Sustainability of sea cucumber fishery at Central Maluku and Southeast Maluku Regency, Indonesia

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Abstract. Sea cucumbers fulfill an important role in marine ecosystems and support fisheries that provide a significant source of employment and income to coastal fishermen which were mostly an artisanal, highly dependents on the resources. High economic value and economic pressure forced the fisher to harvest the resources extensively. Among 34 species found in the study sites, 9 were sea cucumber with high economic value and became main targeted species. Sustainability analysis performed shows that the overall sustainability of this fishery was moderate sustain (56.225) with government involvement in the management, conduct towards indigenous knowledge and unfriendly fishing technique were the most influential attributes affecting sustainability.
Key Words: sea cucumber, management, harvest strategy, status.

Introduction. Sea cucumbers fulfill an important role in marine ecosystems and support fisheries that provide a significant source of employment and income to coastal peoples. From both ecological and socio-economic perspective, the long-term sustainability of sea cucumber fisheries is of great importance to coastal communities. Unfortunately, sea cucumber stocks have been overfished in many countries as a result of ever-increasing market demand, uncontrolled exploitation and/or inadequate fisheries management. Sea cucumber fisheries provide an important source of cash income to isolated coastal communities throughout the Indo-Pacific islands region through the processing and sale of 'bêche-de-mer' (Friedman et al 2008; Purcell 2010).

At least 60 species are fished from more than 40 countries and most of the harvests are processed then exported to Asian markets (Widiyana et al 2009). Sea cucumbers generally appear to have slow rates of population turnover and are easily harvested in shallow waters in the tropics. With retail prices of up to USD 300–500 kg^{-1} (dried), exploitation has often been indiscriminant and excessive (Malik 2013). Overfishing in recent years has led to local extinction of high-value species in some localities and prompted closures of many national fisheries to allow stocks to recover and to allow more sustainable management plans to be established. Apart from a few developed countries, only a small number of sea cucumber fisheries are currently being managed sustainably.

Maluku, in particular Southeast Maluku, is the main sea cucumber supplier for Indonesia (Yusron 2001, 2009; Solihin 2011) but recently the resource declined steadily (DKP Malra 2012). Study conducted by Yusron (2001) in Morela, Central Maluku revealed that density of *Holothuria* spp. was about 0.09-1.03 ind m^{-2}, whilst Malik (2013) at the same site only found density of about 0.004-0.123 ind m^{-2}, signifying a great declined within 11 years of time. What matters mostly, sea cucumber fishery in general is an artisanal, a fishery mainly run by traditional fishers. Decline in this fishery will have a great impact on sea cucumber fishers especially those living in area with high insularity like some areas at Southeast Maluku.

In some parts of the world, a practice of sea cucumber exploitation with no regulation has led to over fishing. Declines of production in term of number and size which lead to sea cucumber extinction have been reported quite recently (Anderson et al

2011). Sea cucumber with less economy value was also heavy exploited. In Costa Rica, Ecuador, India, Papua New Guinea, Solomon Islands, for example, each government had issued a prohibition for sea cucumber harvesting (Conand 2006; Friedman et al 2008). Because of this continuous threaten, CITES had planned to put sea cucumber into a list of endangered species (Appendix II), limiting international trading on endangered species (Conand 2006). This could pursue the government of Indonesia to establish a regulation on sea cucumber management, since there is no specific regulation concerning the management of sea cucumber (Purwati 2005; Wiadnyana et al 2009).

Material and Method. The study was conducted between July to December 2013 at villages of Revav and Taar of Southeast Maluku Regency and at Suli, Pelau, Morela, and Ihamahu of Central Maluku Regency (Figure 1). The objectives of the study were to estimate sustainability of sea cucumber fishery, form of utilisation practices, and indigenous knowledge in sea cucumber management and to propose management plan for sea cucumber fishery through ecosystem based approach.

Data for sustainability study were, based on standard attributes for Rapish Analysis (Kavanagh & Pitcher 2004; Rapfish Group 2006) and analysed with RAPFISH (Rapid Appraisal for Fisheries Status), a multi-dimensional scaling, done through Microsoft Excel software. Data were collected through a questionnaire distributed to sea cucumber fisher. Direct observation was made to investigate harvesting practices whilst interview was made to study indigenous knowledge in fisheries management practices.

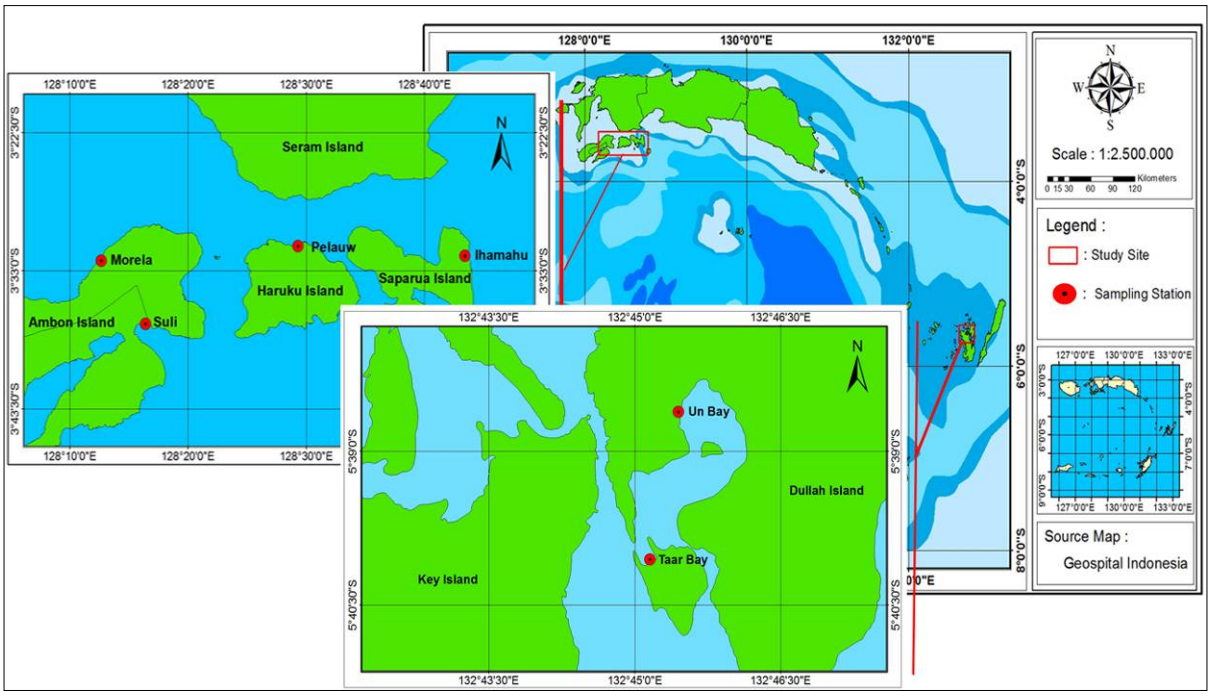

Figure 1. Map of Ambon Island, Central Maluku Regency and Southeast Maluku Regency. Red dot showing study site (Source: Geospatial Indonesia).

Results and Discussion. There were 34 species of sea cucumber found at all study sites belonging to the orders of Actinophyga and Apodida, comprising 9 genera i.e. *Actinopyga, Bohadschia, Holothuria, Pearsonothuria, Thelenota, Stichopus, Opheodosoma, Euapta* and *Synapta.* There were around 9 to 16 species found at each site with *Holothurian* being the highest sea cucumber species among all the species found. Compared to some parts of Indonesia like Takofi in North Maluku (Yusron 2009) and coast of Pramuka Island in Seribu Islands (Hasanah et al 2012; Wulandari et al 2012), species number found in Central and Southeast Maluku was higher.

In terms of economic value, all the species found can be grouped into three major groups *i.e.* group of high economic value, middle and low economic value. Of all the sea

cucumbers found in these study areas some were harvested by the local fisher and some were not. Among the species harvested 9 (nine) were sea cucumber with high economy value (main target species) viz. *Actinophyga echinites, Bohadschia argus, B. marmorata, Holothuria atra, H. edulis, H. scabra, H. leucopsilota, H. nobilis,* and *Thelenota ananas* whilsh the rest were of less economic value but harvested as well by the fisher and sold for local market. The main target species were primarily for regional market even for national market and self consumtion. The main target species were sold for IDR. 500 dry weight kg^{-1} (Malik 2012).

The fishery of sea cucumber has been carried out for quite long time, especially in Southeast Maluku and being one of main fishery commodity for that area. From interviews with local fishers from Revav and Taar Villages, it was clear that some of them have worked as sea cucumber fisher for more than 20 years of time. In Morela, Pelau of Central Maluku and Taar and Revav of Southeast Maluku, the fishers harvested sea cucumber as a source of their income whilst in Suli and Ihamahu mainly as subsistance. In Suli in particular, the fishers were not from that village but they come from Tial Village, a neighbour village. Majority of the fishers have limited education especially fishermen from Taar and Revav of Southeast Maluku which have only elementary education background. This contribute to the way they utilized fish resources in general.

Sea cucumber fishery in general can be classified as artisanal fishery performed by fishermen with less background in sustainable fisheries management. With high demand for supporting economy life and high price of comercial sea cucumber, they tend to harvest the resources with no management regulation. With simple technology like wooden canoe, simple goggle and some time with no flippers at all, the fishers do the dive to collect sea cucumber. In some parts of Southeast Maluku, MTB and Aru Islands Regency, some private local companies provided local fishers with compressors to do the dive. This is due to more depth they have to dive since the fishing gound had extended far off shore and some commercial sea cucumber can live up to 15-20 m depth (Hanna 2011).

For majority of sea cucumber fishermen especially from the villages of Taar, Revav of Southeast Maluku and Morela of Central Maluku, sea cucumber was one of the main shell fish resources they exploited. Decrease in sea cucumber production will affect their income. Data from Marine and Fishery Board of both Southeast Regency and Southeast West Maluku Regency showed the decliened. In 2008, sea cucumber production from Southeast Maluku Regency was 5.25 t dry weight, then decreased to 2.45 t, slightly increased to 2.64 t in 2012 but still below 2008 productin (DKP 2013). Similar result was also found in Southeast West Maluku Regency with 14.2 t dry weight in 2010, then decreased to 12.28 t dry weight in 2011 (DKP 2013). There are no information for sea cucumber from Central Maluku Regency.

Sea cucumber fishery is one of the important natural marine resources exploited by fishers. The major common causes of sea cucumber production decline were high exploitation rate related to high market demand and less sustainable fisheries management (Friedman et al 2008; Conand 2006). Sustainable sea cucumber livelihood will certainly depend on sustainable sea cucumber resources. Analysis of sea cucumber sustainability therefore is an inportant necessity tool for the management of that resources. A Rapfish analysis, which is a multidimensional scaling approach (Pitcher 1999; Kavanagh & Pitcher 2004) was performed to analyse sea cucumber sustainability covering ecology, economy, social, technology, ethic and institutional aspects.

In fisheries management, sustainability of one particular resource is highly dependent on every aspect of the system constituting that fisheries. Rapfish analysis for ecology sustainability of sea cucumber at all study sites varied between the sites (Figure 2a) with the avverage of 65.28% of 100% sustainable with stress value of 0.1591 and Root Square Correlatin (R^2) of 0.9326. Of all sites, the Village of Pelau having lowest ecology sustainability (57.31) and Village of Ihamau having highest ecology sustainability (70.90%). Rapfish ordination and Monte Carlo scatter plot (Figure 2b) was performed to analyse the accuracy and validity corresponding to scaling procedure applied in Rapfish analysys. This analysis shows that the Rapfish analysis was quite accurate since anchor and reference fisheries not move in Monte Carlo run (Kavanagh & Pitcher 2004).

High value of ecology sustainability in Ihamahu could be due to a *sasi,* the traditional indigenous knowledge in fisheries management, exercised in this Village which was not pacticed in Pelau Village anymore. During the sasi period, natural resources under sasi could not be harvested for certain period of time. The fishermen of Ihamahu mainly harvested sea cucumber for subsistence purposes only whilst in Pelau and the rest harvested sea cucumber both for sale and their own consumption. Fishermen from Taar and Revav in particular harvested sea cucumber mainly for sale.

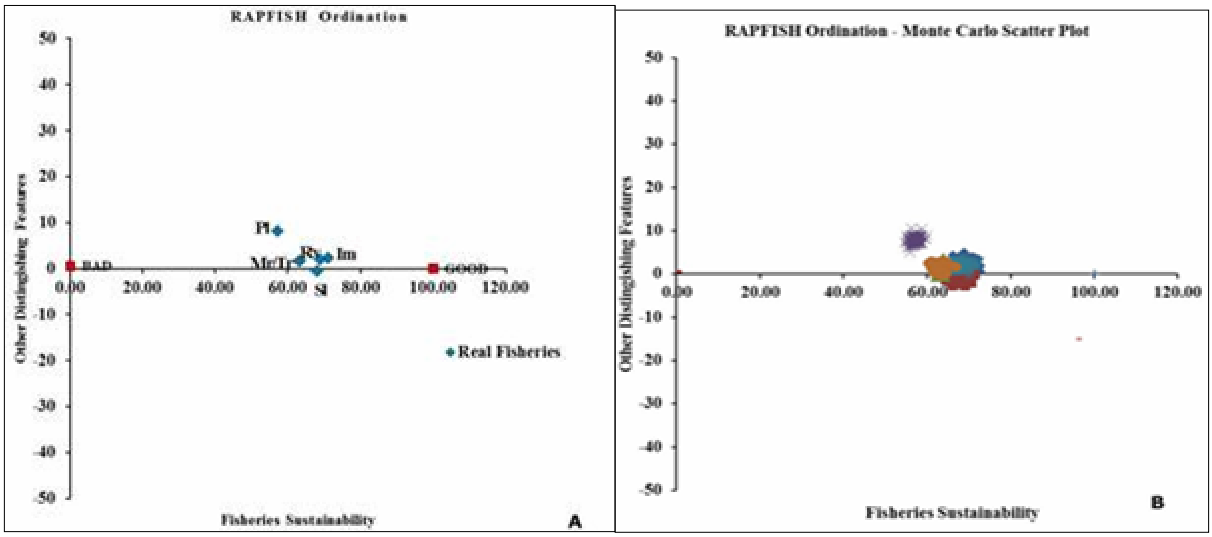

Figure 2. Rapfish analysis (A) and Monte Carlo scatter plot (B) for ecology sustainability attribute for sea cucumber fishery of study sites. Pl (Pelau), Sl (Suli), Mr (Morela) and Im (Ihamahu) for villages of Central Maluku Regency and Rv (Revav) and Tr (Taar) of villages from Southeast Maluku Regency.

Figure 3 shows Leverage analysys for ecology dimension of sea cucumber fishery at all study sites. This analysis was done to assess which attributes truly reflect the status being assessed, and which of the attributes contribute more or less to the sustainability. The value commonly ranged between 2 and 6%, the highest the value means hight contribution to the sustainability (Kavanagh & Pitcher 2004). From this analysis it was found that main target ratio had the higest Root Mean Square (RMS) value (4.35%) indicating the attribute which had high contribution to ecology sustainability of sea cucumber fishery in all study sites. All fishermen exploiting sea cucumber for economic reason look for sea cucumber of high economic value explaining high exploitation on target species.

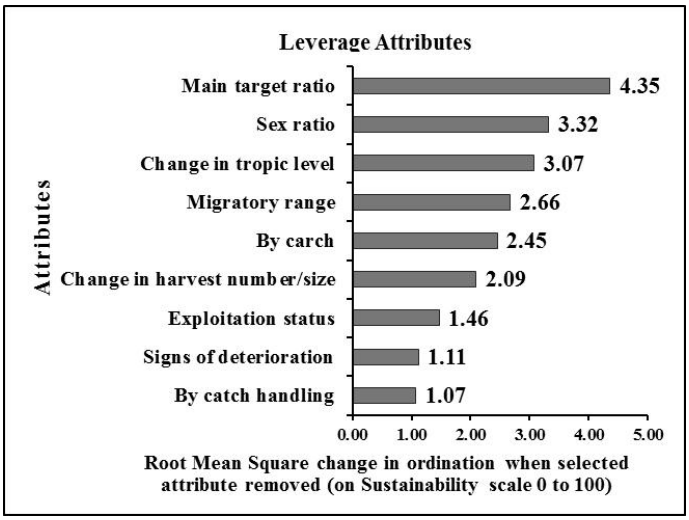

Figure 3. Leverage analysis of ecology sustainability of sea cucumber of all study sites.

Figure 4a shows economic sustainability of sea cucumber fishery at study sites. The mean economic sustainability was 50.39% of 100% sustainability scale. This value was considered as fair sustain by Suyasa (2007) and Cisse et al (2014) with Ihamahu having the hight economy sustainability (72.71%) and Revav having the lowest one (19.22%) with stress values of 13.21% and R^2 of 93.95. Ihamahu was considered of good sustain while Revav was consider of bad sustain. Interviews with local fishers from Ihamahu shown that sea cucumber is harvested mainly for local consumption and amount harvested was far below stock available. Apart from this, the village of Ihamahu still practice *sasi,* the indigenous knowledge in natural resources management. In the contrary, the fishermen from Revav harvested sea cucumber mainly for sale. Majority of the Revav people, including the fishers was having an elementary education which leads to less understading on sustainable fisheries resources management. Suli and Pelau were also considered having poor economic sustainability with the value of 34.19% and 43.77%, respectively. Monte Carlo scatter plot analysis shown in Figure 4b explained that the Rapfish analysis was quite accurate since anchor and reference fisheries were not moved in Monte Carlo run.

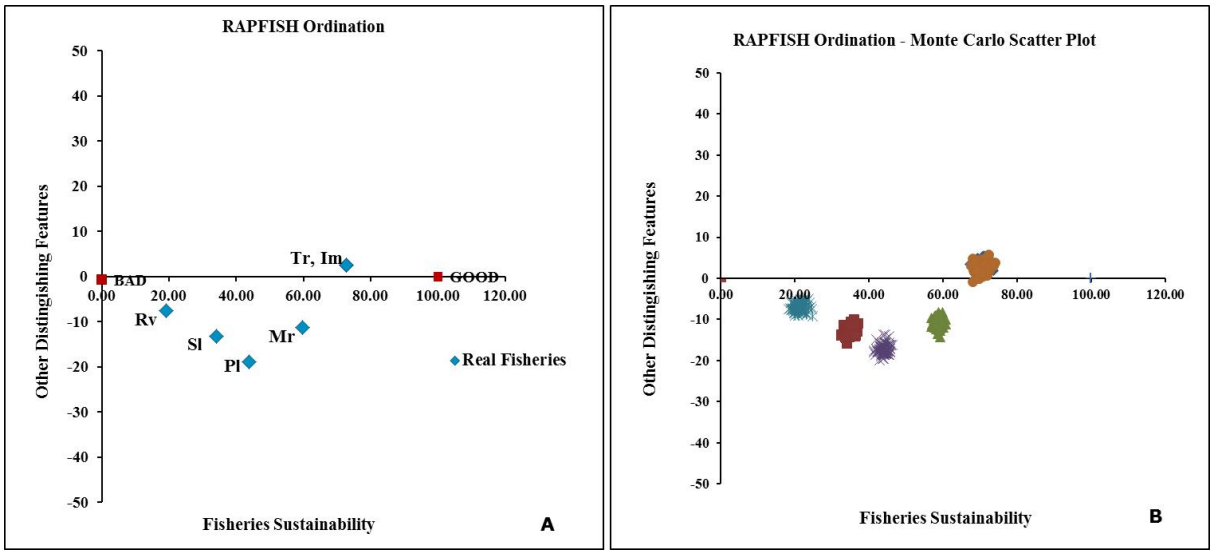

Figure 4. Rapfish analysis (A) and Monte Carlo scatter plot (B) for economy sustainability attribute for sea cucumber fishery of study sites. Pl (Pelau), Sl (Suli), Mr (Morela) and Im (Ihamahu) of villages of Central Maluku Regency and Rv (Revav) and Tr (Taar) for villages of Southeast Maluku Regency.

Leverage analysis was also performed for sea cucumber economy sustainable dimension in order to appraise attributes which significantly contribute to this sustainability index. The results were presented in Figure 5 which showed that other income was the attribute that will have high effect on economy sustainability of sea cucumber fishery in this analysis as shown by higest RMS value of 4.62%. According to Rapfish Group (2006) when fishing of particular fishery is full time than the pressure towards that particular fishery is also high which can lead to unsustainability of that fishery. In this study, sea cucumber fishery especially for the people of Taar, Revav, Morela and Pelau, was one of the targeted resources since the demand and price for this comodity is high. The pressure towards this resources was also high which had lead to unsustainable condition.

Rapfish analysis, Rapfish ordination and Monte Carlo scatter plot as well as leverage analysis were carried out for other remaining sustainable dimension of sea cucumber fishery namely social, ethic, technique and institutional. Table 1 displayed complete results of sea cucumber sustainability indices. This table revealed that an overall sea cucumber sustainability at the study sites was moderate sustain (56.60%) and varies between villages and dimensions. According to leverage analysis for social dimension, conflict status was the most attribute having high effect on social sustainability. Interviews with the local fishers of Taar and Revav revealed that some

time there was a potential of conflict between sea cucumber fishers and sea weed fishers in competing for the area for both fishery activity.

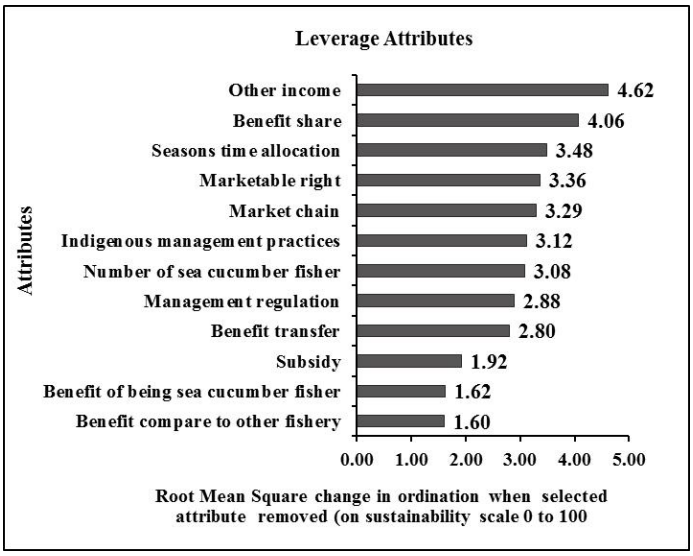

Figure 5. Leverage analysis of economy sustainability of sea cucumber of all study sites.

Table 1

Overall % of sustainability indidices and leverage analysis of sea cucumber fishery in all study sites

Site	*Percentage of dimension sustainability*						
	Ecology	*Economy*	*Social*	*Ethic*	*Technic*	*Institutional*	*Mean*
Ihamahu	63.86	72.71	57.22	64.75	63.92	59.58	63.67
Suli	52.84	34.19	47.77	49.09	73.54	49.80	51.20
Morela	51.03	59.74	60.45	39.95	53.37	52.67	52.87
Pelau	52.84	43.77	51.09	40.71	65.57	51.17	50.86
Revav	48.54	19.22	81.29	47.12	52.29	58.98	51.24
Taar	57.36	72.70	68.30	84.51	70.36	65.15	69.73
Mean	54.41	50.39	61.02	54.36	63.17	56.22	56.60
Stress	18.89	13.21	14.39	17.70	16.26	14.94	
R^2	93.20	93.95	93.46	87.86	87.80	91.25	
Leverage analysis	Target sp. ratio	Other income	Conflict status	Conduct twrds ind. Knwldg	Friendly fishing	Role of government	
RMS (%)	4.35	4.62	3.57	2.29	5.98	4.30	

Other factors that contribute to sustainability were conduct of the community towards indigenoues knowledge in natural resources management and government roles in fisheries resources management. The study of Mosse et al (2013) concerning indigenous knowledge in Southeast Maluku termed *hawear* has shown that local people perception and conduct towards *hawear* have changed. The change in local people perception is mainly due to the fact that the original core value of *hawear* which is mainly focus on natural resources management had changed to political objectives. By some, for example, *hawear* has been used to achieve or solve some political or communal disputes. In some part of Maluku, this indigenous knowledge had become weak or even disappeared mainly due to community leader behave and economic reason. Villages of Morela and Suli for example have no *sasi* exercise anymore. Figure 6 reveals diagram describing whole sustainability dimension of sea cucumber fishery for all study sites.

Government involvement is important in the management of fisheries resources since it has the power, responsibility and justification to issue a regulation concerning management of fish resources. Government also has to take part in helping fishermen on

how to utilize fish resources in sustainable manner. In many cases, this does not happen. This study revealed that government involvement was almost scarce.

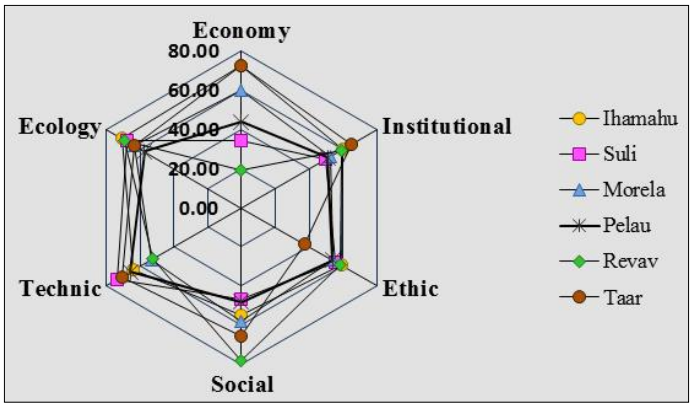

Figure 6. Kite diagram showing all sustainability dimensions scale of sea cucumber fishery of all study sites.

Conclusions. Sea cucumber as economic species product was sold with high price and demand for this product is still high. At the same time majority of local fisher at study sites are highly dependent of this product for their income support. With these reasons coupled with relatively low education level in understanding on sustainable fisheries management force them to exploit the sea cucumber in high intensity which contributes to unsustainable condition of this marine natural resources. The most influential attribute contributing to sustainability were almost no involvement of government role in fisheries management in general, unfriendly fishing, and people conduct towards indigenous knowledge practices.

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