Journal of Dedication in Community (JoDiC)
Vol. 02, Issue. 02, Page. 35 – 44
ISSN: 3026-0760

Optimization of Pamsimas as A Drought Mitigation in Sidomulyo Village, Ngadirojo District, Pacitan

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Article Info:
Received 25 Nopember 2024
Revised: 15 December 2024
Accepted: 20 December 2024
Published: 28 December 2024

Keywords:
PAMSIMAS
Drought
Water Supply
Sidomulyo village
Pacitan

ABSTRACT

This study examines the optimization of the PAMSIMAS (Community-Based Drinking Water and Sanitation Provision) program in Sidomulyo Village, Ngadirojo District, Pacitan, as a proactive strategy to address drought conditions intensified by the village's geographical challenges. This study aimed to achieve two primary objectives: to evaluate the existing water distribution system and to suggest both technical and community-oriented enhancements to secure a more dependable water supply. Field observations and technical analysis indicate that the existing system, dependent on antiquated infrastructure, faces challenges in delivering reliable water access to Ledok Wetan and Ledok Kulon hamlets. To tackle this issue, we suggested the implementation of a booster pump to enhance water pressure and facilitate concurrent water distribution throughout both hamlets. Furthermore, participation from the community in training related to system maintenance and water resource management was promoted to guarantee enduring sustainability. The results indicate that integrating infrastructure enhancements with community education has the potential to enhance water security, offering a framework that may be applied in other drought-impacted areas of Indonesia.

INTRODUCTION

Pacitan is one of the 38 regencies in East Java Province, next to Central Java Province and the Special Region of Yogyakarta. Situated between 110° 55′-111° 25′ E and 7° 55′-8° 17′ S, it covers an area of 1,389.8716 km² (Sholiqin, *et al*. 2021). Approximately 85% of the landscape consists of hills, mountains, and deep ravines dispersed throughout the region (Nita *et al*. 2020; Putra *et al*. 2021). Most of Pacitan is located inside the Pegunungan Seribu mountain range, which stretches down the southern coast of Java Island, while the remainder comprises lowland areas (Nita *et al*. 2020).

The geographical and topographical characteristics of Pacitan Regency, located along the southern coast of Java, present significant challenges for water resource management, particularly in rural areas such as Sidomulyo Village, Ngadirojo District. Despite Pacitan's potential for water availability, largely due to its coastal proximity and underlying karst formations, the region experiences recurrent periods of drought (Widayanti *et al*. 2014). The coastal area of Pacitan is dominated by karst rock formations, which have porous structures capable of absorbing and storing large amounts of water (Hashim & Kaczmarek, 2019). However, these conditions, exacerbated by the nature of karst geology, result in substantial volumes of water being stored deep underground, often beyond the reach of conventional extraction methods. As a result, Sidomulyo Village faces acute difficulties in securing clean water during the dry season, a recurring issue that threatens both the daily livelihoods and the health of its residents.

CASE STUDY

Regardless of prior endeavors, such as borehole excavation, to address this issue, the community continues to depend on precipitation harvesting systems (Fig. 1). The village

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is susceptible to frequent protracted droughts, which have become more frequent in recent years, because of its reliance on seasonal rainfall. This scarcity of pure water poses a grievous risk to public health and sanitation and significantly disrupts agricultural activities, necessitating immediate and effective intervention (Motoshita *et al*. 2011; Ingrao *et al*. 2023).

Figure 1. The rainwater storage systems installed at Sidomulyo Village residents serve an essential function in capturing and preserving water during the rainy season. These facilities provide households with a supplementary water source, particularly beneficial during times of drought or water scarcity.

An effective strategy for addressing the issue is the enhancement of the PAMSIMAS (Community-Based Water Supply and Sanitation) program, a national endeavor executed by the Indonesian government to augment water accessibility in rural regions (Daniel *et al*. 2021; Kurniatin & Maksum, 2022). In Sidomulyo, the implementation of PAMSIMAS infrastructure has been inadequate in mitigating the severity of water shortages, especially during extended dry periods. This research seeks to assess the present condition of PAMSIMAS, concentrating on augmenting its operational efficacy via infrastructure enhancements, including the expansion of borehole networks and the optimization of water distribution systems.

The unpredictable nature of climate patterns and the intensification of drought events highlight the pressing need to enhance Sidomulyo's water supply systems. The main objective of this study is twofold: firstly, to evaluate the current PAMSIMAS infrastructure and its shortcomings in addressing drought impacts, and secondly, to suggest a thorough strategy for enhancing the program. This will entail thorough

assessments of water infrastructure, coupled with engaged community involvement in recognizing local water requirements and conservation methods, thereby fostering a more robust and sustainable water management framework.

The PAMSIMAS program aims to enhance the capabilities of local communities through the promotion of participatory methods in the management of water supply and sanitation. The program effectively meets immediate water needs while simultaneously cultivating a sense of ownership and responsibility within the community through active involvement. This collaborative approach promotes the involvement of local stakeholders in decision-making processes, guaranteeing that the solutions created are specifically designed to address the distinct challenges encountered by the community. In Sidomulyo, utilizing this community-focused strategy is essential to improve the efficacy of the PAMSIMAS program, as it facilitates the incorporation of traditional knowledge and practices in water management with contemporary methods. Through the organization of workshops and discussions, the project can collect important insights from residents about their water usage habits, preferences, and creative conservation methods.

Furthermore, enhancing the PAMSIMAS program in Sidomulyo carries significant implications for water management across Indonesia, especially as the nation confronts the challenges posed by climate change. The insights gained from this study may guide decision-makers and professionals in developing effective strategies to enhance rural water supply systems across the country. With the intensification of climate variability, the urgency for resilient infrastructure and adaptive management practices grows significantly. By documenting the challenges and successes of the PAMSIMAS optimization efforts in Sidomulyo, this study can contribute to a growing body of knowledge aimed at enhancing water security in vulnerable communities. This initiative aims to tackle the pressing water crisis in Sidomulyo while establishing a sustainable framework for rural water management that can be adapted in comparable situations throughout Indonesia.

This research has broader relevance to rural water management and climate adaptation strategies. The successful optimization of PAMSIMAS in Sidomulyo could provide a scalable model for other drought-prone regions, particularly areas with challenging geological conditions. As climate change continues to exacerbate water scarcity globally, developing resilient, community-driven solutions for sustainable water supply systems becomes increasingly critical.

METHOD

This community service program was carried out in Sidomulyo Village, Ngadirojo District, Pacitan, over a period of nine months, from February to October. The program began with a preliminary survey conducted by the PKM team from Unesa. The primary goal of this survey was to assess the existing water sources and the potential distribution networks within the village. In line with the proposed solutions, this community service project adopts a practical and hands-on approach. The procedure for this activity can be visualized through the flowchart shown in Figure 2 below.

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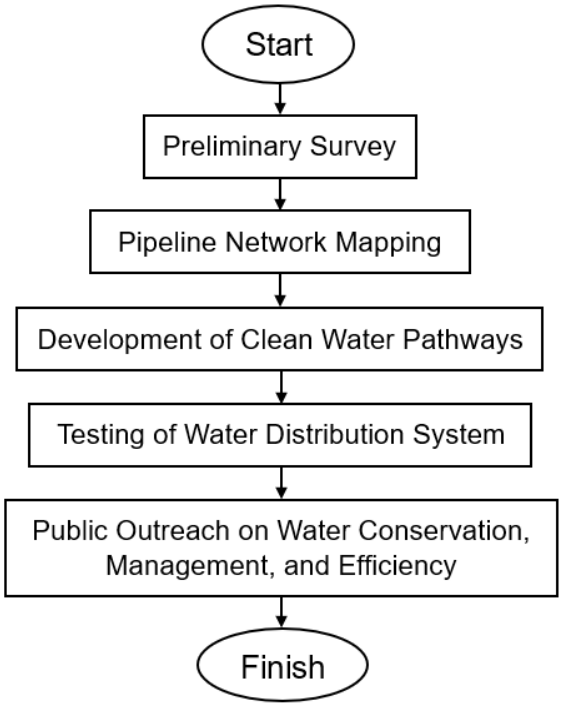
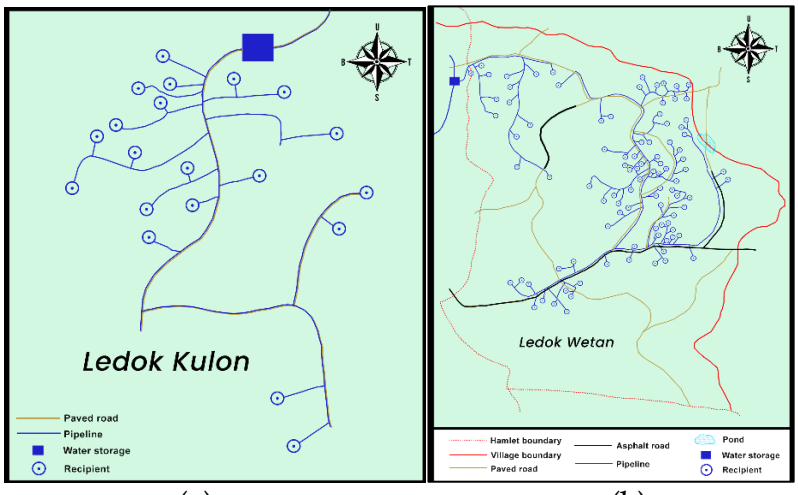


Figure 2. The process flow of the community service project. The project aims to improve access to clean water by establishing a reliable distribution system. It seeks to promote sustainable water management and long-term conservation efforts through careful planning, infrastructure development, and community engagement.

IMPLEMENTATION

According to the survey results, a comprehensive piping network map was created that emphasized the proposed optimization routes and the existing infrastructure. This map was the basis for the construction phase, during which physical water channels, such as pipelines, open channels, and bore wells, were implemented in accordance with the region's geographic features.



(a) (b)

Figure 3. The map highlighting detailed water distribution and infrastructure layouts in (a) Ledok Kulon and (b) Ledok Wetan.

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The project's emphasis shifted to the administration and maintenance of the newly established water system following the construction. To guarantee the system's ongoing sustainability and efficacy, routine maintenance schedules were implemented. The PKM team has implemented community education programs on water conservation and sanitation to facilitate long-term use. These programs are intended to encourage responsible water consumption and the proper maintenance of water sources. The project's success was significantly influenced by the involvement of local stakeholders, such as government agencies and non-governmental organizations, who provided financial and technical assistance. This collaborative approach guaranteed the optimized water system's sustainability and its ability to satisfy the community's requirements in the future.

The PKM team from Universitas Negeri Surabaya (Unesa), local authorities, and community members collaborated to execute the community service initiative in Sidomulyo Village. In February, the project commenced with a series of meetings to guarantee that all stakeholders, including the village government and residents, agreed with the objectives of optimizing the PAMSIMAS system to effectively address the recurring drought issues. Team members and local collaborators were allocated roles and responsibilities during these meetings. Additionally, the required legal permits for construction were obtained from the local government to guarantee adherence to regional regulations.

The construction of new water channels and the optimization of the existing water network commenced upon the acquisition of legal clearances. The construction process was actively participated in by community members, who worked under the guidance of technical experts and the PKM team from Unesa. A local water management committee was established and trained to oversee daily operations, conduct routine maintenance, and resolve any technical issues to guarantee long-term functionality and sustainability. The PKM team provided continuous monitoring and supervision throughout the nine-month project to ensure that the system met the community's requirements and was executed efficiently.

RESULT AND DISCUSSION

Drought Challenges in Ledok Wetan and Ledok Kulon

A total of two sub-villages, Ledok Wetan and Ledok Kulon, situated in Sidomulyo Village, have faced significant challenges in securing clean water supplies during prolonged dry seasons. The ongoing drought's impact is underscored by the water-sharing schedule between these sub-villages, as evidenced by community consultations and field visits. On Mondays and Tuesdays, residents of Ledok Wetan had access to water, while those of Ledok Kulon had access on Wednesdays and Thursdays. In rare instances, an attempt was made to implement a more adaptable water distribution system; however, the arrangement frequently failed to satisfy the daily requirements of the residents. The limited capacity of the water infrastructure to provide simultaneous water to both sub-villages has resulted in the persistence of these conditions, which is indicative of a systemic challenge that necessitates urgent technical intervention.

The alternating water access has resulted in significant disruptions to daily activities, particularly in the areas of domestic water usage, agricultural practices, and sanitation. In accordance with prior research (Motoshita *et al*. 2011; Van-Vilet *et al*. 2021; Salehi, 2022).

The findings here are consistent with regional reports on the limitations of rural water supply systems under stress (Motoshita *et al*., 2011; Corgrove & Loucks, 2015; Daniel *et al*., 2021) and call for an evaluation of the existing water management strategies in place.

Technical Analysis of Water Supply Infrastructure

The technical assessments conducted in this study identified the primary issue as insufficient power of the existing water pump. The pump was determined to be inadequate for generating the pressure required to distribute water concurrently to both Ledok Wetan and Ledok Kulon. Field measurements indicated that the pressure drop within the system was intensified by the aging pipelines, leading to inefficiencies in water delivery. Water distribution between the two sub-villages must be alternated due to constraints in pump capacity and pipeline integrity. After implementing the outlined methodological steps (Fig. 2) and engaging in detailed discussions with the relevant village authorities, a notable mechanical inefficiency was identified within the system. If this issue is not addressed promptly, it may lead to increased system failures and subsequent operational disruptions. The extended inefficiency may substantially elevate overall maintenance costs, thereby taxing available resources and diminishing the system's long-term sustainability.

Furthermore, observations of the pump's operation revealed that prolonged use led to excessive heat generation, increasing the risk of pump malfunction. The findings align with other studies on rural water management (Daniel *et al*. 2021; Kurniatin & Maksum, 2022), highlighting the necessity of enhancing both mechanical and distribution systems to alleviate the impacts of elevated operational demands during peak usage times. A comparison with analogous cases underscores the necessity for extensive upgrades to prevent recurring technical problems (Kurniatin & Maksum, 2022).

Proposed Technological Solution: Booster Pump Installation

To rectify these technical shortcomings, a booster pump was proposed. This pump was chosen for its ability to markedly increase water pressure, facilitating concurrent distribution to both subvillages. The booster pump enhances the pressure generated by the primary pump, thereby ensuring a stable and continuous water flow. Initial performance estimates indicate that the booster pump will effectively eliminate the necessity for alternating water schedules, thus enhancing overall water availability for the residents of Ledok Wetan and Ledok Kulon.

The incorporation of a booster pump enhances the longevity of the current infrastructure by alleviating the load on the primary pump. Long-term advantages encompass reduced maintenance expenses and enhanced reliability of the water supply system. The anticipated performance of the booster pump corresponds with evidence from analogous infrastructure projects, indicating that enhanced pump capacity resulted in significant advancements in water distribution efficiency (Guyer, 2012). Addressing immediate technical issues is crucial; however, ongoing monitoring of system performance is necessary to ensure lasting benefits for the community.

Field Survey Implementation and Community Feedback

This study involved a field survey aimed at assessing the initial implementation of the PAMSIMAS optimization project, with particular emphasis on the water distribution

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system in the two hamlets, Ledok Wetan and Ledok Kulon. The survey encompassed evaluations from the main water source to specific households, gathering information via interviews with community members and village authorities. This method enhanced comprehension of the obstacles encountered by the community in relation to obtaining clean water, especially during the dry season.

Notably, the findings indicated several minor leaks in the distribution pipes, which, while appearing trivial, led to significant water loss. This observation highlights the critical importance of regular maintenance and timely repairs of the water infrastructure to reduce such losses. Additionally, the restricted capacity of the current pump was recognized as a significant obstacle hindering the fair distribution of water between the two hamlets, highlighting the need for more effective optimization of the system to guarantee a reliable and sufficient water supply.

Figure 4. The booster pump displayed in this image is a crucial component of the water supply system, designed to enhance water pressure for effective distribution. The pump, constructed with a durable stainless-steel casing, is connected to the inlet and outlet pipes indicated by the blue fittings at its base. The electrical wiring attached to the motor ensures a reliable power supply for operation. The surrounding environment indicates a well-maintained installation, with a neatly coiled green hose positioned nearby, likely for efficient water distribution to various locations. This setup is essential for ensuring adequate water pressure and flow in the system.

The survey findings and recommended remedies received a mainly positive response from the community. Residents recognized the crucial need for technical measures, such as installing booster pumps, which are expected to improve distribution efficiency. Furthermore, village leaders stressed the necessity of community engagement in maintaining the water distribution system, which would allow for faster resolution of

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concerns such as pipe leaks. Local communities must actively participate in the management of water resources for the system to be sustainable.

Water Management Education and Follow-Up Actions

Understanding the necessity of improved water management strategies, people living in the neighborhood showed interest in more instruction on efficient water maintenance and management methods. Thus, it is suggested that seminars or workshops on sustainable water management concentrate on basic maintenance of the recently installed booster pumps and abilities to spot early indicators of degradation in the distribution system. This project seeks to enable people of the community to participate actively in the operational administration and maintenance of the water system, therefore lessening their need on outside experts.

Figure 5. The gathering demonstrates the different stages of planning and coordination, with stakeholders actively participating in exchanging ideas.

In addition to training, the successfully improved water distribution system will need to be constantly monitored. To do this, routine checks of the booster pumps and other equipment will be conducted, as well as data gathering on their performance. Implementing frequent assessments allows for the prompt identification and resolution of any potential technical difficulties that may develop, reducing disruptions in the water supply.

With the goal to address the urgent issues that are being brought about by the drought conditions, the construction of the booster pump has the potential to greatly increase water access in both Ledok Wetan and Ledok Kulon. The outcomes of this study indicate that technology interventions when paired with community participation and capacity-building, have the potential to result in changes to rural water management systems that are both sustainable and long-lasting. If this effort is successful, it might serve as a model for future programs that are comparable to it in other places that are experiencing drought

CONCLUSION

The PAMSIMAS (Community-Based Water Supply and Sanitation) program was implemented in Sidomulyo Village, Ngadirojo District, Pacitan, to support the program of safe drinking water access by all residents during a period of regular droughts due to rolling geological conditions. The first survey highlighted the problems of clean water in Kalurahan Gadang and sub-villages Ledok Wetan and Ledok Kulon; here, residents have been experiencing periodic access to joint tanks provided by local governments. It was determined through technical assessments that the areas called hamlets were supplied water from aging pumps, and pipelines could not accommodate both of their high demands simultaneously. To fix this problem, we suggested putting a booster pump that would increase pressure and allow a more even distribution of water at the same time. The limited public interest told community involvement would be vital, with locals keen to take part in the water management and maintenance regimen which emphasized local ownership as ultimately key for system sustainability. Our results indicate that blending a technology intervention and socialization can realize an adaptive, high-performance water supply system that could be implemented in other drought-prone regions of Indonesia.

ACKNOWLEDGMENT

The authors would like to express their heartfelt appreciation to the Republic of Indonesia's Ministry of Public Works and Public Housing (PUPR) for conducting the PAMSIMAS initiative, which has shown to be extremely useful and provides chances for future study in this subject. We are also grateful to the State University of Surabaya (Unesa), Indonesia, for providing the financing for this research project. Our deepest appreciation goes to the local government and people of Sidomulyo Village, Ngadirojo District, Pacitan, for their essential support during field activities, as well as to the research team and students who helped with data collecting and analysis.

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