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Modular System Recirculating Aquarium Management for Sustainable Ornamental Coral Production

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Abstract

Indonesian waters have potential ornamental coral resources in South Sulawesi waters, especially in Karanrang Island, which still need to be optimally utilized by the fishing community. The main objective of this community service is to increase the understanding and skills of the community in managing coral transplantation in situ and caring for them in an environmentally friendly modular system aquarium based on re-circulation. Adopting the ABCD (Asset-Based Community Development) method, this approach begins with the identification of local assets, including the expertise and skills of the karanrang island community. Subsequently, capacity building is carried out by utilizing these assets, and the community is actively involved in the planning and implementation process. Results included increased community knowledge on technological innovations of modular circulation systems holding aquarium design at the household scale and post-harvesting of coral transplant farming products for holding in aquariums. This process contributed to the development of the local ornamental coral sector, empowered the community, and opened up product marketing opportunities at both local and international levels.

Keywords Community Empowerment; Modular Aquarium Circulation System; Ornamental Coral Resources; Post-Harvest; Sustainable Development.

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1. INTRODUCTION

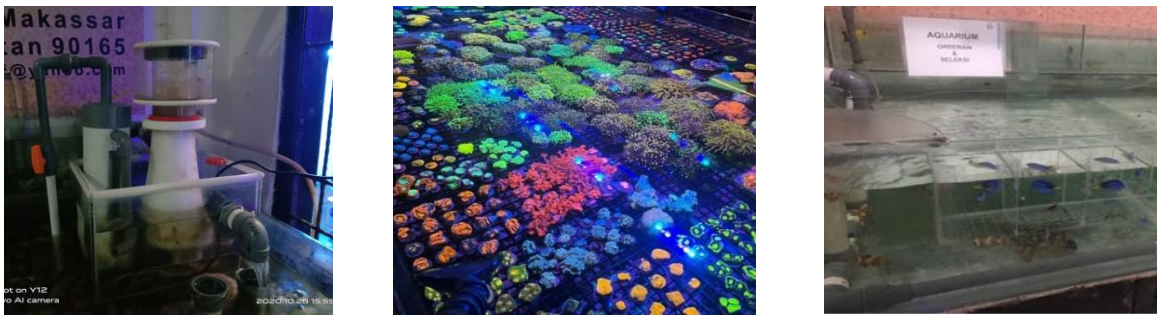
Indonesia is a maritime nation and one of Earth's largest centers of coral reef and marine life diversity (Asy'ari et al., 2023). Efforts to protect marine biodiversity are clearly needed, which requires innovative management strategies. Indonesian waters have the potential for very abundant ornamental coral resources, especially ornamental corals and corals with variations and abundant amounts, with high economic value (Fitriawan et al., 2020); (Junaidi, 2020). Various types of ornamental corals are scattered in various waters, especially inhabiting habitats around coral reefs. Most of the ornamental corals caught from Indonesian waters, in addition to meeting local consumer demand, are also exported abroad and become a potential source of foreign exchange. Strategic, time-efficient, and adaptive solutions and approaches are needed. One of the keys to creating such solutions is collaboration with all stakeholders (Kasmi et al., 2021; Paharuddin, Kasmi, Sulkifli, Irawan, et al., 2022).

Production planning of cultivated resources brings additional complexity to manufacturing goods. Cultivated resources are planted and maintained for some time before being harvested or used (Yunda Sari et al., 2020). Decisions regarding facility location, facility size, and growing time ultimately determine the success of large-scale projects in producing and using cultivated resources. This is particularly challenging for resources with two growth phases (Agdal et al., 2019); (Bakhtiar, 2022).

The utilization of ornamental corals for foreign trade is generally used for aquarium ornaments (Kasmi et al., 2020). Ornamental corals that are used as aquarium ornaments in the international market have a positive impact on foreign exchange and job creation. The international market has certain requirements for both ornamental coral and coral commodities. Generally, export destination countries require each export commodity to be of good quality and free from ornamental coral pests and diseases required by each country (Abdullah & Kasmi, 2020).

Coral farming, as one restoration method, is being considered to address mass coral mortality and illegal utilization (Montseny et al., 2021). Planning how to use resources best for aquaculture projects to cultivate corals for large-scale coral reef restoration is essential to efficiently and sustainably utilize growing corals (Matorres et al., 2023); (Lippmann et al., 2023). Mathematical optimization is needed to determine the optimal number, size, and location of aquaculture facilities to fulfill these large-scale plans successfully (Chambers & Conway, 1992). In designing such facilities, a relevant question is how long resources should be kept in the facility, which significantly affects the optimality of production. There is a trade-off that keeping resources in the facility

longer can increase post-release success but increase in-process inventory and associated operational costs (Boakes et al., 2022).



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

Figure 1. The main components in this figure involve (a) the Water Filter, (b) the transplanted Ornamental Coral Shelter, and (c) the Modular Circulating Aquarium display.

Characterizing the relationship between coral survival and coral growth time can optimize coral culture programs (Lippmann et al., 2023); (Lippmann et al., 2023). Optimal growth timing leads to a trade-off between minimizing facility costs (both capital and operational) and capitalizing on increased survival benefits (Gouezo et al., 2021). Therefore, space and energy savings at lower growth times compete with the benefits of reduced production numbers associated with greater growth times. Coral survival rates are influenced by their size at deployment. Coral growth rates over time, age-dependent survival estimates, and statistically significant size- and age-dependent survival estimates (Asy'ari et al., 2023); (Yuwita et al., 2022). Survival rates of juvenile sea cucumbers plated on tank modular plates were assessed based on mean size (Kasmi et al., 2022).

In the previous community service program (Paharuddin, Kasmi, Sulkifli, Makkulawu, et al., 2022), the main focus was on improving the innovation of ornamental coral transplantation technology through taking fragments of ornamental coral seedlings; this program contributed to the development of coral reefs but has not specifically addressed aspects of improving the quality of in situ cultivation products. Furthermore, the community service program emphasized the transformation of the mindset of fishing communities towards ornamental coral cultivation. Although there has been an improvement in the understanding of technology and cultivation, there is still a need to deepen the management of in situ ornamental coral transplantation and post-harvest in re-circulation-based modular system aquarium shelters (Kasmi et al., 2022) (Abdullah et al., 2021). Based on the results of these activities, community service can fill the gap by emphasizing the community's understanding and skills in managing

coral transplantation in situ and caring for them in an environmentally friendly modular system aquarium. Thus, this community service will serve as a logical and sustainable continuation of the previous research, complementing the knowledge and skills required by the community in sustainable ornamental coral farming practices.

The main objective of this community service is to increase the understanding and skills of the community in managing coral transplantation in situ and caring for them in an environmentally friendly modular system aquarium based on re-circulation.

2. METHODS

The method used in this community service involves an ABCD (Asset-Based Community Development) approach to maximize the potential of ornamental coral resources in South Sulawesi waters, specifically on Karanrang Island. The approach begins with identifying local assets, such as the expertise and skills of the Karanrang Island community, as a first step to building capacity development (García, 2020; Maulana, 2019). The development process was then carried out by utilizing these assets, with a focus on increasing community understanding and skills in managing coral transplantation in situ and caring for them in environmentally friendly re-circulation-based modular system aquariums through standard operational procedures (POS) to produce export standard quality. Measured outcomes include increased community knowledge related to technological innovations in household-scale modular circulation system aquarium design and post-harvest cultivation of coral transplants to be maintained in aquariums. In planning and implementing this activity, active community participation is needed so that the program can be sustainable and successful.

This activity was carried out from September to November 2023 on Karanrang Island, Tuppabiring District, Pangkep Regency. A group of ornamental coral cultivators and catchers (Dewikar). The Ornamental Coral cultivation transplant shelter results are then sold to Rezky Bahari SME. The management of potential ornamental coral resources in South Sulawesi waters, especially on Karanrang Island, can be measured through several indicators. First, increased knowledge and skills of the community in managing coral transplants in situ and maintaining them in a modular system aquarium based on re-circulation. Furthermore, the results of coral transplant cultivation can be maintained in aquariums by complying with standard operating procedures (POS) to produce export standard quality.

3. FINDINGS AND DISCUSSION

Identifying local assets, especially the expertise and skills of the Karanrang Island community, shows that most of the residents on this island are fishermen. They already have expertise and skills related to ornamental coral transplantation technology by taking fragments of coral seedlings. In addition, the fishermen also can do post-harvest maintenance and handling. This is supported by natural seed sources around Karanrang Island, planting sites around the island, and an ornamental coral cultivator and catcher group (Dewikar) that they have formed. Nonetheless, there is a need for further in-depth management of in situ and post-harvest ornamental coral transplantation in re-circulation-based modular system aquarium containers. Therefore, the main emphasis of this community service program is to increase community knowledge about technological innovations in the design of household-scale modular circulation system aquariums and the post-harvest process of coral transplant cultivation products that will be maintained in the holding aquarium.

The application of Modular System Recirculating Aquarium Management Technology for Ornamental Coral Production on a household scale is one of the alternatives for ornamental coral rearing to overcome the problem of location and size of ornamental coral cultivation or transplantation facilities (Conilie et al., 2021; Hasanah, 2021); (Sutopo et al., 2021). Training and Assistance Activities for the Application of Modular System Recirculating Aquarium Management Technology is one of the development efforts in handling production, quarantine methods, or maintenance of ornamental corals and ornamental corals efficiently and effectively (Mâţă Liliana et al., 2023; Moridu et al., 2023). Figure 2 shows the training activities as a medium of knowledge transfer from the team.

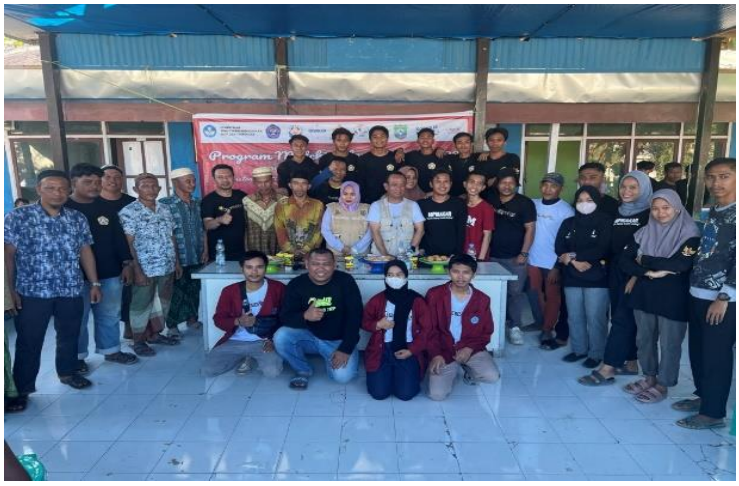
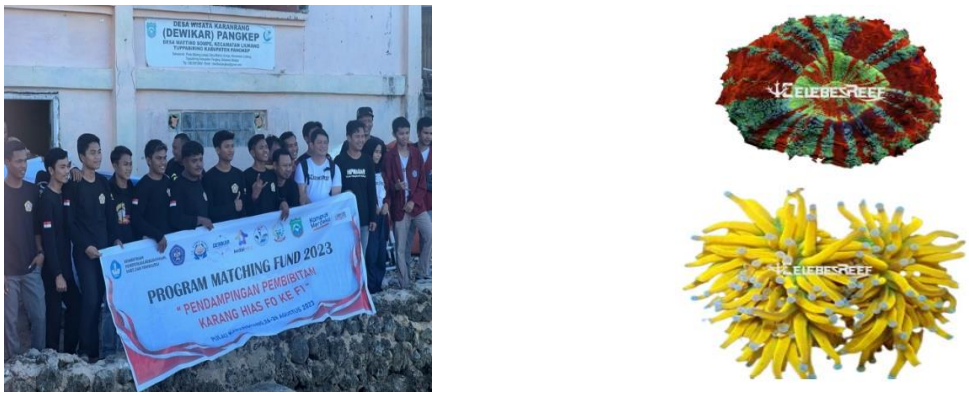


Figure 2. Training for both Matching Farm partners.

The results of the transplantation technique training activities were then practiced and implemented for various purposes, including creating artificial reefs,

rehabilitating damaged coral reefs, and tourism and trade purposes. Of the various purposes of transplantation techniques, transplantation techniques for trade are experiencing rapid development. This is driven by the need for quality coral seedlings and efficiency in producing quality transplant products. The higher the quality, the higher the price. Unlike other commodities, coral reef cultivation always receives guidance and supervision from the Scientific Authority, LIPI, and the Management Authority from the Ministry of Forestry. This action is taken because the transplanted coral saplings are traded internationally and have been included in Appendix II of CITES.

Assistance by understanding legality when obtaining ornamental coral and coral cultivation products. Ornamental coral cultivation licenses are obtained from the Ministry of Marine Affairs and Fisheries (KKP) and the Ministry of Environment and Forestry (KLHK) under the Directorate of the Natural Resources Conservation Center (BKSDA). The raw materials used are ornamental corals taken from nature by the Dewikar UKM fishermen group around the waters of Karanrang Island. The types of ornamental corals that are cultivated according to market demand are to be marketed abroad as aquarium decorations, especially using seawater. Ornamental corals are taken selectively based on recommendations from LIPI according to the type and number of corals that are suitable for use.



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

Figure 3. Assistance Activities for Planting Coral Seedlings (a) DEWIKAR Fishermen Community Assistance (b) Types of Cultivated Ornamental Corals.

After the training, further mentoring activities by providing training on product treatment standards aim to ensure that the ornamental coral quarantine system and procedures are running well and always improving.

1. Standard Operating Procedure for Acclimatization and Adaptation

The purpose of implementing SOPs is to implement good health management of ornamental corals by applying biosecurity principles at every stage of aquaculture

production. In addition, recording or documentation of activities must be done during production until distribution. Through the implementation of SOPs, ornamental coral commodities produced are expected to fulfill health guarantees for ornamental corals. Thus, the competitiveness of exported ornamental coral commodities will increase.

2. Production Flow of a Good Ornamental Coral Quarantine Method (CKIB)

In accordance with the application of risk analysis, the CKIB production flow must be able to determine the critical points in the production process. The activities that must be carried out in implementing the CKIB production flow are at least as follows:

a) Incoming Ornamental Corals

- Incoming ornamental corals must have clear records regarding the health and origin of ornamental corals.
- Ornamental corals are not mixed with consumption corals, and vice versa.
- Ornamental corals sent to exporters must be in good health or show no clinical disease symptoms
- It is equipped with a health certificate from the quarantine of ornamental corals or information from other agencies that can be accounted for the truth.

b) Acclimatization and Adaptation

- Visual and morphological observations select each entry of ornamental corals.
- Conduct acclimatization, adaptation, and observation of clinical symptoms to maintain healthy and quality ornamental corals (stock).
- Ornamental corals do not show clinical symptoms of disease infection or death, and≥ 30% of those are received by exporters, which causes rejection and return.

c) Maintenance

After all the above stages have been carried out, ornamental corals are maintained in the maintenance room/facility. The maintenance stage can potentially cause the spread of disease due to environmental factors and the condition of ornamental corals in the maintenance container.

d) Exile and Treatment of Ornamental Corals

- If it turns out that ornamental corals are sick, then seclusion is carried out for the treatment of ornamental corals. Ornamental corals that have recovered are observed intensively to ensure they are healthy.
- Dead ornamental corals are separated in a special place to prevent the spread of disease.

In the process of seclusion, the health of ornamental corals is checked by laboratorially checking the health of ornamental corals (fungi, parasites, bacteria, and viruses).

e) Isolation/Pre-Harvest

Isolation/Pre-Harvest is an activity to observe the health and quality of ornamental corals for 4-14 days. Aims to meet the standards required by consumers/destination countries.

f) Harvest and Packaging

Harvesting and packaging are done precisely and measured to avoid stress and even death of ornamental corals at the destination. Consumers/destination countries will reject inappropriate ornamental corals, so effective communication is needed to meet the required standards.

3. Standard Operating Procedure for Ornamental Coral Maintenance

Closed recirculating aquariums with modular systems as rearing containers and temporary containers, in the form of buckets and equipment, must be sterilized and ready for use. Seawater treatment for ornamental corals and to reduce stress and disease. After the acclimatization and adaptation process has been carried out, the corals are then transferred to a household-scale modular system recirculating aquarium as a rearing site. A good feeding process and the right amount greatly affect the quality and health of ornamental corals. Therefore, feeding is done in a planned manner. Observations of water quality parameters and health management of ornamental corals were carried out simultaneously, namely in the morning and evening every day. The goal is to see the development of ornamental corals, especially their health.

4. Quarantine Standard Operating Procedure (Pre-Harvest)

Pre-harvest activities occur when there is a planned harvest and consumer demand for specific requirements. Containers should be filled with treated water two to three days before pre-harvesting, and all equipment should be ready for use. Pre-harvest activities are conducted when a customer requests to select ornamental corals according to the order. The rearing period in the pre-harvest unit depends on the destination region/country. The range of rearing time in the pre-harvest unit is 2-14 days. In pre-harvest activities, health observations of ornamental corals and water quality observations are carried out periodically to ensure ornamental corals are in good condition.

5. Harvest and Distribution Standard Operating Procedures

Before harvesting, harvesting equipment must be prepared, such as plastic packaging, cardboard/styrofoam, labels, duct tape, and rubber bands. Packaging is done accurately and according to the destination distance. Calculating the oxygen and water ratio must be precise to avoid the death of ornamental corals during the distribution process. The distribution process is carried out using air transportation to minimize travel time.

6. Standard Operating Procedure for Isolation of Ornamental Coral Disease

Especially for ornamental corals that show symptoms of illness, they must be moved and isolated in a quarantine aquarium. As a quarantine container, the aquarium is already in a sterile state for ornamental coral quarantine measures. Quarantine aims to prevent the spread of diseases that can affect other ornamental corals by taking proper care and administering the appropriate dose of drugs.

7. Standard Operating Procedure for Isolation of Ornamental Coral Disease

Especially for ornamental corals that show symptoms of illness, they must be moved and isolated in a quarantine aquarium under sterile conditions. Quarantining (isolating) ornamental corals prevents the spreading of diseases that can affect other ornamental corals.

8. Activity Success

Indicators and benchmarks of success are by knowing the increase in the target audience's knowledge, skills, and motivation. Success criteria are measured by comparing the level of knowledge and skills before and after the activity (Asfahani et al., 2023); (Kudsiah et al., 2018).

Based on the evaluation of activities carried out by the fishing community, the ornamental coral cultivation group of 15 people. The pre-test results of knowledge and skills about the technological innovation system of aquarium design modular circulation system on a household scale are very low; out of 15 fishermen, only two fishermen have the knowledge and skills. Then, after the training and mentoring process of the technological innovation system of aquarium design modular circulation system on a household scale, it shows that all fishermen (15 people) knew the technology of aquarium design modular circulation system on a household scale.

4. CONCLUSION

Technological innovations in the design of household-scale modular circulation system aquariums and post-harvest cultivation of coral transplants to be maintained in aquariums to increase community understanding and skills in managing coral transplants in situ and caring for them in modular system aquariums based on re-circulation in an environmentally friendly manner. Based on the evaluation of

activities carried out by the fishing community, especially the ornamental coral cultivation group of 15 people. The pre-test results of knowledge and skills about the technological innovation system of modular circulation system aquarium design on a household scale were very low; out of 15 fishermen, only 2 fishermen had the knowledge and skills. Then, the training and mentoring process of the technological innovation system of modular circulation system aquarium design on a household scale showed that all fishermen (15 people) already knew the technology of modular circulation system aquarium design on a household scale. One of the important knowledge and skills of the fishing community is standard operating procedures (SOPs) on all actions and uses of quarantine installation facilities carried out effectively, consistently, and systematically, and meeting biosecurity standards to ensure the health of ornamental corals. This mentoring activity can be continued with training and mentoring on ex-situ ornamental coral transplantation techniques so that fishing communities no longer take ornamental coral seeds from nature.

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