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Training and Implementation of Coastal Waste-Based Bioreeftek for Coral Reef Restoration in Wangel Village, Aru Islands

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ABSTRACT

Coral reef degradation in the coastal areas of the Aru Islands due to overexploitation and coastal waste pollution has become an urgent environmental issue that requires innovative and participatory approaches. This community service activity was conducted from February to March 2026, with the peak activity on April 1, 2026, at Wangel Beach, Aru Islands Regency. The purpose of this activity was to enhance the knowledge and skills of coastal communities in coral reef restoration through training and the implementation of Bioreeftek techniques based on the utilization of coastal waste. The methods employed included a socialization program themed "Save the Reefs, Secure Aru's Future," online training on Bioreeftek media preparation, and direct practice in constructing and deploying the media in coastal waters. The activity involved approximately 50 participants, including coastal residents, youth groups, and local fishermen. The results indicated an improvement in community understanding and skills in processing coastal waste into environmentally friendly coral transplantation media. A total of four Bioreeftek units were successfully constructed and deployed in waters with potential as snorkeling tourism sites. This activity demonstrates that Bioreeftek is an effective innovation for coral reef restoration as well as a strategy for community empowerment. Therefore, this approach is important to be developed as a sustainable model for coastal ecosystem conservation.

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1. INTRODUCTION

Coral reef ecosystems are a critical component in maintaining the balance of coastal and marine ecosystems because they function as habitats for various marine organisms, spawning and nursery grounds for fish, natural coastal protection against abrasion, and supporters of community economic activities through the fisheries and marine tourism sectors (Syaifuddin, 2023). However, various environmental pressures such as resource overexploitation, coastal pollution, sedimentation, and climate

change have caused coral reef degradation across various coastal regions in Indonesia. This condition not only impacts the decline of marine ecosystem quality but also affects the socio-economic sustainability of communities dependent on coastal resources. (Pakaya, P. dkk, 2024)

Aru Islands Regency, Maluku Province, is an archipelagic region possessing high marine resource potential and biodiversity. One of the coastal areas with such ecological and economic potential is Wangel Village, Pulau-Pulau Aru District. Most of the community members in this region work as traditional fishermen who rely on marine catches to meet their daily livelihood needs. However, field observation results indicate that the coral reef ecosystem in the coastal area of Wangel Village has experienced significant damage due to coral mining activities, coastal waste accumulation, sedimentation, and changes in aquatic environmental conditions. This condition leads to a decline in the habitat quality of marine organisms and potentially reduces the fisheries productivity of coastal communities.

In addition to ecological issues, coastal communities face limited access to information, education, and marine conservation technology that can be independently implemented. In fact, the community of Wangel Village possesses quite strong social capital in the form of a culture of mutual cooperation (*gotong royong*), youth group involvement, and community participation in environment-based activities. One innovative approach that can be applied in coral reef rehabilitation is **Bioreeftek (Bio Artificial Reef Technology)**, which is an artificial reef technology that utilizes local materials and coastal waste as media for new coral growth. This technology offers advantages as it is environmentally friendly, economical, easily replicated, and capable of supporting the sustainable recovery of marine organism habitats. Besides providing ecological benefits, the implementation of Bioreeftek also has the potential to open opportunities for marine ecotourism development and economic strengthening of coastal communities. (Qomariyah, A. N., Putri, dkk, 2023, Koroy, K., Wahab, I., & Popa, S, 2021, Nasution, M. A., & Munandar, M, 2018)

Based on these conditions, the main problems faced by the partner community include: (1)The degradation of coral reef ecosystems in coastal areas; (2) Low community knowledge and skills in coral reef restoration activities; and (3) The suboptimal utilization of appropriate technology based on local potential for marine ecosystem rehabilitation. Therefore, this community service activity aims to improve the knowledge and skills of coastal communities through training and implementation of Bioreeftek techniques based on coastal waste utilization as an effort for coral reef restoration and community empowerment strengthening in Wangel Village, Aru Islands Regency.

2. METHODS

This community service activity was conducted in Wangel Village, Aru Islands Regency during the period of February–April 2026 using a participatory approach based on coastal community empowerment. The methods employed were designed to achieve the objective of increasing community knowledge and skills in coral reef restoration through Bioreeftek techniques based on coastal waste utilization.

The implementation stages of the activity included: (1) socialization, delivering material themed *"Jaga Karang Jaga Masa Depan Aru"* (Save the Reefs, Secure Aru's Future) to raise public awareness regarding the importance of coral reefs; (2) training, conducting a workshop on manufacturing Bioreeftek transplantation media; (3) implementation, Executing direct practice in constructing and deploying Bioreeftek media in the waters of Wangel Village; and (4) initial activity evaluation, observing community involvement and response toward the implemented program.

Measurement of the activity's success was carried out using simple descriptive qualitative and quantitative methods. Quantitatively, success indicators included the number of participants involved (around 50 people), the number of Bioreeftek media successfully built and deployed (4 units), and an increase in the number of beneficiaries from 15 to 23 individuals. Qualitatively, success was measured through changes in community understanding and attitudes toward the importance of coral reef conservation, which were observed through active participation in training and deployment activities.

The level of activity achievement was also analyzed from a social perspective, namely the increased involvement of coastal communities and youth groups in conservation activities. From a socio-cultural perspective, there was an increase in collective awareness regarding the importance of preserving the marine ecosystem as part of the livelihood sustainability of coastal communities. Meanwhile, from an economic standpoint, this activity has begun to open opportunities for ecosystem utilization as a snorkeling tourism area as well as the potential for future coral nursery development.

Thus, the methods applied demonstrate that the training and implementation approach based on community participation is effective in supporting the success of the community service activity, as well as providing an initial impact on behavioral, socio-cultural, and economic potential changes among the target community.

3. FINDINGS AND DISCUSSION

The execution of the community service activity through training and implementation of Bioreeftek (Bio Artificial Reef Technology) in Wangel Village, Aru Islands Regency, demonstrated significant achievements in addressing partner problems such as coral reef ecosystem degradation, low community capacity in marine conservation activities, and the unavailability of restoration technology that can be independently applied by coastal communities. This program, conducted from February to April 2026, was designed using a participatory approach so that the community did not only act as beneficiaries but also as main actors in the process of technology transfer and ecosystem restoration implementation.

The initial stage of the activity was carried out through a socialization program involving approximately 30 participants consisting of coastal residents, fishermen, youth groups, and village officials. The high level of community involvement in the initial stage indicates that the issue of coral reef damage has been tangibly felt by the community, particularly regarding the decline in fish catches and changes in aquatic habitat quality. Participatory observation results revealed that prior to the activity, some community members still viewed coral reef damage as a natural process. However, following the socialization process and interactive discussions, a shift in understanding occurred, marked by the community's increased ability to identify the connection between coral mining activities, sedimentation, coastal waste, and the decline in marine resource productivity.

Figure 1. Coral reef conservation socialization activity for the community of Wangel Village.

This shift in ecological awareness indicates that community-based education exerts a strong influence on shaping public conservation behavior. According to the *Panduan Rehabilitasi Terumbu Karang Berbasis Masyarakat* (Community-Based Coral Reef Rehabilitation Guidelines), the success of coastal ecosystem rehabilitation is highly influenced by the level of environmental literacy and active involvement of the local community. A similar view is expressed in *Pengelolaan Sumber Daya Wilayah Pesisir dan Lautan Secara Terpadu* (Integrated Coastal and Marine Resource Management), which

emphasizes that coastal area conservation can only be effective if the community possesses ecological understanding and a sense of ownership over the managed resources.

The subsequent stage focused on training for manufacturing Bioreeftek media as a form of coral reef restoration technology transfer to the community. The training involved 15 core participants who followed all stages of media production, starting from material preparation, material mixing, frame assembly, molding, to a three-day drying process under sunlight. The resulting Bioreeftek media was shaped as a hollow cube with dimensions of 100 x 50 cm, an average weight of 30–35 kg, and an ecological capacity of approximately 18 coral attachment points per unit.

Table 1. Technical Specifications of Bioreeftek Media

Component	Specification
Shape	Hollow cube
Size	100 cm × 50 cm
Weight	±30–35 kg/unit
Main material	Cement, marine sand, gravel
Additional material	Broken clam shells, PVC pipes
Reinforcement structure	Galvanized iron Ø 8 mm
Ecological capacity	±18 coral colonies/unit

Source: Community Service (PkM) activity data

(a) **(b)** **(c)**

Figure 2. Process of manufacturing Bioreeftek media by the community.

The community's success in producing Bioreeftek units indicates that the implemented technology possesses a high level of adaptability to the social and economic conditions of the local community. The use of local materials such as marine sand, clam shells, and PVC pipes makes this technology relatively inexpensive, easy to replicate, and requires no heavy equipment. This finding supports the research results of *Teknologi Rehabilitasi Terumbu Karang* (Coral Reef Rehabilitation Technology), which states that artificial structures made with local materials have higher levels of social acceptance and are more sustainable in community-based restoration programs. Furthermore, a study by Tumion, F. F dkk (2017) shows that Bioreeftek technology is capable of increasing coral larvae attachment opportunities and forming micro-habitats for benthic organisms in degraded coastal areas.

The implementation phase was carried out by deploying Bioreeftek units in the aquatic area of Batu Kora Beach at a depth of 2–5 meters, which had previously been identified as experiencing coral ecosystem damage. The activity results showed that as many as 3 Bioreeftek units were successfully produced and stably installed using a concrete anchor system to prevent displacement caused by ocean currents.

Table 2. Achievements of Bioreeftek Technology Implementation

Indicator	Achievement
Number of units installed	3 units
Location	Batu Kora Beach
Depth	2–5 meters
Field participants	15 people
Mooring system	Concrete anchor

Source: Field implementation data

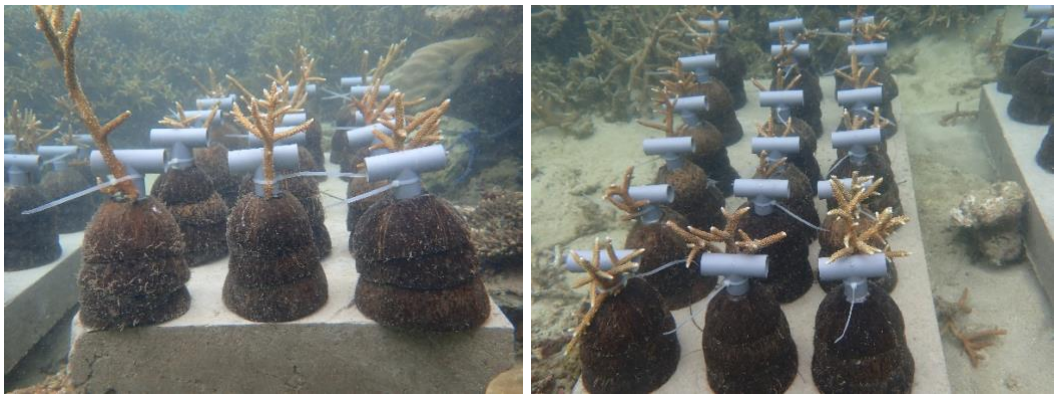

Figure 3. Deployment of Bioreeftek units at the restoration site

Ecologically, the Bioreeftek design serves three main functions: providing a rough surface for coral larvae attachment, creating micro-cavities as shelter for juvenile fish, and maintaining water circulation through 10-cm diameter PVC holes. These characteristics align with the restoration guidelines published by the Ministry of Marine Affairs and Fisheries of the Republic of Indonesia, which explain that the complexity of artificial structures directly influences the rate of marine organism colonization and the stability of new habitats. This result is also consistent with research by Munasik, M., Nugroho, A. A dkk (2020), which found that artificial structures with high cavity and porosity levels can increase reef fish abundance in restoration areas.

Beyond the ecological impact, this program also demonstrated clear social impacts. Post-activity evaluation showed that the number of beneficiaries increased from 15 to 23 individuals, and the program succeeded in creating 2 new jobs during the implementation process. Additionally, the formation of the Marine Care Community Group (*Kelompok Masyarakat Peduli Laut* / KMPL) serves as an indicator of the program's success in strengthening local institutions and ensuring the sustainability of post-implementation monitoring.

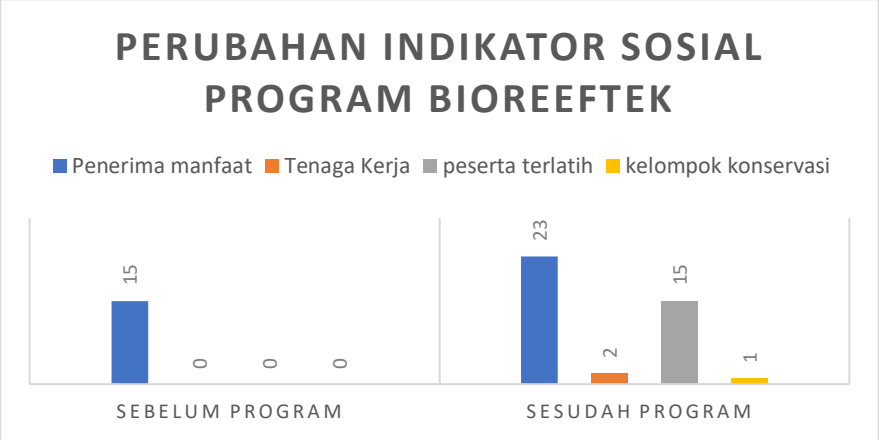

Figure 4. Graph of changes in public social indicators before and after the program.

The improvement in these social indicators demonstrates that the application of Bioreeftek technology not only produces outputs in the form of appropriate technology products but also generates social transformation through capacity building, behavioral shifts, and the strengthening of community institutions. This is in line with a study by Gintulangi, S. O, dkk (2025), which states that the success of coastal area conservation is determined not only by the applied technology but also by the program's ability to build social capital and community participation.

Although initial results indicate positive outcomes, long-term ecological monitoring regarding coral survival rate, marine organism colonization rates, and changes in coral cover could not be optimally performed due to limited observation time. Therefore, the next development phase needs to be directed toward periodic monitoring using the underwater photo monitoring method as recommended by the Indonesian Institute of Sciences (*Lembaga Ilmu Pengetahuan Indonesia*), so that the effectiveness of Bioreeftek as a community-based restoration model can be measured more comprehensively and replicated in other coastal areas of Maluku as well as small island regions in Indonesia.

4. CONCLUSION

The community service activity through training and implementation of the Bioreeftek technique based on coastal waste utilization in Wangel Village, Aru Islands Regency, successfully achieved the program's objectives in increasing the knowledge, skills, and participation of coastal communities toward coral reef restoration efforts. The success in constructing and deploying four Bioreeftek units, along with the formation of the Marine Care Community Group, demonstrates that this technology is not only effective in supporting coastal ecosystem rehabilitation but also strengthens the community's social capacity toward sustainable marine resource management.

Moving forward, long-term monitoring is required to evaluate coral survival rates, marine organism colonization, and the potential development of restoration-based ecotourism as a model for coastal conservation in island regions. The implementation team expresses gratitude to the Pertamina Foundation for the financial support provided through the PFmuda program, as well as to the Government and Community of Wangel Village for their technical support and active participation throughout the activity. The authors declare no conflict of interest in the implementation of the activity or the compilation of this article.

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