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# Socio-economic and institutional sustainability management of coral reef ecosystem based on local communities in Teluk Tanah Merah (Depapre), Jayapura, Indonesia

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**Abstract.** The utilization of the resources of the coral reef ecosystem in Tanah Merah Bay area (Depapre) has been going on for a long time by the local communities around the area. Ironically, the dependents are still using destructive tools and methods, such as the use of blast fishing and tuba roots. On the one hand, local communities' especially of the Tefraa / Tabla tribe have wisdom in coral reef resources that have been passed down through generations, namely the Tiaitiki system. This research will evaluate and assess the sustainability status of socio-economic and institutional aspects of coral reef management by local communities in three villages, namely Tablanusu, Tablasufa and Waiya villages using RAPSOCIO-ECOSYSTEM method modified from a Rapid Appraisal for Fisheries Approach (RAPFISH). Based on the findings of the study, showed that the socio-economic dimensions of the villages of Tablanusu and Tablasufa were in the "less sustainable", and the village of Waiya was "quite sustainable" with the leverage attributes, namely the level of existence of professional tourism guides, the existence of companion NGOs, dependence on fisheries as a livelihood, dependence on marine tourism as a livelihoods and Tiaitiki understanding (goals and benefits). The Institutional dimension shows that the three villages are in the category of "quite sustainable" with the leverage attributes, namely Tiaitiki area monitoring agency, NGO / stakeholders in the management especially the implementation of Tiaitiki, Tiaitiki management strategic document, availability of formal rules for managing Tiaitiki, and socialization (implementation, rules and sanctions) of Tiaitiki.



## 1. Introduction

Depapre Bay, also known as Tanah Merah Bay, has the potential to grow into a new economic zone in Papua, especially in Jayapura, after the issuance of Presidential Regulation No. 65 of 2011 concerning the Acceleration of Development of Papua and West Papua. One of the supporting infrastructure built in the area is the port. Certainly, this will bring benefits since it increases the regional development physically. However, the transformation has an impact not only on the surrounding ecosystems but also on social changes. The Depapre Bay region has the potential of coastal and marine resources, such as mangrove ecosystems, seagrasses and coral reefs that are quite large and varied, even relatively pristine. Coral reef ecosystem resources have long been utilized for various economic activities, such as fishing locations and marine tourism. Even fisheries management has been traditionally managed for a long time with the Tiaitiki system [14]. Utilization of these ecosystems has had a positive impact on the economy of local communities, but ironically the utilization of fisheries resources, especially fishing, is often carried out destructively, such as by using fish bombs and anesthesia with tuba roots [15]; [16].

Destructive fishing can cause the depletion and the decreasing ability of coral reefs in providing environmental services for development needs and human life. In addition, the current growth-oriented global development paradigm is fundamentally incompatible with long-term ecological and social sustainability, and, therefore, economic development must be balanced with environmental conservation [23]. Such conditions have encouraged all nations in the world to implement a new development paradigm so-called sustainable development. Development with the concept of sustainable management of natural resource ecosystems refers to efforts to optimally utilize natural resource ecosystems in balance with sustainable conservation measures [4]. Sustainability is one of the most important aspects in the management of coastal and marine resources, especially the coral reef ecosystem.

On the one hand, the management system of coral reef ecosystems, especially coral resources and reef fish in Depapre Bay, has long been carried out by the community traditionally and for generations with the local wisdom approach of Tiaitiki, namely in the form of closing an area at a certain time; [24]; [14]. Such models have been beneficial to species and are effective in coral reef management [6]. In addition, the local wisdom approach has become an important component of scientific research, conservation and resource management [25] and it has been proven to be practically very supportive of management efforts, especially in Southeast Asian countries and it is more successful in Indonesia and Thailand [22]. This management model has become a significant concern in the Indo-Pacific region [6]. Meanwhile, Chaliluddin [5] stated that cultural values contain a lot of local wisdom that needs to be conserved, adapted or even further developed, especially those that are still relevant to current conditions. According to Paulangan et al. [14], Tiaitiki has run effectively based on the resource management framework of the common pool resources regime, but it has not been defined as a written and formalized rule so that it is still in the form of non-formal custom norms. Although not yet formalized, the management system and model needs to be adopted in the formal management of coral resources.

The solutions to the above-mentioned problems of managing complex coral reef ecosystems in Tanah Merah bay require a multidimensional approach so that the concept of sustainable development can be realized [1]. The aim of this study was to determine the condition and sustainability status of coral resource management based on Tiaitiki's current local wisdom by studying the sustainability aspects of the socio-economic and institutional dimensions.

## 2. Material and Methods

This research was conducted in Waiya Village, Tablasufa Village and Tablanusu Village which are geographically located in the Depapre Bay region and they implement the Tiaitiki system (Figure 1). This research took place from September to December 2017, starting from preparation, survey and data analysis.

The data in this study consisted of two categories: primary data and secondary data. The primary data was obtained from field surveys and in-depth discussions with respondents. The number of respondents was determined based on proportional fishermen in each study village, which was equal to 10% of the total population of fishermen. Meanwhile, the respondents selected for in-depth interviews were determined by purposive sampling with consideration to be able to understand the topics studied

and express their opinions well. The secondary data was obtained from literature reviews, documents and reports from institutions relevant to the study topic.

The method of analysis was carried out by RAPSOCIO-ECOSYSTEM which was modified from MDS RAPFISH approach developed by the Fisheries Center, the University of British Columbia [13]. RAPFISH is a fast and simple multidisciplinary assessment technique to evaluate comparative fisheries sustainability [18], [19], [20]. Data analysis with RAPSOCIO-ECOSYSTEM uses aspects of the dimensions that play a role in the sustainability of sustainable coral reef ecosystems, including socio-economic and institutional aspects (Table 1 and Table 2).

**Table 1.** Attributes, descriptions and guidelines for scoring socio-economic dimensions.

Attributes	Description	Scoring guidelines
Tiaitiki implementation-related conflicts	Utilization conflicts are very influential in coral reef management policies.	Not found (0); few (1); many (2).
Tiaitiki understanding (goals and benefits)	The community and stakeholders' understanding of the goals and benefits of the Tiaitiki system is very important in supporting management efforts	Low (0); medium (1); high (2).
The existence of companion NGOs	The existence of non-governmental organizations (NGOs) is highly expected in the process of knowledge and skills transformation related to environmental conservation. In addition, non-governmental organizations have concepts, strategies and programs for empowering and preserving resources and clear strategies [15].	Not found (0); found (1)
Dependence on fisheries as a livelihood	If dependence on resources is high, the community tends to cooperate or carry out joint actions to overcome the problems they face	Very dependent (0); little (1); not dependent (2)
Dependence on marine tourism as a livelihood	Tourism can be an alternative income for the population because generally other natural resources are very limited. Residents can benefit as a provider of food and accommodation for tourists.	Very dependent (0); less (1); not dependent (2)
Professional tour guide (diving & snorkeling)	The existence of professional tour guides is expected to reduce the impact of destructive and unprofessional marine tourism activities	Not found (0); found (1)
Behavior and actions of tourists related to ecosystems	The behavior and actions of tourists who are environmentally friendly can reduce the potential impact of biological tourism activities.	Do not care (0); sufficiently care (1); really care (2)
Level of (local) community compliance with Tiaitiki rules	Compliance describes the acceptance primarily by the community of the rules that exist Tiaitiki	Obedient (0); fairly obedient (1); disobedient (2).
Alternative livelihood opportunities	The more livelihoods the better, the less chance of resource conversion	high (0); medium (1); low (2)

**Table 2.** Attributes, descriptions and guidelines for scoring institutional dimensions.

Attributes	Description	Scoring guidelines
Availability of formal rules for managing Tiaitiki	Formal and non-formal rules play an important role in resource management and sustainability. The existence of formal rules is particularly necessary as a guideline in every form of intervention carried out	None (0); informally existent (1) existent and has been formalized (2)
Tiaitiki area monitoring agency	Monitoring is very important in the context of law enforcement. The monitoring institution can be a team that has duties in monitoring	existent (0); nonexistent (1)
NGO / stakeholder support in management, especially the implementation of Tiaitiki	The support of stakeholders, especially NGOs, is very important in supporting the implementation of resource management programs, especially in the implementation of Tiaitiki	nonexistent (0); existent (1)
Tiaitiki management strategic document	Strategic Plan Documents are needed as a guide in implementing management programs	nonexistent (0); existent (1)
Socialization (implementation, rules and sanctions) of Tiaitiki	Socialization is very important so that a program is understood and accepted and can be implemented properly as expected	existent (0); rare (1); nonexistent (2)
Village / tribal government cooperation in managing Tiaitiki	Cooperation is needed so that a program can run well.	Nonexistent / not yet existent (0); already initiated/ already existent (1)
Legitimacy of rules (acknowledgment from the government)	The rules must be modified in accordance with the interests of the general public, so that they can be widely accepted that is corroborated by a binding rule.	Nonexistent (0); existent (1)
Monitoring and monitoring system	Monitoring and monitoring system that involves the community is considered more effective and efficient	Officer or community only (0); community and officer (1)
Availability of sanctions for offenders	Sanctions in Tiaitiki are very clear based on the level of violations [14].	No sanctions (0); there are sanctions but they are not well enforced (1); there are sanctions and they are well enforced (2)
Enforcement of Tiaitiki rules in the community	Enforcement of rules is very important in overcoming violations and increasing public confidence in the implementation of sanctions and existing rules. In Tiaitiki, rule enforcement is in the hands of Ondoafi [14]	High (0); medium (1); low (2)

The scores of each attribute were analyzed multidimensionally to determine the sustainability position of the dimensions of coral reef management that were studied relative to the two reference points, namely the "good" point and the "bad" point. The sustainability index of coral reef management has an interval of 0-100%. The index values and sustainability status categories in this study were

arranged in four categories based on an interval base scale of 0-100 (Figure 2), namely an index value of 0.00-25.00 (not sustainable), 25.01-50.00 (less sustainable), 50.01-75.00 (quite sustainable), and 75.01-100.00 (very sustainable).

### 3. Results and Discussion

Goodness of fit of the MDS results was shown by stress values and squared correlation (r-squared) as shown in Table 3. The stress values indicate the proportion of difference variance that is not explained by the model [10]. The stress value which is smaller than 0.25% with a squared correlation value approaching 1 (100%) indicates that the MDS model can be said to be good and can present the issues discussed. The smaller the Stress value, the better [14]. The statistical stress value requirement must be less than 25% [9] and has been sufficient if 25% is obtained (Fisheries.com 1999). The closer the r-squared to 100%, the better. As an example of the ecological dimension above, the stress value is 12.82%. According to the MDS procedure, if stress value is <25% ( $S < 25\%$ ), the RAPSOCIO-ECOSYSTEM analysis has fulfilled the goodness of fit with a given confidence interval correlation of 95.22%. The values and status of sustainability of social-economic dimension in the three studied villages are shown in Table 4.

**Table 3.** Stress and squared correlation.

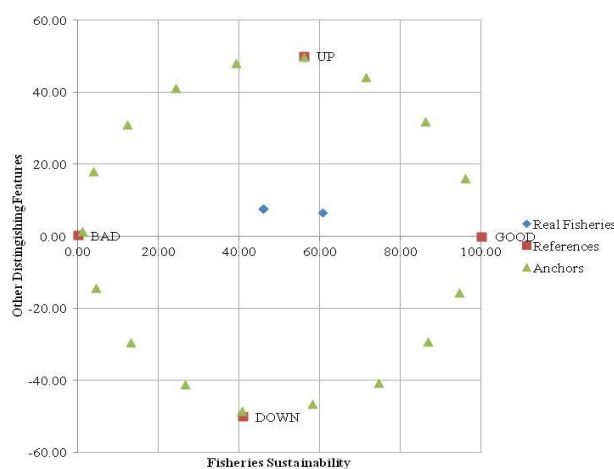
Dimension	Value of Stress (%)	Squared correlation (%)
Social-Economic	14.43*	94.57**
Institutional	12.92*	94.46**

Sources: Result of analysis (2017); Explanation: \*) < 0.25; \*\*) ~1

**Table 4.** The value and status of sustainability of social-economic dimension.

Locations	Value of Sustainability	Status of Sustainability
Tablanusu	45.84	Less Sustainable
Tablasufa	45.84	Less Sustainable
Waiya	60.48	Quite Sustainable

The sustainability position of the socio-economic aspect in Figure 2 shows that the villages of Tablanusu and Tablasufa were in the category of less sustainable, and Waiya village was quite sustainable.



**Figure 1.** Results of the ordination of sustainability index of the socio-economic dimension.



**Figure 2.** Results of leverage analysis of Socio-Economic dimensions.

Based on the results of the leverage of attributes in Figure 3, the attributes that affected the assessment category of the sustainability status of the three villages showed that those who had a strong influence on the assessment of socio-economic sustainability status, namely the existence level of professional tourism guides, was at 5.51, the existence of companion stakeholders 4.83, livelihood dependence on capture fisheries 4.31, livelihood dependence on marine tourism 3.71 and the understanding of Tiaitiki 3.50.

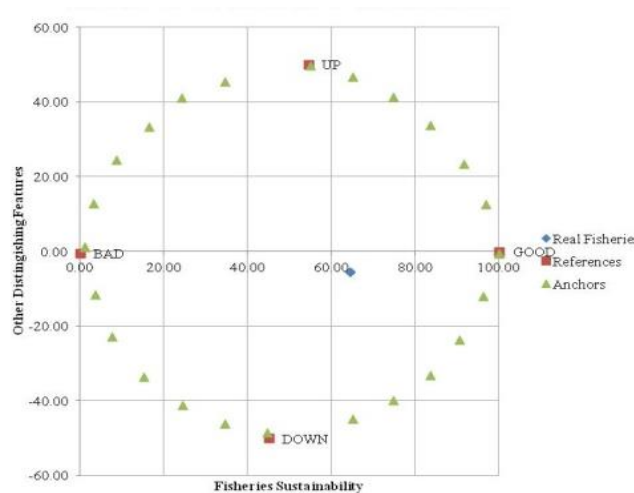
Marine tourism activities in the Depapre Bay region are currently developing. Swimming, diving and snorkeling have begun to be in demand by local, domestic and foreign tourists. Especially for diving and snorkeling activities, if not accompanied by a professional guide, the damage to the ecosystem, particularly coral, is likely to occur. The existence of stakeholders such as non-governmental organization as a companion in the implementation of Tiaitiki has been going on since for several years ago, namely the Locally-Managed Marine Area (LMMA), which is headquartered in Biak. The LMMA institution is one of the institutions that maintains and develops the Tiaitiki local wisdom system to date. Therefore, people's understanding of Tiaitiki is still quite good. In Paulangan et al. [14], the livelihoods of the people in the Depapre Bay region, especially in the villages of Waiya, Tablasufa, Tablanusu, and Kendate are quite limited. Regarding marine resources, people's livelihoods are highly dependent on fishing activities and marine tourism. However, it is slightly different from the community of Kendate village, where the people are more dominant in gardening. The sustainability position of the institutional dimension in Figure 4 shows that the three villages were in the category of quite sustainable.

**Table 5.** The value and status of sustainability of institutional dimension.

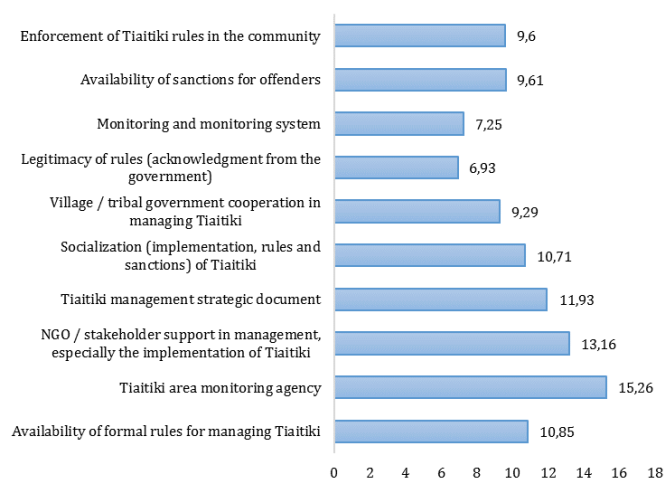
Locations	Value of Sustainability	Status of Sustainability
Tablanusu	64.30	Quite sustainability
Tablasufa	64.30	Quite sustainability
Waiya	64.30	Quite sustainability

Meanwhile, the results of the leverage of attributes of the variables that influence the status assessment category which was quite sustainable in the three villages in Figure 5 showed that the one that had a strong influence was the monitoring activities in the Tiaitiki area of 15.26, the support of stakeholders (such as non-governmental organizations) in the implementation of Tiaitiki 13.16, the Tiaitiki strategic plan document 11.93, the availability of formal rules for Tiaitiki management 10.85, and Tiaitiki socialization (implementation, rules and sanctions) 10.71. Monitoring the implementation of Tiaitiki in the field requires attention because based on observations there was no monitoring coordination carried out by the authorities and the community, and eventually the community was

reluctant to report to the authorities in the event of a violation. The community prefers to report to adat stakeholders and often leads to acts of violence.



**Figure 3.** Results of the ordination of sustainability index of the institutional dimension.



**Figure 4.** Results of leverage analysis of institutional dimensions.

The sustainability index of each dimension in each study site can be seen in Figure 6. Each location had a different level of sustainability. Therefore, the intervention management in each location might be different based on the location characteristics, but the three villages had the highest sustainability value (quite sustainable) in the institutional dimension. The other dimension which was still less sustainable was the socio-economic dimension of Tablanusu village and Tablasufa village, while the technological dimension was less sustainable in the Tablasufa village. Referring to Walla et al., (2016) from the two dimensions above, it could be seen that the institutional dimension had a higher index value than the socio-economic dimension. This means that changes in community institutions were more visible than socio-economic dimension. Socio-economic changes would be seen if the institution was very strong.



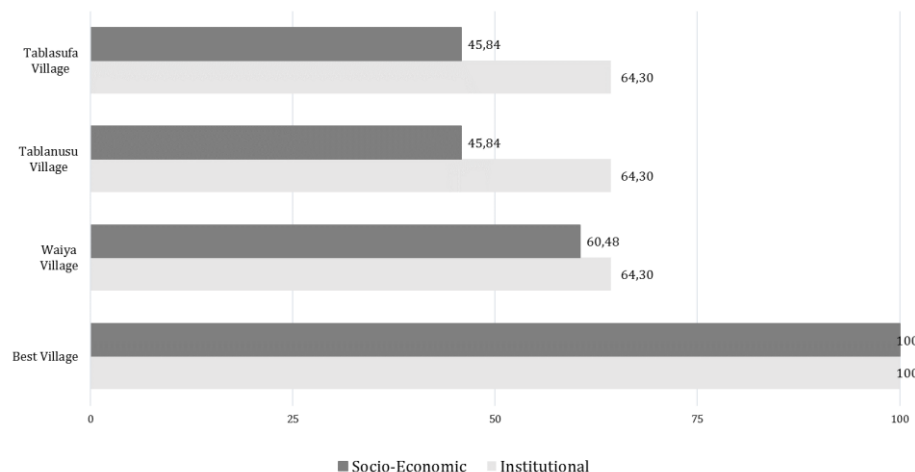


Figure 5. Total sustainability index of socio-economic and institutional dimensions.

#### 4. Conclusion

The sustainability index values of the socio-economic and institutional dimensions of the management of the Tiaitiki-based coral reef ecosystem in the Depapre Bay region were in the category of less sustainable until quite sustainable. The dimension that was less sustainable was the socio-economic dimension, except in Waiya village, which was quite sustainable. The sustainability value of each dimension could be maintained and / or improved by improving the attributes that had a large contribution. The attributes that contributed to the socio-economic dimension were the level of the presence of professional tourist guides, the existence of companion stakeholders, livelihood dependence on capture fisheries, livelihood dependence on marine tourism and understanding of Tiaitiki. The institutional dimensions included monitoring activities in the Tiaitiki area, stakeholder support (such as non-governmental organizations) in the implementation of Tiaitiki, Tiaitiki strategic planning documents, availability of formal rules on Tiaitiki management, and Tiaitiki socialization (implementation, rules and sanctions). This research should be followed up with the preparation of a management strategy by paying a special attention to sensitive attributes (levers) of each dimension.

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