International Journal of GEOMATE, April 2019, Vol.16, Issue 56, pp. 183 - 190
ISSN: 2186-2982 (P), 2186-2990 (O), Japan, DOI: https://doi.org/10.21660/2019.56.4822
Special Issue on Science, Engineering & Environment

IDENTIFICATION OF SUITABLE LOCATION FOR EXPANSION OF FISH AGGREGATING DEVICES (FADs) FOR FISHERMEN ON PACITAN OPEN SEA, INDONESIA

*Tuty Handayani[1], Cinthia[1], Jarot Mulyo Semedi[1], and Sajiharjo Marto Suro[2]

[1]Department of Geography, Universitas Indonesia, Indonesia; [2]STT-PLN, Indonesia

*Corresponding Author, Received: 29 Nov 2018, Revised: 30 Dec. 2018, Accepted: 15 Jan. 2018

Abstract: Pacitan Regency is located on the southern coast of East Java Province, Indonesia. The coastal area of Pacitan consists of a bay and open sea. Fishermen often catch fish with destructive fishing methods. FADs is a tool to increase fisheries production which is placed in a definite location. The purposes of this study were to find out the suitable area to expand FADs, to recognize the characteristics of fishermen, and to find out the benefits and readiness of Pacitan fishermen in using FADs. Fisheries production data was collected using interview techniques for fishermen and boats owners. The method for obtaining suitable location of FADs by using Geographical Information System (GIS) and remote sensing techniques. Parameters of temperature, pH, salinity, current and turbidity using Landsat 8 Image. While for chlorophyll-a by using NOAA imagery. Depth was obtained from the bathymetric map. The results showed that about 70% of sea in front of Pacitan coast is suitable for FADs expansion. In fact, only 10% of local Pacitan fishermen use Deep Sea FADs, and 10% use Shallow Sea FADs. Most FADs users in Pacitan are migrants. Development of Shallow Sea FADs is more profitable for local fishermen, because they can carry out one day fishing, low costs and reduce destructive fishing.

Keywords: Destructive fishing, Remote Sensing Techniques, Fish Aggregating Devices (FADs), Suitable area.

1. INTRODUCTION

Indonesia is an archipelagic country, two-thirds of which are marine areas. This condition encourages people living on the coast to have a livelihood as fishermen. There are still many fishing communities in Indonesia that are classified as traditional fishermen, so the method to get fish is still relatively simple and have fishing boats with a small capacity. Traditional fishermen tend to depend only on the results of the sea, so if the abundant fish resources automatically they will reap profits through traditional fishing, cultivation, and processing. Conversely, if the weather of the sea does not support or fail to sail, they have no source of livelihood.

The south coast of the island of Java has a direction towards the Indian Ocean so that it has the potential of substantial marine fish. Pacitan Regency, which is located on the southern coast of East Java Province, is one of the districts that have a considerable fishery potential.

The exploration of fish resources in the waters of Pacitan by local fishermen mostly located around the coast and using traditional fishing facilities of various shapes and types. Fishing activities in Pacitan Regency until 2004 were dominated by boats without engines and boats less than 10 Gross Ton (GT) in sizes with outboard motors. The ships equipped with fishing gear, gillnet, and fishing line that only operate in coastal waters up to 4 km from the coast. With just a small capacity from the fishermen, the productivity of the catch also lower compared to the area potential. The fishermen usually only catch small pelagic fishes with little economic value such as mackerel tuna, scads, beltfish, and anchovies [1][2].

From year to year, the number of fishing fleets is increasing, especially boats with engines. To increase production, some fishermen use catching methods that tend to damage the environment, such as the use of potassium and explosives, or placing nets and anchors carelessly and inevitably causing environmental damage [3]. Fishing that is not environmentally friendly can cause damage to the ecosystem and can immediately reduce fish catch production. This type of fishing does not support sustainable fishing.

Prayitno [4] mention that Pacitan off-shore sea is rich in resources of large pelagic fish such as skipjack and tuna. The utilization rate of pelagic fish resources in these waters is still below the maximum potential of its sustainability. The value of maximum sustainability yield (MSY) of pelagic fish in the South of East Java in 2009-2013 was 219,189,453 tons/year with an average fish utilization rate of 49.48%. The condition of fish utilization in the area is still below the allowable catch amount of 80% [4]. MSY values for tuna species (yellowfin tuna and large eye tuna) in the southern waters of East Java are estimated to be around 2,568 tons/year with a utilization rate of about 78.81%.

The Pacitan Regency Government [1] through the Office of Marine and Fisheries introduced the use of Fish Aggregating Devices (FADs) to fishermen in early 2005, as well as bringing ships measuring above 30 GT with a seine fishing gear. FADs are aids for fishing in the sea. FADs can gather fish around FADs naturally so that it is easy to be caught by fishermen. FADs divided into three types, namely:

1. Seabed FADs are fishing aids installed and placed on the bottom of sea waters;
2. Shallow Water FADs are fishing aids that are installed and placed on seawater with a depth of up to 200 meters; and
3. Deep-water FADs are fishing aids installed and placed in marine waters with a depth of over 200 meters. FADs installed by Pacitan fishermen is a type of fixed FADs. Installed in waters with a depth of 500-1,500 meters, it classified as Deep Sea FADs.

The use of FADs as a tool for collecting fish in fishing activities has been proven to be able to increase production and productivity of catch in Pacitan Regency [5]. Catch production in this district before the use of FADs was only 500 tons. The use of FADs increased production to 1,560 tons in 2005 and continued to increase in the following years to reach 7,823 tons in 2013.

The increasing production encourages fishermen to install new FADs so that the number of FADs installed by individual fishermen also increasing. By 2015 Pacitan fishermen have begun to complain that as more FADs installed in the waters, their catch was declining. The size of the fish was also smaller, so the selling price was low. The phenomenon means that the randomly installed FADs by the fishermen were not in a suitable location and did not help fishermen to increase their fishing catch. For this reason, it is necessary to find a suitable location to expand FADs, for new installations not to reduce production.

2. RESEARCH OBJECTIVES

Based on the research background related to fish catching in Pacitan Regency, then the purpose of this study can be formulated as follows:

1. To search for a suitable location for the expansion of FADs.
2. To find out the characteristics of fishermen that used FADs.
3. To find out the readiness and benefits obtained by traditional fishermen in using FADs to reduce destructive fishing.

The results of each research objective will be explained further in the results and discussion section.

3. METHOD

3.1. Research Area

Pacitan Regency located on the south coast of East Java Province. Overlooking the Indian Ocean lies on $110^{O}55'$ - $111^{O}25'$ E and $07^{O}55'$ - $08^{O}17'$ S. The Pacitan coastal region consists of the bay and open sea as shown in Fig. 1. Pacitan Regency has a beach length reaching 70,709 km which stretches facing the Indian Ocean with the number of fishermen in the Pacitan Regency of 7,228 people [1][2]. As an area with a long coastline, Pacitan Regency has a lot of marine potentials that can be developed into regional and national income. One of the most prominent in Pacitan is the development of fishing potential in various coastal areas along Pacitan waters.

This research conducted along the Pacitan coastal includes Pacitan Bay. In Pacitan Bay there are no FADs, but the Pacitan Bay chosen because there is Fishery Port called Tamperan Port. The Tamperan is the biggest fisheries port in Pacitan Regency which is very important because it is a landing port for fishermen and a trading place for fish that comes from FADs in the Pacitan waters.

Beside the Tamperan Port, there are also two small fishing traditional ports along the bay, namely Teleng and Plumbung. In these ports also available a fish auction, where the local fishermen sell their fish catch. [6].

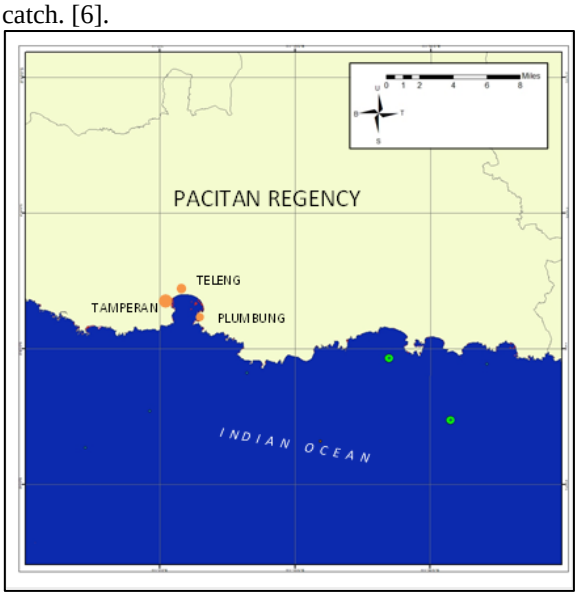

Fig.1 Bay and Open Sea Pacitan Regency

3.2. Research Framework

There are two types of fishermen in Pacitan, residents who generally carry out it in traditional ways and modern ways by utilizing FADs. FADs beneficiaries are not only local Pacitan fishermen but also from outside of Pacitan.

Along with increasing needs, traditional fishermen with small income tend to choose a short

path to increase fish catch productivity. A quick way to improve fish catches is generally opposite to the principles of managing fish catches that are sustainable and tend to damage the environment.

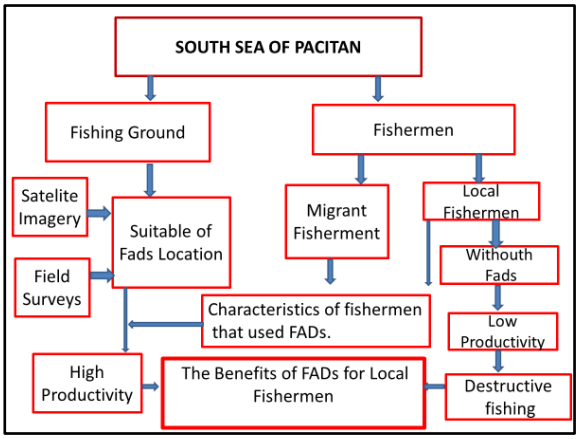

Fig. 2 Research framework

As seen in Fig. 2 that to reduce the destruction of the environment due to the use of potassium and explosive in fishing, it is necessary to find new locations to be used as a place to put FADs. Remote sensing technology can identify and measure oceanographic variables spatially and temporally without having to visit the research area. With the presence of satellite imagery such as the Landsat and Ocean Color NOAA projects, research related to the management and supervision of coastal and marine areas is easy to do.

3.3. Method of Collection and Data Analysis

The suitable location for the FADs development site is located using two satellite imagery, Landsat 8 and NOAA Images [7]. This research used Landsat 8 and NOAA imageries because of its ability to identify oceanography features without having to measure in the research area. Landsat 8 has a temporal resolution of 16 days, which means that the satellite can capture phenomena in the same location every 16 days. Landsat 8 imagery is used to determine various oceanography variables such as sea surface temperature (SST), water salinity, and water turbidity. NOAA satellite data has a very high temporal resolution that is capable of recording the phenomenon of the earth at the same place every day. That is the reason why the chlorophyll-a of Pacitan Ocean is identified using NOAA imagery. The speed of ocean currents and bathymetry data are coming from The Meteorology, Climatology, and Geophysical Agency and Geospatial Information Agency. The pH content of the water was measured by taking water samples around the FADs location, and each of the sampling locations was marked using GPS.

The algorithm used to identify oceanography variables derived from [8] and [9] using Landsat-8 imagery. The Landsat-8 used for the research based on the satellite imagery that has the lowest cloud cover of the area. The algorithm already tested in the tropical waters, especially in Indonesian waters by the previous researcher. The Landsat-8 level 1T data used in the form of raw data in the Digital Number (DN) format which is then radiometrically calibrated uses the gain-offset method to produce data in radians (L(λ)).

$$L(\lambda) = ML \times Qcal + AL \quad (1)$$

L(λ) is a radians sensor (ToA) ((W / (m^2.sr.µm)), ML is radiance_mult_band_n, Qcal is the digital number, and AL is radiance_add_band_n, where n is the band number [9].

The SST in Pacitan waters was identified using an algorithm developed by [8] which has been tested in several Indonesian waters as seen in Eq. (2) below:

$$Ts = BT_{10} + (2.946 \times (BT_{10} - BT_{11}) - 0.083 \quad (2)$$

Ts is SST in Celcius (^{o} C), BT_{10} and BT_{11} are Brightness Temperature at band 10 and 11.

Identification of salinity concentration was carried out using the Son et al. algorithm [Son] as follows:

$$Salinity = 10^{(-0.141 \times Cp)+1.45} \quad (3)$$

While the value of Cp (surface water beam attenuation coefficient) is obtained using the following equation:

$$Cp = (0.70 \times \text{MNDCI}^3) + (0.96 \times \text{MNDCI}^2) + (1.14 \times \text{MNDCI}) - 0.25 \quad (4)$$

MNDCI (Maximum Normalized Difference Carbon Index) is obtained using the following equation:

$$MNDCI = \frac{L_{BoA}\ \text{Green Band} - L_{BoA}\ \text{Blue Band}}{L_{BoA}\ \text{Green Band} + L_{BoA}\ \text{Blue Band}} \quad (5)$$

L_{BoA} is a surface-radians value (W / (m2.sr.µm)) in Landsat-8 images.

Table 1 Water Suitability Requirements for FADs

Parameter	Very Suitable	Suitable	Less Suitable
Velocity of current (m/s)	< 0.3	0.3 - 0.5	> 0.50
Depth (m)	100 - 500	30 - <100	< 30 or >500
Turbidity (NTU)	< 5	5 – 15	>15
Temperature (°C)	14.35 - 26.4	8.35 - <14.35	< 8.35 or >26.4
Salinity (ppt)	30 - 32	32 - 34	> 34
pH	8.1 - 8.2	7.95 - 8.1	< 7.95

Source: Modification from [6]

Interviews were conducted to find out the readiness of local fishermen to move from traditional fishing gear to FADs. The interviews based on the selection of respondents made by technical random sampling for 30 fishermen with a sampling frame Consists of the fishermen in Pacitan Regency, and the respondents are head of household, whether the owner of the ship or just as a worker. [6]

To obtain the conformity region, data analysis used overlay techniques. As for knowing the preparedness of traditional fishermen using FADs as a tool to find fish, conducted by descriptive analysis. In the overlay technique of each layer, the resulting map is given scores as follows in Table 1.

4. RESULT AND DISCUSSION

From the results of the image, a suitable location was obtained for the expansion of the placement of FADs. As for interviews with fishermen, several things were known, including the involvement of local fishermen in the use of FADs. So it can also be seen the role of FADs in reducing destructive fishing and its benefits to fishermen

4.1. Expansion Area of FADs

The existing FADs are considered not enough to supply fish for the whole fishermen in Pacitan Regency. The identification for the suitable area for new FADs are obtained from oceanography variables and parameters derived from the interpretation of Landsat-8 imagery and NOAA satellite imagery.

The suitability of oceanographic parameters in Pacitan Bay shows that most bay areas are not suitable for FADs [11]. Although chlorophyll-a concentration is quite high, its catches production is low. The low fishing productivity is because Pacitan Bay also to be used for the boats traffic of 30 GT or more size, that carrying catches from FADs to Tamperan Fish Port [5] (see Fig.3). Fishermen around the bay, although the results are small, only using a boat without motor or motorboats 3 GT size, but they can survive because they can sell at Teleng and Lumbung small fishing port. Fresh fish trading from the sea is a tourist attraction, and to be a part of nautical tourism. Nowadays marine tourism is starting to be utilized a lot by small fishermen [12]. Along the coast of Pacitan there are also traditional fishermen who use boats without engines, and there are boats with small-sized engines.

Fig 3. The Fishing Boat in Tamperan Port

4.1.1. Suitability with NOAA Stellite Imagery

NOAA Satellite Applications and Research (NOAA STAR) which is part of NOAA's Satellite and Information Service (NESDIS), managing the Ocean Color Product satellite sensors including the Sea-viewing Wide Field-of-view Sensor (SeaWiFS) was used in this process. Moderate Resolution Imaging Spectroradiometer (MODIS), and the Visible Infrared Imaging Radiometer Suite (VIIRS) on the Suomi National Polar-orbiting Partnership (SNPP) and the Joint Polar Satellite System (JPSS) were also used [13]. Figure 3. shows the spatial-temporal pattern of chlorophyll-a concentration of Pacitan Regency open sea during the west monsoon season (October – April 2017).

The image from NASA ocean color data was selected based on the lowest cloud cover during west monsoon season [6]. The spatial pattern of the chlorophyll-a concentration shows that by the time the high concentration is moving closer to the coastline. (see Fig. 4)

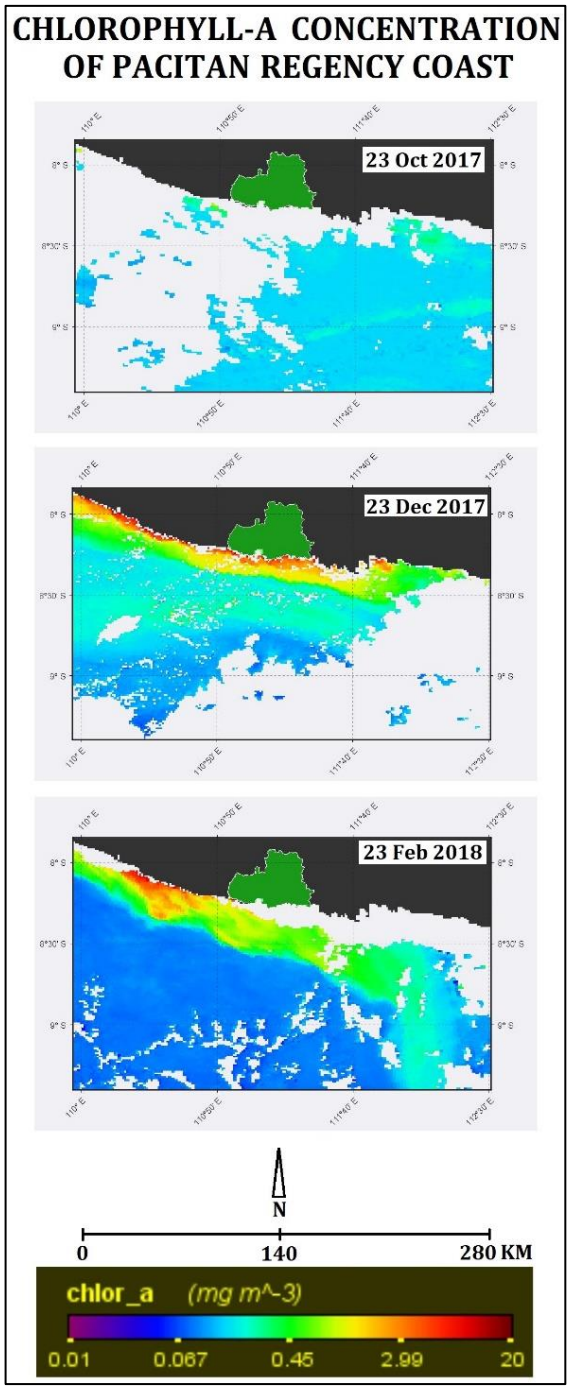

Fig. 4 The chlorophyll-a concentration of Pacitan Regency open sea during west monsoon season

These phenomena also explain why fisherman cannot sail to the open seas; it is because of the chlorophyll-a concentration is very low towards the ocean. The west monsoon also called by a rainy season where the ocean waves are high and will give a high risk for fishermen to sail. Under such conditions, fishermen only catch fish around the coast, some fishermen will stop looking for fish and do other work.

4.1.2. The suitability of the Landsat data.

From Image Processing results downloaded from https://www.usgs.gov/ and sampling pH at sea Pacitan,

Salinity, turbidity, current velocity, and pH of almost entire open sea in Pacitan suitable for FADs. Based on the edge depth is not suitable for Deep Sea FADs. However, the chlorophyll-a abundance at the high edges, making it suitable for simple Shallow Sea FADs. The temperature parameter indicates that there is a less suitable area.

The results of spatial analysis, using GIS technology for various oceanographic parameters. Can be seen in Table 2 below.

Table 2. Suitable FADs area based on oceanographic parameters

Parameter	Value	Suitability	Area (Ha)
Temp.	27-30	Very Suitable	3,035
(ºC)	>30-35	Suitable	4,372
	>35	Less Suitable	21,875
Salinity	>30-34	Very Suitable	22,675
`(ppt)	20-30	Suitable	4,473
	< 20	Less Suitable	3,034
Depth	>100-500	Very Suitable	3,032
(m)	30-100	Suitable	20,675
	<30 / >500	Less Suitable	4,675
pH	> 8.1-8.8	Very Suitable	3,032
	7.95-8.1	Suitable	20,675
	>7.95	Less Suitable	4,675
Velocity	0.1-0.3	Very Suitable	3,032
of current	> 0.3-0.5	Suitable	20,675
(m/t)	> 0.5	Less Suitable	4,675
Turbidity	< 5	Very Suitable	20,667
(NTU)	5-15	Suitable	3,040
	.>15	Less Suitable	4,675

Source : Calculation results in 2018

In the research area shown in the figure above, the less suitable area is near the coastline, with an area of 20675 hectares. The very suitable area has a total area of 4035 hectares. Located on the south coast, outside the area that is not suitable . The suitable areas are at distances above 100 km from the coast, with an area of 3030 hectares, at depths of more than 500 meters. If added between the suitable and very suitable, around 70% of the research area can be used to expand the FAD installation. It needs to be explained here, that the suitable area can be very wide to the sea off the Indian Ocean, but the high seas are already outside the research area.

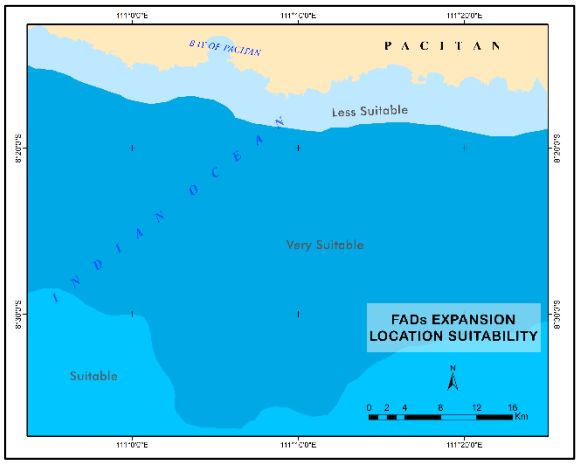

Fig. 5 The suitability of the location for the expansion of FADs

At this time at sea off Pacitan, Deep Sea FADs are installed at locations between latitudes 8^{O} LS to 10^{O} LS. Each Fishing Boat including Trolling Line installs 3-5 FADs at each point. Until 2013 it is estimated that there are 250 units of FADs installed by fishermen, who are mostly, based in Tamperan Port [1].

4.2. The advantages of Using FADs

Fishing boats/boat in Pacitan based on the used machine is divided into the boat without motor (PTM), outboard motor boat (PMT), and motorboat (KM). A boat without a motor is only 6% [14]. PMT dominates the number of fishing boats in Pacitan Regency as much as 1,240 units or 84%. While the motorboat size 30 GT or more as much as 10%. Traditional fishermen use boats under 10 GT, as they only fish up to 4 km. Motorboats are mostly owned by fishermen from outside Pacitan. The engine power used illustrates the range of fishing operations. Kurien [3] explained that fishing gear used by small-scale fishermen is generally passive, selective, used and adapted to specific seasons

Fishermen looking for fish in Pacitan waters consist of traditional local fishermen, local fishermen who use FADs, and migrant fishermen. Traditional fishermen, in general, use boats at low prices. Boats worth 4,000 USD, 90% are used by traditional fishermen. Boats priced at 18,000 USD, 70% are used by traditional fishermen. Whereas boats worth 36,000 USD only 10% are owned by traditional fishermen, 70% are owned by local fishermen who use FADs and 20% are owned by migrant fishermen. The price of boats above 60,000 USD are not owned by traditional fishermen, even those worth 100,000 USD and above, all are owned by migrant fishermen. Can be seen in Table 3.

Traditional fishermen who use boats with prices below 18,000 USD, usually only one day fishing. The expenditure is less than 200 USD. They mostly don't use FADs, only a few use Shallow Sea FADs. The boats that prices 60,000 USD, mostly fishing using Deep Sea FADs. With the distance is less than 40 km from the beach, each trip is around 3 days, and a cost of 1,500 USD. As for boats prices more than 100,000 USD, all use Deep Sea FADs. Each trip for ten days, costs around 7,000 USD - 8,500 USD [14].

Table 3. Percentage of Use of Fishing Boats Based on Price.

The price of fishing boats (USD)	No FADs (%)	With FADs (%)	
	Traditional	Local	Migrant
4000 - 18000	90	10	
18000-36000	70	30	
36000 - 60000	10	70	20
60000 - 100000		40	60
>100000			100

2018 field interviews

Using the fishing gear productivity approach, calculated by the Setyorini equation in [3] is:

$$Average = \frac{\sum Production}{\sum Capture\ effort} \quad (6)$$

The calculation results show that fishing using FADs can increase production. Shallow Sea FADs, increasing production 2 to 4 times. The farther from the coast, the production using Deep Sea FADs is increasing. At a distance of around 40 km it can increase up to 8 times. While the distance of 100 km from the coast, can increase up to 12 times, but with a higher risk of costs, due to the depth of the sea.

4.3. Benefits of FADs on Local Fishermen

From the results of spatial analysis of the expansion area of FADs, show that most of the Pacitan waters are suitable. But many local fishermen do not use FAD technology. Although the average increasement is quite high when using FADs, the fact is that only around 20% of Pacitan local fishermen use FADs, both Deep Sea FADs, and Shallow Sea FADs.

Besides local fishermen, there are fishermen from outside Pacitan Regency. Almost all migrant fishermen use deep-sea FADs. Migrant fishermen are generally labor fishermen. Owners FADs come from the same region as labor, but the owners of FADs have been domiciled in Pacitan Regency.

Fishermen labor Deep Sea FADs come from the two regions. The first is from South Sulawesi

Province, which is about 1,100 km and the second is from Batang Regency, Central Java Province, which is about 300 km from Pacitan. Most labor fishermen from South Sulawesi is located in Pacitan for eight months, returning to their home area for four months. They still have agricultural jobs in Sulawesi. While fishing boat workers from Batang Regency Regency, every three months back to hometown for a month and then to Pacitan again. In general, fishermen labor from Batang has no job in their hometown. Only a few local fishermen utilize fishing with Deep Sea FADs method.

Table 4. Percentage of FADs Users

Fishing Techniques	Local (%)	Migrant (%)
No FADs	79,4	0
Shallow Sea FADs	10,2	0
Deep Sea FADs	10,4	89.6

2018 field interviews

Local fishermen are only about 10% who take advantage of deep-sea FADs. They use FADs which are 30 km from coastline with a depth of 100 to 500 m. The rest are still traditional fishermen who are still not ready to use FADs technology. The reason stated mostly is because of long distances, so they have to be in the sea 3 to 10 days. Local fishermen usually do one day fishing. They have activities on land, both for agricultural and social.

Capital and operating costs are expensive as well be the reason. While technological reason only for a small part of local fishermen. For those who reasoned constraints using FADs are capital and operational, said they are willing to use FADs if they have the funds. The amount of fishermen with each their reasons can be presented in pie chart as shown in Figure 5 below.

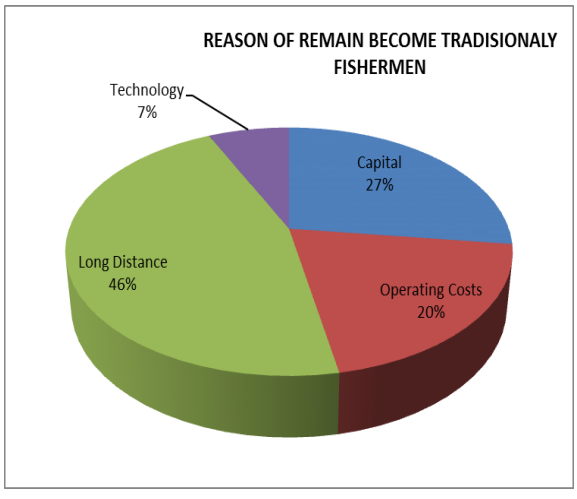

Fig.6. The reason remains a traditional fisherman

The narrower the fishing ground and the increase in the number of fishing boats, the destructive fishing still occurs even though the destructive form of fishing is now no longer blasting. They are aware that blasting is damaging to the environment. However, what cannot be avoided is that the operation of fishing gear is often negligent. Either from anchoring, bumping into a reef, or using a wide net. This was done because they had to compete to get adequate production. It is expected that if local fishermen have Shallow Sea FADs, then fishing destructive will decrease.

5. CONCLUSIONS

1. The expansion of the FADs location can be done in around 70% of the Pacitan Coast.On the coast which is 4 km away, Shallow Sea FADs can be installed at low cost for traditional fishermen.
2. About 90% of Deep Sea FADs are used by migrant fishermen. Most of them are workers who live in Pacitan for 9 months a year. Local fishermen, 80% are traditional fishermen who do not use FADs. Only 10% of local fishermen use Shallow Sea FADs and 10% use Deep Sea FADs
3. Local Fishermen who are traditional fishermen, are not ready to use Deep Sea FADs, because they cannot do one day fishing again, while they still have agricultural jobs. If they get capital, they choose Shallow Sea FADs. If Shallow Sea FADs production increases, destructive fishing will decrease..

6. ACKNOWLEDGEMENTS

The research work reported in this paper was funded by PITTA Grant : No. 2326/UN2.R3.1 /HKP.05.00/2018 Universitas Indonesia (UI).

The authors wish to express their gratitude to Directorate Research and Community Service Universitas Indonesia, also to students in PITTA Grant group in providing the equipment while carrying out this research.

4. REFERENCE

[1] DKP Pacitan District Marine and Fisheries Office, Pacitan Regency Fisheries Statistics Report, 2014.

[2] BPS, Pacitan Regency in Figures 2018., Indonesia Statistic Office (BPS), Pacitan Regency., 2018.

[3] Kurien J., Overcapacity, Overfishing and Subsidies, The 8th Pacific Rim Fisheries Conference, Hanoi, 22–24 March 2006.

[4] Prayitno M. R. E., Simbolon D., Yusfiandayani R., Wiryawan B., Fishing Equipment Productivity Operated Around the Deep Sea FADs. Marine Fisheries Vol. 8, No. 1, May 2017.

[5] Kurniawan M. R., Setyohadi D., Bintoro G., The Influence of FAD Flooding in the Western Season Against Catches. Payang Fishing Gear. PSPK Student Journal, VOL. I. Brawijaya University pp 16-20, 15 May 2013.

[6] Fathanah Y., Analysis of Characteristics of Small Scale Capture Fisheries in Pacitan Regency, Bogor Institute of Agriculture, 2014.

[7] MartinS., An Introduction to Ocean Remote Sensing, TJ International Ltd. Padstow, Cornwall, UK, 2014.

[8] Jaelani L.M. and Adillah Alfatinah., Sea Surface Temperature Mapping at Medium Scale Using Landsat 8 -TIRS Satellite Image. Regional Conference in Civil Engineering (RCCE) The Third International Conference on Civil Engineering Research (ICCER), 2017, pp. 582-586.

[9] Son, Young Baek, Wilford D Gardner, Mary Jo Richardson, Joji Ishizaka, Hyung Ryu, Sang-Hyun Kim, and H Lee. 2012. "Tracing Offshore Low-Salinity Plumes In The Northeastern Gulf Of Mexico During The Summer Season by Use Of Multispectral Remote-Sensing Data." Jurnal Of Oceanography 68 (5): 743–60.

[10] Jaelani L.M.,Fitriana Kartikasari, Gathot Winarso., Analisis Kualitas Air Laut Untuk Penentuan Lokasi Budidaya Kerapu Bebek Menggunakan Citra Satelit LANDSAT-8 (Studi Kasus : Teluk Lampung, Lampung), GEOID Vol. 12 No. 2 Agustus 2016., pp. 100-110

[11] Yatha P. G., Decision Making System for Placement of Marine FADs, Bandung Institute of Technology, 2014, pp.16-18.

[12] Handayani T., Youth Education in Self-Preparing as Marine Ecotourism Guide in Kepulauan Seribu. The 1st International Conference on Geography Education, Malang, Indonesia, 2016, pp. 2-3.

[13] Ocean Color Data, NASA. https://www.star.nesdis.noaa.gov/sod/mecb/color

[14] Taruna R. I., Fishing Boat Construction and Main Dimension in Determining Construction Boat, Pajajaran University, 2012, pp. 45-51.