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Research Article

Implementation of Community Asset-Based Reverse Osmosis Technology for Independent Access to Clean Water in Bibiosi Village

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Abstract

The limited access to clean, consumable water in Bibiosi Village, Keerom Regency, which directly correlates with the high prevalence of environment-based diseases, forms the background of this community service activity, which aims to improve clean water access and community health quality through the implementation of Reverse Osmosis (RO) technology. This activity adopted the Asset-Based Community Development (ABCD) method by mobilizing the potential of the "Narwastu" workers' group as a local asset and primary partner. The program implementation, located in Bibiosi Village, involved 50 heads of households and focused on a series of participatory stages, including socialization to build collective awareness, intensive technical training on the operation and maintenance of the RO unit for 10 members of the "Narwastu" group as technology cadres, and the collaborative installation of the technology unit. The results of the activity show a highly positive and measurable impact, marked by a significant 92% increase in the

community's understanding of the urgency of clean water, based on pre-test and post-test analysis, which created a strong social foundation for technology adoption. Furthermore, the program successfully formed competent local technology cadres, with 85% of them proven to have mastered the operational and basic maintenance skills of the RO unit, and successfully installed one water purification unit that is now fully operational and communally accessible to all residents. This activity concludes that the integration of appropriate technology intervention with a community asset-based empowerment approach is a highly effective strategy not only for providing physical infrastructure but also for building community self-reliance and a sense of ownership, which are essential foundations for the sustainability of health and quality of life improvement programs in disadvantaged regions.

Keywords: Community Service, Reverse Osmosis, Clean Water, Asset-Based Community Development, Community Empowerment

INTRODUCTION

Universal access to safe drinking water and adequate sanitation is a cornerstone of global sustainable development and is explicitly articulated in Sustainable Development Goal (SDG) 6 (Shannon et al., 2008) . The availability of safe and affordable water is not only essential for human health, but also a prerequisite for economic progress, food security, and environmental sustainability (Laksono et al., 2025; Limuris, 2021). In this context, higher education institutions—particularly in Indonesia—are mandated to fulfil the Tri Dharma Perguruan Tinggi, which encompasses education, research, and community service (Firdaus et al., 2023). The role of universities as agents of change is therefore critical, as knowledge and technological innovations developed within academic settings are translated into practical solutions to address national challenges (Bui et al., 2024; Morawska-Jancelewicz, 2022). Community service initiatives in the field of clean water technology are no longer merely incidental programs; rather, they constitute a strategic necessity to bridge technological gaps and improve quality of life. The application of appropriate technology, such as water treatment systems, represents the tangible contribution of academic expertise in responding to national disparities in access to clean water while strengthening synergistic relationships between universities and surrounding communities.

Although Indonesia is rich in water resources, challenges related to distribution and the assurance of clean water quality remain critical in many areas, particularly in frontier, outermost, and underdeveloped (3T) regions such as Papua Province (Hari Hananto, 2020; Ihsan & Ilfan, 2025). One area facing serious constraints is Kampung Bibiosi, Arso Kota, Kabupaten Keerom (Nurjulasti et al., 2024). Field data indicate that only approximately 35% of households (KK) have limited access to clean water sources, while most residents remain heavily dependent on river water and shallow dug wells, the quality of which is highly questionable and not hygienically assured. This situation is compounded by the absence of adequate water treatment technology interventions. Reliance on unsafe water sources is

directly associated with a high prevalence of environmentally related diseases. Based on reports from the local community health center (Puskesmas), more than 120 cases of diarrhea and notable skin diseases were recorded among residents over the past year. These figures underscore the urgency of implementing effective environmental health interventions (Aziz & Zulha, 2018). The "Narwastu" worker group, as a local partner, has also experienced the direct consequences of this crisis, as work productivity declines due to recurrent health problems. The clean water crisis in Kampung Bibiosi is therefore not merely a technical issue; it has become a public health concern that constrains improvements in overall quality of life and community welfare.

A range of community service initiatives has been implemented to address clean water crises across various regions in Indonesia. Common approaches include the use of simple filtration technologies such as slow sand filters and ceramic filters, which have proven effective in reducing turbidity and certain biological contaminants. In addition, rainwater harvesting programs have been introduced as alternative solutions in areas with high rainfall but limited access to groundwater. For specific contaminants—such as elevated iron (Fe) and manganese (Mn) concentrations—aeration and sedimentation technologies are frequently adopted. Alongside technological advancements, more sophisticated treatment systems such as Reverse Osmosis (RO) have increasingly been applied, particularly in areas requiring drinking water with high purity. RO has been shown to be highly effective in removing up to 99% of total dissolved solids (TDS), heavy metals, bacteria, and viruses. Although these technologies have demonstrated success in many settings, the justification for implementing RO in Kampung Bibiosi is grounded in the complex contamination profile of the local water sources and the urgent need for potable water. The novelty of this initiative lies not only in the installation of the technology, but also in a community empowerment model that actively involves the Kelompok Narwastu in operation and maintenance to ensure long-term program sustainability.

In response to the urgent needs and existing solution gaps, this community service program was designed to implement an appropriate technology intervention in Kampung Bibiosi. The proposed solution is the installation and deployment of a Reverse Osmosis (RO)-based clean water treatment unit. This technology was selected due to its superior capability to purify water from multiple types of contaminants, thereby producing water that is not only physically clear but also safe and suitable for direct consumption. The program is structured systematically, covering equipment installation, operational and maintenance training, and ongoing mentoring on management and governance led by the local partner. Accordingly, this initiative explicitly aims to improve access to safe drinking water for the residents of Kampung Bibiosi through the application of Reverse Osmosis (RO) technology to support health and quality of life. Achieving this objective is expected to generate significant benefits, including:

- For participants (the community): Improved access to potable water, increased awareness of the importance of environmental health, and the acquisition of new skills to independently manage clean water technology.
- For the partner institution (Kelompok Narwastu): Enhanced capacity to manage communal clean water facilities and a strengthened active role in local-level community empowerment efforts.
- For the service team: A tangible contribution to improving community health outcomes while expanding productive collaboration networks with local communities for future sustainable programs.

METHODS

This community service program adopted the Asset-Based Community Development (ABCD) method as its primary framework. This approach was selected because it emphasizes identifying and mobilizing existing capacities and assets within the community rather than focusing on deficits or problems. In this context, the main asset identified was the presence of the "Narwastu" worker group, which demonstrates strong social cohesion and a willingness to learn. By leveraging this asset, the implementation of Reverse Osmosis (RO) technology became not merely a technology transfer activity, but a community-embedded empowerment process. The ABCD approach supports long-term program sustainability because active participation and a sense of community ownership—particularly among the "Narwastu" group—serve as the foundation for managing clean water technology. The target beneficiaries of this program were the general residents of Kampung Bibiosi, Kecamatan Arso Kota, Kabupaten Keerom, with a total of 50 household heads participating in the initial socialization stage. Technical empowerment efforts were primarily directed toward the "Narwastu" worker group as the core partner. The main activities were implemented intensively beginning on 6 August 2025 at the community site, namely Kampung Bibiosi, where access to clean water still requires particular attention.

The ABCD framework in this program was operationalized through a series of participatory processes that positioned the community as the primary agent of development. Unlike deficit-based approaches, the service team did not act as experts delivering a single solution; instead, the team served as facilitators who stimulated awareness and optimized local resources. The initial step involved asset mapping conducted jointly with community leaders to identify internal strengths, which highlighted the "Narwastu" group as the most promising form of social capital to be engaged in technology management. The subsequent process linked this asset with an external opportunity, namely Reverse Osmosis (RO) water purification technology. Program implementation was designed in the form of participatory workshops and training sessions. The socialization session included a structured presentation on the urgency of clean water, followed by a Focus Group Discussion (FGD) to explore residents' perceptions and lived experiences. Meanwhile, the technical training session for the "Narwastu" group applied a learning-by-doing model, in which participants not only received theoretical instruction on RO installation and maintenance but also engaged directly in demonstrations and hands-

on installation practice under the team's supervision. This approach provided a practical understanding of how the technology functions and strengthened partners' confidence to manage it independently in the future.

Program delivery was structured systematically into four interconnected stages to ensure comprehensive achievement of the objectives. The program began with a one-day socialization stage involving 50 household heads in Kampung Bibiosi. This stage aimed to build collective awareness regarding the importance of consuming safe and adequate clean water and its implications for health. The effectiveness of the socialization was assessed by evaluating participants' understanding using pre-test and post-test instruments. The program then proceeded to a more targeted technical training stage for 10 members of the "Narwastu" worker group, who served as technology cadres. This training was conducted over two days and focused on transferring knowledge and practical skills related to installing, operating, and performing routine maintenance of the RO purification system. As in the previous stage, improvements in participant competence were measured using pre-test and post-test assessments. The next stage focused on implementation: over two days, the service team collaborated with the community and the "Narwastu" group to install the RO unit at an agreed location. Evaluation at this stage was conducted qualitatively through observation of the availability and functionality of the installed clean water unit. Finally, the program concluded with a sustainability stage, in which the service team committed to conducting monthly monitoring and evaluation visits to inspect equipment conditions and provide additional assistance as needed.

To assess program success objectively and systematically, several evaluation instruments were applied in alignment with each program stage. The primary instrument consisted of pre-test and post-test questionnaires. These questionnaires were designed to measure changes in participants' knowledge and understanding before and after the socialization session on the importance of clean water, as well as before and after the technical training session on RO technology. Quantitative data derived from the questionnaires were analyzed statistically to determine the significance of improvements in participant understanding. In addition, to capture participation and practical skill development, a structured observation sheet was used. This sheet was completed by the service team during the training and installation phases. Observed indicators included the level of participant engagement in discussions, the ability to follow instructions, proficiency in assembling components, and initiative in problem-solving. The success of the physical implementation was also measured using a functionality checklist to confirm that the RO unit was installed correctly and was capable of producing clean water in accordance with the expected standards. Finally, to assess participant satisfaction and perceptions of the overall program, a feedback questionnaire was distributed at the end of the activity series. This instrument included closed-ended and open-ended questions regarding the relevance of the materials, the delivery methods, and the benefits perceived by the community.

RESULT AND DISSCUSSION

The implementation of the community service program in Kampung Bibiosi, Kabupaten Keerom, was successfully completed through a series of structured and participatory stages. All activities were designed to ensure the achievement of the primary objective, namely improving access to potable clean water through the implementation of Reverse Osmosis (RO) technology. The following presents a detailed account of the outcomes achieved at each stage of the program.

Stage 1: Socialization and Strengthening Community Awareness

The first stage focused on establishing a foundation of collective awareness among community members regarding the urgency of clean water and its health implications. This socialization activity was conducted on 3 August 2025 at the Kampung Bibiosi community meeting hall and successfully engaged the active participation of 50 household heads (KK). The session began with a presentation of contextual data on water access conditions in the village, indicating that only approximately 35% of households had limited access to relatively cleaner water sources. The service team directly linked this situation to local health data from the Puskesmas, which recorded more than 120 cases of diarrhea and skin diseases over the past year, providing concrete evidence of the health impacts associated with consuming water of unverified quality. The socialization materials covered three main pillars: (1) identifying high-risk water sources and recognizing indicators of contaminated water; (2) explaining waterborne diseases and their impacts on productivity and household welfare; and (3) introducing Reverse Osmosis (RO) technology as an appropriate solution to be implemented, with emphasis on its advantages in filtering harmful contaminants down to microscopic levels.

Figure 1. Socialization on the Use of RO Technology and Clean Water for Participants

To measure the effectiveness of knowledge transfer, evaluation instruments in the form of pre-tests and post-tests were used. The pre-test administered at the beginning of the session showed that the community's initial understanding of the relationship between water quality and health remained at a basic level, with an average score of 48 out of 100. Most participants did not yet understand specifically how contaminants in river water or shallow dug wells could cause disease. After the material presentation and the Focus Group Discussion, the post-test was administered using the same set of questions. The analysis indicated a highly

significant increase in understanding, with the average score rising to 89 out of 100. This improvement suggests that the interactive and contextual socialization method was effective in fostering new awareness and understanding within the community.

Stage 2: Technical Training and Empowerment of Local Cadres

Following the socialization stage, the program continued with a more intensive two-day technical training. This stage specifically targeted 10 members of the "Narwastu" worker group, who had been identified as a community asset and prepared to serve as local technology cadres. The training adopted a learning-by-doing model in which theory and practice were integrated directly to ensure deep mastery of skills. Training materials covered a comprehensive spectrum, including the basic principles of RO membrane technology, an introduction to each component of the installation unit, correct assembly and installation procedures, and daily operational guidelines. Particular emphasis was placed on routine maintenance, such as backwashing techniques to clean the membrane, schedules for replacing sediment and carbon filters, and the identification and handling of common issues that may occur (troubleshooting).

Figure 2. Socialization on the Benefits of Water in Bibiosi

Evaluation at this stage also used pre-test and post-test approaches to measure improvements in technical knowledge, as well as a structured observation sheet to assess practical skill mastery. The pre-test results indicated that participants' initial technical knowledge of the RO system was very limited (average score of 35). However, after two days of intensive training, post-test results showed a dramatic increase in understanding, with an average score reaching 91. More importantly, practice-based observational evaluation demonstrated that participants developed strong competence. They were able to collaboratively assemble the RO unit from separate components, operate the system according to procedures, and conduct basic maintenance simulations under minimal supervision from the service team.

Stage 3: Implementation and Installation of the RO Technology Unit

The implementation stage represented the culmination of the technology transfer, during which the RO-based water purification unit was permanently installed at a location agreed upon with the community. This two-day activity was conducted collaboratively, involving the service team, trained members of the "Narwastu" group, and participation from nearby residents. This installation process also served as a practical skills assessment for the "Narwastu" cadres, as they led the assembly and installation process while the service team acted as facilitators. The RO unit was placed in a strategic and easily accessible location for all residents, ensuring equitable distribution of benefits.

Figure 3. Deployment and Testing of RO Equipment Use

Evaluation at this stage was qualitative and functional. The team used a functionality checklist to confirm that all components were installed correctly, that there were no leaks in the piping system, and that the unit could operate stably. After installation was completed, the first operational test successfully produced clean water. An initial field-based quality test of the treated water was conducted in a simple manner, indicating a sharp reduction in total dissolved solids (TDS) compared with the source water. The successful installation and functionality of the unit provided concrete physical evidence of technology implementation and directly established a new clean water source for the community of Kampung Bibiosi.

Stage 4: Monitoring and Sustainability Plan

The final stage involved designing a sustainability mechanism to ensure that program benefits can be realized over the long term. The service team committed to conducting regular monthly monitoring and evaluation visits for the next six months. The objectives of this monitoring are to inspect the physical condition and functionality of the equipment, provide additional assistance to the "Narwastu" group if operational constraints are identified, and ensure that water management and distribution mechanisms operate according to community agreements. The

sustainability of this program relies on the independence of the "Narwastu" group as the primary manager.

Table 1. Comparison of Community Knowledge, Skills, and Access to Clean Water Before and After the Program

No	Before the Program	After the Program
1	The general community's understanding of the relationship between water quality and health was at a basic level (average pre-test score 48/100).	General community understanding increased significantly, with an average post-test score of 89/100.
2	The local cadres' technical knowledge (Kelompok Narwastu) regarding Reverse Osmosis (RO) water treatment technology was very limited (average pre-test score 35/100).	Local cadres' technical knowledge increased sharply, with an average post-test score of 91/100.
3	Local cadres did not yet have practical skills to operate, maintain, and conduct basic troubleshooting on the water treatment unit.	As many as 85% of local cadres (Kelompok Narwastu) became skilled and able to independently practice basic operation and maintenance of RO technology.
4	Access to potable clean water was very limited (only ~35% of households), with most residents relying on river water and shallow dug wells of uncertain quality.	The community gained direct and sustainable access to potable clean water from the installed RO technology unit.
5	High prevalence of environmentally related diseases, with more than 120 cases of diarrhea and skin diseases recorded in the past year.	The risk of environmentally related diseases can be reduced significantly due to the availability of safe and hygienic water sources.
6	There was no structured, independent community-based management system for communal clean water facilities.	Community self-reliance was established through Kelompok Narwastu serving as the primary manager of the communal clean water facility.
7	Full dependence on natural water sources of questionable quality without adequate water treatment technology intervention.	The community became able to adopt and utilize appropriate technology (RO) to independently ensure the quality and availability of clean water.

The main outcomes of the overall community service program are as follows:

1. A total of 92% of socialization participants stated that their understanding increased significantly regarding the importance of using clean water for health, based on analysis of pre-test and post-test data.
2. As many as 85% of the trained technology cadres (members of Kelompok Narwastu) were able to independently demonstrate basic use and maintenance of RO technology, based on practical observation results.
3. Participant satisfaction with the overall program reached 95%, based on the distributed feedback questionnaire, indicating that the program was very well received and considered relevant by the community.

4. The community of Kampung Bibiosi now demonstrably has direct access to potable clean water through one RO technology unit that has been installed and is fully operational.
5. Kelompok Narwastu has acquired adequate technical skills in the management and maintenance of clean water technology, serving as the main foundation for program sustainability.
6. An early foundation of community self-reliance has been established in maintaining the quality and sustainability of the communal clean water source, managed by local cadres from within the community itself.

To provide a clearer illustration of participants' knowledge improvement, the pre-test and post-test data can be presented in the form of a comparative bar chart as illustrated in Figure 1 (not shown).

Discussion

A detailed analysis of the outcomes indicates that this community service program was not only procedurally successful, but also substantively achieved its objectives and generated a meaningful impact. The following discussion explains how these results logically address the program objectives, their practical implications for the partner community, their position within a broader scientific context, and a critical reflection on the program's strengths and limitations.

Achievement of the program's primary objective—"to improve the community of Kampung Bibiosi's access to potable clean water through the application of Reverse Osmosis (RO) technology to support health and quality of life"—can be directly verified through the outcomes presented above. First, the physical installation of the RO unit that is now fully operational in Kampung Bibiosi constitutes the most concrete manifestation of improved access. Previously, the community relied on unverified water sources; now, residents have an alternative source that has undergone high-standard purification. Second, this achievement is not merely technical, but is also supported by increased human resource capacity. A 92% improvement in understanding among the general community regarding the importance of clean water creates demand and appreciation for this new facility. This is crucial because without awareness, even advanced technology risks being underutilized. Third, the technical skill mastery demonstrated by 85% of Kelompok Narwastu members serves as a pillar of sustainability. This ensures that access to clean water will not cease after the service team leaves the site. Their ability to operate and maintain the RO unit independently provides assurance that the technology will continue to function and support community quality of life in the long term. Thus, the combination of physical infrastructure provision (the RO unit), awareness building (knowledge), and empowerment of local managers (skills) has synergistically achieved the stated objective.

The practical implications of these outcomes for the community of Kampung Bibiosi are transformative and multidimensional. The most direct and vital benefit concerns public health (Wulandari Putri, 2024). With access to potable water, the risk

of environmentally related diseases such as diarrhea and skin diseases—previously exceeding 120 cases per year—can be reduced significantly. This directly contributes to improved community health status, lowers the burden of medical expenses, and increases residents' productivity, including that of the "Narwastu" worker group, which had previously been frequently disrupted by health issues. Socially, the program strengthened social capital within the community. Empowering Kelompok Narwastu as technology cadres provided them with a new and positive role and standing within the community, while also fostering collective ownership and responsibility for the communal facility. This community-based management model, rooted in the Asset-Based Community Development (ABCD) approach, ensures that the solution introduced is not an "outsider's project," but rather a "shared asset." Economically, although not measured directly, the availability of clean water may reduce household spending on bottled drinking water or on fuel for boiling water. Moreover, the new skills acquired by Kelompok Narwastu may create opportunities for social entrepreneurship in the future—for example, by managing a small-scale refill drinking water unit for the village. Accordingly, the program outcomes extend beyond water provision alone by also affecting health, social cohesion, and potential community economic gains (Kementerian Kesehatan, 2017).

Within the broader academic context and community service practice, these results provide several important confirmations and contributions. The successful application of RO technology for community-level drinking water provision aligns with previous findings, as reported by (Sisnayati, 2022), (Suhartawan, 2025) in Desa Buruk Bakul. This further reinforces that membrane-based technology, particularly RO, is highly effective for addressing complex water quality problems across various regions of Indonesia. However, the main novelty and contribution of this program lies in the strong integration of technological intervention (hard-system) with an asset-based community empowerment approach, namely Asset-Based Community Development (ABCD) (soft-system), a framework advocated by (Hidayat, 2023). Unlike many technology transfer programs that are top-down, the ABCD approach applied here—mobilizing Kelompok Narwastu as an internal asset—proved effective in cultivating a strong sense of ownership and ensuring sustainability. These results support the argument of (Mathie & Cunningham, 2015) that a paradigm shift from "clients" to active "citizens" is a key determinant of success in community-based development. Therefore, this program not only demonstrates the technical effectiveness of RO, but also presents a participatory implementation model that can be replicated for similar programs in other locations, particularly in 3T areas.

Although the program is considered successful, a critical reflection indicates several limitations that should be acknowledged. First, there is a limitation in the scale of empowerment. Intensive technical training was focused only on 10 members of Kelompok Narwastu. While effective in establishing a competent core team, this creates a risk of high dependence on a small number of individuals. Regeneration processes and further knowledge transfer to other community members have not yet been formally institutionalized, posing a challenge for long-term sustainability. Second, the economic sustainability dimension has not been fully addressed. The

program provided initial installation and mentoring, but long-term operational costs—particularly for replacing RO membranes, which have a limited lifespan and are relatively expensive—require an independent financial scheme. Follow-up actions are needed to design a contribution model or a small-scale business unit to ensure that future maintenance costs can be covered independently by the community. On the other hand, the program's main strength lies in its methodological approach. The use of ABCD from the outset ensured that the program was designed with the community, not for the community. Identifying and leveraging Kelompok Narwastu as a local asset was a key success factor that made the technology feel familiar and easier to adopt. Another strength is the selection of appropriate RO technology, which provides the highest assurance of water quality and comprehensively addresses complex contamination problems that cannot be resolved by simple filters.

CONCLUSION

The community service program in Kampung Bibiosi successfully implemented Reverse Osmosis (RO) technology as a solution for providing potable clean water through a structured and participatory empowerment approach. Based on the analysis of the results and discussion, it can be concluded that the program's primary objective—improving community access to clean water to support health and quality of life—was achieved comprehensively. This conclusion is supported by several key indicators: first, a substantial increase in community understanding (92%) regarding the urgency of clean water, which established a foundation of collective awareness; second, the development of local technical capacity through intensive training, with 85% of cadres from Kelompok Narwastu now able to operate and maintain the RO unit independently; and third, the installation of a fully functional RO unit that has tangibly provided the community with direct access to a water source with assured quality. This achievement resulted from synergy between technological intervention (hard-system) and human resource empowerment (soft-system) through the adoption of the Asset-Based Community Development (ABCD) framework, which mobilized Kelompok Narwastu as an internal community asset. Accordingly, the program not only delivered physical infrastructure but also established a strong foundation of self-reliance and community ownership, which is essential for sustaining program benefits over the long term.

Recommendations

Based on reflections on the implementation process and the outcomes achieved, several recommendations are proposed for partners and future community service implementers to ensure program sustainability and continued development. For the partner, Kelompok Pekerja "Narwastu" (Kelompok Narwastu), as the primary management cadre, it is recommended to take proactive steps to institutionalize a sustainable management system. This includes designing and disseminating an affordable communal contribution scheme or developing a micro-enterprise based on the sale of refill drinking water. Such a mechanism is intended to strengthen financial self-reliance to cover routine operational costs and, most importantly, future RO membrane replacement costs. In addition, Kelompok Narwastu should establish a

structured regeneration and knowledge-transfer program for other community members, particularly younger generations, to prevent over-reliance on a small number of individuals and to ensure that clean water management skills become a shared asset of the broader community. For future community service teams and researchers working on similar issues, it is recommended that subsequent initiatives strengthen both impact evaluation and the economic sustainability dimension. Specifically, long-term quantitative research methods should be integrated to statistically measure the intervention's effect on reducing the prevalence of waterborne diseases by periodically comparing health data before and after the program. Moreover, follow-up work may focus on designing and implementing a comprehensive social business model for communal water treatment units that addresses not only financial sustainability but also organizational management and social marketing strategies, thereby producing a tested pilot model that can be replicated in other communities with similar characteristics.

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