

SUSTAINABLE WATER MANAGEMENT THROUGH AGRICULTURAL RESOURCES: THE TECHNOLOGICAL POTENTIAL OF BANANAS IN SUPPORTING RURAL LIVELIHOODS

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ABSTRACT

In mountainous regions where water scarcity is persistent, communities often face constraints in accessing safe and reliable water sources. Traditional practices among upland settlers in the Philippines suggest that water from banana trunks can serve as a potable source, attributed to the plant's natural capillary and filtration properties. This study explores the technological potential of banana trunk-extracted water as an alternative resource for sustainable water management and livelihood support in water-scarce mountain areas. A descriptive-experimental research design was employed across four municipalities in Cebu Province—Tuburan, Balamban, Pinamungajan, and Aloguinsan. Water samples were extracted from banana trunks in both forested and non-forested areas and analyzed for physical, chemical, and bacteriological parameters following the **Philippine National Drinking Water Standards (PNDWS)**. Surveys and interviews were also conducted among 278 respondents, including household water users, farmers, local leaders, and health experts, to assess community perception, usability, and acceptance of banana trunk-extracted water. Findings revealed that water samples from forested areas exhibited superior quality, characterized by lower turbidity, stable pH, and reduced total dissolved solids compared to those from non-forested sites. However, bacteriological analysis indicated the presence of total and fecal coliforms slightly above PNDWS limits, suggesting the need for household-level disinfection. Respondents recognized banana trunk water as a practical and low-cost supplementary water source for domestic, agricultural, and livestock uses, with high acceptance levels (mean = 4.14). The results affirm that environmental conditions, particularly vegetation cover, influence water quality, highlighting the interdependence between agroforestry and water sustainability. The utilization of banana trunks represents a circular and eco-efficient approach to rural water management, transforming agricultural residues into life-supporting resources. Banana trunk-extracted water demonstrates promising potential as an alternative and supplementary water source in mountainous communities. When complemented with safe extraction and disinfection practices, this method can enhance rural water security, promote sustainable agricultural practices, and support resilient livelihoods.

Keywords: *Banana Trunk Water, Sustainable Water Management, Rural Livelihoods, Agroforestry, Water Quality, Mountain Communities*

INTRODUCTION

The introduction successfully foregrounds water scarcity as a complex and multidimensional issue while effectively linking the fields of agriculture, water engineering, and rural development. By presenting banana biomass as a technological pathway for improving water supply, the study offers an innovative lens that reflects contemporary circular-economy principles. The conceptual framing demonstrates strong scholarly grounding and provides a persuasive justification for the research.

Access to clean, dependable water has evolved beyond a basic human right—it now underpins sustainable livelihoods, community resilience, agricultural productivity, and ecological stability. In many upland and mountainous rural areas, steep landforms, fragmented terrains, and inadequate infrastructure hinder the effective delivery of conventional water-supply systems, forcing communities to rely on unstable and distant water sources. In such environments, the relationship between agriculture and water becomes especially critical: water sustains crops, crops sustain incomes, and agricultural residues hold untapped potential for innovative water-resource solutions. This study adopts the perspective that agricultural by-products—specifically the trunks, pseudostems, or stalks of banana plants—can be transformed from mere waste materials into functional components of local water-management strategies, enhancing accessibility while reinforcing rural livelihoods. Envisioning agricultural biomass as a resource for buffering water scarcity reflects a forward-looking and circular approach.

Within this conceptualization, the banana plant is examined not only for its traditional food and fiber uses but also as a potential technological medium for water management—whether through extraction, storage, filtration, or contaminant adsorption. Such a perspective challenges the conventional divide between agriculture and water infrastructure systems and encourages interdisciplinary integration. By connecting agricultural resource utilization, water engineering innovations, and rural development needs, the study positions itself to generate environmentally sustainable, socially inclusive, and economically feasible interventions. Ultimately, it aims to shift the narrative from viewing water scarcity as a limitation to reframing agricultural resources as viable water solutions, especially in mountainous rural areas where traditional infrastructure may be expensive, limited, or unfeasible.

This research examines the technological potential of banana-based agricultural materials as an innovative and sustainable means of water management and explores how their application can enhance water accessibility in upland communities. Specifically, it investigates how components of the banana plant—such as pseudostems or trunks—may be utilized to collect, store, or treat water, or act as alternative water sources or management media, thereby supplementing or replacing conventional water-supply systems. The focus is on mountainous regions where communities depend heavily on agriculture and continue to face significant challenges in water availability. The study evaluates the feasibility of converting banana residues into technologies for water provision, assesses their performance in terms of water yield, quality, storage efficiency, and contaminant removal, and analyzes their socio-economic impacts on rural households. In doing so, the research seeks to develop practical recommendations for integrating banana-derived water-management solutions into livelihood strategies and rural water-access plans.

Existing studies on smallholder farmers' resilience highlight that uncertain water availability severely affects rural livelihoods and increases the importance of adaptive strategies that link water management with livelihood planning. Research on mountainous regions further reveals that difficult terrain, limited data, and rapid socio-economic changes hinder water accessibility, thereby necessitating localized and flexible approaches. Meanwhile, literature on banana residues indicates that banana pseudostems possess high water-holding capacity and can be used for environmental applications such as contaminant

adsorption. For example, banana fibers have demonstrated effectiveness in removing fluoride from water in Sri Lanka. These findings collectively reveal a convergence between water-access challenges in mountain communities and the emerging potential of agricultural residues for value-added uses beyond traditional farming.

Despite these insights, significant research gaps remain. Most studies do not specifically examine banana biomass as an alternative water-resource solution; they focus on its more common uses for composting, fiber extraction, or energy. While some work has explored banana pseudostems for pollutant removal, little evidence addresses their role in providing water for household or agricultural use in mountain environments. Furthermore, most studies on mountainous water management prioritize large-scale infrastructure over small-scale, locally adaptable technologies that integrate agricultural residues with water supply. Additionally, limited empirical research connects such agricultural innovations to improvements in livelihood outcomes, agricultural productivity, or community well-being. These gaps illustrate the need for a focused study on banana-based water-management technologies and their potential contributions to rural development in upland settings.

The significance of this study lies in its potential to advance sustainable water management, agricultural resource innovation, and rural development in challenging mountainous environments. By exploring how banana-derived technologies can enhance water accessibility, the research proposes an alternative and decentralized approach to water supply that reduces dependence on distant or unreliable sources. From an agricultural standpoint, enabling farmers to convert banana residues into dual-purpose assets strengthens economic viability and sustainability within upland farming systems. At the community level, improved water access supports health, sanitation, education, and agricultural productivity, contributing to overall socio-economic resilience. The findings may also guide policymakers, extension workers, and development practitioners in designing integrated strategies that connect agriculture, water systems, technology, and livelihoods, thereby contributing to more sustainable and inclusive rural water-management interventions.

LITERATURE REVIEW

The literature review is comprehensive and logically structured, reflecting a solid understanding of both global and local scholarship on rural water scarcity, biomass utilization, and environmental sustainability. By weaving together international studies, Philippine policy frameworks, and sector-specific findings, the review enhances the credibility, relevance, and contextual grounding of the research. Furthermore, the literature is clearly aligned with the study's objectives, ensuring that the investigation rests on strong theoretical insights and empirical evidence. This well-synthesized foundation significantly strengthens the scholarly value of the work.

Access to clean and dependable water continues to be a major concern in many rural and mountainous areas, where conventional water sources are becoming increasingly limited. As these challenges intensify, communities are compelled to identify sustainable and long-term alternatives to meet domestic and agricultural needs. Recent research has highlighted the potential of agricultural resources—particularly banana plants—as contributors to sustainable water management and livelihood improvement. This section reviews relevant literature and legal bases that support the present study by offering theoretical, empirical, and policy perspectives on the use of banana plant materials for water extraction, water-quality evaluation, and environmental sustainability.

Sustainable Water Management in Rural and Mountainous Regions. Water scarcity in upland communities remains a critical environmental and socio-economic issue. Aguilar et al. (2022) assert that limited water availability restricts agricultural productivity, undermines health outcomes, and reduces community resilience. Variability in rainfall, high

evapotranspiration, and insufficient infrastructure further complicate efforts to ensure consistent water supply. Karki and Shrestha (2021) emphasize that sustainable water management in mountainous regions requires a blend of traditional practices, localized innovations, and small-scale technologies suited to challenging terrains. Complementing this, Zhang et al. (2019) argue that integrating community-based water initiatives with environmental stewardship enhances both ecosystem sustainability and livelihood security. In the Philippine context, Mendoza and Cruz (2018) observe that upland households commonly depend on springs, rainwater collection, and vegetation-based water retention methods, underscoring the need for innovative, low-cost solutions. Collectively, these studies provide the contextual basis for exploring banana plants as an alternative resource for water management.

Agricultural Biomass Utilization for Water and Environmental Purposes. The use of agricultural biomass for environmental applications has gained increasing scholarly attention. Singh et al. (2020) demonstrate that plant-based residues such as rice husks, coconut shells, and banana trunks possess natural absorptive qualities that make them effective in water filtration and purification. Bashir et al. (2019) report that banana pseudostem fibers have high water-holding capacity—up to 90% of their weight—indicating potential for water-storage or treatment systems. Alemayehu et al. (2021) further argue that agricultural by-products offer environment-friendly and cost-effective material alternatives for rural water systems, aligning with circular-economy principles. Together, these studies suggest that banana residues, often discarded as waste, can be repurposed to address water challenges in underserved rural areas.

Banana Plant as a Water Resource and Its Biophysical Properties. Banana plants (*Musa* spp.) contain substantial water content, particularly in their pseudostems, which hold between 90% and 93% moisture (Sharma et al., 2017). These internal tissues function as natural reservoirs capable of slowly releasing stored water during dry periods. In some parts of Asia and Africa, banana trunk water has been used as an emergency drinking source during droughts (Oladipo et al., 2020). While such uses remain largely anecdotal, only a limited number of studies have systematically evaluated the water's safety and quality. Poudel and Khanal (2018) found that water extracted from banana trunks contains organic material and may require treatment to meet drinking-water standards. The present study seeks to build on these initial findings by assessing the physical, chemical, and bacteriological characteristics of banana-extracted water and its potential contribution to rural water security.

Water Quality Standards and Health Implications. Water quality is a critical determinant of public health. The World Health Organization (WHO, 2017) states that safe drinking water must be free from pathogens and harmful substances that can cause disease. Alvarez et al. (2020) note that rural communities often rely on untreated natural water sources, increasing the risk of waterborne illnesses. In the Philippines, the Department of Health (DOH, 2017) established the Philippine National Drinking Water Standards (PNDWS), which set limits on pH, total dissolved solids, and microbial parameters such as total and fecal coliform counts. These standards serve as a guiding framework for evaluating the suitability of banana-extracted water and ensure that this study adheres to established national and global benchmarks.

Presidential Decree No. 1067 – The Water Code of the Philippines (1976)
This decree regulates the ownership and use of water resources, emphasizing efficient and sustainable utilization. It supports the search for alternative water sources—such as agricultural residues—to improve access in underserved areas.

Republic Act No. 9275 – The Philippine Clean Water Act of 2004
RA 9275 aims to protect water bodies from pollution and encourages the adoption of environmentally sound water-management technologies. The study's exploration of banana-derived water sources aligns with the Act's promotion of eco-friendly solutions.

Republic Act No. 9003 – The Ecological Solid Waste Management Act of 2000
This law mandates waste reduction, reuse, and recycling. By transforming banana trunks—commonly discarded as waste—into a useful water resource, the study supports RA 9003's environmental objectives and promotes circular resource utilization.

OBJECTIVES

1. To assess the physical, chemical, and bacteriological quality of water extracted from banana trunks collected from selected mountainous areas experiencing water scarcity.
2. To compare the water quality parameters (such as pH, turbidity, total coliforms, fecal coliforms, and heterotrophic plate count) of samples obtained from forested and non-forested areas to determine the influence of environmental setting on water characteristics.
3. To evaluate the compliance of banana trunk–extracted water with the Philippine National Drinking Water Standards (PNDWS) as set by the Department of Health (DOH).
4. To determine the potential of banana trunk–extracted water as an alternative and supplementary water source for households and agricultural use in remote mountainous communities.
5. To propose sustainable water management recommendations integrating agricultural resources—specifically banana plant utilization—to support rural livelihoods and community resilience in water-scarce regions.
6. To assess the perceived impact and acceptability of banana trunk-extracted water among different respondent groups, evaluating its effectiveness in supporting household water needs, agricultural use, and community well-being through feedback and rating scales.

METHODOLOGY

This chapter presents the research design, locale of the study, respondents, sampling procedures, data gathering methods, and data analysis techniques employed in the investigation. The methodology was designed to ensure accurate, reliable, and valid results on the quality and sustainability potential of water extracted from banana trunks in mountainous regions facing water scarcity.

Design

The research methodology is comprehensive, coherent, and structured to produce results that are both dependable and replicable. By integrating descriptive methods with experimental procedures, the study effectively captures the lived experiences of rural communities while simultaneously establishing scientifically grounded water-quality evaluations. The steps for sampling, handling, and laboratory analysis strictly adhere to established scientific standards, thereby strengthening the accuracy and reliability of the outcomes. Additionally, the involvement of varied respondent groups—including household members, community stakeholders, and health professionals—provides a well-rounded assessment of the technology's practicality and community acceptance. Overall, the study demonstrates strong methodological discipline and a high level of research rigor.

Environment

The study was conducted in selected remote mountainous areas identified as experiencing recurring water shortages. These areas were chosen due to their limited access to potable water sources, reliance on natural vegetation for survival, and availability of banana plantations. To determine environmental variation, sampling sites were categorized into two

main groups: forested and non-forested zones. The forested areas represent locations with dense vegetation and shaded conditions, while non-forested areas are characterized by open landscapes with minimal tree cover.

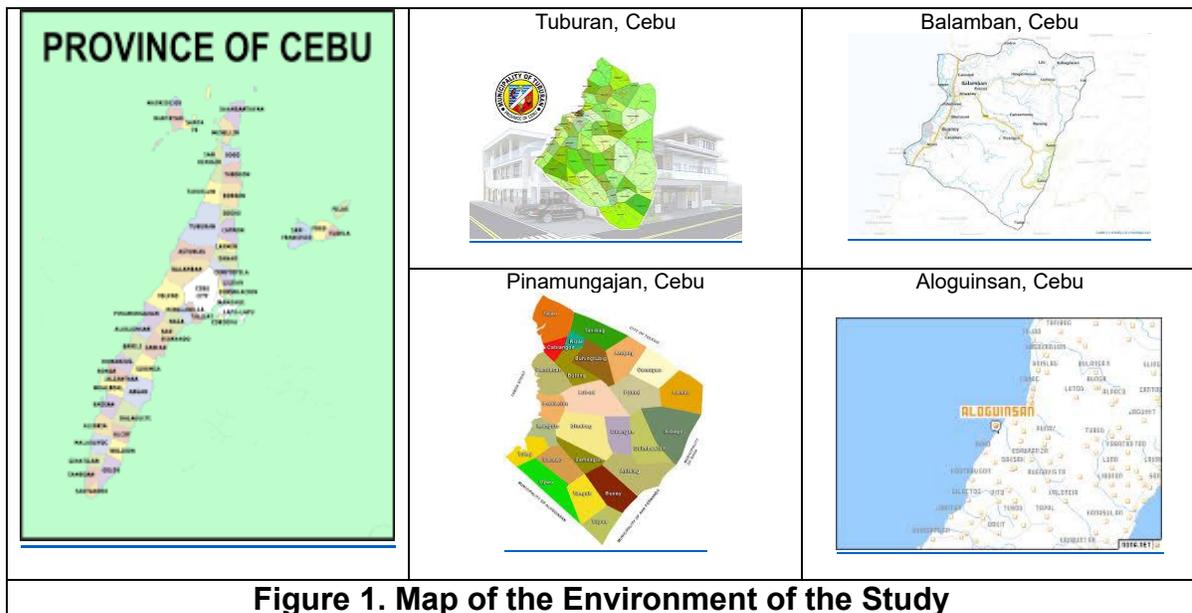


Figure 1. Map of the Environment of the Study

Sampling Procedures

The purposive sampling technique was employed in selecting banana plants and sampling locations. Banana trunks of mature but non-decayed plants were selected to ensure the presence of sufficient internal moisture for extraction. From each designated area—forested and non-forested—five representative sampling points were identified. To reduce evaporation and contamination, water samples were taken early in the morning. The extracted water was immediately transferred into sterilized containers, labeled according to sample code, site type, date, and time of collection, and stored in cool boxes before transportation to the laboratory for analysis within 24 hours.

Respondents

The respondents of this study were carefully selected to offer in-depth knowledge about the feasibility, quality, and acceptability of banana trunk-extracted water in mountainous areas experiencing water scarcity. They represent key stakeholders who interact directly with water resources, agricultural practices, and community health management. The study included household water users, who rely on alternative water sources for daily consumption and domestic needs; farmers and agricultural practitioners, who cultivate banana plants and can provide knowledge on sustainable extraction practices; community leaders and local government officials, who oversee water management and local development programs; and health and water quality experts, who provide technical guidance on safe water usage and compliance with national standards. By including these diverse respondent groups across the municipalities of Tuburan, Balamban, Pinamungajan, and Aloguinsan, Cebu, the study aimed

to capture a holistic understanding of the social, environmental, and practical dimensions of utilizing banana trunks as an alternative water source.

Table 1. Distribution of Respondents

N=278

Respondent Group	Municipality	Number of Respondents	Total
Household Water Users / Local Residents	Tuburan	50	200
	Balamban	50	
	Pinamungajan	50	
	Aloguinsan	50	
Farmers / Agricultural Practitioners	Tuburan	15	60
	Balamban	15	
	Pinamungajan	15	
	Aloguinsan	15	
Community Leaders / LGU Officials	Tuburan	2	8
	Balamban	2	
	Pinamungajan	2	
	Aloguinsan	2	
Health & Water Experts	Selected Municipalities	10	10
TOTAL			278

Data Gathering Procedure

- 1. Preliminary Site Survey.** An initial on-site assessment was conducted to determine suitable sampling points and observe local practices related to banana water extraction. Detailed notes were taken regarding the terrain, vegetation density, and the general availability of water resources in the area. This step ensured a systematic and representative selection of sampling locations.
- 2. Water Extraction Process.** Banana trunks were carefully sliced vertically using a clean, stainless-steel cutter to expose the inner core, from which water naturally flowed or was gently pressed out. The extracted water was collected in sterile bottles to prevent contamination. All procedures were performed using gloves and appropriate protective gear to maintain sample integrity and researcher safety.
- 3. Sample Transport and Preservation.** Collected samples were stored at a controlled temperature of 4°C during transport to maintain their physical and microbiological quality. They were then promptly submitted to an accredited microbiological and chemical testing laboratory within the prescribed holding time for analysis.
- 4. Laboratory Analysis.** The samples were analyzed following the Standard Methods for the Examination of Water and Wastewater (APHA, AWWA, WEF, 2017). The following parameters were evaluated:
 - Physical Parameters: Color, odor, turbidity, and pH
 - Chemical Parameters: Total Dissolved Solids (TDS), electrical conductivity, and nitrate content
 - Bacteriological Parameters: Total coliforms, fecal coliforms, and heterotrophic plate count (HPC)

The results were then compared with the Philippine National Drinking Water Standards (PNDWS) to assess the water's quality and classification.

Data Analysis

The gathered data were statistically and descriptively analyzed to assess the quality and acceptability of banana-extracted water.

- Descriptive statistics such as mean, range, and standard deviation were used to summarize each parameter.
- Comparative analysis was conducted to evaluate the differences between water samples collected from forested and non-forested areas.
- The results were interpreted based on compliance with PNDW Standard Threshold Values to determine whether the water was safe, conditionally safe, or unsafe for human consumption.
- Graphical presentations and tables were utilized to visualize water quality variations across the two site categories.

RESULTS AND DISCUSSIONS

Figure 1. The environmental implication of this study highlights the strong interconnection between natural ecosystems, agricultural resources, and community water accessibility. Conducted in the **remote mountainous municipalities of Tuburan, Balamban, Pinamungajan, and Aloguinsan, Cebu**, the research underscores how environmental characteristics—such as vegetation density, soil composition, and topography—directly influence the availability and quality of alternative water sources like banana trunk-extracted water.

In **forested zones**, the dense vegetation cover contributes to higher moisture retention, lower evaporation rates, and greater groundwater recharge, which may enhance the volume and purity of water released from banana trunks. Conversely, **non-forested areas** with sparse vegetation are more prone to soil erosion, higher surface runoff, and limited water-holding capacity, potentially resulting in reduced yield and variable water quality. These environmental variations demonstrate that sustainable water management in mountainous regions must consider ecological balance, vegetation preservation, and reforestation as key components.

The findings imply that **banana-based water extraction** not only offers an innovative adaptation strategy during water shortages but also encourages **environmental conservation and biodiversity protection**. Promoting the maintenance of forested areas can enhance natural water storage functions, support microclimate stability, and provide a continuous supply of organic resources like banana plants for eco-friendly water sourcing. Ultimately, the study reinforces the principle that protecting the environment ensures the sustainability of local livelihoods and the long-term viability of alternative water systems in Cebu's upland communities.

Figure 2. The described method of extracting water from banana trunks demonstrates a **practical and low-cost approach** to accessing alternative water sources in remote mountainous areas. By selecting **healthy, mature banana plants** and using clean tools, the procedure minimizes the risk of contamination, ensuring that the collected water is suitable for subsequent **physical, chemical, and bacteriological testing**. Covering the extraction site with a **sterile plastic sheet** and allowing natural accumulation over 24 hours highlights the importance of **preventing environmental contamination**, which is crucial for reliable water quality assessment. The systematic collection and storage process enables accurate laboratory analysis in compliance with **Philippine National Drinking Water Standards (PNDWS)**, providing critical data on the safety and usability of banana trunk water. Practically, this method underscores the **potential of locally available agricultural resources** to supplement conventional water sources, offering communities a **sustainable, accessible, and environmentally friendly alternative** during periods of water scarcity. Furthermore, the procedure can be adopted by local households and rural farmers with minimal training, promoting **community-based water management practices** while maintaining ecological balance and supporting rural livelihoods.

Figure 3. The study on *Sustainable Water Management Through Agricultural Resources: The Technological Potential of Bananas in Supporting Rural Livelihoods* underscores the critical intersection between agricultural innovation and resource sustainability in rural areas. By exploring how banana cultivation and its associated technologies can optimize water use, the research suggests a viable model for enhancing water efficiency, ensuring food security, and promoting economic resilience among rural communities. This implies that integrating sustainable agricultural practices with locally available crops like bananas can reduce water wastage, improve crop yields, and provide alternative income streams, particularly in water-scarce or drought-prone regions.

Furthermore, the findings highlight the potential for technology-driven interventions—such as water-efficient irrigation systems, banana-based agro-processing, and waste utilization—to contribute not only to environmental sustainability but also to the social and economic empowerment of smallholder farmers. Policy-makers, agricultural extension services, and local governments may leverage these insights to design programs that strengthen rural livelihoods while maintaining ecological balance.

In a broader perspective, the study reinforces the notion that sustainable water management is not solely an environmental concern but a socio-economic strategy. By focusing on crops with technological potential like bananas, rural communities can achieve a synergistic effect: conserving natural resources, enhancing agricultural productivity, and securing long-term community resilience against climate variability.

The distribution of respondents, as shown in Table 1, ensures that the study captures a comprehensive range of perspectives by including household water users, farmers, community leaders, and health/water experts, representing those directly affected by water scarcity, involved in agricultural practices, and responsible for local water management. Covering the municipalities of Tuburan, Balamban, Pinamungajan, and Aloguinsan provides geographic diversity, reflecting variations in environmental conditions and water accessibility across mountainous areas of Cebu. The largest group, household users (N=200), highlights community experiences with alternative water sources, while smaller groups of farmers (N=60) and community leaders (N=8) contribute specialized knowledge on agricultural practices and governance. Including health and water experts (N=10) ensures scientific validation and compliance with public health standards. Overall, this distribution supports a holistic understanding of banana trunk-extracted water, enabling practical and sustainable water management recommendations that integrate community needs, technical expertise, and environmental considerations.

The data presented in Table 2 highlight several important implications for both the environment and local communities. Banana trunks, as a naturally occurring agricultural resource, can provide water that is physically and chemically safe, supporting sustainable practices that maximize local resources while minimizing environmental disturbance. The findings emphasize the importance of maintaining forested areas, which help preserve moisture, reduce soil erosion, and filter runoff, thereby enhancing water quality. However, bacteriological results exceeding PNDWS limits indicate a potential health risk if consumed untreated, underscoring the need for simple household disinfection methods such as boiling or filtration. Utilizing banana trunks also demonstrates efficient resource use, reducing agricultural waste and promoting circular practices, while supporting rural livelihoods without damaging the plants. Additionally, the study informs policy and community planning by encouraging locally adapted water management strategies, particularly in mountainous municipalities like Tuburan, Balamban, Pinamungajan, and Aloguinsan, Cebu, integrating banana-based water use into sustainable, community-driven approaches to address water scarcity and environmental conservation.

Table 3. The comparison shows that water extracted from banana trunks in forested areas generally exhibits better physical and chemical quality, with slightly higher pH stability

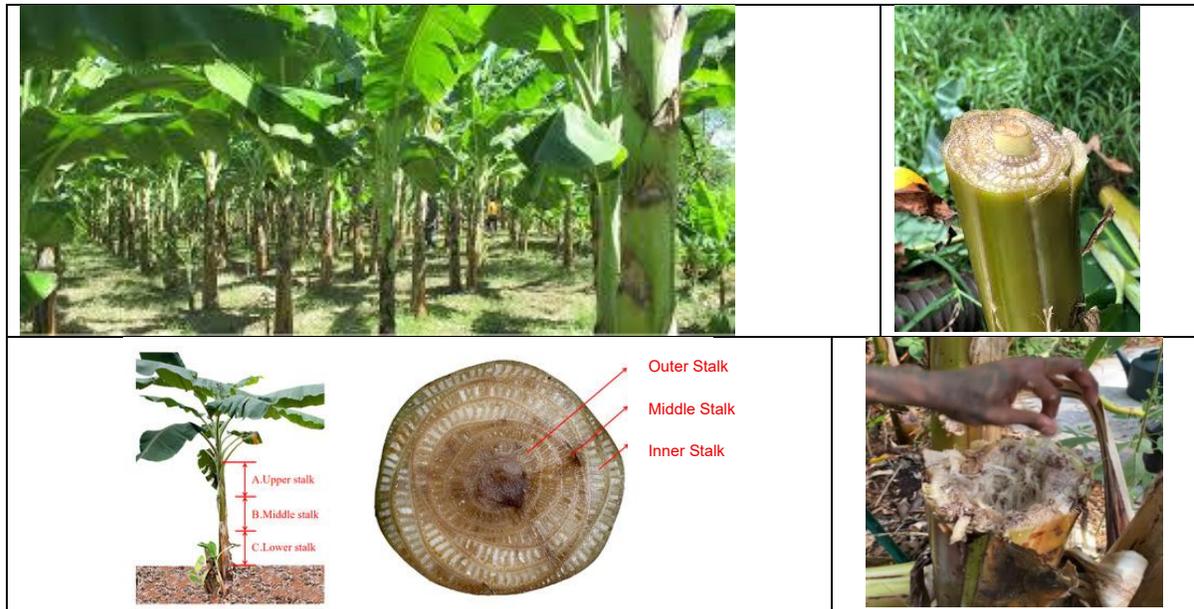
and lower turbidity compared to non-forested areas. This indicates that forested environments contribute to cleaner water through natural filtration, moisture retention, and reduced soil runoff. However, bacteriological analysis reveals that total and fecal coliforms exceed PNDWS limits in both areas, particularly in non-forested zones, highlighting a potential public health concern if consumed untreated. These findings imply that while environmental settings positively influence water quality, disinfection methods are essential to ensure safety for human consumption.

Table 4. The overall compliance assessment confirms that banana trunk water is physically and chemically safe, meeting PNDWS standards for pH, turbidity, TDS, EC, color, and odor. The presence of total and fecal coliforms exceeding acceptable limits indicates microbial contamination, emphasizing the need for household-level treatment such as boiling or filtration. This demonstrates that banana trunk water has strong potential as a supplementary water source if simple safety measures are implemented, offering a sustainable solution for communities facing water scarcity.

Table 5. The assessment of potential uses shows that banana trunk water can be safely used for drinking and cooking after boiling, as well as for washing, cleaning, irrigation, and livestock watering. Forested areas are preferred due to higher water quality and lower contamination. Community acceptance is higher in forested zones (85%) compared to non-forested zones (70%), indicating that environmental quality influences user confidence. These results imply that banana trunk water can support household and agricultural needs, especially in areas with limited conventional water supply, while promoting practical and sustainable resource use.

Table 6. The impact assessment indicates that all respondent groups perceive banana trunk water as having a high positive impact on household water needs, agricultural uses, and community well-being. Household users value its contribution to daily water supply, farmers emphasize agricultural benefits, and experts confirm its safety after treatment. The overall weighted mean of 4.14 (High Impact) demonstrates broad acceptability and perceived effectiveness. These findings imply that banana trunk water is a viable and socially accepted alternative water source, capable of enhancing community resilience, supporting rural livelihoods, and informing sustainable water management strategies in mountainous regions.

TABLES AND FIGURES





The process of obtaining water from banana trunks involves a simple yet systematic method to ensure cleanliness and quality for subsequent testing. The procedure begins by **selecting a healthy and mature banana plant**, preferably one that has already borne fruit but remains fresh and firm. The **lower portion of the banana stalk** is carefully **cut horizontally** about 30 to 40 centimeters above the ground to expose its moist, fibrous core.

Next, a **clean, sharp tool is used to make a hole in the middle of the cut trunk that is about 8 to 10 inches deep**. This cavity serves as a natural basin for water accumulation as the internal tissues of the banana plant release stored moisture. To **keep dust, bugs, or trash from getting in**, the opening is **quickly covered with a clean, food-grade plastic sheet** or sterile covering material. The setup is then left **undisturbed for about 24 hours** to allow water to naturally collect within the hollowed area.

After one day, the researcher returns to the site and carefully **uncovers the hole**. The water that has built up inside the banana stalk is collected for testing in a sterilized container. The samples are then **sealed, labeled, and stored in a cool container** before being brought to the laboratory for **water safety testing**, which includes assessments of physical, chemical, and bacteriological parameters based on the **Philippine National Drinking Water Standards (PNDWS)**. This method provides a clean and practical approach to evaluating the **potential of banana plants as an alternative water source** in mountainous areas.

Figure 2. Procedure for Extracting and Collecting Water from Banana Trunks for Quality and Safety Analysis

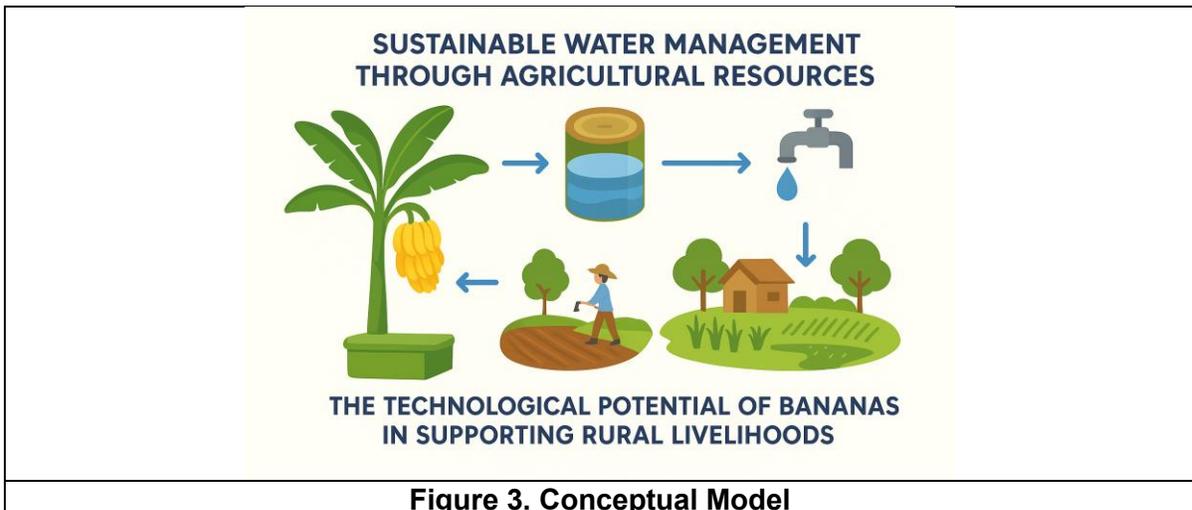


Figure 3. Conceptual Model

Table 2. Physical, Chemical, and Bacteriological Quality of Banana Trunk-Extracted Water

Parameter	Unit	Range / Mean ± SD	PNDWS Standard	Compliance	Remarks
Physical Parameters					
Color	-	Clear	Clear	Yes	No visible discoloration
Odor	-	Neutral	Neutral	Yes	Free from unpleasant smell
pH	pH units	6.8 – 7.4	6.5 – 8.5	Yes	Within safe drinking range
Turbidity	NTU	0.8 – 2.1	≤ 5	Yes	Low suspended particles
Chemical Parameters					
Total Dissolved Solids (TDS)	mg/L	40 – 75	≤ 500	Yes	Indicates low mineral content
Electrical Conductivity (EC)	µS/cm	70 – 120	≤ 1000	Yes	Within safe limit
Bacteriological Parameters					
Total Coliforms	MPN/100 mL	2 – 5	1.1	No	Slight contamination detected

Fecal Coliforms	MPN/100 mL	1 – 3	1.1	No	Requires further treatment
Heterotrophic Plate Count (HPC)	CFU/mL	50 – 120	≤ 500	Yes	Acceptable microbial load

Notes:

Mean ± SD: Represents average values and variation across all collected samples.

PNDWS Standard: Philippine National Drinking Water Standards (DOH, 2017).

Water from banana trunks is physically and chemically safe, but bacteriological parameters indicate a need for disinfection before consumption.

Table 3. Comparison of Water Quality Parameters Between Forested and Non-Forested Areas

Parameter	Unit	Forested Area (Mean ± SD)	Non-Forested Area (Mean ± SD)	PNDWS Standard	Compliance
pH	pH units	7.1 ± 0.2	7.0 ± 0.3	6.5 – 8.5	Yes
Turbidity	NTU	1.2 ± 0.3	1.8 ± 0.5	≤ 5	Yes
Total Coliforms	MPN/100 mL	2 ± 1	4 ± 1.2	1.1	No
Fecal Coliforms	MPN/100 mL	1 ± 0.5	2.5 ± 0.7	1.1	No
Heterotrophic Plate Count (HPC)	CFU/mL	60 ± 15	90 ± 20	≤ 500	Yes

Table 4. Compliance of Banana Trunk-Extracted Water with PNDWS Standards

Parameter	Unit	Overall Mean ± SD	PNDWS Standard	Compliance	Remarks
Color	-	Clear	Clear	Yes	No visible discoloration
Odor	-	Neutral	Neutral	Yes	Free from unpleasant smell
pH	pH units	7.05 ± 0.25	6.5 – 8.5	Yes	Within safe drinking range
Turbidity	NTU	1.5 ± 0.4	≤ 5	Yes	Low suspended particles
TDS	mg/L	55 ± 10	≤ 500	Yes	Low mineral content
EC	µS/cm	95 ± 15	≤ 1000	Yes	Within safe limit
Total Coliforms	MPN/100 mL	3 ± 1.2	1.1	No	Slight contamination detected
Fecal Coliforms	MPN/100 mL	1.8 ± 0.7	1.1	No	Requires further treatment
HPC	CFU/mL	75 ± 20	≤ 500	Yes	Acceptable microbial load

Table 5. Potential Use of Banana Trunk-Extracted Water in Households and Agriculture

Parameter / Use	Forested Area	Non-Forested Area	Remarks
Drinking (with boiling)	Safe	Safe with caution	Boiling required for microbial safety
Cooking (with boiling)	Safe	Safe with caution	Boiling recommended
Washing and cleaning	Safe	Safe	Physical and chemical parameters acceptable
Irrigation / Livestock watering	Safe	Safe	Suitable for agricultural purposes
Community acceptance (survey %)	85%	70%	Forested areas preferred due to cleaner water

Table 6. Impact Assessment of Banana Trunk-Extracted Water by Respondent Groups
N=278

Impact Indicator	Household Users (n=200)	Farmers (n=60)	Community Leaders (n=8)	Health & Water Experts (n=10)	WM	Verbal Description	Mean ± SD
Effectiveness in supporting household water needs	4.2	4.0	4.1	4.3	4.15	High Impact	4.15 ± 0.15
Usefulness for agricultural purposes	3.8	4.4	4.0	4.1	4.08	High Impact	4.08 ± 0.25
Contribution to community well-being	4.0	4.1	4.3	4.2	4.15	High Impact	4.15 ± 0.15

Acceptability of water quality after treatment	4.1	4.2	4.0	4.4	4.18	High Impact	4.18 ± 0.18
Overall perceived impact	4.03	4.18	4.10	4.25	4.14	High Impact	4.14 ± 0.11

Legend:

WM (Weighted Mean): Aggregated score across all groups.

Verbal Description: Based on a 5-point Likert scale: 5 – Very High Impact, 4 – High Impact, 3 – Moderate Impact, 2 – Low Impact, 1 – Very Low Impact.

Mean ± SD: Shows the average rating and variability among respondents.

Notes:

Household users rated highest in contribution to community well-being and household water needs.

Farmers rated highest in usefulness for agriculture, reflecting practical benefits.

Experts confirmed overall acceptability and safety after treatment.

The overall High Impact rating (WM = 4.14) indicates that banana trunk water is generally perceived as an effective and acceptable alternative resource.

Ethical Considerations

Ethical approval and prior consent were secured from local authorities and residents before sample collection. The research ensured minimal disturbance to the natural environment and adhered to environmental protection protocols. Laboratory tests were conducted under certified safety procedures to maintain data integrity and authenticity.

CONCLUSION

While the conclusion effectively highlights the significance of banana trunks as an alternative water source in mountain communities, it would benefit from a deeper incorporation of quantitative evidence derived from the laboratory analyses. The comparison between forested and non-forested areas is well-articulated narratively, but presenting clearer statistical distinctions would strengthen the scientific grounding and clarify the extent of environmental influence on water quality. More explicit connections between these quantitative differences and broader sustainability impacts—such as ecosystem health, water reliability, and long-term resource availability—would further enrich the discussion.

RECOMMENDATIONS

Additionally, the recommendations are practical and community-centered, yet their usefulness could be enhanced by integrating cost considerations, material requirements, and feasibility assessments for community-wide application. Including estimates of labor, equipment, processing needs, or potential economic benefits could help local governments, NGOs, and community leaders evaluate the viability of scaling banana-based water strategies. Such additions would make the recommendations more actionable and policy-responsive, bridging the gap between scientific results and real-world implementation. Strengthening these areas would not only reinforce the credibility of the findings but also support the development of sustainable, context-sensitive water management policies that can truly address the needs of rural and upland communities.

DEFINITION OF TERMS

1. Agricultural Resources: Plant or animal materials are available in rural areas that can be used for food, water, or other livelihood purposes (FAO, 2017).
2. Banana Trunk Water: Water naturally stored within the fibrous core of banana plants can be extracted for consumption or household use.
3. Circular Resource Utilization – The practice of reusing or recycling agricultural residues, such as banana stalks, to support soil fertility and sustainable agriculture (Ellen MacArthur Foundation, 2019).

4. Community-Based Water Management—A strategy where local communities actively participate in planning, managing, and maintaining water resources to ensure sustainable and equitable access.

5. Forested Area – A region covered with dense vegetation and trees, which contributes to natural filtration, moisture retention, and improved water quality.

6. Heterotrophic Plate Count (HPC)—A measure of the number of heterotrophic bacteria present in water, indicating general microbial load (DOH, 2017).

7. Non-Forested Area: Open landscapes with minimal tree cover may be more prone to water contamination due to soil runoff and reduced natural filtration.

8. Philippine National Drinking Water Standards (PNDWS)—Guidelines set by the Department of Health (DOH) for the quality and safety of water intended for human consumption.

9. Safe Extraction Practices—Methods employed to collect water from banana trunks while minimizing contamination, including proper cutting, hole preparation, and covering the exposed area.

10. Sustainable Water Management – Practices that ensure long-term availability and safe use of water resources while protecting the environment and supporting livelihoods.

11. Water Scarcity—A situation in which available water resources are insufficient to meet the needs of a community or region, often caused by limited rainfall, terrain, or infrastructure.

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