

Management options for restoring artificial coral reefs in Indonesia: strengthening in institutional approach

Rudianto^{1,2*}, Ahmad Zainul¹

¹ Faculty of Fisheries and Marine Science, Brawijaya University

² Head of Laboratory for Exploration of fisheries and marine resources

*Corresponding author: rudiantoita@gmail.com

Abstract. The degradation and deterioration of coral reefs in Indonesia has continued for several decades due to the use of destructive fishing gear, increased pollution, global troubles of coral bleaching, coral diseases and predation. The best conditions in central Indonesia with 5.48 percent are very good, 29.39 percent good, 44.38 percent bad, and 20.75 percent bad. Whereas for the status of western Indonesia is 4.94 percent very good, 28.92 percent good, 36.68 percent bad, and 29.45 percent bad. Therefore, the use of artificial reefs are alternatives that can be used to reduce the pressure of fishing and destruction of natural coral reefs. The objective to be achieved in this research is to arrange management option for artificial reef restoration based on institutional approach, so that the service function is optimal. The SWOT method will be used to know the strength, weaknesses, opportunities and constraints of artificial reefs. Interpretive Structured Modelling (ISM) Methods is to identify related and influential institutions for managing artificial reefs. The results of this research showed that Forum is built to establish strategic management plan with a focus on stopping the decline and restoring the basic conditions of artificial reefs.

1. Introduction

The objective to be achieved in this research is to arrange management options to restore artificial coral function by using institutional strengthening approach. The underlying reasons for goal setting are based on the understanding that artificial reefs are a solution to restoration or recovery of resources in coral reef ecosystems. Artificial reefs are made by looking at the living patterns of fish and other biota in the waters as artificial habitats, to replace the main function of natural coral reefs. (State the objectives of the work)

The decline of coral reefs in Indonesia are caused by various things, such as sedimentation, land-borne contamination such as industrial and domestic waste disposal, coral mining for construction materials or other physical damages such as over exploitation of marine resources, and unsustainable fishing practices such as the use of explosives and toxins such as potassium [1]. Based on the division of the region about the condition of coral reefs in Indonesia, it is known that (1) the western part of Indonesia is very good condition 8.97%, good by 22.99%, sufficient condition of 34.71% and ugly conditions of 33.33%. For (ii) the central part of Indonesia is known to be very good condition of 4.91%, good condition of 24.57%, sufficient condition of 33.42% and ugly condition of 37.10%, and (iii) eastern part of Indonesia known conditions each is very good 6.39%, good condition is 23.40%, condition is quite 35.06%, and bad condition is 35.15% [2]. Based on the data, it can be concluded that the condition of coral reefs in Indonesia as a whole is very alarming. The condition of coral damage



will continue, especially at this time of global warming in the form of sea water temperature rise and the occurrence of tsunami disaster. To overcome the predicted sea-temperature rise between 1- 2°C and the next century, the impact of coral reefs is the occurrence of events coral bleaching. Various efforts have been made by stakeholders to restore coral reefs, but the recovery of coral reefs is slow, while anthropogenic factors and natural problems continue to run rapidly [3]. The institutional factors become the key to restoration of coral reefs. Regardless of which programs and activities are formulated or designed technically, without going through the institutional capacity building especially in the community, it is impossible to succeed [4].

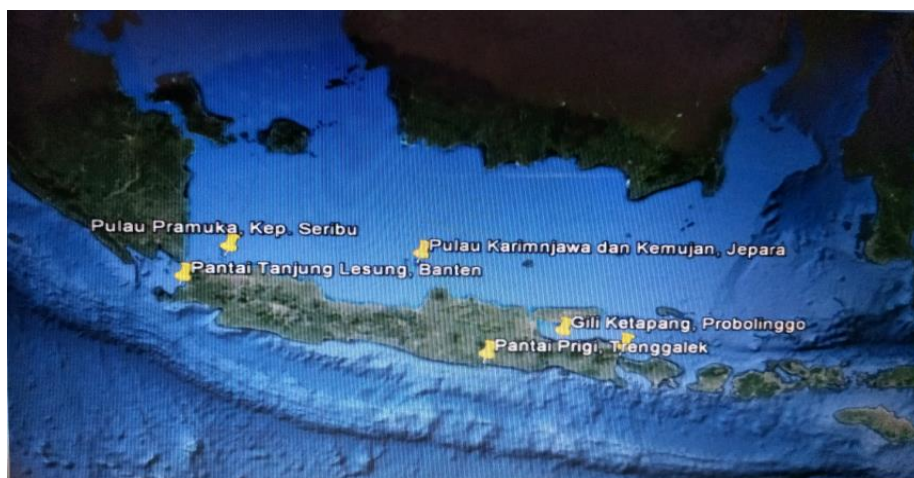
2. Material and methods

Research management options for restoring artificial coral reefs in Indonesia took 6 (six) sampling locations as seen Table 1.

Table 1. Conditions of coral reefs.

No	Location of Coral Reefs	Condition	Name Reserachers
1.	Gili Ketapang	Average corals cover 31,32 %	Wicaksono, Agung (2015)
2.	Prigi, Trenggalek	Average live corals: 40,17 % Average corals dead: 59,81 %	Fitriani RA (2018)
3.	Pramuka Islands, Thousand islands, Jakarta	Corals cover year 2002: 54,05 % Coral cover year 2003: 49,02 % Coral cover year 2013: 35 % Coral cover year 2014: 36,10 % Coral cover year 2015: 32,06 %	Irkhami, Taufik Rifai (2016)
4.	Tabuhan Island, Banyuwangi	Coral cover : 24,90 %	Suprayogi, Iwan (2017)
5.	Tanjung Lesung Banten	Average live corals: 31,2 % Average Corals Dead: 30 %	Widiaji, M. Ichwan (2017)
6.	Karimunjawa National park and Kemujan island	Live corals year 2004: 40,0 % Live cover year 2009: 54,5 % Live coral year 2015: 62,3 % Live cover year 2016: 67,5 %	Mukti, Agung Setyo (2017)

Based on Table 1 above, the coral cover on the location taken as a study based on previous studies indicates that the dead coral cover is an average of 49%.



reserchers as shown in Table 1.

2.1. General descriptive of degraded coral reefs in in study areas

In the study areas of coral reef degradation is not due to lack of hard substrate. However, the critical issue is the management of the degraded natural reefs. It is estimated that about 49% of the coral reefs in six locations are in poor condition and their condition indicates that there is no chance of recovery in the near future. Declining reef quality means a loss of economic value goods and services, and loss of food security and work for coastal communities. Most of whom depend largely on fish and coral reefs. Damage to coral reefs in the research area is caused by natural problems such as: increased sedimentation resulting from land use change and weak watershed management. While the causes of human factors are waste disposal, nutrient addition and eutrophication from agricultural activities, coral mining, and overfishing.

2.2. Restoration and artificial coral reefs

Damaged coral reefs have the potential to recover [3]. This recovery capability can be said to be profitable, because many people depend on coral reefs for their lives. The primary aim of restoration is to improve the degraded reef in terms of ecosystem structure and function [5]. Attributes to be considered might be biodiversity and complexity on one hand and biomass and productivity on the other. Over the past decade, coral transplant efforts have become a wider concern and these efforts have gained recognition as a key management tool for coral reef restoration [6].

2.3. SWOT analysis and interpretive structured modelling (ISM)

SWOT and Interpretive Structural Modelling (ISM) analysis is used to develop management options for restoring artificial coral. SWOT is used to develop artificial reef restoration strategies, while ISM is used for institutional role analysis to optimize the role of artificial corals.

3. Results

3.1. SWOT analysis

Based on the problems in the research area as shown in Table 1, the problem tree is prepared to describe the cause and effect of coral reef degradation and its solution by making artificial reefs. Table 2 describes the factors of strength, weakness, opportunities and constraints of artificial reef management.

Table 2. List of strength, weakness, opportunities and threats on artificial reefs.

Strengths	Weaknesses
1. Availability of coral measurement station of Environment Conservation Organization; 2. Local Community participation; 3. Local Institutional and Private interest; 4. Co-management on stakeholder participation (local community, government and private); 5. High market seasonality for marine tourists.	1. Shortage of suitable spaces 2. Limited funds for research and money; 3. Awareness of local people to maximize artificially coral reefs; 4. Vulnerability of marine ecosystems; 5. Lack of coordination for monitoring the growth of artificial coral reefs.
Opportunities	Threats
1. International and national promotion for marine tourism and visibility; 2. Programme restoration for damaged coral reefs; 3. The uniqueness of coral reef as marine ecotourism area	1. Damaged coral colonies by Sedimentation, coral mining, waste disposal, temperature rise, tsunami; 2. Presenting Fishing net and fishing hook; 3. Spatial conflict between Marine Protected areas and tourists area; 4. No management coastal artificial coral reefs for stakeholder involvements;

Based on Table 2, an analysis of strength-opportunity strategies, strength-constraints strategies and weakness - opportunities strategies as well as weakness-constraints strategies. The issues of SWOT strategy for artificial reefs can be seen in Table 3.

Table 3. Issues of SWOT strategy for artificial reefs.

	External	Opportunity	Threats
Internal		1. International and national promotion for marine tourism and visibility; 2. Programme restoration for damaged coral reefs; 3. The uniqueness of coral reef as marine ecotourism area	1. Damaged coral colonies by Sedimentation, coral mining, waste disposal, sea temperature rise, tsunami; 2. Presenting Fishing net and fishing hook in coral site to fish; 3. Intense tourism impact; 4. Spatial conflict between Marine Protected areas and tourists area; 5. No management coastal artificial coral reefs for stakeholder involvement.
Strength		STRATEGY S-O (Using the power to seize the opportunity)	STRATEGY S-T (Using the power to overcome the threat)
1. Appropriate Environmental position for coral reefs waters; 2. Availability of coral measurement station of Environment Conservation Organization; 3. Local Community participation; 4. Local Institutional and Private interest; 5. Co-management on stakeholder participation (local community, government and private); 6. High market seasonality for marine tourism.		1. To encourage co-management among community, government and private for preparing and implementing restoration artificial coral reefs documents; 2. Local community involve in protecting, maintaining, marine ecotourism area; 3. To give chance for private to allocate CSR fund to maintain artificial coral reefs; 4. Intensify the provision of basic data on artificial reefs, from planning, implementation to monitoring and evaluation	1. To establish co-management among local community, government and private to prevent activities dealing with sedimentation, coral mining, waste disposal; 2. Local government prepare and supervise the local people for adaptation of natural disasters; 3. To prevent impact of intense tourism by supplying sufficient infrastructure; 4. Co-management to enforcing spatial law

Weakness	STRATEGY W – O (Overcoming Weakness to seize opportunity)	STRATEGY W – T (Overcoming weakness to seize threats)
1. Limited funds for research, monitoring and evaluation;	1. To increase allocated budget for reserach, and monev from national and foreign;	1. To establish coordination to prevent damaged artificial coral reefs begin from planning, implementing, monitoring, evaluation;
2. Awareness of local people to maximize artifically coral reefs;	2. Preparing program for artificial coral reefs restoration for 5 years program;	2. Preparing management plan for artificials coral reefs for protecting vulnerability of marine ecosystems;
3. Vulnerability of marine ecosystems;	3. To improve coordination among stakeholders to prevent further coral reef damage through artificial coral reefs.	3. counseling to raise public awareness about the importance of environmentally friendly fishing gear
4. Lack of coordination for monitoring the growth of artificial coral reefs.		

3.2. Alternative strategy assessment

Based on the alternative assessment of the strategy from table 3, it is ranked from the ranking one to four: (a) to encourage co-management between communities, government and private for preparing and implementing restoration of artificial coral reefs documents; (b). to establish co-management between local community, government and private to prevent activities dealing with sedimentation, coral mining, waste disposal; (c) to increase allocated budget for reserach, and monitoring and evaluation from national and foreign; (d). to prepare management plan for artificial coral reefs for protecting vulnerability of marine ecosystems;

4. Discussion

4.1. Management options for restoring artificial coral reefs

Management option for the first strategy is to encourage co-management between communities, government and private for preparing and implementing restoration of artificial coral reefs documents. The steps to achieve the first strategy like to establish strategic management, to forecast the future changes on the status of ecosystem, to review all research as basic data, to plan the impact of global climate change and overfishing, and to coordinate all stakeholders concerned.

Management option for the second strategy is to establish co-management between local community, government and private to prevent activities dealing with sedimentation, coral mining, and waste disposal like to prepare the strategic management document, to establish local forum to revent the destruction of artificial reefs, to prepare public information about the current status of coral reefs, as well as information on the various programs that have been undertaken by the forum.

Management option for the third strategy to increase allocated budget for research, and monitoring and evaluation from national and foreign budget resources like to increase the budget allocated for research, and monitoring and evaluation, to develop cost effective, reliable and efficient technologies for enabling progress in artificial coral reefs science, and to observe monitoring, surveying and forecasting of physical, biological and chemical parameters in marine ecosystems,

Management option for the fourth strategy to prepare management plan for artificial coral reefs for protecting vulnerability of marine ecosystems like to protect the vulnerability of coral reef damage, to develop a network to develop and integrate research on artificial reefs with other places, to establish biodiversity and the structure and dynamics of coastal ecosystems, and to focus on basic data collection and develop models to assess and forecast the impact of socio-economic-cultural mechanisms on artificial reefs, as well as contribute to the development of mitigation and restoration strategies to develop existing artificial reefs.

4.2. Interpretive structured modelling (ISM) analysis

The first step is to build an ISM analysis by compiling a table of Structural Self Interaction Matrix (SSIM). Then based on the SSIM table the Rechability Matrix (RM) table is arranged. Parameters consisting of Dependence (D), Hierarchy (H), Driven Power (DP), Ranking (R) are calculated to be compiled in the drawing of the Model diagram of the hierarchical structure of sub-program objectives. The results of ISM shows that: a) it needs establish strategic management of vision, mission, values, goals, programs, and activities with a focus on stopping the decline and restoring the basic conditions of artificial reefs; b) the strategic management document also contains a review of all research results and review used as basic data for planning with scenarios ranging from high, medium and low scenarios; c) the strategic management document also contains a review of all research results and review used as basic data for planning with scenarios ranging from high, medium and low scenarios; d) the Forum should also prevent the impact of destructive and highly extractive fishing gear use. In addition, the forum focused on reducing the destruction of fish habitat on artificial reefs and attempting to reduce pollution, restore damaged reefs, reduce global threats to coral reefs and the impact of trade on the utilization of coral reef resources

5. Conclusion

Management option for artificial reef restoration is to compile a strategic plan. Forum, consisting of relevant stakeholders, is built to establish strategic management plan with a focus on stopping the decline and restoring the basic conditions of artificial reefs. Besides, the strategic management document also contains a review of all research results and reviews used as basic data. It is also contains a review of all research results and reviews used as basic data for planning. In addition, the forum is dedicated to reducing pollution, restoring damaged reefs, reducing global threats to coral reefs and the impact of trade on the utilization of coral reef resources.

6. References

- [1] Giyanto, Abrar M, Aryono T, Budiyanto H A, Hafizt M, Salatalohy A and Iswari M Y 2018 *The Status of Indonesian Coral Reefs 2017*. (Jakarta: COREMAP-CTI Research Center for Oceanography-LIPI)
- [2] Wilkinson, Clive, Souter D and Goldberg J 2006 *Status of Coral Reefs in Tsunami Affected Countries* GCRMN (Global Coral Reefs Monitoring Network) (Australia: Australian Government and Australian Institute of Marine Science)
- [3] Westmacott S, Teleki K, Wells S and West J M 2000 *Management of Coral Reefs That Have Been Bleached and Damaged Critically* (UK: IUCN, Gland, Switzerland and Cambridge) p 36
- [4] Rudianto and Qomariyah D N 2018 *J. Biodiver. Environ. Sci. (JBES)* **12(6)** 147-159
- [5] Edwards A J and Gomez E D 2007 *In Reef Restoration Concepts and Guidelines: Making Sensible Management Choices in the Face of Uncertainty* (Australia: Coral Reef Targeted Research & Capacity Building for Management Programme , St Lucia) p 38
- [6] Epstein N, Bak R P M and Rinkevich B 2003 *Aquat. Conserv.* **13** 387-395

Acknowledgment

The corresponding author is gratefully to thank Rector of Brawijaya University to give permission for survey. I also would like to thank Professor Dr. Ir. Happy Nursyami, dean of faculty of fisheries and marine science of Brawijaya University whose help me to grant research permit.

Reproduced with permission of copyright owner. Further reproduction prohibited without permission.