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Sustainability of Fad-Based Pelagic Fisheries around Kei Islands, South-East Maluku Regency

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Abstract

Fish aggregating devices (FADs), locally called rumpon, play an important role in supporting the pelagic fisheries around Kei Islands, Southeast Maluku Regency. Some benefits from such devices include certainty in fishing location, hence reducing operational costs and improving fishing productivity. This study was aimed to analyze sustainability of the fisheries with multi-dimensional perspectives (i.e. ecological, technical, economic and social aspects) and to formulate alternative management policies promoting its sustainability. This study was conducted from January to July 2014 in Kei Island to collect data required for RAPFISH (REFS). The status of local FAD-based pelagic fisheries was under sufficient category. Key factors were included to sensitive attributes of sustainability dimensions are local marine zoning, feasibility of fisheries business (i.e. B/C ratio), conflicts in resources used among fishermen, and conflict both fishermen and other stakeholders.

***Keywords*:** fisheries management; fish aggregating devices; RAPFISH; Kei Island.

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1. Introduction

Fish aggregating devices (FADs) have been used widely due to some advantages including more efficient fishing operation, *e.g.* reduced operational cost by saving fuel consumption [14]; shortened fishing trips by directing boats to locations of FADs and improved fishing productivity [17,9,1]. Pelagic fishing with FADs around the Kei Island, South-East Maluku Regency has been practiced since 2006. Higher fish catch obtained by fishermen with FADs stimulated some conflicts with other fishermen with no FADS. The conflicts were related to the use of fishing area, fishing gear, types of fish and volume of landings. Conflicts were also between the FADs fishermen and shipping lane users in which the later damaged the FADs.

Considerations in selecting type of fishing technology should address some issues on impacts on fish resources and environment, social and economic profitability, and fishing sustainability, as advised by Code of Conduct for Responsible Fisheries [7,13]. In FADs-based fisheries around Kei Island, expectation of the fishing communities includes community-wide economic benefits and easy access to abundant fish resources. While the fisheries has been going on for about 10 years, it is important to examine whether the fisheries has developed in a sustainable way. Based on the above issues, it is necessary to carry out the assessments of the sustainability status of fisheries management in the waters of the Kei Islands in Southeast Maluku Regency, and to identify potential factors that required for focusing attention to promote fisheries sustainability [12,6]. The objectives of this study were 1) to determine the sustainability status of FADs as a management tool of pelagic fisheries in the Kei Islands, and 2) to determine the factors that affected sustainability.

2. Materials and Methods

Data collected for this study consisted of attributes that constructed the four dimensions of sustainability of the fisheries, *i.e.* ecology, technology, economy and social. The data were collected Kei islands, Regency of South-East Maluku (Figure 1) over a period of 7 months, from January 2014 to July 2014. Some data were obtained from the owners of FADs, mini purse seine, troll lines and drift long lines boats who used FADs in the Nerong strait. The fishing fleets operated mini purse seines, troll lines, and handlines, which mainly caught scads (*Decapterus russelli*), Indian mackerels (*Rastrelliger kanagurta*), selar (*Selaroides leptolepsis*) and tongkol (*Auxis thazard*). Their fishing grounds were located 2-3 miles from their fishing base, reachable within 30-60 minutes. A total of 36 fishing trips were observed directly to obtain catch data, fish composition, and size range of fish. Secondary data were obtained from the Central Bureau of Statistics (Regency and City), the local Marine and Fisheries Agency, scientific research journals, and research reports. The sustainability status of the FADs-based fisheries was assessed by applying RAPFISH developed and introduced by [12]. The analysis was carried through three steps, i.e. (1) determination of sustainability attributes of the fisheries and their scoring criteria, (2) assessment of fisheries attributes, (3) analysis of ordinal scores of each sustainability dimension using multi dimensional scaling (MDS) approach. Step 3 yielded attributes sensitiveness, i.e. changes in value of root mean square (DRMS). Higher changes in the value means more sensitive, *vice versa*. Attributes with high sensitivity were considered significant factors that must be carefully managed, e.g. [12,5,16].

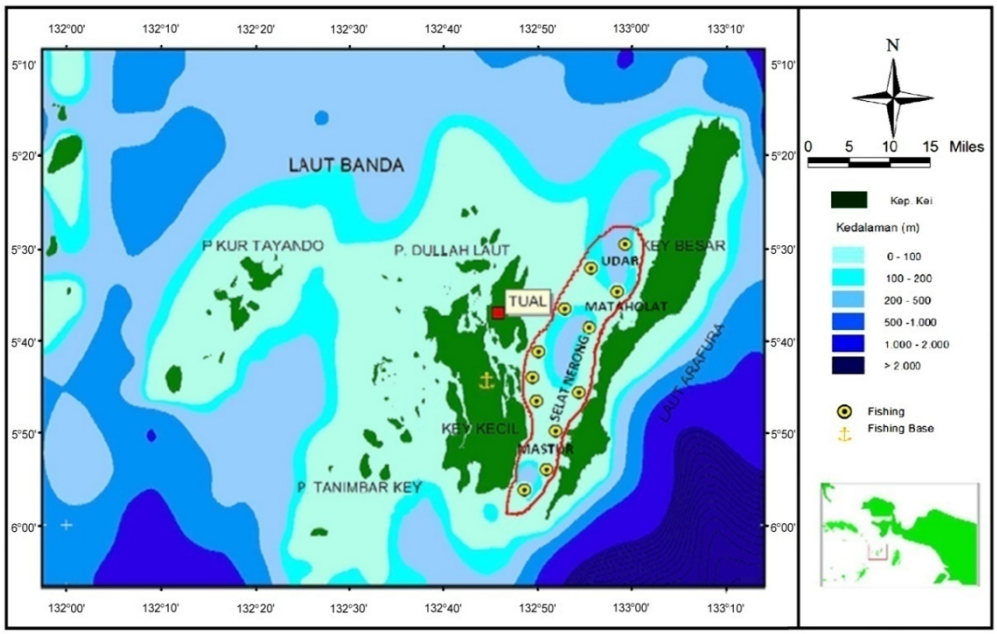

Figure 1: Study area indicating locations of fishing where FADs were deployed in the Nerong strait

3. Results and Discussion

The observation results at research sites in the Nerong Strait in the waters of the Kei Islands in Southeast Maluku Regency were related with 36 times of fishing operations on the FAD using mini purse seine, troll lines and drift long lines. The analysis results of the sustainability leverage of FAD management were based on 4 dimensions, namely dimension ecology, technology, economy and social with number of attributes as 9, 7, 7 and 9, respectively.

The results of field observations indicated that there was no regulation in zoning utilization and *rumpon* installation which could cause a territorial competition in the use of FADs. The results of the interviews with fishermen guarding the FADs and those operating purse seine troll lines and drift long lines showed that the conflict occurrences were mainly triggered by the competition of fishing ground location, peaking at the destruction of FADs. The fishing activities on FADs indicated that the water temperature was in the range of 28.17^{o}C to 26.24^{o}C and salinity 28.5 $^{o}/_{oo}$ and wind speed 0.75 knots, which was still at the level of the maximum limit. This could be seen from the type of fish caught on FADs which was increasing but dominated by small pelagic fish with a maximum size of *layang* fish (*Decapterus russelli*) 24.36 cm, *selar* (*Selaroides leptolepis*) 23.32 cm, *kembung* (*Rastrelliger brachysoma*) 24.3 cm, as well as tuna (*Auxis thazard*) 26.4. The FAD attractors used were coconut leaf midribs as many as 50-100 pieces mounted on the FAD with a depth of 15-25 m. Meanwhile, the durability of attractors ranged from 3-4 weeks and a FAD 1-2 years. [19]; stated that an FAD could attract fish because of its attractor. The fish move closer to an FAD for food, gathering, association, and as reference point for the small pelagic fish that are migrating and passing through these waters.

With FADs, fishermen are no longer looking for a distant fishing areas. Instead, they do the fishing activity in the FADs so as to save fuel costs. The results of field observations showed that with FADs the fishermen

operating FADs would have better profits compared to without FADs, where they experienced getting low profits due to low catch results. The fishermen guarding FADs and those operating mini purse seine, troll lines, and drift long lines used a boat size ranging from 3 to 5 GT. The placement of FADs in the Kei Islands waters ranged from 600-800 m, less than the provision of the FAD installation, so that this could affect the behavior of fish which were attracted to the FAD. The result of the calculation of environmentally friendly technology on 11 fishing gears was that 8 fishing gears had a low selectivity and 3 fishing gears had high selectivity, namely of drag trawl, implanted *sero* and fish traps. Accountability levels on fishing courses and fishing tools in the management area of fisheries in the waters of the Kei Islands have not been applied. This was indicated by the results of the interviews with the fisherman guarding the FADs and operating mini purse seine, troll lines and drift long lines, where they revealed that government rule until now has not been implemented, so they just use the customary laws (*hukum adat*) of the community.

[6] stated that one of the backbones of the economy in coastal regions and small islands was vulnerable fisheries resources due to economic activity. Based on the analysis results, the value of B / C ratio was found, which was used to determine the balance between the revenue and the expenses for the FAD-based operation costs. The analysis showed that the fishing activities using FADs, mini purse seine fishing gear, troll lines and drift long lines were worth continuing because the B / C ratio was > 1. The income of the fishermen operating mini purse seine, troll lines, drift long lines, and guarding an FAD in the waters of the Kei Islands, Southeast Maluku Regency fluctuated widely from month to month (there is peak season, moderate season and low season). The calculations showed that on average the fisherman guarding a FAD had a net monthly income amounting to Rp 13,678,593; mini purse seine fisherman Rp 804,624 and the vessel owner of mini purse seine Rp 27,357,187; troll lines fisherman Rp 2,694,444 and the ship owners of troll lines Rp16.166.667; drift long lines fisherman Rp 2,101,666 and the owner of the vessel of drift long lines Rp 13,678,593. When compared with the Decree of Maluku Governor on determination of the Provincial Minimum Wage (UMP) 2014 in Maluku which is Rp 1,450,000, it can be said that the wages of the fisherman guarding an FAD and those operating lines fisherman and drift long lines fisherman were above the UMP, while the wages of mini purse seine fisherman were under the UMP. The research results showed that the net income of fisherman guarding an FAD, purse seine fisherman, troll lines fisherman and drift long lines fisherman in the waters of the Kei Islands, in terms of the number of crew (ABK), was not the same which could affect the net income per / month. The income of the fisherman guarding an FAD could meet the needs of his household characterized by the consumption of rice and could cope with the cost of education and health care of the household. The analysis in the field showed that the investment to build one unit of FAD in the shallow sea at a depth of 150-200 m was Rp13,714,000. Meanwhile, the local revenue was determined by the number of fish production in 2010-2014. Based on the production data, the higest catch was *selar* fish (3236.9 tons in 2013) and the lowest catch was *kembung* fish (1789.7 tons in 2010). The average highest production was *selar* fish (998.54 tons) and the lowest was *kembung* fish (367.39 tons). The study results in 2014 showed that the factors affecting the production of pelagic fish catches in the waters of the Kei Islands were fishing season, the number of fishing vessels, and the effectiveness of fishing tools.

The analysis result of the social dimension showed that the potential for conflict among fishermen was an important concern because it had occurred two (2) times between the fishermen of FADs and the owners of mini

pure seine fishing gear. The results of the field study showed that conflicts happened because the fishermen guarding FADs claimed that the FAD placement area belonged to the territory of their management.

The catches of the fishermen guarding an FADs and mini purse seine fishermen are still fresh because the fishing activities are carried out from 05.30-06.30, after which they go back to fishing base. The fishing activity using mini purse seine on FAD area often catches protected fish such as dolphins, leatherback turtles and dugongs. The fishermen in the waters of the Kei Islands in Southeast Maluku Regency are still using traditional fishing gear like the roots of a tree to kill fish on the lowest tides in October in rocky areas. In addition, the fishermen also use explosive and cyanide to catch pelagic fish and demersal fish. The average education level of the fishermen in the waters of the Kei Islands in Southeast Maluku Regency is either elementary school or junior high school graduates. Their ages ranged from 21-30 years (93.33%), 31-40 years (60%) and 41-50 (16.6 %).

3.1 Sustainability Status of the Fisheries

Scores for each of the four dimensions are within a range of 50-75% (Figure 2). Such values indicate the fishery is being at a status of moderate sustainability [11]. Among all dimensions exercised in this study, technological dimension had the highest score (i.e. 72%) while social dimension had the lowest score (i.e. 51%).

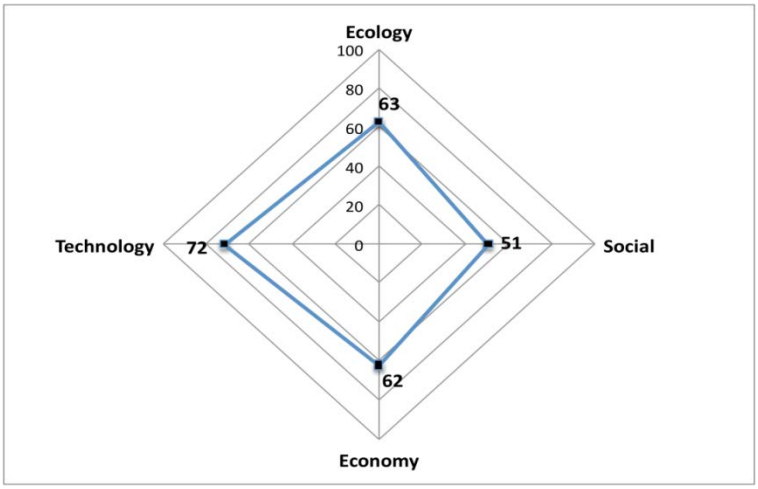

Figure 2: Sustainability scores of four dimensions of FADs-based pelagic fisheries around Kei Islands, South-East Maluku Regency

3.2 Attributes

Among attributes within each sustainability dimension of the fisheries, FADs management area appeared the most significant attribute of the ecological dimension (DRMS = 14.94) while the B/C ratio of fishing business was the most significant attribute of the economic dimension (DRMS = 7.79). Both fuel consumption and potential conflict among fishermen were the most significant attributes for technological and social dimension, respectively.

Table 1: Significance of sustainability attributes of the FADs-based pelagic fisheries in Kei Islands, South-East Maluku Regency

Dimensions	No	Attributes	DRMS
Ecological Dimension	1*	FADs management area	14.94
	2	Water currents	9.37
	3	Water salinity	7.19
	4	Depth of fish attractors of the FADs	7.32
	5	Area borders	6.56
	6	Water temperature	4.43
	7	Fish behavior around the FADs	3.15
	8	Changes in size of fish caught	2.79
	9	Changes in species composition	1.09
Technological Dimension	10*	Fuel consumption	5.55
	11	Fishermen profits	5.50
	12	Application of environmentally friendly technology	5.26
	13	Distance among FADs	4.50
	14	Accountability, CCRF, Fisheries Law and Local Regulation	4.13
	15	Size of fishing boats	3.55
	16	Fish production and TAC ratio	0.30
Economic Dimension	17*	B/C ratio	7.79
	18	FADs owner income	6.44
	19	Economic contribution to local regional income	5.30
	20	Investment of FADs	4.94
	21	Ratio to fishing business	4.11
	22	Growth of fisheries supporting industries	3.33
	23	Consumption of households of FADs owners	1.34
Social Dimension	24*	Potential conflict among fishermen	3.62
	25	Effects on fish habitats	2.66
	26	Use of dangerous materials	2.41
	27	Effects on protected fish species	1.98
	28	Access to health services	1.35
	29	Level of fishermen education	1.14
	30	Effects on fishermen life	0.98
	31	Security in the surroundings of FADs	0.92
	32	Effects on biodiversity	0.42

*Note: attributes with significance effect on fisheries sustainability

Attributes of FAD management zone are considered as sensitive attributes because the current installations of FADs in the Nerong Strait, in the Kei Islands, have not considered FAD management zone. Zoning is very important because a zone is a space which is based on biological characteristics, resource potential, and carrying capacity of an ecosystem. Attributes such as currents and salinity of waters are sensitive attributes because the placement of FADs with physical and chemical parameters is the carrying capacity of the aquatic environment where the life of fish is associated with FADs. If the carrying capacity of waters on pelagic fish is low, the productivity is also low, and this affects the sustainability of the FADs installed. The attributes of FAD attractor depth are sensitive attributes because attractors are major components of FADs which serve as a means of collecting fish. [20], the general requirements of attractors are: they should (1) have the power to collect to fish, (2) be durable, (3) have a shape of vertical section position with a downward direction, (4) protect small fish, and (5) are made of strong materials and low in price. The attractors that are widely used are natural leaves like palm leaves, nets and ropes tied to raft parts. These attractors greatly help the effectiveness of FADs in luring fish groups. The attributes of the boundary of waters are also sensitive because these attributes are closely associated with FADs management area boundary. [15] For waters 2 nautical miles until 4 nautical miles, measured from the shoreline at the lowest point of ebb, the licensor is a regent / mayor, with the license validity period of 2 years. For waters above 4 nautical miles until 12 nautical miles, measured from the shoreline at the lowest point of ebb, the licensor is a governor with a license validity period of 2 years. For waters above 12 nautical miles and ZEEI, the licensor is Directorate General Capture Fishery with a validity period of 2 years.

The attributes of fuel oil use became sensitive attributes because the cost of fuel oil used for fishing ranged from 50-60% of the total operational costs. In accordance with the [7]; the fishing activity should have a principle of consuming lower fuel. The results showed that fuel oil-related operational cost required for one fishing trip at sea was about Rp 263,000. According to [18]; in the waters of Malalayang, Manado, the cost of fuel oil per fishing trip to an FAD was Rp. 175,000, lower than the operational cost of fuel oil that was used in the waters of the Kei Islands, Southeast Maluku Regency. The sensitive attributes of fishermen's profits were from fishing activities around the FAD with fishing technology value by using FAD tools. In general, the operation of mini purse seine, troll lines and drift long lines was conducted on a 1-day fishing operation / trip basis. In his research, [10]; showed that the fishing season in the waters of the Kei Islands is divided into three, namely, peak season/ Western monsoon (December-March), period of shortage before harvest / transitional period I (April-July), East monsoon (June-August) and temperate season / transitional period II (September-November). The sensitive attributes of the application of environmentally friendly technologies, through the selectivity of fishing gear, made catch ratio not exceed TAC so that the fishermen could continuously fish around FADs. Great attention should be paid to all sensitive attributes based on [7]; so as to improve the status of FADs sustainability management in the waters of the Kei Islands. The sensitive attributes of FAD distance were implemented by considering the carrying capacity of fish resources and the environment as well as the socio-cultural aspect of local communities.

The ratio attributes of fishery business that relied on FADs as sensitive attributes with the greatest value in the economic dimension resulted from the use of FADs as fishing tools were a fishing effort ratio dependent on the increased FADs. The fisheries using mini purse seine, troll lines and drift long lines were worth continuing in the Nerong Strait, the Kei Islands, Southeast Maluku Regency because it has a value of B / C Ratio> 1. The

attributes of fishermen's income utilizing FADs in the waters of the Nerong Strait, the Kei Islands, emerged as sensitive attributes because the presence of FADs as fishing tools increased the number of catches. It can also generate greater profits for fishermen using mini purse seine, troll lines, and drift long lines. The result of one season catch could give doubled profit compared with the other fishermen. The attribute of contribution to local revenues appeared as a sensitive attribute, because in Southeast Maluku regency there are two management areas, namely: a management area of Banda sea 714 and a management area of Arafura Sea 718. The total fishing area in Southeast Maluku regency is 34,140 km², consisting of the Kei Islands 17,879 km², and Aru Islands 16,261 km². [4]; amounted to 66,835.71 tons with a production value of Rp 342,108,950. Fisheries production is obtained from such commodities as pelagic fish, demersal fish and reef fish and non fish. The attributes of investment in FADs also emerged as sensitive attributes as a determining factor in the improvement of the marine capture fisheries in the Kei Islands. Investment is a working capital that is used to build ships and FADs, and to buy fishing tools and machine. The analysis results indicated that in order to build one unit of FAD in the Strait of Nerong, the Kei Islands, it required Rp. 13.564 million. In the meantime, in her research [9]; showed that the investment for a FAD in Manggar Baru, Balikpapan, cost Rp. 11,410,000.

The attributes of stakeholder potential conflicts among fishermen appeared as an sensitive attribute because of the social jealousy between the fishermen who utilized FADs and those who did not use FADs as a place to operate their fishing gear, causing conflicts among the fishermen. The results showed that there had been three times where conflicts occurred between FAD employers and FAD fishermen who claimed the placement of FADs, and they often destroyed FADs and untied the ropes of FADs. [2,3]; research stated that the conflicts were multidimensional in nature and generally involved various stakeholders in a complex relationship. There were three dimensions that triggered the conflicts, namely: the actors, the availability of resources, and environmental dimensions. The effect on biodiversity was the attribute which had the lowest contribution to the sustainability index of FAD management in the waters of the Nerong Strait in the Kei Islands. This could occur because the operation of FADs did not interfere with or damage the habitat of biodiversity and social issues. The effect attributes on habitats was a sensitive attribute because the existence of FADs would affect the habitat of fish resources in case of inappropriate placement of the FADs, destructing habitats of other marine resources. Another thing to note was disrupting the activity of fishing operations using fishing gear as well as transport ships in the waters of the Kei Islands. The status attribute of using hazardous substances appeared as a sensitive attribute because fishermen often used toxic materials and bombs as the local fishermen used *tubah* roots to kill fish in the lowest tides in October.

Attribute of influence sensitive attribute as the current social level of fishermen is low so that they do not care about the type and size of fish allowed to catch. This is evidenced by the many fish caught were small and the protected ones which remained on sale.

4. Conclusion

There are two conclusions of the research. First, the FADs-based pelagic fisheries in the waters of the Kei Islands, Southeast Maluku Regency, based on the Rapfish analysis using four dimensions was categorized as having a status of "sustainable". Second, the important factors for the ecological dimension were the zones of

FADs management, currents of waters, salinity of waters and depth of FAD attractors. The technological dimension factors were the use of fuel oil for fishing activities in FADs, fishermen's profits, and the application of environmentally friendly technologies. The economical dimension factors were the value of B/C ratio of catching at FADs, the income FAD fishermen, the contribution to local revenues, and the investment value of FADs. The social dimension factors were the potential conflict between fishermen, the effect on the habitat and the status of the use of hazardous substances.

5. Recommendations

1. It is necessary to determine FADs management zones based on the carrying capacity of ecological, economic and social dimensions so that it can be recommended on the determination of FADS management zones and the fishing capacity with the FADs in the waters of the Kei Islands, Southeast Maluku Regency.
2. Interactionamong fellowfishermen should be maintained for realizing FADs fishery management by paying attention tothe aspirations ofthose who enjoy direct benefits to avoid unproductive conflicts.

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