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Assistance for Pokdarwis Zwageri Borneo in providing clean water needs for rural tourism areas

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ABSTRACT

The dune plays a crucial role in the community life of Sumberkejayan Village, Mayang Subdistrict, Jember Regency. The decline in its functionality began in 2017, coinciding with a tornado and a reduction in the water discharge from community water sources around the dune. In response to these developments, the team initiated a program aimed at restoring the functionality of the dune within the Sumberkejayan Village area. The objective of this program is twofold: to reinstate the functionality of the dune and to emphasize the importance of caution in the buying and selling of dunes by its owners. Vegetative and renegotiation methods are employed through replanting (reforestation) using Sengon Solomon planting media. Sengon Solomon was selected for its rapid development compared to other types of sengon. Concurrently, renegotiation serves as a remedy in the buying and selling process, addressing disparities in agreements regarding dunes. Renegotiation provides alternative solutions for disadvantaged parties, aiming to restore the terms of the agreement and the conditions of the involved parties.

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1. INTRODUCTION

Manunggal Jaya Village serves as the administrative center of Tenggarong Seberang Subdistrict in Kutai Kartanegara Regency, which was formerly one of the transmigration villages established in the 1980s, comprising settlers from various villages in Java and West Nusa Tenggara. Presently, the village has a population of 3,818 inhabitants, with 15.6 percent engaged in private employment, 10.7 percent in entrepreneurship, and 5.1 percent in agriculture or horticulture. Geographically, the area of Manunggal Jaya Village spans 261.02 hectares, with agricultural land occupying 23.5 percent, settlements 11 percent, and communal forests 23.3 percent (Pemerintah Desa Manunggal Jaya, 2023).

Agriculture constitutes a significant livelihood source in Manunggal Jaya Village. However, over time, agricultural areas have become encircled by mining zones, leading to land use conversion. Efforts to mitigate this conversion include the establishment of multifunctional farmer groups, designated

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as facilitator entities for local farmers. Collaborative programs between these multifunctional farmer groups and individual farmers aim to empower and sustain agricultural practices in Manunggal Jaya Village. The ample agricultural land in the village is being leveraged to foster community involvement by establishing a Tourism Awareness Group (Pokdarwis) and developing a "Zwageri Borneo" Rice Field Tourism Village. The formation of Pokdarwis is anticipated to initiate efforts to raise awareness among locals regarding the pivotal role of tourism in comprehensive and sustainable village development.

The planned tourism attractions in Manunggal Jaya Village are primarily based on agro-tourism. Agro-tourism aligns well with Indonesia's tourism development goals (Syah, 2017). Activities envisaged by Pokdarwis Zwageri Borneo include rice farming, fruit orchards, fisheries, and animal husbandry. Present facilities include one gazebo, two designated photo spots within the rice field area, a solar power generator with a capacity of 3,000 watts, and a water reservoir with a capacity of 2,000 liters (Meicahayanti et al., 2023).

Tourism sites in Kutai Kartanegara Regency lack adequate development in terms of infrastructure and facilities renewal to attract tourists (Kurniawan et al., 2017). Agro-tourism activities necessitate supportive infrastructure and facilities. Key infrastructure requirements include general facilities such as clean water supply, electricity supply, road networks, telecommunication networks, and drainage systems (Suwantoro, 2004) as indicated by Trimurtiningrum & Saves (2022) and Ferdy et al. (2022).

Observations conducted on-site reveal that the planned agro-tourism site managed by Pokdarwis Kampoeng Sawah Zwageri Borneo faces challenges due to inadequate supporting infrastructure. One lacking facility is the provision of clean water for sanitation, UMKM (Micro, Small, and Medium Enterprises) stalls, etc. Raw water sources available at the tourism site are from former mining ponds currently unused for mining activities. While the quantity of raw water is deemed sufficient for tourism purposes, its quality requires improvement, particularly regarding turbidity (7.54 – 24.7 NTU), Fe (0.7 – 1 mg/l), and Mn (0.1 – 0.3 mg/l), exceeding the standard thresholds. Initial studies indicate a total water demand for Kampoeng Sawah Zwageri Borneo at 33,339.43 liters per day or 33.34 cubic meters per day (Meicahayanti et al., 2023).

The determination of water treatment technology suitable for the moderate turbidity level entails the utilization of Horizontal Roughing Filter (HRF) units. HRF units function as physical treatment systems aimed at reducing particles causing turbidity, including non-settleable colloidal particles (< 1µm) and small supracolloidal particles (< 10µm) (Losleben, 2008; Wegelin, 1986). Horizontal Roughing Filters exhibit higher effectiveness compared to vertical roughing filter types (Nkwonta, 2010; Ochieng & Otieno, 2006; Setyobudiarso et al., 2022). Moreover, the raw water quality containing Fe and Mn can be mitigated through aeration, filtration, or chemical addition. Aeration-filtration combinations are also viable (Masduqi & Assomadi, 2019). The Multiple Tray Aerator is selected for application in the water treatment plant unit due to its design featuring several perforated trays facilitating natural gas transfer (Abshar et al., 2023; Putri & Mirwan, 2020). The advantage of this aeration type lies in its minimal space requirement, making it suitable for small to medium processing capacities (Arifiani & Hadiwidodo, 2007). The selection of the HRF and multiple tray aeration unit combination is highly suitable for reducing turbidity, Fe, and Mn concentrations in raw water from the former mining pond at Kampoeng Sawah.

Given the aforementioned issues, the objective of this community service project is to assist the community in meeting their clean water needs for the tourism area with an easily operable and maintainable water treatment technology, namely the roughing filter-aeration combination.

2. METHODS

Activity Design

The location of this activity was carried out in Kampoeng Sawah, Manunggal Jaya Village, Tenggarong Seberang District, Kutai Kartanegara Regency, East Kalimantan. The partner for this community service activity is Pokdarwis Zwageri Borneo which has 37 members consisting of 26 men and 11 women.

Implementation Method

This community service activity is carried out using several methods. The observation method is carried out by direct observation of the location/area that will be used as a natural science development location. Interview and discussion methods with the community and Pokdarwis members were carried out as an effort to obtain qualitative information related to identifying daily water needs. The mentoring method is carried out as an empowerment process which aims to enable the community to carry out subsequent activity processes independently and sustainably.

Implementation Stages

The steps to carry out activities in implementing community service are carried out based on these stages.

Preparation stage

At this stage, preliminary survey activities are carried out to observe directly in the field regarding community, environmental and socio-economic conditions. Apart from surveys, structured and unstructured interviews were conducted with the community, community leaders and members of the Pokdarwis. Problems related to infrastructure and existing problems at the Pokdarwis were explored by holding discussions in groups focused on Pokdarwis activities. This activity involves students, the PKM team with the community, village government, and Pokdarwis members and administrators.

Implementation stage of clean water treatment facilities development

At this stage, activities were carried out to build a clean water processing unit using raw mine pool water using a combination of roughing filter-tray aeration technology. This technology was chosen considering operational ease so that it does not require operators with special skills. Ease of operation is also related to this technology, which does not require certain doses of chemicals. The stages in this activity are as shown in Table 1.

Mentoring/technology transfer stage

The mentoring activities take place after the completion of water treatment facility construction, thus facilitating the Pokdarwis partner in independently continuing the operation of the established water treatment plant through technology transfer. This endeavor involves providing training on operational techniques of the treatment unit, routine maintenance procedures, and troubleshooting strategies for addressing any operational challenges or issues that may arise. Engaging environmental engineering students as part of their Integrated Environmental Engineering Design course responsibilities constitutes a part of this activity.

Table 1. The implementation stages of the construction of a water treatment plant

Stage 1. Site surveys	
Activity	- Survey the location where the water treatment plant will be built - FGD with Pokdarwis administrators
Objective	- Ensure the location of the water treatment plant construction area - Discuss various possibilities/considerations in selecting the location of a water treatment plant
Implementation time	- Second week of August 2023
Stage 2. Installation of foundations and construction of water treatment plants	
Activity	- Selection of materials and type of building construction to be built - FGD related to construction selection and suitability with existing budget
Objective	- To expedite the process of building water treatment plants - Ensure that water treatment installations can be built in accordance with existing designs and budgets
Implementation time	- Third week of August – Fourth week of September 2023
Stage 3. Tray, pipe, and pump installation	
Activity	- Installation of pipe installations from the intake to the water treatment plant - Installation of water treatment plant pipes and pumps - Monitoring development progress
Objective	- Project work supervision practices - Installation of pump installations, pipes and complementary accessories
Implementation time	- First week of October 2023
Stage 4. Media loading	
Activity	- Media cleaning - Media filling in water treatment installation units - Supervision
Objective	- Prepare media for water treatment installation units that are free from contamination that reduces the quality of treated water
Implementation time	- Second – third week of October 2023
Stage 5. Testing of water treatment plant units	
Activity	- Carrying out running or testing of water treatment plants - Monitoring problems during testing
Objective	- Know the problems that occur before the water treatment plant is operated
Implementation time	- Fourth week of October 2023

Evaluation stage

Evaluation in the implementation of community service programs is essential for assessing the progress and achievements of the program activities. Success indicators for this initiative include the completion of the water treatment plant according to the planned design and timeline. Success indicators for the partner organization involve their capability as the water treatment plant manager to operate the facility and adhere to the standard operating procedures (SOPs) for its operation and maintenance.

3. RESULTS AND DISCUSSION

Results

The results of activities that have been achieved include survey and observation activities, unit construction according to the water treatment installation unit design plan.

Observation

Manunggal Jaya Village is situated adjacent to mining areas, leading to several village residents being employed by mining companies. Currently, some of these mines are ceasing operations, resulting in layoffs for village residents employed in the mining sector. The community's economy is greatly affected by this situation, and as a result, the community hopes that the development of tourism in the area can contribute to improving their economic situation.

A water reservoir covering an area of approximately 0.3 hectares was initially designated as a mining company's disposal pond. However, due to various considerations, this activity was not pursued. Laboratory tests have indicated that the water quality in this reservoir is safe for use as the raw water source for a water treatment facility. The reservoir has a depth of 1 meter around its edges and 5 meters at its center. Observations conducted during the project indicate that during the extreme drought conditions of 2023, the decrease in water surface height was not significant (approximately 50 cm). This finding suggests that the water flow rate is adequate for use as the raw water source for a water treatment facility.

Construction of water treatment installation units

The initial activity in planning the treatment unit involves identifying the clean water needs of the community in Pokdarwis Zwageri Borneo. This identification is based on the results of Focus Group Discussions involving the entire community service team, students, and members of Pokdarwis, while also considering the capacity of the water reservoir (Meicahayanti et al., 2023). The data on clean water needs and the flow rate of the water treatment facility to be constructed are summarized in Table 2.

Table 2. Water needs for Kampoeng Sawah Zwageri Borneo Tourism

Water needs	Volume/day (in liter)	Information
Domestic	18.200	28 households x 130 liters/person/day x 5 person/household
Stalls	1.000	50 stalls
Water banks	440	22 banks
Public toilets	1.000	100 users
Fish ponds	5.142,85	Water replacement every 14 days
Total	27.782,85714	
Assumed leaks (20%)	5.556,5714	
Qrmean	33.339,4285	
Qhm	34,728 liters/minute	Multiplier (x1.5)
Qjp	48,3812 liters/minute	Multiplier (x2)
Operating discharge	46,3812 liters/minute	12 hours/day

Based on the average water requirement of 33,339.4285 liters/day, it is planned to operate the water treatment unit for 12 hours/day with a flow rate of 46.3812 liters/minute. The water treatment facility with this flow rate consists of a roughing filter unit and a tray aeration unit, with unit dimensions as shown in Table 3.

Table 3. Dimensions of the roughing filter - tray aeration Unit at the Sawah Village water treatment plant

Units	Length	Width	Depth
Roughing Filter			
- Compartment I	3 m	1,5 m	1,5 m
- Compartment II	2 m	1,5 m	1,5 m
- Compartment III	1,2 m	1,5 m	1,5 m
Aeration Tray	2 m	1m	1 m
- Total number of holes	4.096 holes/tray		
- Hole diameter	0,6 cm		
- Number of trays	4 levels		
- Distance between trays	60 cm		

The planned concrete pipe for the intake structure is replaced with locally sourced materials, specifically ulin wood. This decision is motivated by the susceptibility of concrete pipes to breakage during transportation to the raw water reservoir site. Additionally, a layer of rock, 25 cm deep, is added to the bottom of the intake structure.

The construction of the water treatment plant is executed in several stages as outlined in Table 1. The initial stage involves surveying the Sawah Village site to determine the location of the water treatment plant. Following discussions with Pokdarwis, two feasible locations are identified: one near the raw water reservoir and the other within the tourist area. Option 1 involves constructing the water treatment plant near the raw water reservoir, requiring a shorter transmission pipeline. Option 2, if built within the tourist area, necessitates a transmission pipeline of approximately 70 meters. Both locations require a pump; however, the location within the tourist area is chosen due to its higher elevation, eliminating the need for a pump in its distribution network. All stages of this process are conducted through Focus Group Discussions (FGD) with Pokdarwis as the partner organization.

Figure 1. Survey of water treatment plant construction sites

The next stage involves commencing the construction of the water treatment plant starting from the foundation, formwork, and the construction of the water treatment facility as depicted in Figure 2. The construction process is assisted by on-site supervision from Pokdarwis partners and oversight from the community service team. This arrangement is feasible due to the relatively short distance between the site and the campus, which can be traveled in approximately 45 minutes. Material selection is tailored to local conditions, such as the use of *ulin* wood for supporting tray columns, chosen for its sturdiness against weather and wind conditions.

Figure 2. Water treatment plant construction process

The next stage involves the installation of pumps, pipes, and accessories, including the installation of trays in the tray aeration unit. In the design process, the team chose to use 4-inch pipes cut into two sections for the trays. These pipes are then perforated with a diameter of 1.5mm, with a total of 4,096 holes per tray level. Each tray level comprises 8 pipes, with a total of 4 tray levels. Documentation of this stage of the activity is provided in Figure 3.

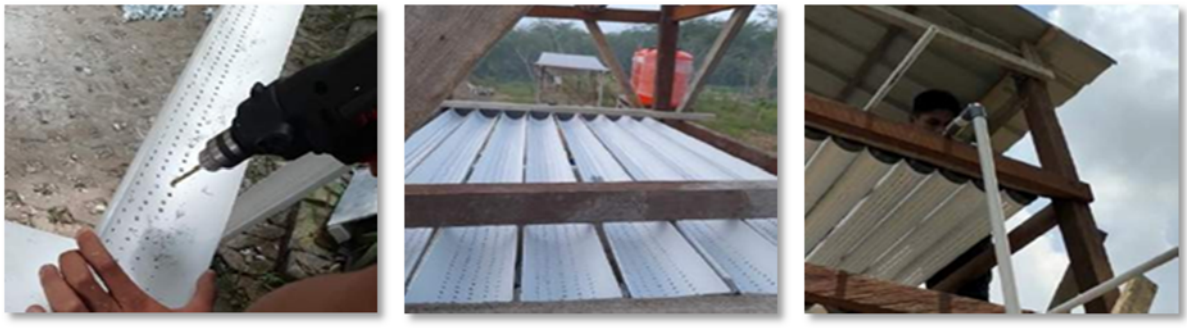


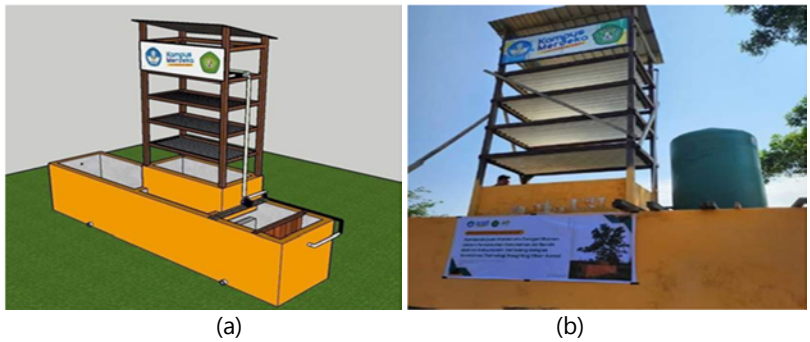
Figure 3. Aeration tray and pipe installation process

Next, the use of roughing filter media is tailored to local conditions, and therefore, coral, laban/ ulin wood charcoal, coconut fibers, and silica sand are chosen for the tray filter. Before being placed in the compartments, these media undergo washing and drying processes (Figure 4). The objective is to prevent water contamination in the processed product from impurities present in the media.

The next stage involves conducting trials to determine whether the equipment is functioning optimally. This is also necessary to identify any potential leaks in the constructed water treatment unit. Documentation of this activity is provided in Figure 5.

Figure 4. Media cleaning and filling process

Figure 5. Sampling and testing water quality in the field



(a) (b)

Figure 6. Kampoeng Sawah water treatment plant unit: (a) 3D illustration; (b) Built water treatment plant

The completion of the water treatment plant construction can be visualized from the description or illustration of the water treatment unit as shown in Figure 6a, and the completed water treatment installation as depicted in Figure 6b. The results of laboratory analysis of the raw and treated water are provided in Table 4.

Table 4. Laboratory test results and field measurements of raw water and processed water

SampleS	Temp	DO	pH	TDS	Turbidity	Nitrate	Nitrite
Raw water	30,05	5,01	7,49	229	4,07	0,054	0,02
Aeration tray outlet	28	5,87	8,1	222	2,78	0,038	0,02
Quality standards*	±3	-	6,5 - 8,5	< 300	< 3	20	3
Unit	°C	mg/L	-	Ppm	NTU	mg/L	mg/L

The laboratory test results and field measurements indicate that the water quality meets the requirements for hygiene and sanitation purposes according to the Minister of Health Regulation No. 2 of 2023 on the Implementation Regulation of Government Regulation No. 66 of 2014 concerning Environmental Health for water hygiene and sanitation purposes.

Technology transfer assistance

Once the construction of the water treatment plant is completed, the operation and maintenance of the unit will be carried out by the management, namely Pokdarwis Zwageri Borneo. The community requires socialization/training regarding this matter. The selection of the HRF and multiple tray aeration units is highly suitable for reducing the concentration of turbidity, organic matter, Fe, and Mn from the raw water, which has a relatively low turbidity concentration. This type of aeration was chosen because it does not require extensive land and is suitable for small to medium processing capacities (Arifiani & Hadiwidodo, 2007). The modification of the clean water treatment unit design with the HRF-multiple tray aeration technology combination built in Kampoeng Sawah Zwageri Borneo, Manunggal Jaya Village, is conducted to facilitate maintenance and operation.

Technology transfer through mentoring and operational training of the water treatment plant is conducted to ensure that the Pokdarwis, as the managers of the water treatment plant, understand the operational standards for routine maintenance, which include: (1) Disposal of sludge/deposits in the roughing filter compartments by opening the drainage valves located between compartments 1 and 2, as well as the drainage valve in compartment 3; (2) Cleaning of sludge/deposits in the filters by flowing water through the filter and then opening the drainage valve; (3) Cleaning of tray components from leaves, iron scales, or other impurities manually or using a cleaning brush. The trays are made of PVC pipes, making them easy to clean and resistant to rust.

(a) (b)

Figure 7. (a) Operational training and maintenance of water treatment installations (b) Handover of water treatment installation units to *Pokdarwis* Zwageri Borneo

The completed water treatment plant unit, which has been tested, is handed over to the management of Pokdarwis Zwageri Borneo for utilization in the development of rice field tourism (see Figure 7). The handover took place on December 7, 2023, by the university's community service team to the management of Pokdarwis Zwageri Borneo, represented by the secretary and vice chairman of Pokdarwis. Also present at the handover event were representatives from the village government and mining companies operating in the vicinity of Manunggal Jaya Village.

Discussion

The results of observations indicate a decline in the economy due to layoffs, necessitating efforts to address this issue. Development needs to be carried out by studying and promoting the village tourism sector based on the concept of Community Based Learning (CBL) linked with Community Based Tourism (CBT). CBT is a tourism program that provides opportunities for local communities to have involvement and control in the planning, implementation, and evaluation of tourism management. Three essential elements related to CBT are the involvement of local communities, economic access equality for the community, and capacity building, thus forming tourism managed and owned by the community for the community. This concept is expected to increase community awareness and willingness to learn about tourism management, planning, and promotion. Good tourism management will lead to increased welfare for the local community. Village tourism development assistance can be conducted through participatory design techniques, where residents actively participate with facilitators in developing existing potentials (both physical and non-physical), thereby having the opportunity to become the locus of tourist attractions. This concept has been successfully applied in community service by Subadyo (2018) in Kampung Topeng, Malang.

The implementation of the water treatment plant construction activities proceeded smoothly with the assistance of Pokdarwis, with active involvement in supervision and labor. Several changes occurred from the initial plan, based on considerations such as replacing concrete pipes with ulin wood boxes for constructing the raw water intake. This decision was made due to the vulnerability of concrete pipes to breakage during transportation to the intake location. Additionally, a layer of rock was added to the bottom of the intake structure to prevent sediment from being sucked into the pump, thus reducing the quality of raw water. Small-scale water treatment technology using filters has also been used by community service teams (Earnestly et al., 2021) in Panti Asuhan Aisyiyah Cabang Koto Tangah, Padang, using groundwater as the source. The selection of water treatment technology is based on the quality of the raw water used. Roughing filter (RF) is a physical treatment unit designed to reduce particles causing turbidity. This unit is suitable for raw water with moderate turbidity levels. RF can reduce non-settleable colloidal (< 1µm) and small supracolloidal particles (< 10µm) (Losleben, 2008). Horizontal roughing filter units (HRF) are more effective than vertical roughing filter types (Nkwonta, 2010; Ochieng & Otieno, 2006; Setyobudiarso et al., 2022). The media used typically includes gravel with various sizes (smaller in subsequent compartments) or coarse sand (Nkwonta, 2010; Nkwonta & Ochieng, 2009), shell fragments, and pumice stones (Setyobudiarso et al., 2022), broken red bricks (Sarwono et al., 2017). The constructed water treatment plant uses coral stone, ulin wood charcoal, and ijuk as media, adapting to the availability of locally-sourced materials. The second technology used is the multiple tray aerator, which consists of several perforated trays. Water passing through the trays enters the holes and falls downward through several levels, ending up in the collection tank at the bottom (Abshar et al., 2023). Gas transfer in the tray aerator occurs naturally, influenced by the surface area and spacing between trays (Putri & Mirwan, 2020).

Training and handover activities for the water treatment plant were attended by representatives from the village government and mining companies operating around Manunggal Jaya Village. The presence of these parties is expected to familiarize them with the rice field tourism program, enabling collaboration in the future to support village tourism development through various programs.

Unstructured interviews between the PKM grant team and members of Pokdarwis Zwageri Borneo, along with direct observations during the activities, yielded the following results: (1) The implementation

of this community service program has increased and enhanced knowledge about water treatment technology, as evidenced by direct practice during operational testing of the water treatment plant; (2) The establishment of supporting infrastructure for tourism development, especially facilities related to clean water supply.

Several factors supported the implementation of this community service program: (1) Assistance provided by partners, such as labor support, supervision during construction, and other supportive assistance, ensuring the smooth progress of constructing the water treatment plant; (2) The interest, enthusiasm, and dedication of Pokdarwis members during the project's implementation; (3) Efforts for tourism development, including adding photo spots and initiating the construction of stalls for sales, albeit in a simple form; (4) The absence of other activities that could disrupt the community service program's progress.

During the implementation of this community service program, several minor disruptive factors occurred, though they did not significantly hinder activities: (1) The existing solar power system encountered difficulties, requiring repairs with spare parts that took time in the process; (2) Seasonal changes necessitated consideration of potential rain during the construction of the water treatment plant and other activities. However, these challenges were within normal limits and did not significantly disrupt or impede the program's progress.

4. CONCLUSION AND RECOMMENDATIONS

Based on the analysis of the achieved activity stages for the community empowerment partnership scheme, it can be concluded that the establishment of the water treatment plant significantly contributes to the planned tourism development by fulfilling the need for clean water, which is vital infrastructure for tourism activities. The targets set for this community service program have been achieved, namely the completion of the water treatment plant according to the planned design and the improvement of knowledge among the Pokdarwis members who manage the water treatment plant. The increase in new facilities, the availability of space, partner involvement, and community support are key factors in the success of achieving the program's objectives. It is hoped that this activity will enhance the development of agriculture-based tourism, thereby improving the local economy.

To ensure the sustainability of the water source for the established water treatment plant, it is necessary to provide regular mentoring and monitoring to maintain the continuity of the water catchment area. This ensures that the quantity of raw water remains adequate to meet the clean water needs of the tourism area being developed. Cross-sectoral cooperation is required with the district and provincial tourism departments, the village government, and private sector entities to support Pokdarwis activities. It is essential to refine the concept of agriculture-based tourism with mentoring from relevant departments, as well as to conduct socialization and promotion activities that support the dissemination of tourism information.

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