Detailed Engineering Design (DED) for the integrated Rainwater Harvesting (RWH) system was prepared. The engineering design included the configuration of roof gutters, initial flow diverters, filtration units, storage tank capacity, distribution piping, support structures, and an overflow system. Materials were then procured in accordance with the approved engineering specifications.

Construction activities were carried out collaboratively with the active participation of the local community. Implementation included the installation of rain gutters, PVC conveyor pipes, filtration tanks, 500L polyethylene storage tanks, tank supports, and distribution piping connected to sanitation facilities. Following installation, the entire system underwent a pilot test to verify water flow, leak prevention, filtration performance, and distribution efficiency before being officially handed over to the community.

The program successfully achieved all planned technical implementation targets. One integrated rainwater harvesting system was fully constructed and operational at the Hargosari Rest Area. The installed system consisted of a rooftop rainwater collection facility, a pre-flow diverter, a filtration unit, a 500 L storage tank, a tank stand, distribution pipes, and an overflow system.

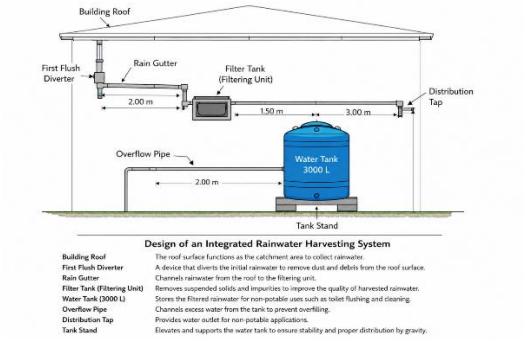

Figure 4. Engineering design of the integrated Rainwater Harvesting system.
Source: (Badan Standardisasi Nasional, 2015)

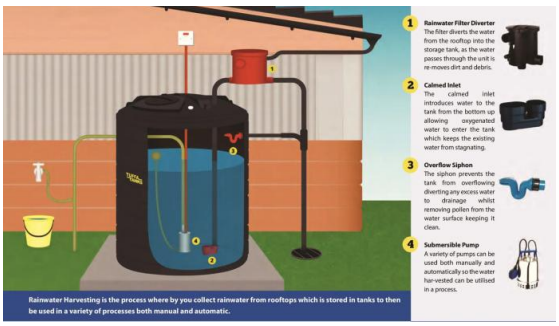

Figure 5. Engineering design of the integrated Rainwater Harvesting system.
Source: (Badan Standardisasi Nasional, 2015)

The most significant outcome of the program was the availability of an alternative water source through rainwater harvesting. Prior to the intervention, sanitation facilities were entirely

dependent on PDAM water, resulting in relatively high operational costs and vulnerability during periods of water shortages. After implementation, the harvested rainwater is available for non-potable uses such as toilet flushing, cleaning activities, and ablution facilities.



Figure 6. Tower Mount Installation

Source: Author's Work, 2026



Figure 7. Tower Installation

Source: Author's Work, 2026



Figure 8. Installation of Gutter Installation

Source: Author's Work, 2026



Figure 8. Installation of the Tower Installation to the Ablution Place

Source: Author's Work, 2026



Figure 9. Replacing the Ablution Water Faucet

Source: Author's Work, 2026

Table. 1 Community satisfaction survey results.
Tables must be numbered, for example: Table 1. Statistical Description

Point	Satisfaction			
	SS	S	TS	STS
1	7	3	0	0
2	8	2	0	0
3	5	5	0	0
4	8	2	0	0
5	9	1	0	0
6	6	4	0	0
7	10	0	0	0
8	10	0	0	0
9	9	1	0	0
10	7	3	0	0

Source: Author's Work, 2026

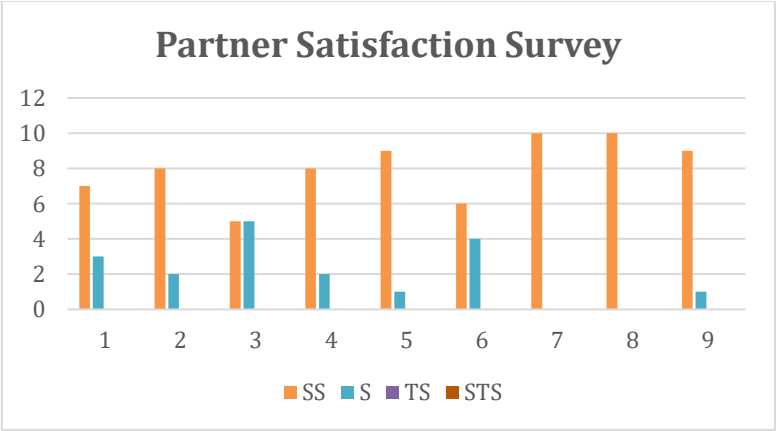

Figure 10. Partner Satisfaction Survey Graph

Source: Author's Work, 2026

Based on the results of the partner satisfaction survey—conducted among the residents of Hargosari village who use the water at the Hargosari rest area—respondents rated their satisfaction within the "very satisfied" to "satisfied" range, as shown in the table above.

Discussion

The community service program was successfully implemented at the Hargosari Rest Area, Gunungkidul Regency, Special Region of Yogyakarta, Indonesia. The project aimed to improve the availability of alternative water resources by designing and implementing an integrated Rainwater Harvesting (RWH) system while strengthening community capacity in sustainable water resource management. The implementation was carried out through several stages, beginning with preliminary coordination between the research team, village government, and rest area managers. A field survey and technical measurements were conducted to evaluate rooftop catchment areas, identify suitable locations for storage facilities, estimate water demand, and assess existing infrastructure conditions. Based on these findings, a Detailed Engineering Design (DED) was prepared to determine the specifications of gutters, first flush diverters, filtration units, storage tanks, supporting structures, and distribution pipelines.

Following material procurement, construction activities were completed collaboratively with active participation from local community members. The installed system consists of rooftop rainwater collection gutters, a first flush diverter, filtration unit, 500 L storage tank, overflow pipe, and distribution pipeline supplying water for sanitation facilities. After construction, commissioning tests confirmed that all system components functioned according to design specifications without leakage or operational deficiencies. Community capacity-building activities were subsequently conducted through technical training covering system operation, preventive maintenance, routine inspection, gutter cleaning, and filtration maintenance. These activities ensured that local stakeholders possessed adequate knowledge to independently operate and maintain the system after project completion.

Technical evaluation demonstrated that the integrated Rainwater Harvesting system operated effectively throughout the commissioning process. Rainwater collected from the rooftop catchment area flowed through the first flush diverter before entering the filtration unit, thereby reducing suspended solids and contaminants prior to storage. Filtered water was successfully stored within the 500 L storage tank and distributed to sanitation facilities without interruption. The successful commissioning indicated that the engineering design adequately addressed local environmental conditions. No leakage was observed within the gutter system, pipelines, storage tank, or supporting infrastructure. The overflow pipe also functioned properly, preventing excessive water accumulation during heavy rainfall events.

The availability of an alternative water source significantly reduced dependence on municipal water supplies (PDAM), particularly during the rainy season. Although long-term water consumption monitoring is still required, the installed system provides substantial potential for reducing operational water costs while improving the reliability of public sanitation services. Community acceptance was evaluated through a post-implementation satisfaction survey involving ten respondents representing rest area managers and community members. The questionnaire consisted of nine evaluation indicators measured using a four-point Likert scale.

The survey demonstrated exceptionally positive results. All respondents selected either Strongly Agree or Agree for every evaluation indicator, while no respondents selected Disagree or Strongly Disagree. Seven indicators received between 80% and 100% "Strongly Agree" responses, indicating a high degree of user satisfaction regarding the quality, functionality, usefulness, and sustainability of the installed system. These findings indicate that the implemented Rainwater Harvesting technology successfully addressed the community's priority needs while remaining simple enough to be operated and maintained using locally available resources.

The community service program has strengthened community awareness regarding water conservation and sustainable environmental management. The availability of a reliable alternative water source has improved sanitation services within the rest area, thereby increasing visitor comfort and supporting tourism-related activities. Moreover, community

participation throughout implementation has strengthened collaboration between local government, residents, and academic institutions.

Prior to the intervention, all sanitation facilities relied exclusively on PDAM water supplies financed through the village budget (APBDes). The implementation of the Rainwater Harvesting system provides an alternative water source that can substantially reduce municipal water consumption during the rainy season. Consequently, operational expenditures for water supply are expected to decrease over time, allowing village financial resources to be allocated toward other community development priorities. The environmental benefits of the project include increased utilization of rainwater that would otherwise become surface runoff. Harvesting rainwater contributes to water conservation, improves climate resilience, and promotes more sustainable utilization of natural resources. The project also supports Sustainable Development Goal (SDG) 9 by encouraging innovation in public infrastructure while simultaneously contributing to SDG 6 concerning sustainable water management.

According to Khanal and Parajuli (2020), rainwater harvesting systems hold significant potential as an alternative strategy for increasing water availability, particularly in regions facing limited water supplies. Rainwater collected via catchment surfaces, such as building roofs, is channeled into storage facilities before being reused for specific purposes. FAO (2013) also reported that decentralized rainwater harvesting systems are particularly suitable for dry and semi-arid regions where conventional water resources remain limited. The present project extends these findings by integrating engineering implementation with community empowerment. Rather than focusing solely on infrastructure construction, the program simultaneously developed local capacity through technical training and participatory implementation. This integrated approach distinguishes the present community service from many previous engineering interventions by ensuring that the installed technology can be independently operated and maintained by the beneficiary community. Long-term sustainability of the program depends largely on community commitment to routine maintenance. During the final implementation stage, operational guidelines were provided to the rest area management team covering regular inspection schedules, filter cleaning, gutter maintenance, storage tank cleaning, and pipeline inspection.

Rainwater harvesting systems operate by capturing rainwater falling on building surfaces—primarily roofs—and channeling it through a network of pipes to a pre-filtration unit and a storage tank. According to Yildirim and Demir (2022), the key components of a rainwater harvesting system include the catchment area, water conveyance system, filtration devices, storage facilities, and distribution system. The system's effectiveness is influenced by several factors, such as rainfall patterns, catchment surface area, storage capacity, and user demand characteristics. Ghaffarian Hoseini et al. (2021) explain that the design of rainwater harvesting systems must consider aspects of water quantity and quality to ensure the system operates optimally and safely in accordance with its intended use. Zhou et al. (2024) state that integrating rainwater harvesting systems into buildings and urban areas can enhance water resilience by reducing fresh water consumption and optimizing the use of local water resources.

The installed infrastructure requires relatively simple maintenance procedures and utilizes locally available construction materials, making future repairs technically and economically feasible. Consequently, the Rainwater Harvesting system possesses strong potential for long-term operation. Furthermore, the implementation model can be replicated in other tourism facilities, schools, village offices, mosques, community halls, and public buildings located in regions experiencing seasonal water shortages. Because the engineering design is modular, storage capacity and pipeline configurations can be adapted according to local rainfall characteristics and water demand.

Conclusion

This community service program successfully achieved its primary objective of designing and implementing an integrated Rainwater Harvesting (RWH) system in the Hargosari Rest Area, Gunungkidul Regency, while simultaneously enhancing community capacity in sustainable water resource management. The participatory implementation approach, which integrated engineering design, infrastructure development, and community empowerment, proved effective in addressing local challenges related to limited water availability and dependence on municipal water supplies.

The results demonstrated that the installed Rainwater Harvesting system operated according to the intended engineering design. The system successfully collected rainwater from rooftop catchment areas, filtered and stored the collected water in a 500 L storage tank, and supplied water for non-potable sanitation purposes. Operational trials confirmed that all system components functioned properly without leaks or operational failures. In addition to the physical infrastructure, the program significantly improved the community's technical knowledge and skills related to system operation, routine maintenance, and water conservation practices. Positive feedback from community satisfaction surveys further demonstrated that the implemented technology was perceived as practical, beneficial, and appropriate to local conditions.

The primary strength of this community service program lies in the integration of engineering solutions with participatory community engagement. Unlike many infrastructure-based interventions that primarily emphasize physical construction, this project combines capacity building, technical training, and community engagement at every stage of implementation. This integrated approach enhances the sustainability of the installed infrastructure by ensuring that local stakeholders have the knowledge and skills necessary to operate and maintain the system independently. Consequently, the project provides a practical model that can be replicated in other public facilities located in water-scarce areas, particularly in karst environments.

In conclusion, this community service program demonstrates that an integrated rainwater harvesting system is an effective, economically viable, and environmentally sustainable solution for increasing water availability in public facilities. The combination of appropriate engineering design, community participation, and institutional collaboration has yielded measurable technical, social, economic, and environmental benefits. In addition to addressing local water scarcity, the program provides a replicable community-based model for water management.

Acknowledgements

This research is based on the results of the Expert Assistant Community Service Report (PkMAA). The author would like to express his gratitude to the Politeknik Negeri Jakarta, which funded this research through a grant from the Politeknik Negeri Jakarta (Contract Number 517/DST/PL3.14/B/PM.01.03/2026).

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