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Implementation of hydram pump technology to solve clean water crisis in Kalipuro, Banyuwangi

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ABSTRACT

Bulusari Village in Banyuwangi Regency, despite its abundant water resources, faces a significant clean water crisis that adversely affects the quality of life and health of its residents. This community service program was initiated to address this crisis through the implementation of environmentally friendly hydraulic pump technology. The primary objective was to provide a sustainable solution for clean water delivery to the rural community. The project was carried out in several stages, including community socialization, elevation measurement, hydraulic pump design, preparation of tools and materials, pump assembly, trial runs, application, and ongoing evaluation and monitoring. The hydraulic pump was designed to lift water up to 150 meters by harnessing the energy from water falling from an 8-meter height. The implementation of the hydraulic pump in Bulusari Village has had a significant positive impact, resulting in increased access to clean water, improved health outcomes, and enhanced environmental awareness among villagers. The pump has consistently delivered water at a rate of 4.8 liters per minute, proving its effectiveness. Guidelines for periodic monitoring and evaluation have been established to ensure the long-term functionality of the pump. This project has successfully alleviated the clean water crisis in Bulusari Village, thereby improving the villagers' quality of life and health.

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1. INTRODUCTION

Geographically, Bulusari Village is located in the Kalipuro District, Banyuwangi Regency. This village faces significant issues with clean water supply shortages. Although Bulusari Village is located in an area with abundant water sources, the local residents have not been able to utilize the water resources effectively. The Chairman of the Youth Organization, stated that every day the villagers have to descend a steep hill for a distance of 150 meters just to fetch clean water. This daily task is not only physically demanding but also poses significant health risks. The villagers are constantly at risk of slipping and falling while navigating the treacherous path. Furthermore, the physical exhaustion from carrying heavy containers of water uphill can lead to various health issues, including musculoskeletal problems and chronic fatigue, making this a serious concern for the well-being of the entire community.

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The increasing need for sustainable energy has led the community to seek alternative energy sources (Darma & Wardhana, 2020). Developing sustainable and environmentally friendly energy sources has become one of the main challenges in the modern era (Surbakti et al., 2023). A highly promising potential lies in the use of hydropower, especially in areas with abundant river flow, such as in Bulusari Village, Banyuwangi Regency. In certain areas, the need for water can only be met from very limited sources, especially during the dry season (Ucok & Mukhtar, 2020). In mountainous areas designated for agriculture, most of the land surface is higher than the water sources, making it difficult to obtain water for daily needs, including irrigation (Setiawan, 2018). Efforts by the villagers to obtain clean water often require the use of water pumps powered by diesel engines or high-pressure electric pumps (Iskandar & Saepudin, 2020). When calculated in nominal terms, the costs associated with renting such water pumps can be quite high (Awwaliyah et al., 2020). It is estimated that the community needs approximately Rp. 3,000,000 per month to cover the rental and maintenance expenses of either electric or fuel-powered water pumps, which they cannot afford due to the economic challenges faced by the residents in that district.

Hydraulic ram pumps represent an innovative alternative technology that does not require electricity or fuel for irrigation purposes. This technology is particularly valuable in highland areas or locations situated above river surfaces (Setiawan, 2018). Unlike conventional pumps that rely on external power sources, hydraulic ram pumps utilize the kinetic energy of falling water to lift water to higher elevations. A hydram pump is an automatic pump that operates without using electrical energy, instead using the energy from water flow to lift water from the source to the storage area (Wangi & Kuncoro, 2021). The hydram pump operates without the use of fuel or additional external energy (Herlambang & Wahjono, 2006). This is a highly relevant and suitable technological strategy to address the problems in Bulusari Village. The working principle of the hydraulic ram pump involves the process of converting the kinetic energy of water flow into dynamic energy, resulting in a water hammer effect that creates high pressure inside the pipe (Supriyono, 2018). This characteristic and advantages makes them suitable for regions where access to electricity or fuel is limited (Rahmiati, 2020). By adopting hydraulic ram pumps, communities can significantly reduce the costs associated with the rental and maintenance of traditional pumping systems. These conventional systems often involve substantial ongoing expenses for fuel and electricity, which can impose a heavy financial burden on local farmers and landowners. In contrast, hydraulic ram pumps, being low-maintenance and requiring no external power, offer a cost-effective solution for sustainable water management. In this community service program, we have explored the natural potential for implementing hydraulic ram pump technology in Bulusari Village. Our observations and studies indicate that this innovative technology provides an effective means of harnessing water energy for irrigation needs. The introduction of hydraulic ram pumps in Bulusari Village is expected to alleviate the financial strain on villagers, promote sustainable agricultural practices, and improve overall access to water resources. This approach not only supports the villagers significant health risks but also contributes to the long-term sustainability of water management practices.

Based on the village's topological characteristics, the authors plan to design a pump capable of delivering water up to 150 meters from the water source. This community service program aims to identify and explore the natural potential in Bulusari Village, particularly in the context of developing environmentally friendly pump technology and develop effective solutions for utilizing the available water energy in the area through the innovation of the hydram pump. It is hoped that the availability of clean water in Bulusari Village will be met, thereby improving the quality of life of the community, particularly in terms of health issues and sanitation.

2. METHODS

Key Partner of Community Service Program

The activity took place in Bulusari Village, Kalipuro District, Banyuwangi Regency, East Java, from July 2023 to December 2023. The key partner in this community service initiative is the Bulusari Youth Organization (Karang Taruna), which comprises 52 members, 42 men and 10 women. This organization is dedicated to empowering young people to remain productive.

Implementation Method

Water is not only an essential element for the lives of humans, animals, and plants but also a vital natural source of mechanical energy (Utomo et al., 2015). This community service program aims to address the serious challenge of a sustainable clean water supply shortage in Bulusari Village, Kalipuro area. This issue has become a primary concern due to its significant impact on the daily lives of local residents.

Through the implementation of hydram pump technology, it is hoped that all residents of Bulusari Village, especially the approximately 150 households, will gain adequate access to clean water. Besides enhancing their well-being, this project is also expected to create new opportunities for the sustainable development of integrated farming in the village. The project implementation method includes several well-structured stages, starting with: (1) Activity awareness campaign to the community; (2) Measuring elevation to determine the optimal location; (3) Designing an efficient pump device; (4) Preparing equipment; (5) Assembling the pump; (6) Testing and installing the technology; and (7) Periodic evaluation and monitoring to ensure the project's smooth operation and effectiveness.

The application of hydram pump technology is expected not only to directly solve the clean water shortage problem but also to provide long-term positive impacts for the Bulusari Village community, such as improved quality of life and opportunities for sustainable local economic development.

Additionally, the schedule is intended to provide a clear timeline that helps manage expectations and track progress. This structured timeline is crucial for maintaining momentum and ensuring that the project stays on course, particularly in community-driven initiatives where delays can lead to disengagement. Furthermore, the schedule allows for periodic evaluations and adjustments, which are essential for addressing any unforeseen challenges that may arise during implementation.

Table 1. The implementation stages and schedule

Stage 1	**Activity Awareness Campaign**
Activity	Socialization Activities, Survey and Planning, and Planning of Installation and Operation
Objective	The objective of the socialization activities was to foster community engagement and raise awareness about the clean water shortage, ensuring active participation and commitment from local residents and leaders in finding sustainable solutions.
Implementation Time	12 July 2023 - 15 July 2023
Stage 2	**Measurement of Elevation from Water Source to Hydram Pump**
Activity	Elevation Measurements
Objective	The objective of conducting these elevation measurements is to ensure the hydram pump's optimal operation by accurately determining the height difference between the reservoir and the pump.
Implementation Time	20 July 2023 - 4 August 2023

Stage 3	**Hydram Pump Design**
Activity	Design and Development of Hydram Pump
Objective	The primary objective is to create a hydram pump that excels in water delivery performance by optimizing its design for handling significant water volumes efficiently. The dual discharge channels aim to increase water output and ensure consistent pressure, making the pump more effective in various applications.
Implementation Time	5 August 2023 - 31 August 2023
Stage 4	**Tools and Component Preparation**
Activity	The activity involves meticulously preparing the pump components, with a particular focus on the water input and output channels.
Objective	The primary objective of this stage is to ensure that all necessary components are properly prepared to guarantee the hydram pump operates effectively. Another objective is to enhance the safety and reliability of the pump system by incorporating measures such as compression tubes to mitigate water hammer effects and a stop valve in the outlet channel.
Implementation Time	5 September 2023 - 18 September 2023
Stage 5	**Hydram Pump Fabrication**
Activity	The activity involves the careful assembly of the hydram pump, which includes measuring, cutting, and preparing materials according to the provided design.
Objective	The primary objective is to ensure the hydram pump is assembled with precision, leading to optimal operational efficiency and longevity. Another objective is to adhere to strict quality assurance protocols throughout the assembly process. This involves continuous monitoring, testing, and implementing safety standards to ensure the assembled components are of high integrity and functionality.
Implementation Time	20 September 2023 - 3 October 2023
Stage 6	**Testing and Installation Process of the Hydram Pump**
Activity	The activity involves testing the hydram pump at a water source located approximately 75 meters below the residential area. Following successful testing, the installation process is carried out. This involves securely positioning the pump, integrating it into the local water distribution system, aligning components, verifying connections, and implementing safety measures.
Objective	The primary objective of the testing phase is to validate the hydram pump's performance, ensuring it meets operational standards and delivers water effectively to the desired height and distance.
Implementation Time	5 October 2023 - 7 November 2023
Stage 7	**Evaluation and Monitoring**
Activity	The activity involves the systematic evaluation and monitoring of the hydram pump system to ensure its optimal performance and longevity. This includes assessing operational parameters such as output consistency, pressure maintenance, and overall durability.
Objective	The primary objective of the evaluation and monitoring phase is to ensure that the hydram pump system operates efficiently and effectively over time.
Implementation Time	10 November 2023 - 15 December 2023

3. RESULTS AND DISCUSSION

Result in Activity Awareness Campaign (Pre-Survey)

The head of Youth Organization (*Karang Taruna*), along with several active local residents, attended and actively participated in the socialization activities. Their presence underscored the community's strong commitment and direct involvement in tackling the pressing issue of the shortage of clean water supply, which was the central theme of the event. This collective engagement not only showcased the spirit of local solidarity but also highlighted a shared resolve to explore and implement sustainable solutions to meet essential communal needs, ensuring a better quality of life for all residents of Bulusari Village.

Figure 1. Activity awareness campaign

Based on the survey conducted, the author found that the hydram pump is planned to be installed approximately 50 meters below the residential area. The design aims for the hydram pump to effectively deliver water up to 150 meters from its location. The operation of this hydram pump system relies on the principle of using the downward flow of water from a height to create pressure that pushes water to higher locations (Suarda, 2019). This technological approach is considered highly suitable and relevant for addressing the issue of water supply shortage in Bulusari Village, Kalipuro District.

By harnessing the potential energy from water flow, the hydram pump does not require other external energy sources such as electricity, making it environmentally friendly and sustainable in the long term. The presence of this innovation is expected to provide an effective solution for approximately 50 households in Bulusari Village to gain stable access to clean water. Furthermore, the implementation of this technology, which took place from 12 July 2023 to 15 July 2023, can also open up new opportunities for the development of agriculture and sustainable livelihoods at the local level, supporting economic growth and community welfare broadly.

Measurement of Elevation from Water Source to Hydram Pump

In the next step, the author will conduct precise elevation measurements using equipment such as an auto level, theodolite, and total station to accurately determine the vertical distance between the input pipe from the reservoir to the hydram pump. In the measurement plan, the placement of the reservoir to the hydram pump has been carefully considered, with the overall result indicating a vertical distance of 8.74 meters. The total vertical distance between the reservoir and the hydram pump, including all relevant elevation changes, amounts to 32.4 meters. This accurate measurement process is crucial to ensure that the hydram pump can operate optimally by utilizing the water pressure generated from this significant height difference.

With the measured data collected from 20 July 2023 to 4 August 2023, it is expected that the implementation of the hydram pump can be carried out efficiently, optimizing the use of existing natural resources without requiring additional energy (Afifi, 2022).

Figure 2. Elevation measurement using autolevel

Hydram Pump Design

The hydram pump design we've developed between 5 August 2023 and 31 August 2023 is an innovative solution that integrates a 6-inch diameter tube with dual discharge channels. This design features a sizable tube capable of handling significant water volumes efficiently. The inclusion of two discharge channels is strategically aimed at enhancing water output and ensuring stable pressure levels throughout operation. By synergizing these elements, our objective is to engineer a hydram pump that not only excels in water delivery performance but also proves versatile for diverse applications in irrigation systems and providing access to clean water. This innovation holds promise for enhancing water resource management and supporting sustainable practices across agricultural and community water supply initiatives.

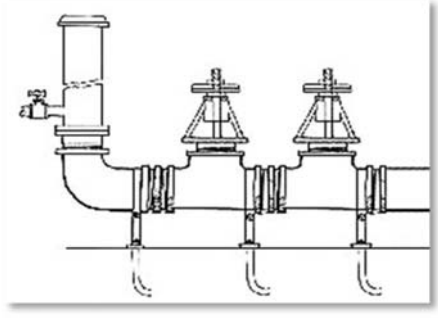

Figure 3. 6-inch hydram pump design with dual discharge channels

Tools and Component Preparation

In the stage of tools and component preparation, the pump components can be meticulously prepared, focusing on the water input and output channels as the main components. Preparation steps involve several stages, including preparing a 2.5-inch water input pipe connected to the main component via threaded sockets. Additionally, pipes for the discharge channel or valve waste, shockdrat pipes inside, and pipes towards the transmitter valve are also prepared to ensure the pump process runs effectively. As a safety measure, compression tubes were created between 5 September 2023 and 18 September

2023 to handle potential water hammer phenomena. Finally, the creation of the outlet channel leading to the water reservoir is equipped with a stop valve as part of this preparation.

Hydram Pump Fabrication

In this stage, the assembly of the hydram pump, which takes place from 20 September 2023 to 3 October 2023, involves responsibilities such as measuring, cutting, and preparing materials according to the design provided by the executor. The executor also provides guidance during the manufacturing process to prevent errors in pipe cutting. One critical parameter to consider is the distance between the check valve and the volume of the compression tube or vacuum, which should range from 150 cm to 300 cm. Additionally, the height between the discharge check valve and the tube check valve should also be approximately ±300 cm.

Figure 4. Tools and component preparation

Ensuring precise measurements and alignment during assembly is crucial to the pump's operational efficiency and longevity. Careful attention is given to aligning components accurately to maintain proper functionality and optimize water flow performance. The executor oversees the entire assembly process, ensuring that each step adheres to safety standards and design specifications. Moreover, quality control checks are implemented throughout assembly to verify the integrity and functionality of assembled components.

Figure 5. Assembly process of the hydram pump

Regular inspections and adjustments are conducted to ensure that all connections are secure and that components fit seamlessly together. This meticulous approach helps mitigate potential risks and ensures the hydram pump's reliability in delivering water efficiently. Collaborative efforts between the

executor and the team are essential to address any challenges that may arise during assembly, fostering a supportive environment for problem-solving and continuous improvement.

By adhering to meticulous assembly practices and quality assurance protocols, the executor ensures that the hydram pump meets performance expectations and serves its intended purpose effectively. Continuous monitoring and testing throughout the assembly process validate the pump's functionality and readiness for deployment in the community. This systematic approach not only enhances operational efficiency but also contributes to sustainable water management practices, supporting long-term environmental and community benefits.

Testing and Installation Process of the Hydram Pump

Testing and implementing the Hydram Pump is carried out from 5 October 2023 to 7 November 2023 at a water source located approximately 75 meters below the residential area. The installation of this Hydram Pump utilizes the flow of water from a source with a height of about ±8 meters, and the test results indicate that within 1 minute, the device can produce an average water output of 4.8 liters. Despite the water output reaching up to 75 meters, this pump is fundamentally capable of delivering water up to a distance of 150 meters from its source.

The testing phase involves assessing various operational parameters, including water flow consistency, pressure maintenance, and overall efficiency in delivering water to the desired height. Regular monitoring during the testing phase ensures that the pump meets performance standards and operational requirements (Zulhendri et al., 2019). Additionally, adjustments are made as needed to optimize the pump's output and ensure reliable functionality over time.

Upon successful completion of the testing phase, the installation process begins, focusing on securely positioning the pump and integrating it into the local water distribution system. This involves carefully aligning components, verifying connections, and implementing safety measures to prevent leaks or operational issues (Guerin, 2014). Collaboration between technicians and local stakeholders ensures that the installation is executed efficiently, with attention to both technical specifications and environmental considerations. Training sessions may also be conducted to familiarize local personnel with the pump's operation and maintenance procedures, ensuring sustainable use and longevity of the hydram pump system.

Figure 6. Testing and installation process of the hydram pump

Evaluation and Monitoring

Evaluation and monitoring are crucial phases in ensuring the optimal performance and longevity of the hydram pump system. This process involves systematic assessment of various operational parameters

and performance metrics to verify that the pump operates efficiently and effectively over time. During the evaluation phase, comprehensive checks are conducted to assess the pump's output consistency, pressure maintenance capabilities, and overall durability. Technicians and engineers closely examine data collected from operational tests to identify any deviations from expected performance levels. This helps in pinpointing potential issues early on and implementing corrective measures promptly.

The evaluation and monitoring of the hydram pump activities, conducted from 10 November 2023 to 15 December 2023, indicate that the installed equipment functions well, and the operational mechanisms are understood by the community group. Following this, the equipment is handed over to the community group for further development at other locations (see Figure 7). The water discharged from the output channel is then distributed using plastic pipes to provide flexibility in directing the water flow. It is expected that households and the mosque will continue to receive a daily water supply. Therefore, the residents are given instructions on how to maintain the hydram pump.

Figure 7. Evaluation and monitoring of the hydram pump activities

The Implementation Stages and Specification

The objective of outlining the implementation stages and schedule for this project is to ensure a systematic and efficient approach to addressing the critical issue of clean water supply in Bulusari Village, Kalipuro District, Banyuwangi Regency, East Java. By clearly defining each step of the process, the project aims to achieve a structured progression that maximizes resource utilization, minimizes potential disruptions, and ensures timely completion. The meticulous planning of stages allows for a clear understanding of the responsibilities and expectations at each phase, promoting better coordination among the project team, local partners, and the community (Zunaidi, 2024).

The hydram pump was tested at a water source located 75 meters below the residential area. The results indicated an average water output of 4.8 liters per minute, with the capability to deliver water up to 150 meters. These results, along with the testing procedures, are thoroughly documented.

Table 2. Hydram pump specifications

Pressure	Flow Velocity	Elevation	Capacity
250 psi	8 meters/second	75 meters	4.8 liters/minute

The hydram pump implemented in Bulusari Village is a robust and sustainable solution for addressing the local water shortage. The pump's design allows it to operate without external energy sources, relying solely on the potential energy from water flow. This product not only meets the

community's immediate water needs but also supports physical health and economic development. The dissemination of this activity includes delivering materials on the hydram pump, its benefits, and its applications, especially in addressing the serious issue of the shortage of clean water supply in Bulusari Village.

Discussion

The hydram pump project in Bulusari Village demonstrates a successful implementation of appropriate technology tailored to the community's needs. The results show that the pump efficiently addresses the water supply shortage by delivering a consistent flow of water to the local residents. When compared to previous similar activities reported in community service journals, this project stands out due to its comprehensive approach and active community involvement.

The hydram pump's performance exceeded expectations, providing a stable water supply over a significant distance without the need for external energy. This aligns with the project's objective to develop a sustainable and efficient water supply system. Comparing these results with similar projects in other regions, the Bulusari Village project benefited from meticulous planning and execution, leading to enhanced operational efficiency and community engagement.

Figure 8. Hydram pump piping system

The positive impact of the hydram pump installation on the community is evident in several areas. Firstly, the project has empowered the local youth through active participation in the training and installation process, enhancing their technical skills and knowledge. Secondly, the successful operation of the pump has improved the community's access to clean water, directly benefiting approximately 50 households. This has not only improved the quality of life but also opened up opportunities for agricultural development, contributing to the community's economic growth. The implementation of the hydram pump in Bulusari Village showcases the potential of simple, yet innovative, technologies in addressing critical community needs. The project has demonstrated how appropriate technology can be effectively integrated into rural settings, promoting sustainable practices and self-reliance. The community's ability to maintain and potentially replicate the system in other areas underscores the project's success in fostering local innovation and scientific understanding.

Overall, the hydram pump project has not only fulfilled its immediate objectives but has also laid the groundwork for continued development and innovation within the community. The positive outcomes from this initiative highlight the importance of tailored, community-focused approaches in achieving sustainable development goals.

4. CONCLUSION AND RECOMMENDATIONS

This community service program successfully achieved its objectives, as evidenced by the smooth implementation of the hydram pump and the positive response from the local community. The high enthusiasm and active participation from residents reflect their strong hope for improved access to clean water, aligning directly with the project's goals. The hydram pump system demonstrated its effectiveness, generating sufficient water pressure to meet the community's needs, as indicated by the data. This success not only addresses the immediate water scarcity but also enhances the village's economic potential and their physical health, providing a model for replication in other areas. Continuous support and monitoring will ensure the long-term sustainability of this initiative, fostering local empowerment and laying the foundation for sustainable development.

Establishing partnerships with local (Non-Governmental Organization-NGOs), governmental agencies, and community organizations is essential for ensuring sustainable support and effective implementation of similar community service program s. These collaborations facilitate the pooling of resources, including funding, expertise, and infrastructure, thereby ensuring adequate financial and logistical support to sustain project activities over time. Moreover, partnering allows for the exchange of diverse perspectives, experiences, and knowledge, enhancing the project's effectiveness and efficiency through shared best practices and innovative ideas. Additionally, involving local NGOs and community groups fosters deeper community engagement, leveraging their established trust and networks to better understand local needs, preferences, and cultural sensitivities. This approach enables more tailored and culturally appropriate project designs and implementations, thereby maximizing the project's reach and impact across the community. By leveraging diverse resources, knowledge, and community networks, these partnerships contribute to the long-term sustainability of projects, ensuring that the benefits continue to be realized even after initial funding or external support ends. Overall, collaborative partnerships are pivotal in fostering a resilient and responsive approach to addressing community challenges and opportunities, promoting lasting positive impacts and sustainable development outcomes.

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