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EMPOWERING WATER ACCESS THROUGH SUSTAINABLE ENGINEERING: A RAM PUMP SYSTEM FOR BARANGAY TUBTUBON, SIBULAN, NEGROS ORIENTAL, PHILIPPINES

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ABSTRACT:
This study explores the development and implementation of a hydraulic ram pump to provide sustainable water access to elevated areas without electricity consumption. The ram pump utilizes the kinetic energy of flowing water to transport a portion of it to a higher elevation, eliminating the need for electrical or fuel-based power sources. Using data from Clemson University's Table, the research confirmed that the required water output exceeded the daily water demand of the residents, validating the suitability of a 1 ¼-inch drive pipe diameter. A measured distance of 10.3 meters from the water source to the pump location, combined with a 30-meter delivery pipe to the header tank, ensured optimal system efficiency. Water is then stored in the tank before being accessed through a communal faucet 130 meters away, serving five households. Evaluation results indicate that Barangay Tubtubon residents rated the project as "Highly Substantial" (4.80 out of 5), underscoring its significant impact on their daily water needs.
KEYWORDS: Hydraulic Ram Pump, System Efficiency, Water Accessibility, Extension Program

INTRODUCTION:

Access to clean and reliable water remains a persistent challenge in many rural and upland communities across the Philippines. Despite the presence of natural springs, areas such as Barangay Tubtubon in Sibulan, Negros Oriental continue to face logistical and infrastructural barriers that hinder equitable water distribution. Residents often rely on labor-intensive methods to collect water, which not only consumes time and energy but also limits access during critical periods. According to the World Bank [1], approximately 7.5 million Filipinos lack access to safe and sustainable water sources, with rural populations disproportionately affected.

Although hydraulic ram pumps have been used globally for over two centuries, their application in Philippine rural settings remains underutilized and underrepresented in recent engineering discourse. This study addresses that gap by evaluating the feasibility, design, and community impact of a hydraulic ram pump system tailored to the topographical and socioeconomic conditions of Barangay Tubtubon. The system operates without electricity or fuel, relying solely on the kinetic energy of flowing water, a feature that aligns with the principles of renewable energy and low-maintenance engineering.

The purpose of this research is to demonstrate how sustainable engineering solutions can empower underserved communities through decentralized water access. By integrating technical design with community engagement, the project aims to validate the hydraulic ram pump as a scalable model for rural water infrastructure. Recent studies have emphasized the importance of such technologies in improving public health, reducing environmental impact, and fostering local ownership [2] [5]. Moreover, innovations in ram pump design and deployment have shown promising results in optimizing delivery head and system efficiency in off-grid settings [6].

METHODS AND METHODOLOGY

This research applied a mixed methods engineering approach grounded in participatory action research, designed to ensure both technical accuracy and community responsiveness. The methodology was systematically organized

into five phases: site assessment, system design, implementation, community engagement, and performance evaluation, as illustrated in Figure 1.

Phase 1: Site Assessment
The initial reconnaissance was conducted in Barangay Tubtubon to determine the feasibility of deploying a hydraulic ram pump. GPS mapping identified elevation gradients and pipeline routes, while flow rate measurements and semi-structured interviews with residents established baseline demand. These insights enabled a context-specific engineering strategy aligned with environmental constraints and resource availability.

Phase 2: System Design
Technical specifications were adapted from Clemson University's performance tables to configure the hydraulic ram pump. As outlined in Table 1, a 1¼-inch drive pipe was selected for its optimal balance between pressure and flow capacity. The intake line extended 10.3 meters from the source, with a vertical lift of 30 meters to a storage header tank, and a 130-meter distribution line delivering water to a communal faucet serving five households. Material selection emphasized cost-efficiency, rural accessibility, and long-term durability.

Table 1 Technical Specifications of the Ram Pump System

Parameter	**Value**
Drive Pipe Diameter	1¼ inch
Source-to-Pump Distance	10.3 meters
Vertical Lift to Header Tank	30 meters
Distribution Length	130 meters
Households Served	5

Phase 3: Implementation
The system was installed collaboratively by faculty and engineers from Negros Oriental State University (NORSU), barangay officials, and trained community volunteers. A Memorandum of Agreement (MOA) delineated stakeholder roles to ensure accountability throughout deployment. Safety procedures and engineering guidelines governed the construction process, supported by on-site capacity-building workshops and technical briefings.

Phase 4: Community Engagement
An Information, Education, and Communication (IEC) campaign ran alongside system deployment. Fifty community members participated in feedback sessions that evaluated awareness, usability, and relevance through 5-point Likert-scale surveys. These sessions reinforced local ownership and enhanced knowledge transfer, a key pillar in the participatory engineering model.

Phase 5: Performance Evaluation
The final phase included a three-week observational period to monitor system efficiency, water delivery rates, and community satisfaction. Survey analysis yielded an average rating of 4.80 out of 5, denoting "Highly Substantial" community impact. This affirmed the ram pump's success in providing sustainable, low-maintenance water access and reducing the manual water collection burden.

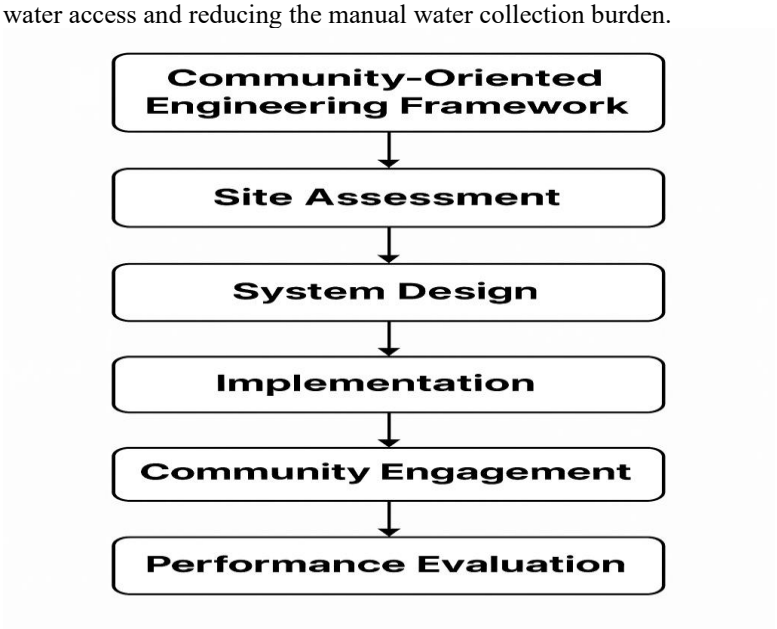

Figure 1. Research Framework Diagram

RESULTS AND DISCUSSIONS

The evaluation of the hydraulic ram pump extension training in Barangay Tubtubon yielded consistently high satisfaction ratings across all dimensions, as shown in **Table 1**. The weighted mean scores reflect the effectiveness of the intervention in enhancing technical knowledge, training delivery, and logistical support.

Table 2 Dimensions of the Evaluation

Dimension	**Specific Factor**	**Weighted Mean**	**Verbal Interpretation**
Knowledge and Skills Assessment	Knowledge Before and After Training	2.87	Limited
Training Effectiveness	Objectives and Learning Content	4.79	Highly Substantial
	Learning Tools, Materials, and Activities	4.72	Highly Substantial
	Teaching and Subject Mastery	4.85	Highly Substantial
	Overall Training Effectiveness	4.85	Highly Substantial
	Overall Satisfaction Rating	4.80	Highly Substantial
Logistics	Venue, Food, and Support Services	4.81	Highly Substantial

Legend: 4:51 – 5.00 (Highly Substantial)
3.51 – 4.50 (Substantial)
2:51 – 3.50 (Limited)
1.51 – 2.50 (Very Limited)
1.00 – 1.50 (None)

The pre-training knowledge score of 2.87 indicates that most participants had limited familiarity with hydraulic ram pump systems prior to the intervention. This baseline highlights the necessity of targeted technical education in rural engineering contexts. Post-training scores across all categories exceeded 4.70, signifying a substantial improvement in understanding and satisfaction.

The objectives and content delivery received a weighted mean of 4.79, suggesting that the training was well-aligned with community needs. This aligns with findings from Than et al. [7], who emphasized that contextualized training significantly enhances retention and applicability in hydraulic ram pump deployments.

The teaching and subject mastery dimension scored the highest at 4.85, reinforcing the importance of facilitator expertise in technical capacity-building. Studies by Osome et al. [8] support this, noting that community acceptance and system sustainability are strongly correlated with the quality of instruction and stakeholder engagement.

Slightly lower scores in learning tools and materials (4.72) suggest room for improvement in instructional design. Credo [9] recommends incorporating visual aids and hands-on demonstrations to enhance comprehension, especially in mechanical systems like ram pumps.

The logistics dimension, with a score of 4.81, reflects the effectiveness of venue setup and support services in fostering a conducive learning environment. Camero et al. [10] argue that logistical comfort contributes to higher engagement and satisfaction in rural training programs.

Overall, the results affirm the success of the training model in bridging technical gaps and empowering local stakeholders. The findings support the scalability of this approach to other underserved communities, with potential benefits in water access, public health, and climate resilience.

CONCLUSION

The successful implementation of the hydraulic ram pump system in Barangay Tubtubon, Sibulan, reinforces its viability as a sustainable and cost-effective solution for improving water accessibility in geographically isolated communities. With a measured intake of 10.3 meters, a vertical lift of 30 meters, and a 130-meter distribution pipeline serving five households, the system demonstrated technical reliability and operational efficiency without

dependence on electricity or fuel. The high satisfaction rating of 4.80 out of 5 from beneficiary evaluations reflects its substantial impact on reducing water collection burden and enhancing daily quality of life.

Training and capacity-building efforts yielded notable improvements in participant knowledge, with post-training scores shifting from "Limited" to "Highly Substantial," confirming the effectiveness of the educational strategy. The consistently high ratings in seminar delivery, teaching mastery, and logistical arrangements underscore the project's strength as both an engineering solution and a community engagement model.

Given these outcomes, the study recommends installing an expanded water storage tank to increase capacity and serve more households, as well as replicating the hydraulic ram pump system in other subzones of Barangay Tubtubon to extend access and promote fair water distribution.

Scaling this initiative across neighboring communities can reinforce the strategic relevance of hydraulic ram pumps as an engineering solution aligned with the Philippines' rural development agenda and sustainable water management goals.

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2) Data Availability
The data supporting the findings of this study are available upon reasonable request from the corresponding author. Where applicable, supplementary materials and relevant datasets may also be accessed through designated public repositories, subject to institutional approval and ethical guidelines.

3) Conflict of Interest
The authors affirm that there are no financial, personal, or professional conflicts of interest that could have influenced the conduct or outcomes of this research. All aspects of the study were carried out with academic integrity and impartiality.

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