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Introduction of Solar Desalination Technology with Cooling Fans for Clean Water Supply in Warmon Kokoda Village Sorong City Southwest Papua

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Abstract: The issue of clean water availability in coastal areas remains a serious challenge, particularly due to increasing seawater intrusion, which causes groundwater to become brackish and unfit for consumption. This condition is also experienced by the community in Warmon Kokoda Village, Sorong Regency, who have long depended on well water sources with high salinity levels. This community service activity aimed to introduce and train residents in the use of single-roof solar desalination technology with a solar-powered cooling fan as an energy-efficient and environmentally friendly solution for brackish water purification. The approach used was Participatory Action Research (PAR), in which the community was actively involved in socialization, learning, and hands-on practice in the manufacture and operation of the device. The results of this activity showed an increase in community knowledge about the working principles and benefits of solar desalination technology, as evidenced by the community's ability to conduct trials on the device. Technical tests showed that the device was able to reduce the salinity of brackish water from 5% to 0%, producing water suitable for consumption according to WHO standards, with good thermal efficiency for the household category. This activity had a significant impact in providing access to safe and potable water for the local community, as well as increasing independence in water resource management.
Keywords: Solar desalination, brackish water, renewable energy, cooling fan.

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INTRODUCTION

The availability of clean water is one of the global strategic issues that directly impacts the sustainability of human life, especially in coastal and island areas that are vulnerable to seawater intrusion. Globally, more than 2.2 billion people still do not have access to proper drinking water, with nearly 40% of them living in tropical regions where water quality continues to decline due to climate change and increasing salinity (Delgado et al., 2020; Shammi et al., 2019). Seawater intrusion causes an increase in salt levels in groundwater, reduces agricultural productivity, and affects public health due to high sodium levels in drinking water, which can trigger hypertension and kidney disorders (Indonesian Ministry of Health, 2010; Shammi et al., 2019). In this context, the use of renewable energy especially solar power—is one of the most promising solutions for providing sustainable and environmentally friendly clean water (Wulandari & Hamzah, 2021).

In Indonesia, similar challenges occur in various coastal areas, including eastern regions such as Southwest Papua, where most communities still rely on shallow groundwater as their main source of domestic water. Data from the Ministry of Public Works and Public Housing (2023) shows that more than 18% of Indonesia's coastal areas have experienced a decline in groundwater quality due to seawater intrusion. This condition is also experienced by the community of Kampung Warmon Kokoda, Sorong Regency, who use well water with high salt content as their daily water source. Field observations show that the well water in this area is brackish, with a salinity level exceeding 4–5%, making it unfit for consumption without purification. Limited clean water infrastructure and the unavailability of inexpensive and easy-to-apply water treatment technology at the household level exacerbate this condition.

One potential approach to address this problem is solar desalination, which is a technology for purifying brackish or seawater by utilizing solar energy for evaporation and condensation. This technology is very suitable for application in tropical climates such as Indonesia because it is low-cost, eco-friendly, and does not rely on fossil fuels (El-Morsi et al., 2012; El-Aziz et al., 2013; Ghermandi et al., 2017; Sitorus & Arifin, 2024). Research shows that solar desalination systems are capable of producing high-efficiency, potable freshwater. Ahmad, Lestari, and Putra (2020) found that modifying the condenser in solar distillation systems can increase freshwater production efficiency by up to 30%. Efficiency improvements were also reported by Rahman, Hidayat, and Sari (2021), who applied an active cooling mechanism to accelerate the water vapor condensation process. Additionally, research by Putra and Santoso (2022) showed that active cooling-based desalination systems produce clean water with more stable productivity under high temperature variations.

Recent developments in this field show significant improvements through the application of cooling fan and external collector systems to accelerate the condensation process and maintain temperature stability. Research by Hidayat et al. (2024) shows that the integration of solar-powered cooling fans in distillation systems increases clean water productivity by up to 25% compared to conventional systems without cooling. Meanwhile, Pradana, Rini, and Nugroho (2022) emphasize that the combination of external cooling and active air circulation can optimize the distillation process with up to 40% higher thermal efficiency. These studies confirm that innovations in solar desalination technology are key to the sustainable provision of clean water in tropical regions.

This community service activity adapts the results of this research by introducing a single-roof solar desalination technology with the help of solar-powered cooling fans, which were developed and adapted to the needs of the Warmon Kokoda community. This tool is designed to be easy to make, low cost, and can be operated independently using local materials such as glass, metal, and flannel fabric. Through training and hands-on practice, the community was invited to understand the basic principles of solar desalination and test the effectiveness of the device in reducing the salinity of brackish water to meet drinking water standards (WHO, 2023; Indonesian Ministry of Health, 2010). This program is implemented using a Participatory Action Research (PAR) approach that emphasizes collaborative learning and capacity building for the community in the use of appropriate technology (Qomar et al., 2022; Soedarwo et al., 2022). Thus, this activity not only contributes to the provision of clean water but also to increasing the technological literacy and ecological awareness of coastal communities, in line with the achievement of Sustainable Development Goals (SDGs) point 6 (Clean Water and Sanitation) and point 7 (Affordable and Clean Energy).

METHOD

2.1. Activity Approach

This community service activity uses the Participatory Action Research (PAR) approach, which places the community as active partners in every stage of the activity, from problem identification, tool design, prototype training, to evaluation of results and reflection. This approach was chosen because it is in line with the principle of community empowerment, which is oriented towards collaborative learning and behavior change based on community participation (Lestari et al., 2021). Through this approach, the community is not only the beneficiary but also the main actor in the process of imple*menting appropriate technology.*

2.2. Location, Time, and Activity Participants

The activity was carried out in Warmon Kokoda Village, Mayamuk District, Sorong Regency, Southwest Papua Province, in October 2025. This area was chosen based on the results of a preliminary survey which showed that the residents' well water was brackish with a TDS level of more than 5000 ppm and a salinity level of more than 4% (measured with hand refractometer). The activity was attended by eight participants who were representatives of the Warmon Kokoda community, consisting of the neighborhood association (RT) chairman, youth, and village leaders. The number of participants was limited due to the activities of the surrounding community outside the village (fishing and gathering forest products).

2.3. Materials and Tools

The main materials used in the construction of the desalination system included brackish water as the raw material, tempered glass as the collector cover, aluminum reflector containers, flannel cloth wicks as the absorption medium, and solar-powered fans as the condensation cooling system. A 30 W solar panel was used as the main energy source to power the fans. The supporting tools used include a digital thermometer, multimeter, digital scale, pH meter, and salinity meter to monitor the effectiveness of the distillation process. The selection of materials and tools is based on the principles of low-cost, local-based, and sustainable, so that this technology can be replicated independently by the local community using available local resources.

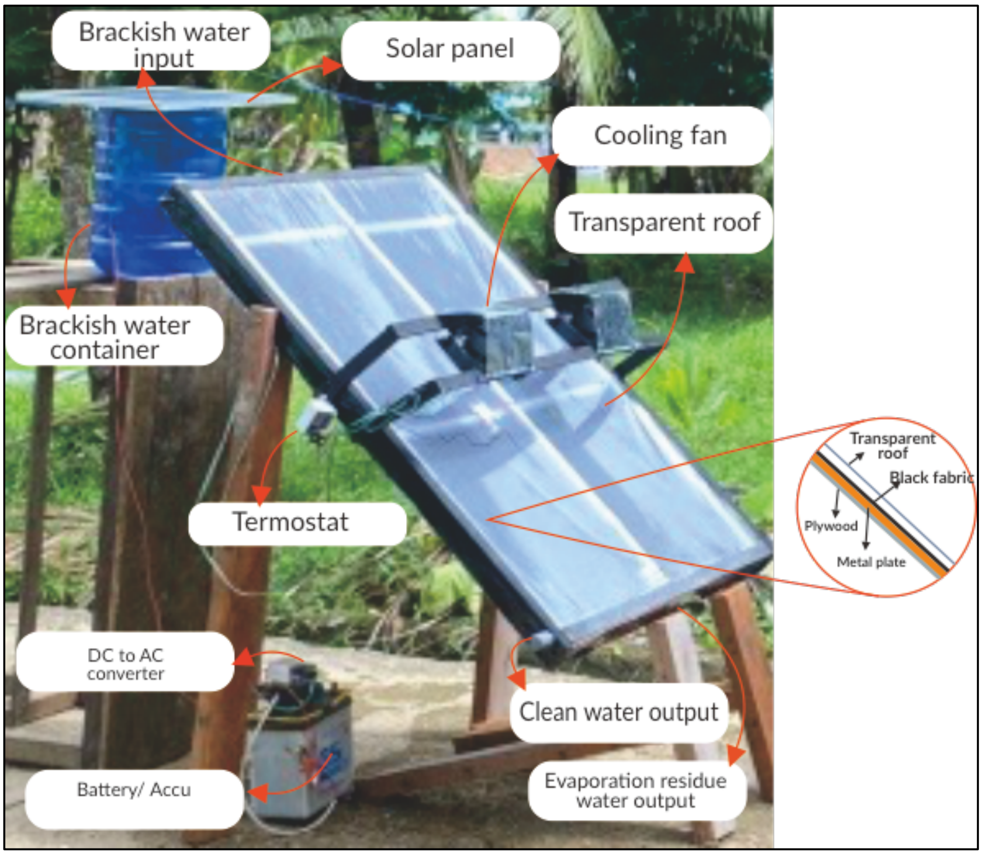

Figure 1. Design of a solar desalination device with an axial system and cooling fan.

2.4. Activity Stages Based on the PAR Cycle

The activities were carried out in four main stages in accordance with the Participatory Action Research (PAR) cycle: planning, acting, observing–reflecting, and replanning.

2.4.1. Planning Stage

This stage began with a survey of water conditions in Warmon Kokoda Village to identify the salinity and quality of residents' well water. The implementation team then held group discussions with the community to map out the problems and determine appropriate technological solutions. Together with the participants, a plan was drawn up to build a cooling fan-based solar desalination device using local materials. At this stage, evaluation instruments were also prepared in the form of observation sheets, pre-test and post-test questionnaires, and practical worksheets to monitor participant involvement and understanding during the activity.

2.4.2. Acting Stage

The core stage of the activity was hands-on training in the manufacture of solar desalination devices. Participants were trained directly to assemble prototypes through the following steps: (a) preparing glass containers and heat collectors, (b) installing flannel wicks as a medium for brackish water capillarization, (c) placing solar panels and cooling fan systems in optimal positions to increase condensation, and (d) conducting initial trials of the distillation process. The training was conducted collaboratively between lecturers, students, and the community, so that participants understood the working principles of the device and could operate it independently.

2.4.3. Observation and Reflection Stage

At this stage, observations were made on the performance of the device during the distillation process, including measurements of temperature, volume of distilled water, and salinity level of the clean water produced. The implementation team and the community recorded the changes that occurred and discussed the test results through a joint reflection session. The reflection focused on technical constraints (such as temperature stability, condensation efficiency, and material strength) and the potential for developing the system for household use. Through this process, participants not only evaluated the results but also understood the scientific principles behind solar desalination technology.

2.4.4. Reorientation (Replanning) Stage

Based on the reflection results, a follow-up plan was developed in the form of technical assistance in equipment maintenance and further training for long-term efficiency testing. Participants are also invited to identify the potential for replicating the equipment in their own homes by utilizing local materials such as used glass, reflector cans, and simple DC fans. This stage is an important step in ensuring the sustainability of the program and expanding the social and ecological impact of community service activities in Warmon Kokoda Village.

2.5 Data Collection and Analysis Techniques

Data was collected through participatory observation, semi-structured interviews, and documentation during the activities. In addition, pre-tests and post-tests were conducted to measure the increase in community knowledge about the working principles and benefits of solar desalination technology. Data analysis was conducted using descriptive qualitative methods, comparing the level of understanding and skills of the community before and after the activity, as well as evaluating the effectiveness of the tools by measuring the volume of distilled water and the reduction in salinity levels.

RESULTS AND DISCUSSION

The community service activity on the application of solar desalination technology with a cooling fan system was carried out in Warmon Kokoda Village, Aimas District, Sorong Regency, involving eight community representatives consisting of housewives and local youths. Before the activity began, the community did not have an understanding of the working principles of solar desalination technology or methods of brackish water purification, because they had been relying on brackish well water due to seawater intrusion. The activity began with a socialization session on the importance of sustainable water resource management and the impact of seawater intrusion on health, followed by a training session and hands-on training on making simple solar desalination devices. The device introduced was a single-roof solar desalination system with a cooling fan powered by solar energy, designed to be easily replicated by the community at low cost using locally available materials. The structure of the device consists of a black-coated metal basin as a heat collector, a flannel axis for brackish water capillarization, slanted transparent glass as a condensation roof, and a low-power DC fan driven by a 30-watt solar panel to accelerate cooling and water vapor condensation. This single-roof design allows the evaporation and condensation processes to occur in one compact unit, with a working principle that relies on solar heat and active air circulation to increase distillation efficiency.

After the device was assembled with the community, a field test was conducted using brackish water from a local well. Salinity measurements were taken using a special handheld salinity refractometer to compare conditions before and after the purification process. The test results showed that brackish water with an initial salinity level of 5% (5,000 ppm) was successfully purified to a salt level of 0% (0 ppm) after undergoing a desalination process for about five hours under solar radiation intensity of 920–950 W/m². These results prove that the distilled water is suitable for consumption, in accordance with WHO (2023) standards for clean drinking water. The average volume of water produced reached 2 liters per square meter per day with a sufficiently high thermal efficiency for a household appliance. The use of solar-powered cooling fans has been proven to increase the condensation rate and volume of fresh water production by around 20–25% compared to conventional systems without cooling, as also reported by Hidayat (2024). The success of this trial confirms that the device's design is not only energy efficient but also capable of meeting the community's need for clean water in a practical and sustainable manner.

Beyond the technical aspects, this activity also showed a significant increase in community knowledge and attitudes toward brackish water management and solar desalination technology. Based on the results of a pre–post test evaluation of three main indicators—knowledge about brackish water purification, understanding of solar desalination methods, and interest in replicating the device—all participants showed a very high increase after the activity. As shown in Figure 1, residents' knowledge of brackish water purification increased from 0% to 85%, understanding of solar desalination methods increased to 85%, and interest in replicating the device in their own homes reached 90%. This improvement shows that the Participatory Action Research (PAR) approach with a hands-on training model is effective in building technological literacy and ecological awareness among coastal communities. The community not only understands the scientific principles behind the solar distillation process, but is also able to assemble and operate the device independently, and shows a strong desire to apply this technology in their daily lives.

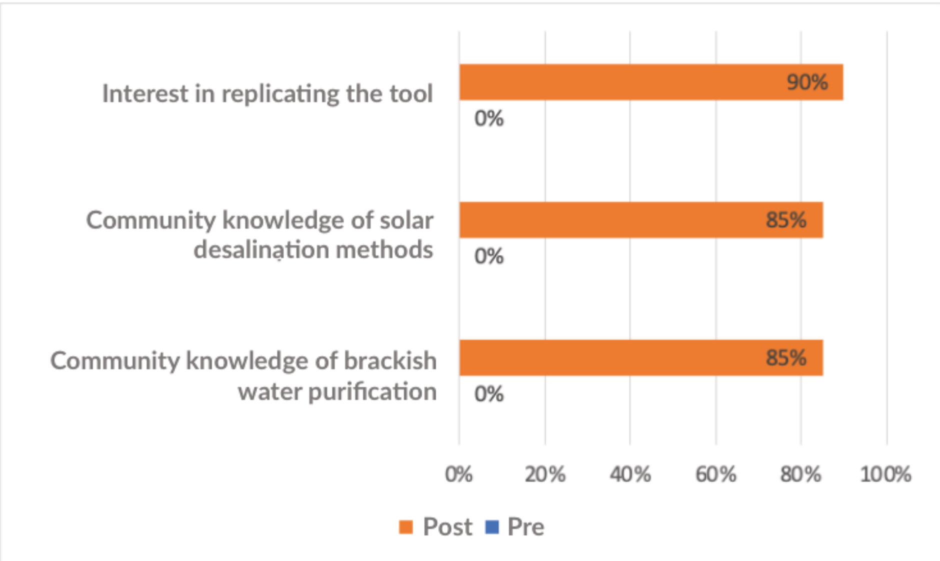

Figure 2. Results of measuring community knowledge related to solar desalination methods and interest in replicating the device before and after the activity.

Overall, this community service activity shows that the single-roof solar desalination technology with an axis system and solar-powered cooling fans can be a practical and sustainable solution for coastal communities facing seawater intrusion problems. Through a participatory approach and hands-on training, this activity has succeeded in increasing the community's knowledge, skills, and awareness of clean water management based on renewable energy. In addition to contributing to improving the quality of life of the Warmon

Kokoda community, the application of this technology also supports the achievement of Sustainable Development Goals (SDGs) point 6 (Clean Water and Sanitation) and point 7 (Affordable and Clean Energy), emphasizing the importance of utilizing solar energy as a local solution to global problems related to clean water availability.

Based on interviews with the local neighborhood association (RT) chairman, the community responded positively to this community service activity. The RT chairman said that residents were very grateful for the solar desalination device and enthusiastically welcomed this innovation. He also understands that this device is a form of applying science and technology in meeting clean water needs. The community's hope for the future is that this technology can continue to be developed and applied more widely, especially in areas that still have limited access to clean water.

Figure 3. Documentation of activities, (a) Field observation; (b) Design, tool testing, and redesign; (c) Implementation of activities.

CONCLUSION

The community service activities in Warmon Kokoda Village show that the application of a single-roof solar desalination technology system with the help of solar-powered cooling fans is an effective and sustainable solution to overcome brackish water problems caused by seawater intrusion. Through the Participatory Action Research (PAR) approach, the community was involved in socialization, learning, and hands-on practice activities on how to make and operate the device, thereby gaining a new understanding of solar-based water purification technology. The results of the activity showed that the device introduced was able to purify brackish water into potable water with good efficiency and without dependence on fossil fuels. This activity successfully increased community knowledge and awareness of the importance of independent water resource management and the potential for utilizing renewable energy in their environment. Overall, this program made a real contribution to the achievement of Sustainable Development Goals (SDGs) point 6 (Clean Water and Sanitation) and point 7 (Affordable and Clean Energy), and served as an example of the application of appropriate technology that is relevant and replicable in other coastal areas in Southwest Papua.

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