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Abdul Syukur
Department of Sciences Education, Faculty of Teacher Training and Education, Mataram University, Indonesia; Jalan Majapahit No 56 Mataram Nusa Tenggra Barat

Mahrus
Department of Sciences Education, Faculty of Teacher Training and Education, Mataram University, Indonesia; Jalan Majapahit No 56 Mataram Nusa Tenggra Barat.

Syachruddin AR
Department of Sciences Education, Faculty of Teacher Training and Education, Mataram University, Indonesia; Jalan Majapahit No 56 Mataram Nusa Tenggra Barat

Correspondence
Abdul Syukur
Department of Sciences Education, Faculty of Teacher Training and Education, Mataram University, Indonesia; Jalan Majapahit No 56 Mataram Nusa Tenggra Barat

The potential assessment environment friendly aquaculture of small-scale fishermen as a conservation strategy seagrass beds in coastal areas of Tanjung Luar East Lombok, Indonesia

Abdul Syukur, Mahrus, Syachruddin AR

Abstract
Environment friendly cultivation is a significant strategy for small-scale economic development. The goal is to solve the problems of small-scale economies that could play an active role in the conservation of seagrass beds. Data were collected through observation and interviews were analyzed statistically. The main indicators to support environment friendly is a potential rabbit fish (*Siganus sp*) stock adequate; shares lobster species *Panulirus ornatus* and *Panulirus homarus* 25.256/month; and sufficient sources of natural feed available from around the cultivation environment. The impact of small-scale cultivation for conservation of seagrass beds as actively contributing to preventing the use of destructive and improve an agreement among the farmers for environmental security around cultivation. In this case, the environment-friendly farming by small scale may be recommended as a solution for economic development and as a strategy for the conservation of seagrass beds in the area of research.

Keywords: Environment flriendly, Aquaculture, Small-scale, Conservation of seagrass beds

Introduction
There are approximately 0.4 million fishermen associated with capture fishery and aquaculture in year 2010 in Indonesia compare to 54.8 million in the world [1]. The aquaculture production value in 2014 amounted to 9.53 million tonnes [2]. Although fish farming in Indonesia is generally a small-scale activity, it has high contribution on aquaculture production of the world [3]. In this connection, a new innovation is needed in designing sustainable aquaculture based on ecological functions that may be achieved through:
(1) Management innovation;
(2) Development of a broader perspective on the level of managers, farmers and stakeholders;
(3) forming a partnership environment; and
(4) An integrated approach to management [4, 5, 6].
The concept of the development of sustainable marine aquaculture encompasses:
(1) Expanding the cultivation of low trophic levels;
(2) Reduction of fish oil in the feeds;
(3) Development of an integrated farming systems; and
(4) Promotion of environment friendly cultivation practices [7]. Another aspect that is very important for the sustainability of aquaculture is the enforcement of environmental regulations. All these parameters are not specific but each may be an integrated operational plan to achieve the purpose of aquaculture and conservation [8, 9].
Small-scale fishermen are an important instrument in achieving the goal of sustainability of food supply and coastal environment sustainability. However, small-scale fishermen often identically with poverty as a target of the catch consists of many species; work individually; and financial investment are relatively low [10, 11]. On the other hand, they have the adaptive capacity in the face of social change and ecological and has been a major contribution to food security and poverty reduction although less attention in government policy [12-18]. Therefore, it needs the support of policies to prevent the exploitation that is both destructive and sustainable; solutions in the utilization of environment friendly coastal zone in an integrated management system [19, 20, 21].

The economic development solution of the small-scale fishermen is the development of environment friendly marine aquaculture. It is consistent with the purposes of cultivation, namely, reducing poverty, as a new source of livelihood, and supporting household economy of fishermen [22, 23, 24]. The parameters that determine the sustainability of marine aquaculture production at the level of small-scale fishermen include production capacity, growth, variability, geographical settings and biogeography [25]. Additional parameters are market access, development of cultivation techniques, maintenance of water quality, training, organization, support from the government and non-government [26, 27, 28,]. Other significant factors for the sustainability of aquaculture at the level of small-scale fishermen include customary values and cultural preferences in coastal communities, integration of aquaculture with ecological conservation perspective, and regulations at the level of farmers and associations at the regional and national level [29, 30, 31].

The main problem of small-scale fishermen in the study area is the continuous decline of catches allegedly caused by some kinds of target fish already exceeded the total allowable catches such as sardines, squids, and the type of squid beyond the sustainability potential [32, 33]. In addition, there has been a scarcity of some types of marine organisms at the location of seagrass beds, such as sea cucumbers, crabs and sea-urchins due to over exploitation by fishermen and seagrass damage caused by using environment unfriendly tools [27]. The condition of fish resources and the threat of damage on seagrass on a wider scale could adversely affect the economic sustainability of small-scale fishermen in the study area. However, the untapped potential for economic development of small-scale fishermen is the marine culture of 557 ha [34]. Therefore, research is needed on environment friendly cultivation by small-scale fishermen as a seagrass conservation strategy. The indicators in the design of environment friendly cultivation in the study area are the availability of stocks and feed sourced from the surrounding environment. The goal of this reseach is to solve the economic problems of small-scale fishermen and to activate them to conserve the seagrass beds ecosystem.

Materials and Methods

Research Location

This study was conducted from May to October 2015 in the coastal waters of Tanjung Luar East Lombok and its surrounding areas such as Gili Maringkik, Telong-Elong and Ketapang Raya (Figure 1).

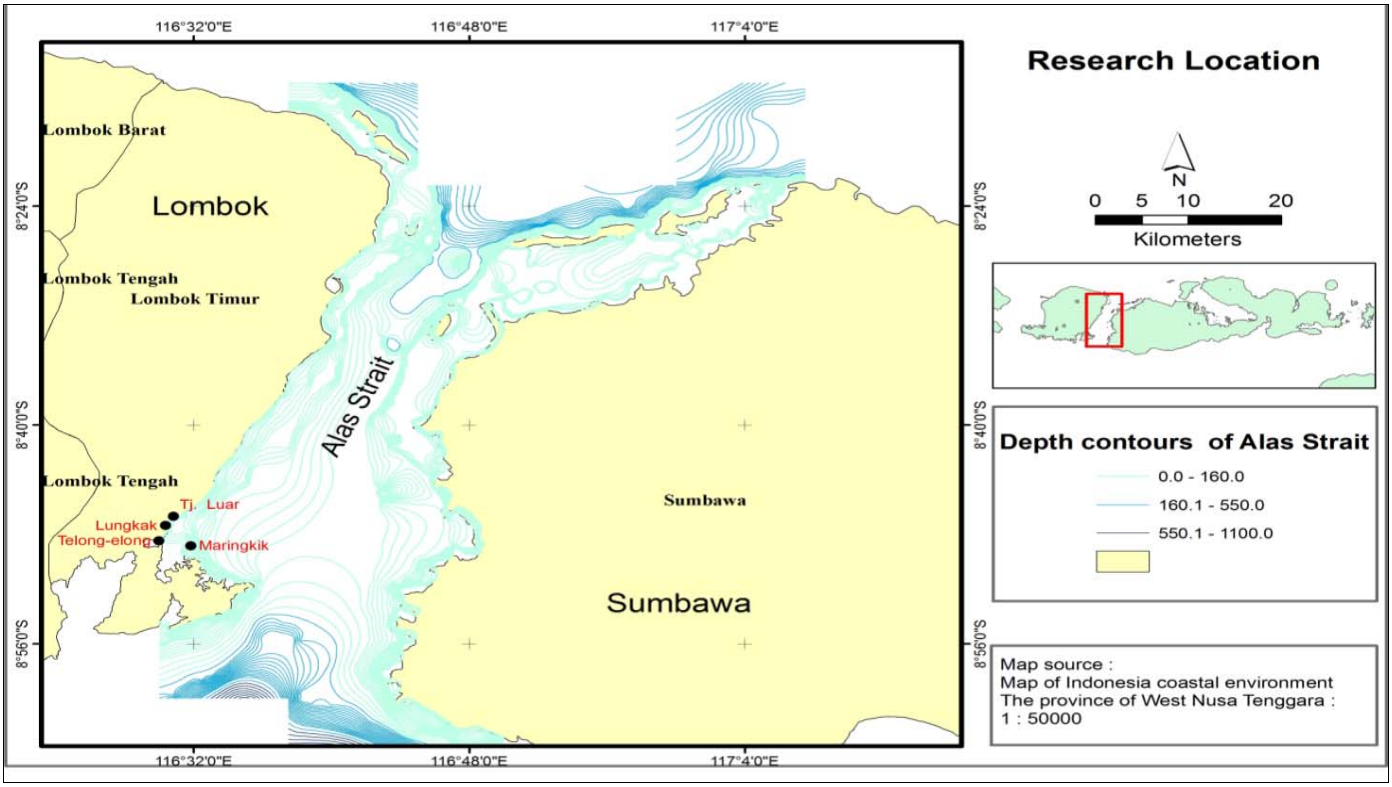

Fig 1: Location of Tanjung Luar East Lombok and surrounding areas

Collecting Data

The potential aquaculture that can be developed by small-scale fishermen in the study area is the cultivation of fish and lobster. In this case the data sources of potential fish species to be cultivated are based on their availability in nature [35]. The types of fish are Siganidae (Rabbitfish), Mugilidae (Mullets), Lutjanidae (Snappers), Haemulidae (Grunts) and Mullidae (Goatfish). In addition, data on the potential stocks of five fish species in the marine waters of Tanjung Affairs were obtained through direct interviews with individual fishermen. The selection of fishermen informants was based on snowball sampling technique, with the informants having a minimum experience of 10 years as fisherman [36]. Furthermore, data collection of lobsters was carried out once a week from May to August 2015. Informants in this case were fishermen who caught shrimp lobster by using lamp [37]. The number of respondents in this case was 15 fishermen determined randomly. Data collection related to the potential feed was conducted once a week from September to October 2015. A floating net measuring 100 m^2, and broad nets measuring 81 m^2, with a net mesh size of 0.5-inch (1.27 cm) were used to evaluate potential feed. In addition, data were collected on the impact of aquaculture activities of small-scale fishermen on the conservation of seagrass. The types of data collected

consisted of: (1) the use of fishing gear like gillnets, troll and others in the location of seagrass beds and around the area of seagrass; (2) The value of the presence of farmers in preventing the use of bombs and toxic materials such as potassium; (3) The presence of several types of fish with economic value in the surrounding area; (4) The activity of farmers in catching fishes around the areas of seagrass beds; (5) The activity of farming family looking for living marine organisms such as sea-urchins, mollusks and sea cucumbers on the location of seagrass beds as an additional livelihood source; (6) Forms of other uses of floating net having an economic value; (7) informal agreement on the level of fishing by the communities including a ban on the use of mini trolls and the like, the prevention of the use of tools and materials that are not environment friendly (bombs and potassium) and zone settings of cultivation. Collection of all the data was carried out through in-depth interviews and discussions. Informants were determined by purposive sampling technique, with a minimum experience of 10 years as a cultivator and fishing experience around the areas of seagrass. All data obtained in this research were validated through a focused group discussion [31].

Data Analysis

The data were analyzed partially in accordance with the functions of each type of data. Data of potential fish, lobster and shrimp were analyzed by using simple descriptive statistics. Furthermore, the impacts of environment friendly aquaculture on the conservation of seagrass beds were analyzed descriptively. The analysis consisted of synthesis, evaluation and making conclusions, to describe the conditions in an objective, systematic and conceptual manner [38, 39].

Results and Discussion

Environment friendly aquaculture indicators of small-scale fishermen

The sustainability of fish and other marine organisms is highly dependent on the availability of stocks [40]. An assessment had been carried out on five economically important fish species (rabbit fishes, mullets, snappers, grants sweetlips and goatfishes) (Figure 2). Furthermore, based on interviews with the fishermen, rabbit fishes have the highest abundance especially during the rainy season from January to April. One of research reported that *Siganus canaliculatus* belonging to the family Siganidae are found in large quantities from February to May [41].

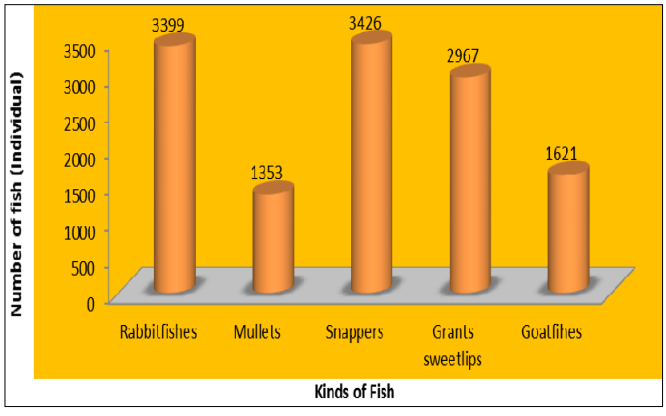

Fig 2: Potential stocks of five fish species caught by using a mini troll and a stationary lift net from March to April 2015 [35]

Fishermen chosed rabbitfishes for the development of environment friendly farming with some rational considerations, namely: (1) The availability of natural rabbit fishes stocks in large quantities; (2) The type of rabbit fishes can be easily caught by fishermen using simple fishing gears; (3) The type of feed for rabbit fishes not dependent on feed derived from mixture of trash fish and some kinds of other small fishes; (4) Rabbit fishes can be cultivated easily and can grow quickly.

Besides fish shrimp lobster farming is an environment friendly aquaculture for the economic development of small-scale fishermen. An evaluation had been conducted on the potential stocks of shrimp lobster for cultivation by small-scale fishermen. The potential stocks of lobsters from 15 fishermen are presented in Figure 3. As many as 18,335 lobster tails, consisting of sand lobster (*Panulirus homarus*) and pearl lobster (*Panulirus ornatus*). Furthermore, the average amount of lobsters stocks caught by each fisherman was 14 individuals/day and as many as 4,584 individuals per month. The total potential stocks of shrimp lobster in the study area can be estimated based on: (1) the number of fishermen actively capturing lobsters per day with an average of 82 individuals; (2) the number of effective days (22 days per month) in capturing lobsters; and (3) the average of 14 lobsters per day caught by one fisherman. Based on these three variables, the lobsters caught by fishermen in the study area amounted to 1,148 individuals/day and 25,256 individuals/month from May to August 2015.

The potential shrimp lobster stocks coming mostly from nearby study area such as Gulf of Awang, Bumbang and Gerupuk are big enough, but not fully utilized for cultivation by small-scale fishermen [37]. The habitat of natural lobster stocks is in the reef area, i.e shallow waters to a depth of 100 m below sea level [42]. Furthermore, the natural habitat favored by young sand lobster in the coral reef waters ranges between 0.3 to 0.5 m deep [43]. Based on the natural habitat of lobster stocks and assessment, the potential stocks of shrimp lobster in the study area can be summarized as: (1) The environmental conditions of marine waters in the study area are quite appropriate as a natural habitat for stocks of shrimp lobster; (2) Shrimp lobster farming can be a solution to the economic development of small-scale fishermen; and (3) The conservation of the marine environment especially conservation of seagrass beds ecosystem to preserve the natural habitat of lobster stocks.

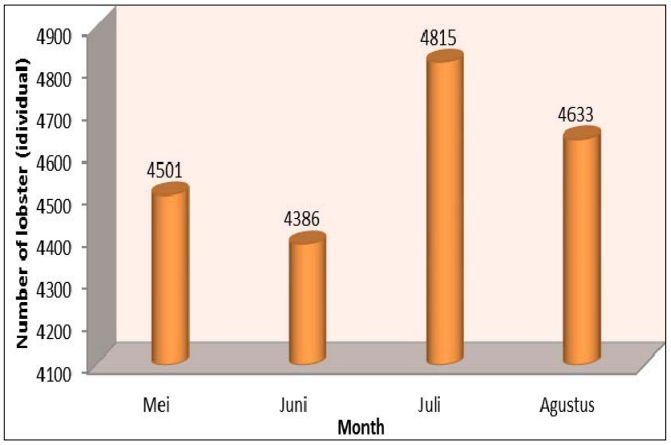

Fig 3: The catch of natural lobster stocks from 15 fishermen of Tanjung Luar Waters from May to August 2015

In addition to the stocks, feed availability is an important indicator for the development of the cultivation of shrimp lobster by small-scale fishermen. The feed mixture of trash fish and snails influences the relative growth rate and daily growth rates of lobster [44]. The amount of feed and frequency causes the lobster to grow faster and healthy and also free from diseases [45]. In this study, assessment of the feed source of small-scale fishermen was derived from the catch by buoyant nets.

Data of catches from floating nets indicated an average fish production of 34 kg/day, and average total effective production of 748 kg for 22 days/month. The composition of fish species consisted of 14 families and 37 species (Table 1). The fish that were quite dominant are *Thryssa setirostris, Leiognahus bindus* and *Leiognathus equulus*. The fishes are predominantly small-sized species of the family Enggrulidae and of moderate size from the family Lionagtidae [46]. Fishes of the family Lionagtidae are quite dominant in the coastal waters of Tanjung Luar [47]. In addition, some other small fish species are dominant in the marine waters of Tanjung Luar: Engraulidae, Clupeidae besides *Sardinella lemuru*, Chanidae and Apogonidae. Therefore, the potential of natural feed is sufficient to support the environment friendly farming of small-scale fishermen in the study area.

Table 1**:** Family and species of catch by buoyancy nets from September to October 2015

Family	Species	Species Number
Siganidae	*Siganus canaliculatus, Siganus guttaus*	2
Enggrulidae	*Stolephorus commersonnii, Lacepe, Stolephorus indicus, Stolephorus waitei, Thryssa baelama,Thryssa setirosris*	5
Chirocentridae	*Chirocentris dorab*	1
Clupeidae	*Amblygaster sirm, Dussumieria elopsoides, Sardinella gibbosa,Sardinella melanura*	4
Synodontidae	*Seurida nebulosa, Valenciennes*	1
Atheinidae	*Atherinomorus duodecimalis,Atherinomorus laccunosus*	2
Belonidae	*Tylosurus crocoditus crocodilus*	1
Hemiramphidae	*Hemiramphus far*	1
Apogonidae	*Archamia goni,Foa brachygramma*	2
Carangidae	*Scombriodes tala, Trachinotus biochii, Atule mate, Caranx melampygus, Caranx sexfasiatus*	5
Lionagtidae	*Gaza achlamys, Gaza rhombea, Leiognahusbindus, Leiognathus daura, Leiognathus equulus, Leiognathus fasciatus, Leiognathus smithursti, Leiognathus splendens, Leiognathus rapsoni,Secutor interruptus*	10
Ephippidae	*Drepane punctata*	1
Pomacentridae	*Abudefduduf sexfaciatus*	1
Diodontidae	*Diodon holocanthus*	1

Sustainable aquaculture as an instrument of seagrass conservation

Preservation of ecology functions for seagrass ecosystems is a decisive factor of economic sustainability of small-scale fishermen [48, 49]. It is a form of ecological services in supporting abundance of seagrass, richness of fish species and an increasing shrimp population [50]. One example is the conservation of seagrass by using restoration method which can increase the number of 15 commercial fish species [51]. In addition, seagrass beds in the small islands in the tropics are an economic resource for small-scale fishermen, and as indicators for sustainable conservation of fish resources. Therefore the concept developed for the conservation of seagrass is the protection of biodiversity and sustainability of food security [52, 53, 54]. In this case the ecological impact of the use of gillnets, infrastructure development, industrial runoff, and agriculture causing degradation of seagrass can be a research priority, management, and conservation [55, 56].

This study had successfully grouped three positive impacts of aquaculture by small-scale fishermen that are relevant to the conservation efforts of seagrass in the study area. Firstly, on spatial and temporal aspects, the cultivation systems developed by the small-scale fishermen consist of floating nets. The positive impact relates to the perspective of the farmers regarding conservation of seagrass: (1) Significant reduction of the number of fishermen who catch fish by using fishing gear like gillnets, troll and others; (2) Cultivators serving as supervisors and preventers of using bombs and potassium materials for fishing; and (3) Many species of economically important fish such as from family Haemulidae, Lutjanidae, Lethrinidae, Ephipidae and others in the surrounding area. In this case some of the economically important fish such as Lutjanidae and Haemulidae have potential to be cultivated by small-scale fishermen [35]. Cultivation can function to reduce the rate of overexploitation, support sustainability of biodiversity, and increase the population of rabbitfish significantly, resulting in habitat complexity similar to seagrass that serves to improve fish productivities, macro-invertebrates and export of fish biomass [57, 58, 59]. This is consistent with the objective of sustainable farming systems, namely food production through the preservation of natural resources, which can be only achieved when the production system is used to minimize the ecological impact [60]. Other studies indicate that there is little impact of aquaculture on the abundance and structure of demersal macrofauna (such as in the Fitzgerald Gulf), the average value of the abundance of species is higher at the control station around the area of cultivation, fish farming can cause an increase in organic material and sedimentation, and effect of the macrofauna collection on changes in seagrass beds [61, 62].

Secondly, on the aspects of livelihood source, cultivation which is done by small-scale fishermen serves as a supplement. Fish farming in marine waters has a positive effect namely export of fish biomass from cultivation place to another place on a local scale and highly profitable for the small-scale fishermen [12]. In addition, several positive implications of cultivation towards fishermen's life are cost of healthcare, children's education, and supporting the household economy and savings [63]. In this case, the aquaculture has a positive impact in the lives of fishermen continuously and as a source of additional livelihood [28, 24, 37]. The most dominant aquaculture is lobster farming, namely sand lobster (Panulirus homarus) and pearl lobster (*Panulirus ornatus*). Some positive impacts of the activity of farming towards the conservation of seagrass are: (1) All the cultivators do not catch fishes around the areas of seagrass beds; (2) The families of cultivators do not look for the marine organisms such as sea-urchins, mollusks and sea cucumbers in the location of seagrass beds, as a source of additional livelihood; (3) The cultivators make stationary lift nets as fishing location for many groups of anglers, especially during holidays. This condition can be described as changes in the utilization patterns by a section of fishermen, especially the cultivators from exploitative culture towards culture of sustainable use.

The third aspect concerns the regulation: forming an informal agreement at the community level of fishermen can be an effective

instrument for conservation of seagrass in the study area. The structure of the informal agreement at the community level is: (1) Prohibiting the use of mini trolls and the like by all fishermen; (2) Preventing the use of tools and materials that are not environment friendly (bombs and potassium); (3) Forming the zones of cultivation based on residence of fishermen.

Conclusions

Based on the results and discussion, the study indicated that an environment friendly aquaculture has a strategic significance for the economic development of small-scale fishermen in sustainable environmental conditions. The main requirement of sustainability in environment friendly aquaculture by small-scale fishermen in the study area is the availability of stocks and feed derived from the surrounding environment. The type of cultivation which has the highest feasibility value is rabbitfishes and lobsters. Furthermore, based on the positive implications of environment friendly aquaculture by small-scale fishermen from the spatial and temporal aspects, an additional livelihood source for the small-scale fishermen and informal regulation at the fishing community level will be an effective strategy for the conservation of seagrass in the study area.

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