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Sustainability status of lagoon ecosystem in Ihamahu village, Maluku, Indonesia

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Abstract
The coastal area of Ihamahu Village, Maluku, Indonesia consists of three important tropical ecosystems namely, mangrove, seagrass, and coral reef as well as lagoon ecosystem. There are nine lagoons in this area. The biodiversity of the lagoon ecosystem is high which could be utilized by the community to fulfill their needs. The objective of the present study was to analyze the sustainability status of the lagoon ecosystem in Ihamahu Village. Lagoon sustainability status was analyzed by using Rapid Appraisal for Fisheries (RAPFISH) method, a multi-dimensional scale analysis. Lagoon sustainability analysis was performed based on ecological, social, economic, institutional and technological dimensions. The result showed that there were differences concerning the sustainability index for each dimension. According to the sustainability category classification, the ecological dimension belonged to the sustainable category (85.51%) and the social dimension was considered moderate sustain (50.88%). On the contrary, the dimension of the economy (49.81%) and institutional (46.57%) was categorized as less sustain while technological dimension (32.84%) was considered as unsustain in a sustainable management approach context. The recommendations for management guideline were the determination of protected and utilized zone, strengthening village institution, and increasing capability and economy of Ihamahu community.

Keywords: Community, coastal area, fish resources, utilization, sustainable category

1. Introduction
The lagoon ecosystem has high productivity in providing resources and environmental services in a coastal area such as fisheries resources and coastal tourism [1-3]. This ecosystem is functioning as shelter area, feeding and spawning ground for fish populations of fresh and marine waters. Another important contribution of the lagoon ecosystem is a carbon dioxide absorption area. The primary producers (phytoplankton and aquatic plant) in the lagoon ecosystems can decrease the impact of climate change through carbon dioxide absorption [1].
The coastal area of Ihamahu village of Maluku Province, Indonesia, consists of important ecosystems namely, mangrove, seagrass, and coral reef as well as lagoon ecosystems. There are nine lagoons with different sizes ranging from large, medium to small size. The local community utilizes the resources of the lagoon ecosystem to fulfill their needs. Based on the population data, there is an increase of population number in this area from 1,402 individuals in 2010 to 1,551 individuals in 2015 [4].
An increased utilization activity of local community towards fish resources in the lagoon would have an impact on decreasing the resources of the lagoon ecosystem [5]. The local fishers of Ihamahu use several fishing gears such as gillnet, pole and line, and beach seine. The beach seine has been banned for fishing based on a regulation issued by the Minister of Marine and Fisheries Affairs of the Republic Indonesia, Act No. 2/2015 [6]. This fishing gear is categorized as unfriendly fishing gear due to its unselective in target fish and destruction of habitat. The prohibition of this gear, on the other hand, will also lead to unemployment which will decrease some local fishers' income. To manage lagoon ecosystem in Ihamahu in a manner that can sustain its function in providing fish resources and ecosystem services for the community, the management of lagoon ecosystem should incorporate other supporting components for this lagoon i.e. ecological, economic, social, technological and institutional.
Considering the situation mentioned above, the objectives of the present study, therefore, were to analyze the sustainability status of lagoon ecosystem in Ihamahu Village based on conditions of ecological, social, economic, institutional and technological aspects and to

recommend a management guideline following sustainability status of this lagoon.

2. Materials and Methods

2.1 Study Site

The study was carried out in Ihamahu Village, East Saparua sub-Regency, Central Maluku (Figure 1) from May to June 2017.

2.2 Data collection

The primary data was collected through questionnaires distributed to respondent randomly selected from local community and interview through Focus Group Discussion (FGD). While secondary data collection was obtained by means of literature review and related information from Ihamahu Village demography data.

2.3 Data analysis

The sustainability status of lagoon ecosystem management in Ihamahu Village was analyzed using the Rapid Appraisal for Fisheries (Rapfish) method, a multidimensional scaling (MDS) approach [7, 8]. This multidimensional analysis was used to determine points in Rapfish which two points would be used as a reference: good and bad. Data for sustainability study were, based on standard attributes for Rapfish Analysis with some modification [8, 9]. The sustainability index ranged from 0 to 100% scale of sustainability. Sustainability status category of lagoon ecosystem was then classified into five categories based on sustainable management approach according to Pitcher *et al.* (2009) [10].

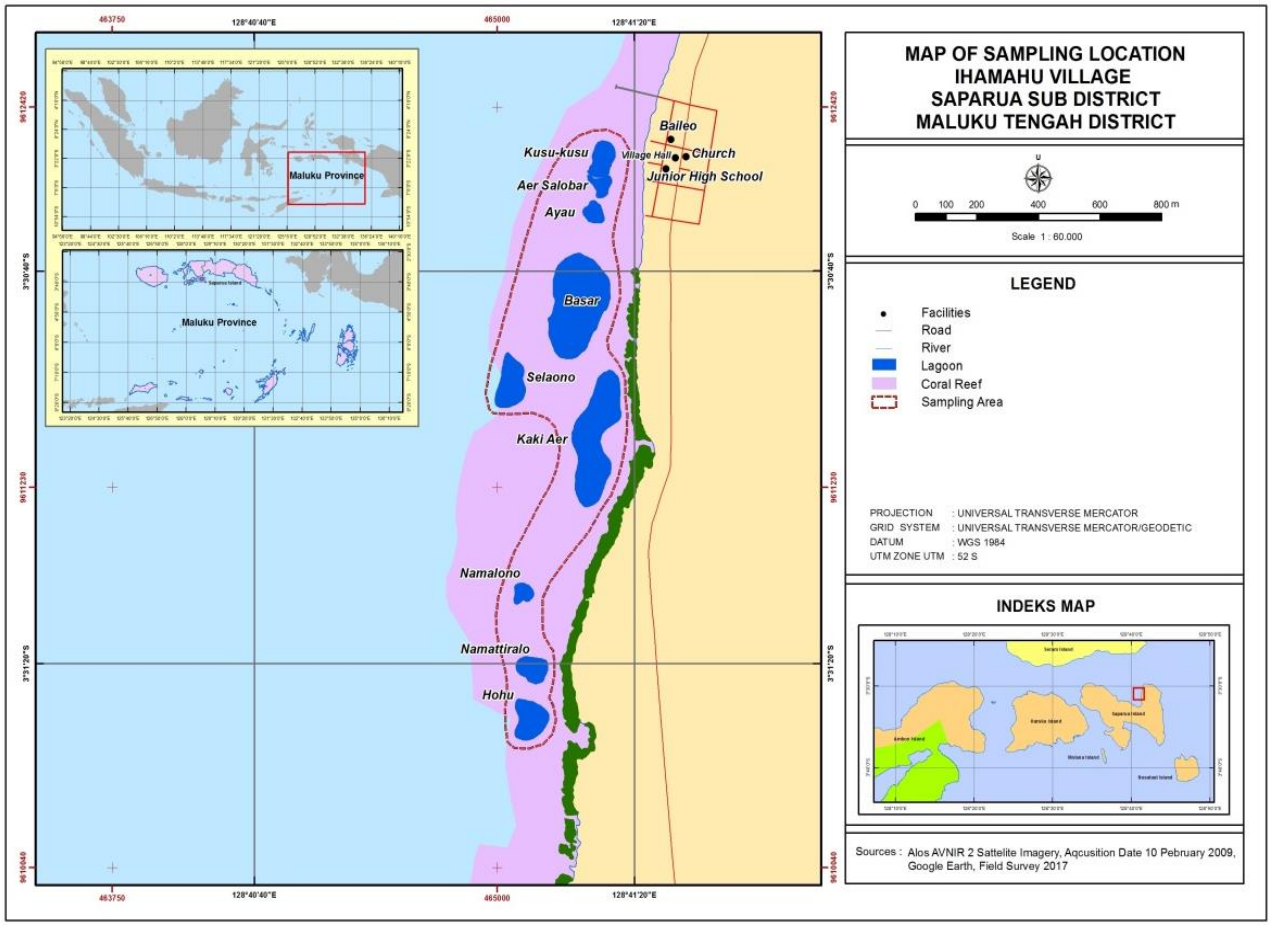

Fig 1: Map showing study site

3. Results and Discussion

3.1 The sustainability status of the ecological dimension

Ecological dimension is an assessment of ecological and ecosystem attributes that can foster or inhibit the sustainability status of resources at the lagoon ecosystem. The ecological sustainability analysis encompasses 9 attributes *i.e.* salinity, temperature, pH, depth, which describe water quality supporting resources of the lagoon and exploitation status, fishing of immature gonad, range of collapse, number of species caught, size changes of fish harvested which describe productivity of the resources. The Rapfish analysis result indicated that ecological sustainability of the lagoon ecosystem was 88.51% of 100% sustainable scale (Figure 2A) which is considered as sustain in sustainable management approach [10, 11].

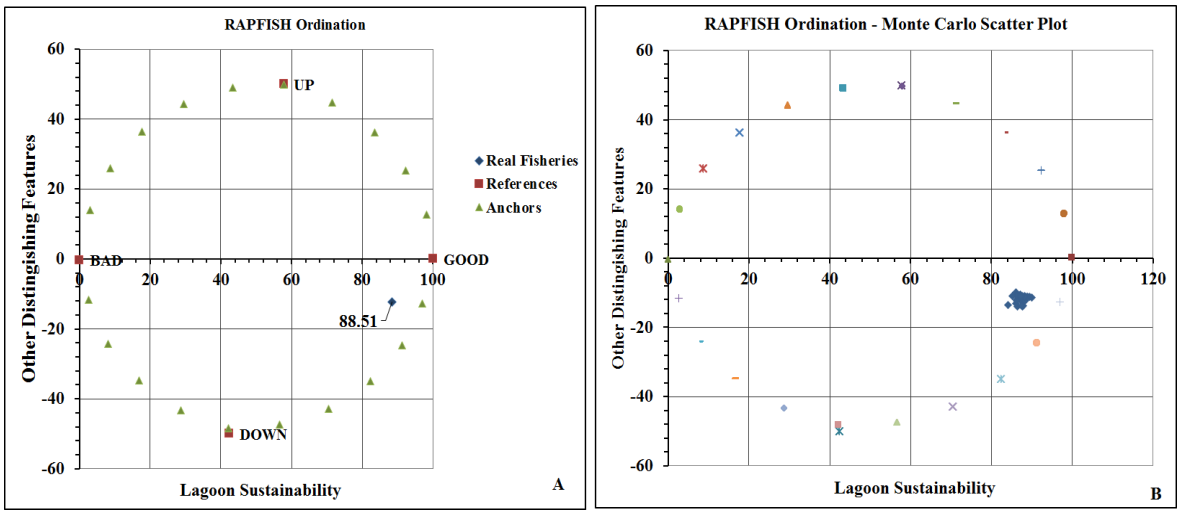

Fig 2: Rapfish analysis (A) and Monte Carlo scatter plot (B) for ecological dimension sustainability of lagoon ecosystem in Ihamahu Village.

Monte Carlo scatter plot from Rapfish ordination was intended to analyze the goodness of fit of Rapfish analysis. The result shows that Rapfish analysis for ecological sustainability was accurate shown by stress value of 0.1342 which is less than 0.25 as reported by Clarke & Warwick (1997) [12] with a squared correlation of 0.9515. Figure 2 B also shows that anchor and reference fisheries do not move in Monte Carlo run suggesting an accuracy of the analysis [8].

The leverage analysis showed that changes in harvest size and number of species caught were more sensitive than other attributes (Figure 3). The FGD results revealed that 60% of the respondents stated the harvest size declined to a small individual size in the last 5-10 years. There were 50% respondents suggesting that there were other species which have been also caught. This means that there was an unbalance comparison between fishing of target species and other fish due to unfriendly fishing gear. Some fishing gears used at the surrounding waters of lagoon ecosystems were beach seine, hand line, gill net and lift net. Beach seine is one of the unselective fishing gears operated in coastal waters, and this gear could be categorized as unfriendly fishing gear. In Chapter 4 of the Ministry of Marine Affairs and Fisheries Act, No.12/PERMEN-KP/2015 is clearly stated the prohibition of using trawl and seine nets including beach seine in Fisheries Management Area of the Republic Indonesia [6].

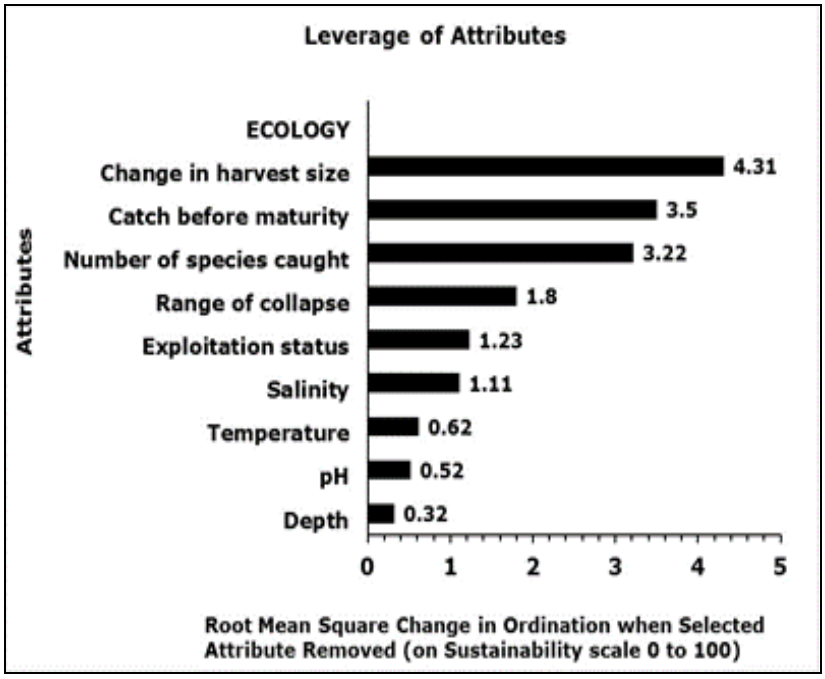

Fig 3: Leverage analysis for ecological dimension of lagoon ecosystem

3.2. The sustainability status of the social dimension

The social dimension in Rapfish analysis assesses social attributes that can foster or inhibit the biological sustainability of the resources [11]. The Rapfish analysis showed that the social dimension of the lagoon ecosystem was 50.88% of 100% sustainable scale and it is considered to be moderate sustains (Figure 4 A). The Monte Carlo Scatter Plot for the goodness of fit analysis showed a clumsiness' of the plot which had the same position as real fisheries in Rapfish analysis (Figure 4 B). This explains that anchor and reference fisheries do not move during Monte Carlo run which means a good accuracy in analysis. Stress value was 0.1375 which also less than 2.5 and considered as good [12] whilst square correlation (R^2) was high (0.9526) as well.

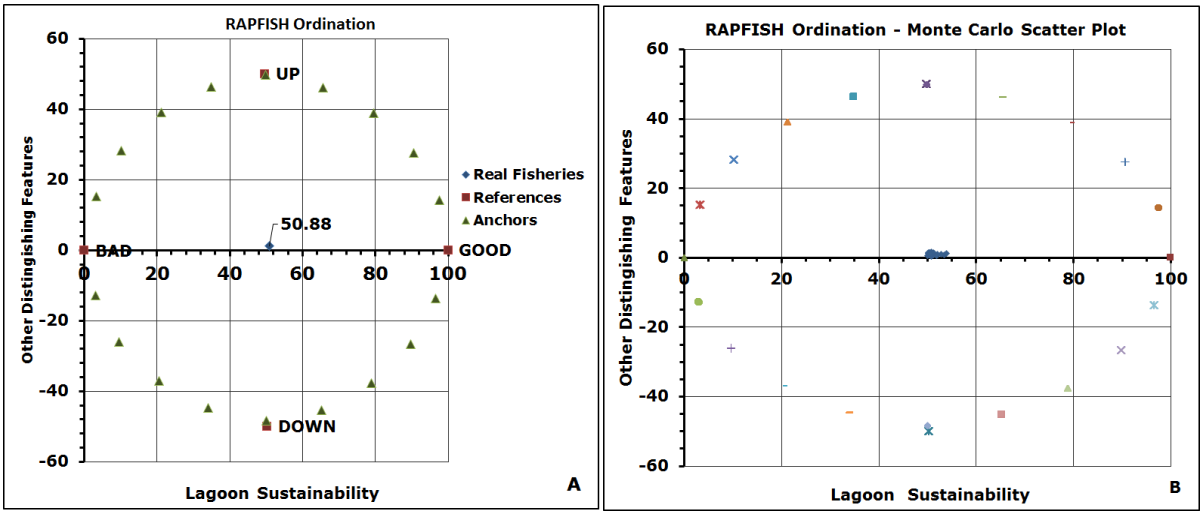

Fig 4: Rapfish analysis (A) and Monte Carlo scatter plot (B) for social dimension sustainability of lagoon ecosystem in Ihamahu Village

There were eleven attributes used in social dimension sustainability analysis. Leverage analysis intended to analyze the most sensitive attribute towards social sustainability, and the result showed four out of eleven attributes i.e. knowledge on sustainability development, attitude towards resources degradation, knowledge in fisheries management and socialization in management had high sensitivity value (Figure 5). Knowledge of sustainability development assesses how depth is the community understanding of sustainability development. Knowledge has a relationship to education level, but in the case of Ihamahu Village, the community education level is considered good. Another factor that could be attributable to this situation is special knowledge of sustainable principles.

The second attribute with high sensitivity was the attitude towards resources degradation. During FGD it was found that the community realized about declining of fish resources harvested as well as the negative impact of beach seine used in fishing and they just ignored it. Because of economic reasons, the local fisher keeps using beach seine. This assertiveness of local fisher could be due to their level of education since the majority of them (70%) having only elementary education. Many studies have shown that education level affects the attitude of the community [13, 14]. In the past, Ihamahu Village has a traditional institution locally called *kewang*, who regulated the management and utilization of natural resources include fish resources. Currently, this institution is in a state of weakening for several internal reasons and this probably causes the attitude of the community towards sustainable management (personal communication).

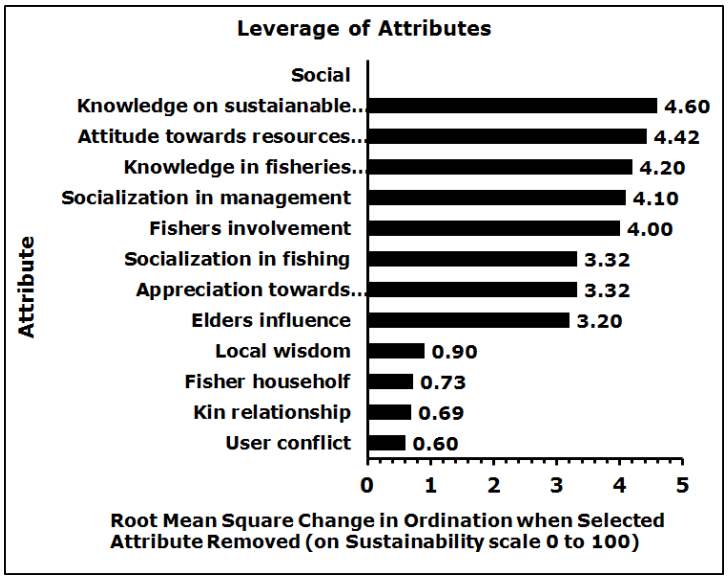

Fig 5: Leverage analysis for social dimension of lagoon ecosystem.

The third attribute was knowledge in fisheries management regulation specifically in the lagoon ecosystem. From FGD and questionnaire collected, it was found that some people did not know about the regulations concerning fisheries management. This attribute has a strong relationship with the fourth-highest attribute, socialization in management, which assesses the involvement of the community in fisheries management. Government institution responsible towards fisheries management should actively and regularly conducting advocacy and training in fisheries management and should include local community especially the fishers. Interviewed with local fishers revealed that not only the activity but also the involvement on the local fisher in fisheries management is very limited.

3.3 The sustainability status of institutional dimension

Institutional dimension in sustainability analysis incorporates some social, economic and ethical status of human being which could foster or inhibit ecology or fish resources sustainability [11, 15]. Rapfish analysis for institutional dimension showed that sustainability index of this dimension was 46.57% of 100% sustainable scale (Figure 6 A) and in sustainable management, categorized as less sustain [10]. The institutional Rapfish field encompasses both for governance (quality and legality) and management (regulation, reporting, and protection) as well as local environmental knowledge in fisheries management [11]. Monte Carlo scatter plot of Rapfish ordination (Figure 6 B) showed clumsiness of the plot suggesting the validity of analysis as also shown by stress value of 0.1451 which is less than 0.25 explaining high goodness of fit and also shown by high square correlation (R^2=0.9494).

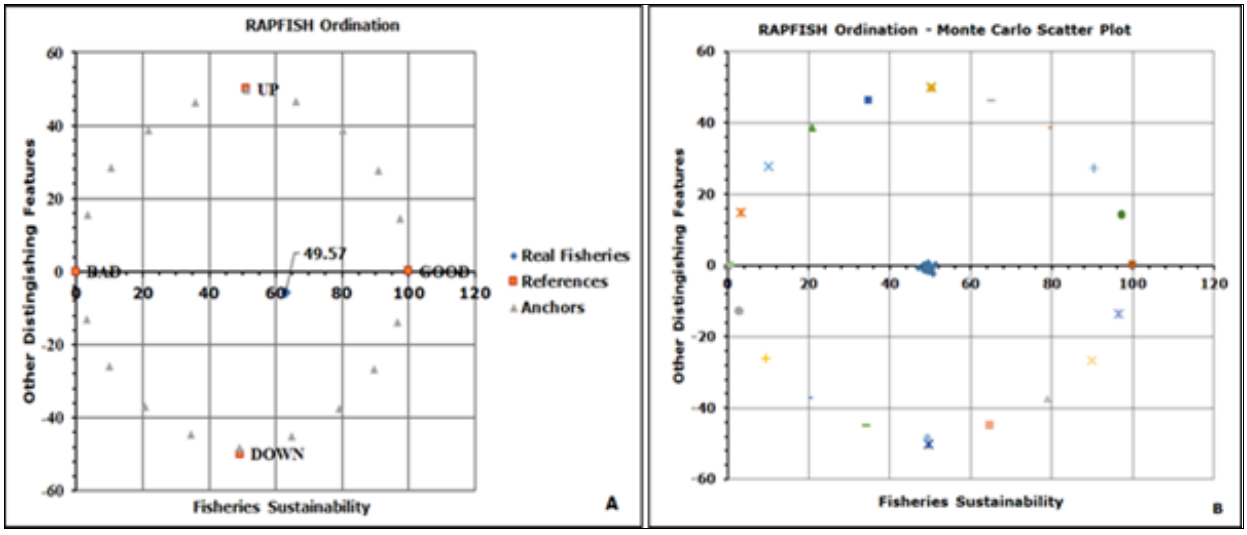

Fig 6: Rapfish analysis (A) and Monte Carlo scatter plot (B) for institutional dimension sustainability of lagoon ecosystem in Ihamahu Village.

The institution is strongly related to regulation, sanction, and control in the use of resources and habitat which can be performed either by the local village or by the government agency. The leverage analysis pointed out three sensitive attributes out of eleven attributes from the institutional dimensions which have high sensitivity affecting the sustainability of the lagoon ecosystem (Figure 7). These three attributes were regulation existence in the utilization of resources of lagoon ecosystems, governance role in fisheries management of lagoon's resources and village regulation concerning the utilization of coastal and marine resources especially the lagoon ecosystem.

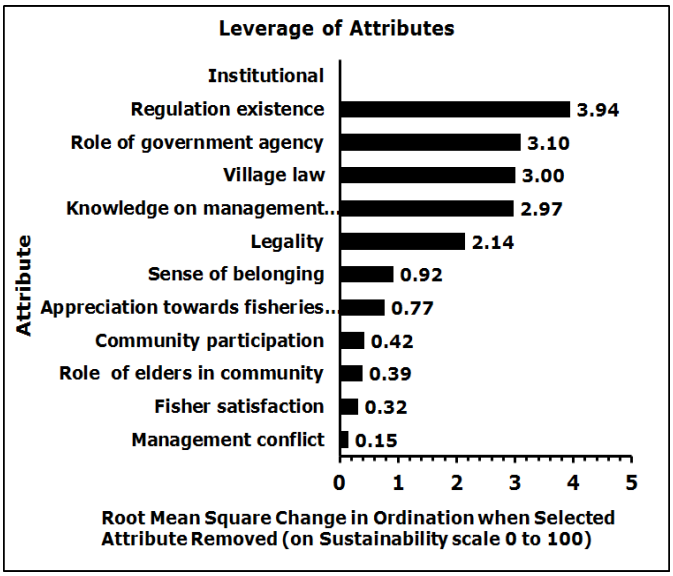

Fig 7: Leverage analysis for ecological dimension of lagoon ecosystem.

The institution can be comprehended here as a body of organization or norm or values which exist and live within the community [16]. Regulation existence assesses the availability of the regulation or rules in managing fisheries resources as well as ecosystem and habitat. At the national level, there are several regulations concerning that topic such as Ministry of Marine Affairs and Fisheries Act No. 30/PERMEN-KP/2012 and 57/PERMEN-KP/2014 concerning capture-based fisheries [17, 18], Government Act. No 60/2007 concerning the conservation of fish resources [19] and many more. The problem is, at the local level, the majority of the community knows very little about those regulations.

The second most sensitive attribute was the role of the government agency in the management of fish resources and the ecosystem. Pitcher *et al* (2013) [11] described government agency in term of quality or capacity of government to provide enabling conditions for legal, regulated, reported and protected fisheries and ecosystem. According to Ihamahu people, almost none of these have been conducted by the government. Not surprising that local fisher keeps doing fishing with beach seine, for example, which has been banned by the government. Improvement of government capability and their involvement in the management could foster ecology and fish resources sustainability of the lagoon ecosystem. Studied by Natan *et al* (2016) [20] and Tetelepta *et al* (2017, 2019a, b) [21-23] shown unsustainable institutional dimension in the management of sea cucumber and mud crab *Scylla serrata* respectively at Central Maluku and Western Seram District as well as Buru District and mainly due to government quality in fisheries management.

Ihamahu Village is one of the villages in Central Maluku which runs under customary tradition. One of the traditional customaries (indigenous knowledge) which relate to natural resources management is called *sasi* [24-26]. This customary could be classified as community-based resources

management [27]. The management of lagoon resources and ecosystem, therefore, could be done through traditional norm approaches. Some studies [25, 28, 29] revealed a weakening of *sasi* in Central Maluku due to local village leader quality.

3.4. The sustainability status of the economic dimension

The economic field in Rapfish analysis analyzes how economic variables (attributes) will have an effect either fostering or inhibiting bio-ecology sustainability [9, 11]. Rapfish analysis showed that the economic sustainability of the lagoon ecosystem was 49.81% of 100% sustainability scale and was considered less sustain in sustainable fisheries management [10]. Figure 8A shows Rapfish ordination for economic sustainability. Monte Carlo scatter plot (Figure 8B) for validity analysis showed a consistency of scatter plot to Rapfish ordination meaning high accuracy in analysis. Stress value was 0.1491 which is less than 0.25 also considered as good [12] as well as square correlation with $R^2 = 0.9421$.

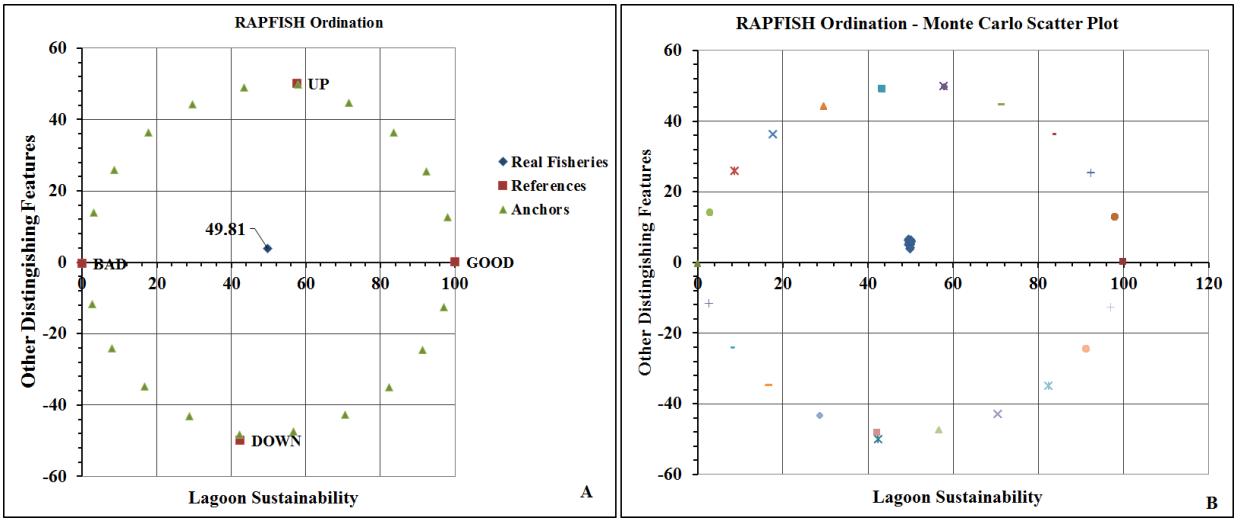

Fig 8: Rapfish analysis (A) and Monte Carlo scatter plot (B) for economy dimension sustainability of lagoon ecosystem in Ihamahu Village.

In economy sustainability analysis of lagoon ecosystem, eleven attributes were used and Leverage analysis. This analysis revealed that the three most sensitive attributes were lagoon economy benefit, amount of benefit obtained and harvesting time (Figure 9). Generally, sustainability Rapfish analysis for economy dimension intended to analyze economy variable(s) which could foster or inhibit bio-ecology sustainability. Economy benefit obtained from lagoon ecosystem can fulfill community livelihood thus will motivate the community to protect the lagoon ecosystem. The economy benefit is also related to amount of benefits obtained, which benefits obtained mainly goes to local community *i.e.* the fisher then they will foster lagoon resources sustainability and vice versa [9].

Focus group discussion result showed that economy benefit obtained from lagoon utilization in term of average income was similar to other sources of income or even smaller. In Rapfish analysis perspective, lower-income or benefit will inhibit the sustainability of the resources. Lower-income will drive the fisher to use more resources from the lagoon ecosystem. With poor management from institutional dimension, this will even increase the pressure towards the lagoon ecosystem. The economic benefit of local fisher from fish resources can be improved into secondary products which mean the processing of fish harvested into another form of the product. From interviewed it was found that there were no such thing practices. Fish harvested from the lagoon ecosystem will directly sold or for own consumption only.

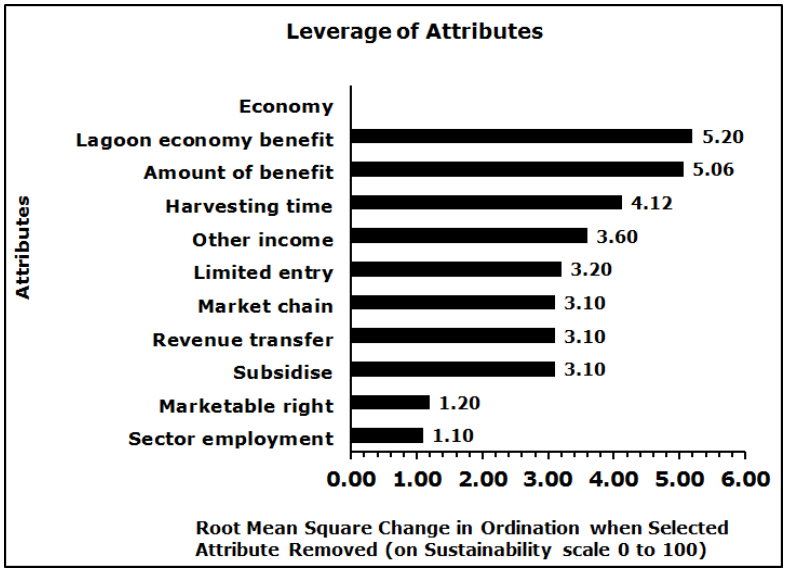

Fig 9: Leverage analysis for economy dimension of lagoon ecosystem.

3.5. The Sustainability Status of the Technology Dimension

In the context of fishing technique and sustainability of the resources, there are many factors (variables) which could either foster the resources and ecosystem (habitat) or decrease it. Gear selectivity, gear effect, handling of the product, size of gear, etc., are an example of factors affecting sustainability. The local fisher of Ihamahu Village uses traditional fishing equipment like hand line, net, and harpoon for fishing on the lagoon ecosystem. There is also a traditional way of harvesting fish resources locally called *bameti* which is the picking of fish resources with small scoop or spear during low tide. Rapfish analysis showed that the sustainability level of lagoon ecosystem was 32.84% of 100% sustainable scale (Figure 10 A), categorized as unsustain in a sustainable management approach context (Pitcher et al 2009) [10]. Monte Carlo analysis for the test of goodness of fit (Figure 10 B) showed good analysis since anchor and fisheries references did not move in Monte Carlo run [18]. The stress value was 0.1345 which is lower than 0.25 indicating good analysis [12] and square correlation (R^2) = 0.9467, all explain good validity of the test.

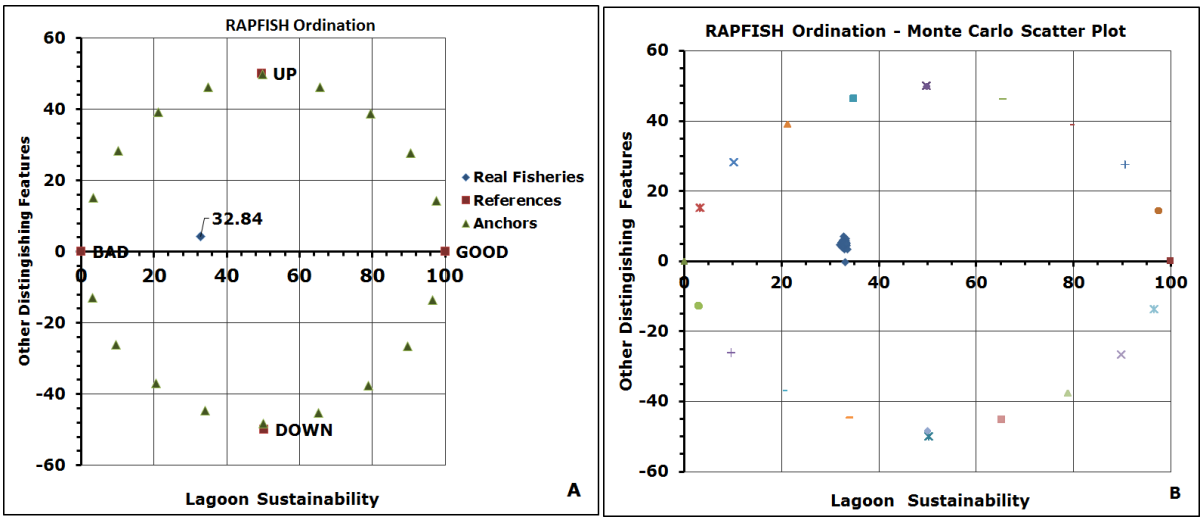

Fig 10: Rapfish analysis (A) and Monte Carlo scatter plot (B) for technology dimension sustainability of lagoon ecosystem in Ihamahu Village.

Leverage analysis for sensitive attribute on technology sustainability showed that the three most sensitive attributes were gear selectivity, gear side effect and type and gear characteristic (Figure 11). Between the three fishing gear used by local fisher, beach seine is the most unfriendly fishing gear. Gear effect from beach seine could arise from net mesh size which is not selective. With a small mesh size of the net, fish with is undersize could be retained as well as discard and by catch as a consequence as non-target species. From operational technique, beach seine could damage the coral reef and other benthic organisms.

Knowledge on sustainable fisheries management, attitude towards habitat degradation, equity in economic benefit, an alternative source of income, management quality, evaluation, controlling and other factors also contribute to the sustainability of lagoon ecosystem. All those factors come from a different dimension and as a whole contribute to the sustainability of the lagoon and its resources. In an ecosystem approach to fisheries management, ecology, socio-economy, and institutional dimension have to be integrated into the management of the resources [11, 30].

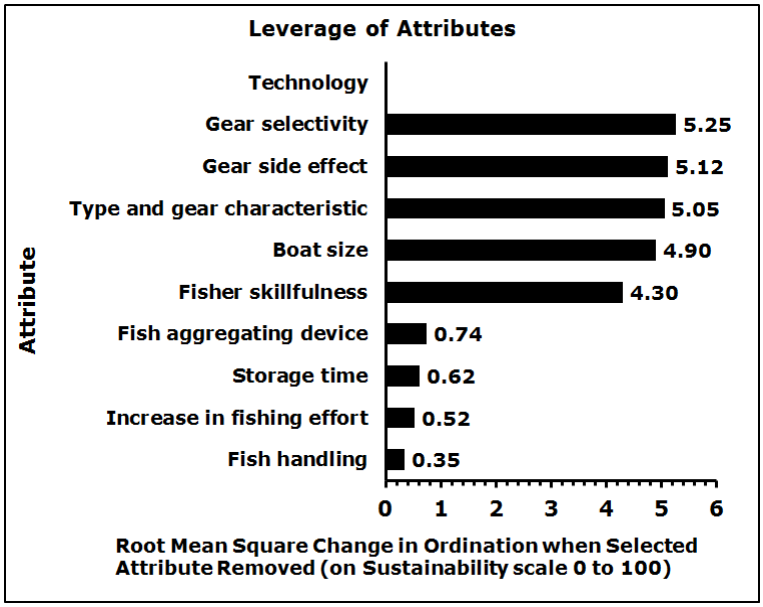

Fig 11: Leverage analysis for technology dimension of lagoon ecosystem.

The gear selectivity, its side effect and other factors from the technology dimension merely do not contribute to the sustainability of the lagoon ecosystem and its resources. Based on sustainability analysis results of lagoon ecosystem in Ihamahu Village, the following management guidelines was proposed for a sustainable management of lagoon ecosystem:

1. Identification of protection and utilization zone based on lagoon resources;
2. Strengthening both government and local institution quality and capability in sustainable management approach on fisheries management;
3. Empowering community awareness and capability through education and training which will increase their understanding and skilled on sustainable utilization of lagoon ecosystem and its resources;
4. Increasing the economic power of the fisher community by introducing secondary fish products.

4. Conclusions

The present study indicated that sustainability indices were different for each dimension. The sustainability index of ecology dimension was in the sustainable category and it was moderate sustain for social dimension. Whereas the sustainability indexes for the economy, institution and technology belonged to less sustain category. There were four management guidelines to protect and to conserve lagoon ecosystem resources i.e. zonation on lagoon ecosystem, institution strengthening, community capability empowering and increasing fisher community welfare from an economic point of view.

5. Acknowledgement

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6. References

1. Anthony A, Atwood J, August P, Byron C, Cobb S, Foster C *et al*. Coastal lagoons and climate change: ecological and social ramifications in U.S. Atlantic and Gulf coast ecosystems. Ecology and Society 2009; 14(1):8.
2. Dolbeth M, Stalnacke P, Alves FL, Sousa LP, Gooch GD, Khokhlov V *et al*. An integrated Pan-European perspective on coastal lagoons management through a Mosaic-DPSIR approach. Scientific Reports 2016, 6.
3. Villerías SS, Violante GJ, García CN, Alonzo GL. Environmental deterioration of the Tecomate Coastal Lagoon, in the Guerrero State, Mexico. International Journal of Geosciences 2016; 7:1-10.
4. BPS (Badan Pusat Statistik). East Saparua Sub District in Figure. BPS Kabupaten Maluku Tengah. (in Indonesian), 2016
5. Ellepola G, Ranawana KB, Harischandra S. Utilization of fishery resources in the Panama lagoon, Ampara District, Sri Lanka. International Journal of Fisheries and Aquatic Studies. 2014; 1(5):32-37.
6. MMFA. Ministry of Marine and Fisheries Affairs Regulation No. 2/2015 concerning the prohibition in using trawls and seine nets in fishing at fisheries management area of the Republic of Indonesia. (in Indonesia), 2015
7. Pitcher TJ, Preikshot D. Rapfish: A rapid appraisal technique to evaluate the sustainaibility status of fisheries. Fisheries Research. 2001; 49:255-270.
8. Kavanagh P, Pitcher TJ. Implementing Microsoft Excel Software for Rapfish: A technique for the Rapid Appraisal of Fisheries Status. Canada: University of British Columbia, Fisheries Centre Research Reports. 2004; 12(2).
9. Rapidfish Group. Standard attributes for rapfish analyses: evaluation fields for ecological, technological, economic, social and ethical status. Fisheries Centre, UBC, Vancouver, 2006.
10. Pitcher TJ, Kalikoski D, Short K, Varkey D, Pramoda G. An evaluation of progress in implementing ecosystem-based management of fisheries in 33 countries. Marine Policy. 2009; 33:223-232.
11. Pitcher TJ, Lam ME, Ainsworth C, Martindale A, Nakamura K, Perry RI *et al*. Improvements to Rapfish: a rapid evaluation technique for fisheries integrating ecological and human dimensions. Journal of Fish Biology. 2013; 83:865-889.
12. Clarke KR, Warwick RM. Change in Marine Communities: An Approach to Statistical Analysis and Interpretation. Plymouth Marine Laboratory, UK. 1997, 144.
13. Winata A. Coastal community role in implementing conservation strategy for marine resources. (Case in Pelabuhanratu, Sub-district Pelabuhanratu, Sukabumi District). Jurnal Matematika, Sains dan Teknologi. 2010; 11(2):122-132 (in Indonesia).
14. Nanlohy H. Correlation analysis of social and economy components of coastal community in utilization of mangrove ecosystem in Kotania Bay, District of West Seram, Maluku Province. Jurnal Insei. 2015; 4(2):1-11 (in Indonesia).
15. Ostrom E. A general framework for analyzing sustainability of social-ecological systems. Science. 2009; 325:419-422; doi: 10.1126/science.1172133.
16. Dahuri R, Rais J, Ginting SP, Sitepu MJ. Integrated Management of Coastal Area and Marine Resources. Pradnya Paramita Jakarta, 2001. (in Indonesia).
17. MMFA. Ministry of Marine and Fisheries Affairs of Indonesia Regulation No. 30/MEN/2012 concerning the capture based fisheries at fisheries management area of the Republic of Indonesia, 2013. (in Indonesia).
18. MMFA. Ministry of Marine and Fisheries Affairs Indonesia Regulation No. 57/PERMEN-KP/2014 concerning the second amendment of PERMEN KP No. 30/MEN/2012 concerning capture based fisheries at fisheries management area of the Republic of Indonesia, 2014. (in Indonesia).
19. PerPem. Government of The Republic of Indonesia Act No. 60/2007 concerning the conservation of fish resources, 2007. (in Indonesia).
20. Natan Y, Tetelepta JMS, Uneputty PA. Sustainability of sea cucumber fishery at Central Maluku and Southeast Maluku Regency, Indonesia. AACL Bioflux. 2016; 9(1):34-41
21. Tetelepta JMS, Khouw AS, Natan Y, Ongkers OTS. Some biological aspects of mud crab *Scylla serrata* (Forskal) Fisheries at Pelita Jaya Bay, Western Seram Regency, Indonesia. International Journal of Fisheries and Aquatic Studies. 2017; 5(5):272-277.
22. Tetelepta JMS, Natan Y, Pattikawa JA, Ongkers OTS,

Pattiasina BJ. Fishery of mud crab *Scylla serrata* of Kotania Bay, Western Seram District: potency, stock status and sustainable management. IOP Conf. Series: Earth and Environmental Science. 2019a; 339:012002, 11.
23. Tetelepta JMS, Lopulalan Y, Pattikawa JA. Status of mud crab (*Scylla* sp.) fishery and mangrove ecosystem of Sanleko Village, Buru District, Indonesia. IOP Conf. Series: Earth and Environmental Science. 2019b; 339:012008, 9.
24. Nikijuluw VPH. Community-based fisheries management (*sasi*) in Central Maluku. IARD Journal. 1995; 17(2):33-39.
25. Harkes I. An institutional analysis of sasi laut, a fisheries management system in Indonesia. Proceeding of the International Workshop on Fisheries Co-Management, 2003, 9.
26. Adhuri DS. How can traditional marine resources management support responsible fishery? Lessons learn from Maluku. IFFET, Japan Proceedings, 2004, 1-13.
27. Nikijuluw VPH. Regime of Fisheries Resource Management. P3R Jakarta, 2002. (In Indonesian).
28. Novaczek I, Harkes IHT, Sopacua J, Tatuhey MDD. An Institutional Analysis of Sasi Laut in Maluku, Indonesia. ICLARM Technical Report. 2001; 59:327.
29. Harkes I. Fisheries co-management, the role of local institutions and decentralisation in Southeast Asia With specific reference to marine *sasi* in Central Maluku, Indonesia. PhD Thesis. Institute of Environmental Sciences (CML) Leiden University, 2006.
30. FAO. Fisheries management. 4. Marine Protected Areas and Fisheries. FAO Technical Guidelines for Responsible Fisheries. UN Food and Agriculture Organization, Rome. 2011; 4(4):198.