The Evidence of Seagrass Environmental Support for Local People's Economic on the South Coast of Lombok Island

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Abstract: The richness of marine biota associated with seagrass has many economic values and has been used by the community as a source of livelihoods such as fish, mollusks, bivalves, crustaceans, and echinoderms. Therefore, this study aims to investigate the contribution of seagrass and its surrounding environment as a source of livelihood for local communities in the study area. This research method uses observation, interviews, questionnaires, and in-depth discussions. Furthermore, the number of samples was determined by purposive sampling. 265 fishers, 128 local non-fishermen, and 125 tourism service providers. The analysis of the average income of respondents (fishermen) based on animal groups obtained from seagrass and surrounding areas is US$16167.5. Meanwhile, the average income of respondents (local non-fishermen) from seagrass areas, especially housewives, is US$3401.63/season (full moon and dead moon) at low tide. Furthermore, the average income of respondents from providers of tourist services (especially for snorkeling, diving, swimming, and transportation services) is US$19353.85/month. The conclusion is that seagrass conservation can be an economical solution for local communities in a global climate change situation.

Keywords: Conservation, Seagrass, Economic and Local Communities

1. Introduction

Seagrass ecosystems have a rich diversity of marine biota, their function as a regulator of CO\textsubscript{2} and O\textsubscript{2} gases, and a source of world fishery production. Other than that, the existence of seagrass has a significant value from an ecological aspect, especially in its function of preventing coastal erosion, storing and absorbing carbon [1,2]. On the other hand, an estimated 20\% of the world's seagrasses have been lost [3]. Meanwhile, other threats come from anthropogenic activities and natural factors such as climate change [4,5]. Climate change has a significant impact on the faunal diversity associated with seagrass. One indicator of the effects of climate change is the increase in temperature and extreme weather, such as El Nio and La Nia, and very influential on natural ecosystems, agriculture, and fisheries sectors [4]. Communities living in coastal areas, especially fishermen, have economic vulnerability due to climate change. However, several studies have shown that coastal ecosystems (i.e., mangroves, seagrass, and coral reefs) contribute to a source of livelihood, tiny fishermen [6,7]. One of the ecosystem functions Seagrass is to support the survival of marine biota diversity [8,9], such as seagrass serving as a place for spawning, foraging, and rearing [10,11]. In addition, seagrass beds in tropical waters fauna associated with seagrasses, such as fish, crustaceans, bivalves, and echinoderms, are groups of marine animals that are targeted by fishermen and local communities [12]. Meanwhile, local communities in small islands and tropical coasts have a high financial dependence on seagrass fisheries [13]. Furthermore, seagrasses provide a habitat for fish breeding and production to support world fisheries and provide sustainable human welfare [14].

Fishery production from seagrass areas on the south coast of Lombok Island is estimated at US$ 61.1774/ha/year, which is sourced from the diversity of marine life such as fish and crustaceans mollusks and echinoderms [15]. Meanwhile, the richness of fish species associated with seagrass and the diversity of bivalved species are scientific evidence supporting seagrass conservation at scale [16, 17].
Furthermore, the seagrass area in the study location has developed as a natural tourism object and has become a conservation instrument in an integrated management system [18]. However, local scale seagrass conservation at the location has not yet been studied from seagrass support for the economic sustainability of local communities, which are then used as additional scientific parameters for seagrass conservation. Therefore, the purpose of this study is to investigate and describe the ecological evidence of support for seagrass ecosystems and the environment for the economic resilience of local communities from the effects of climate change. The benefit of this research is that it becomes a variable that can be considered for policies on managing seagrass ecosystems and other ecosystems, through conservation, especially at the study site and other locations.

2. Materials and Method

2.1 Place and time of research

This research was conducted in April-August 2021 on the South Coast of Lombok Island. The research location is the southern coastal area of Lombok Island, which has developed its use, especially in coastal waters used to create local scale marine aquaculture and ecotourism [18]. Meanwhile, the local community in the study area has a livelihood dependence, which is sourced from the mangrove ecosystem [19]. Surviving biota that has economic value around seagrass meadows and has become a source of livelihood for local communities is a positive impact of the success of mangrove revegetation [19].

Figure 1. Research Location Map.

2.2 Data Collection and Analysis

This study was designed to describe evidence of the support of seagrass ecosystem resources and the environment on the economic resilience of local communities due to climate change. Therefore, the source of research data comes from stakeholders who utilize seagrass resources both directly and indirectly. The stakeholders who were the respondents in this study were small fishermen, local non-fishing communities, and groups of tourism service providers (traders and providers of snorkeling, swimming, and transportation equipment). The research variables for each of the respondent's areas are in Table 1.
Table 1. Group of respondents and research variables.

| No | Respondent group                                      | Variable                                                                 | Respondent Criteria                                                                 | Data collection method                                                                 |
|----|-------------------------------------------------------|--------------------------------------------------------------------------|-------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------|
| 1  | Small fisherman                                       | 1. Catch target biota (fish, shrimp, and crab)                            | 1. Small fisherman                                                                | Surveys, observations, interviews with semi-open questionnaires                        |
|    |                                                       | 2. Total catch (Kg/day)                                                  | 2. Minimum 20 years experience as a fisherman                                      |                                                                                        |
|    |                                                       | 3. Catch value $/Kg                                                      | 3. The catchment area of the seagrass meadow and its surroundings                  |                                                                                        |
|    |                                                       | 4. Number of days at sea/month                                           |                                                                                    |                                                                                        |
| 2  | Non-fishing community                                 | 1. Target biota (Bivalvia, Echinoderms, and other biotias from seagrass beds) | 1. Residents of the research site villages                                         | Surveys, observations, interviews with semi-open questionnaires                        |
|    |                                                       | 2. Total yield Kg/day                                                    | 2. Regular collectors of economically valuable marine life from the seagrass meadow |                                                                                        |
|    |                                                       | 3. Collected value U$                                                    | 3. Length of work as a collector of biota that has an economic value from seagrass for at least 15 years |
|    |                                                       | 4. Number of days                                                        | 4. Own a boat                                                                      |                                                                                        |
| 3  | Tour service providers (sword stalls, snorkeling, diving, and transportation) | 1. Total income/day (US)                                                | 1. Villagers of the research location                                              | Surveys, observations, interviews with semi-open questionnaires                        |
|    |                                                       | 2. Number of working days/month                                          | 2. Have a stall                                                                    |                                                                                        |
|    |                                                       |                                                                         | 3. Have snorkeling and diving equipment                                           |                                                                                        |
|    |                                                       |                                                                         | 4. Own a boat                                                                      |                                                                                        |

Furthermore, another variable is the respondent's ecological knowledge about climate change which directly affects the livelihoods of local communities. In addition, a market survey was conducted to confirm the unit price (Rp), and converted into US of each commodity. Meanwhile, the technique of determining the number of respondents at each research location is proportional. The number of respondents for each group is as (Table 2), and the method of collecting data is purposive sampling.

Table 2. The proportion of Number of Respondents in four Research Locations

| No | Location     | Fisherman | Non-fishing community | Service providers (traders, tourism service providers) |
|----|--------------|-----------|------------------------|--------------------------------------------------------|
| 1  | Tanjung Luar | 100       | 40                     | 45                                                     |
| 2  | Awang        | 50        | 25                     | 20                                                     |
| 3  | Kuta         | 65        | 35                     | 40                                                     |
| 4  | Gerupuk      | 50        | 28                     | 20                                                     |
|    | Total        | 265       | 128                    | 125                                                    |

Data analysis: The first step of data analysis is identifying fish species, crustaceans, mollusks, and echinoderms. The two collected data are processed through: (1) tabulation of data according to the characteristics of data from all respondents, (2) performing verification to mark the type of data required according to research objectives, and (3) synthesis and evaluation. Third, validating all data through focus group discussions (FGD). Furthermore, all data from the validation results were analyzed using descriptive statistical analysis.

3. Results and Discussion

3.1 The results of the identification of four marine fauna commodities by respondents at the research location
The fish species caught by small fishermen in all research locations consisted of 19 families with 57 fish species, three families with seven crustacean species (Figure 2). The composition of fish species at the four research sites showed that the highest family was Clupeidae, with nine species (15.78%). Meanwhile, 14 families consist of one species (1.75%), including Apogonidae, Atherinidae, Canidae, Dussumieriidae, Hemiramphidae, Gerreidae, Lethrinidae, Mosasauridae, Polynemidae, Russulaceae, Sciaenidae, Scombridae, Terapontidae, Trichiuridae. Furthermore, the species composition of crustaceans caught by small fishermen at the four research locations, the family with the highest species consisted of two families with six species, one family having one species. Despite the existence of fish families with an unequal number of species, they are targets for small fisherman's catches that have economic value.

Figure 2. Family composition and species fish and crustaceans at the four research sites.

Meanwhile, the composition of fish and crustacean species at research location (Table 3). Furthermore, the composition of fish species caught by fishermen shows that Kuta has the highest number of species, namely 25 species (43.84%) of all species in all research locations. Furthermore, the location with the lowest number of species was Gerupuk, 11 species (19.29%). Meanwhile, the highest crustacean species composition was in Awang with seven species, and the lowest was in Tanjung Luar and Gerupuk with three species. Furthermore, the results of observations, surveys and interviews with all small fishermen, several species that are always or most often obtained by fishermen consist of 12 fish species, including Amblygaster sirm, Atule mate, Eleutheronema tetradyctylum, Herklotsichthys dispilonotus, Johnius trachycephalus, Leiognathus equulus, Leiognathus bindus, Leiognathus equulus, Sardinella gibbose, Sillago macrolepis, Sillago Sihama and Stolepholus commersonnii. Meanwhile, three species of crustaceans are Litopenaeus vannamei, Portunus pelagicus and Portunus trituberculatus. The 12 groups of fish species and three crustacean species had a strong relationship with seagrass presence in the four study sites. One of the relations between seagrass and the diversity of fish species is that seagrass provides protection services, a place to find food for various fish species, both those that have economic value and those that do not have economic value [13,16]. In addition, the presence of economically valuable fish species and crustacean species at the four research sites can be evidence of support for the existence of seagrass ecosystems and their environment in supporting the sustainability of small fishermen's livelihoods. Therefore, the livelihood parameters of small fishers originating from seagrass beds and their environment can indicate local scale seagrass conservation, such as in the study location.
### Table 3. Result Identification of marine fauna from seagrass and environment in four research sites

|        | Fish                        | Crustaceans     |
|--------|-----------------------------|-----------------|
| **Tanjung Luar** | Atula mate                  | Litopenaeus vannamei |
|        | Amblygaster sirm            | Portunus pelagicus |
|        | Empheris oualensis          | Portunus trituberculatus |
|        | Escualosa thoracata         |                 |
|        | Gazza aehlamyys             |                 |
|        | Gazza Dentex                |                 |
|        | Gazza minuta                |                 |
|        | Herklotsichthys dyspilonotus|                 |
|        | Johnius trachycephalus      |                 |
|        | Karalla dussumieri          |                 |
|        | Laqjans Latianus            |                 |
|        | Sardinella albella         |                 |
|        | Sardinella brasiliensis     |                 |
|        | Sardinella leonaru         |                 |
|        | Sardinella melanura        |                 |
|        | Selaroides leptolepis      |                 |
|        | Siganus canaliculatus      |                 |
|        | Stolepholus commersonnii   |                 |
|        | Therapists                 |                 |
|        | Trichirius lepturus        |                 |
|        | Tylosurus crocodilus       |                 |
|        | Upeneus Vitidatus          |                 |
| **Awang**  | Atula mate                  | Litopenaeus vannamei |
|        | Caesio cuning               | Metapenaeus ensis |
|        | Caranx ignobilis            | Nephropidae      |
|        | Decapterus macarelli       | Panulirus versicolor |
|        | Dussumieria acuta          | Penaeus latiscutatus |
|        | Elagatis bimninulata       | Portunus pelagicus |
|        | Eleutheronema tetradactylum| Portunus trituberculatus |
|        | Gazza aehlamyys            | Scyilla serrat |
|        | Gazza minuta               |                 |
|        | Gemiramphus brasiliensis   |                 |
|        | Lactarius lactarius       |                 |
|        | Scomber australastus       |                 |
|        | crumenophthalbus dact      |                 |
|        | Siganus guttatus           |                 |
|        | Sphyraena barracuda        |                 |
|        | Sphyraena flavicuda        |                 |
|        | Stolephorus indicus        |                 |
|        | Tenualeose toil            |                 |
|        | jarbua therapy             |                 |
|        | Therapists                 |                 |
|        | Tylosurus crocodilus       |                 |
| **Kuta**  | Apogonichthys ocellatus    | Metapenaeus sensis |
|        | Ambassiss buruensis        | Nephropidae      |
|        | Atherinomirus lacanusus     | Panulirusversicolor |
|        | Atule mate                 | Penaeus latiscutatus |
|        | Chorinenus tuning          | Portunus pelagicus |
|        | Gerres Oyena               | Scyilla serrat |
|        | Hemirampus far             |                 |
|        | Herklotsichthys dyspilonotus|                 |
|        | Leognatthus bindus         |                 |
|        | Leognatthus equulus        |                 |
|        | Lethrinus lentjan          |                 |
|        | Latjans bouton             |                 |
|        | Latjans Campechanus        |                 |
|        | Mugil cephalus             |                 |
Seagrass ecosystem services and their environment are not only used directly by small fishermen as a source of livelihood, but their existence has an object of livelihood for non-fishing communities. The results of observations, surveys, questionnaires, and deep interviews show that the diversity of marine biota that is the target of their livelihood is in the location of seagrass beds (Table 4). The composition of marine fauna in the four research locations showed that the highest number of fish species was in Tanjung Luar and Awang, four species. Furthermore, the location with the lowest number of species in Gerupuk is two species. Meanwhile, the highest mollusk species in Kuta are six species. Furthermore, the location with the lowest number of species in Gerupuk is two species. Furthermore, the highest crustacean species were found in Awang and Kuta with four species each, the weakest in Tanjung Luar, two species. Furthermore, echinoderm species at the four research sites were found to have one species each. The diversity of fauna species associated with seagrass and becoming the target of catch or livelihood of non-fishing communities is proof that seagrass and its environment can be a source of livelihood for local communities in a sustainable manner. Therefore, the dependent variable of local communities can be considered in local scale seagrass conservation efforts such as at the study site.

**Table 4. Result identification of marine fauna from seagrass and environment in four research sites**

| Fish                  | Mollusca                  | Crustaceans               | Echinodermenes        |
|-----------------------|---------------------------|---------------------------|-----------------------|
| Tanjung Luar          | Sardinella melanura      | Octopus sp.               | Tripneustes gratilla  |
|                       | Stolephorus commersonii   | Octopus sp.               |                       |
|                       | Johnius trachycephalus    | Loligo sp.                |                       |
|                       | Amblygaster sirm          |                          |                       |
|                       | Sepia sp                  |                           |                       |
|                       | Portunus pelagicus        |                           |                       |
|                       | Portunus trituberculatus  |                           |                       |
| Awang                 | Atule mate                | Charybdis tunicate        | Tripneustes gratilla  |
|                       | Eleutheronema tetractylum | Litopenaeus vannamei      |                       |
|                       | Johnius trachycephalus    | Panulus spp.              |                       |
|                       | Octopus sp.               |                           |                       |
|                       | Sepia sp                  |                           |                       |
|                       | Portunus pelagicus        |                           |                       |
|                       | Portunus trituberculatus  |                           |                       |
| Kuta                  | Leiognathus bindus        | Charybdis tunicate        | Tripneustes gratilla  |
|                       | Leiognathus equulus       | Penaues monodon           |                       |
|                       | Latjanus Latjanus         | Penaues monodon           |                       |
|                       | Codakia tigerina          | Portunus pelagicus        |                       |
|                       | Gafrarium tumidum         |                           |                       |
|                       | Sepia sp                  |                           |                       |
|                       | Tripneustes gratilla      |                           |                       |
| Gerupuk               | Leiognathus equulus       | Penaues monodon           | Tripneustes gratilla  |
|                       | Silago Sihama             | Litopenaeus vannamei      |                       |
|                       | Octopus sp.               |                           |                       |
3.2 Economic Value of Seagrass Ecosystem Resources and the Surrounding Environment from the respondent's perspective

The existence of seagrass has benefits for the habitat of marine biota and also local communities who live on the southern coast of the island of Lombok, distributed in the coastal areas of Kuta, Gerupuk, and Awang. Seagrasses also provide goods and services by producing various marine and ecological fishery products [11]. The contribution of seagrass can be felt by local people who also work as fishermen and service providers (Table 5). The results of observations and interviews showed that the income of fishermen in one month at sea amounts to US$1979.8 per/month, crabs US$5348.5 per/month, shrimp US$8839.2 per/month so that fishermen’s income in one month at sea amounting to US$ 16167.5 per/month. Economic income from the seagrass ecosystem of non-fishing communities has a high monetary value, especially in the catch of mollusks with a selling value equivalent to US$324.99 per/month so that the income of non-fishermen in one month amounts to US$3401.63 per/month. Economic income from the seagrass ecosystem has a high monetary value, especially in terms of boat transportation in dollars worth US$13714 per/month, diving US$2100 per/month, snorkeling US$2640 per/month, swimming US$899.85 per/month so that the provider's income services amounted to US$19353.85 per/month. Income sourced from seagrass ecosystems is agreed upon by all respondents 85 per/month so that the service provider's revenue is US$19353.85 per/month. Income sourced from seagrass ecosystems is agreed upon by all respondents 85 per/month so that the service provider's income is US$19353.85 per/month. All respondents agree upon income sourced from seagrass ecosystems that seagrass and marine life can improve the economy in Kuta Beach, Gerupuk and Awang, Central Lombok. [11]

Table 5. Total average income of respondents in the four research locations

| Respondent                        | Average Catch (kg/day) | Long time at sea (day/1 month) | Total catch (Kg/Month) | Unit Price (kg) | Total Price (Rp/Month) | Total Value ($) | Total Respondents | Total Value ($) |
|-----------------------------------|------------------------|-------------------------------|------------------------|----------------|------------------------|----------------|------------------|-----------------|
| Small Fisherman                   |                        |                               |                        |                |                        |                |                  |                 |
| Fish                              | 6.6                    | 20                            | 132                    | 15000          | 1980000               | 141.42         | 140              | 1979.8          |
| Crab                              | 2.4                    | 20                            | 48                     | 60000          | 2880000               | 205.714        | 26               | 5348.5          |
| Shrimp                            | 2.5                    | 20                            | 50                     | 25000          | 1250000               | 89.28          | 99               | 8839.2          |
| Amount                            |                        |                               |                        |                |                        |                |                  |                 |
| Non-Fishermen Community           |                        |                               |                        |                |                        |                |                  |                 |
| Mollusca                          | 4                      | 5                             | 20                     | 20000          | 400000                | 28.571         | 49               | 1399.9          |
| Crab                              | 1.7                    | 5                             | 8.5                    | 60000          | 510000                | 36.428         | 35               | 1274.98         |
| Shrimp                            | 1.5                    | 5                             | 7.5                    | 25000          | 187500                | 13.392         | 30               | 401.76          |
| Sea Urchin                        | 1.3                    | 5                             | 6.5                    | 50000          | 325000                | 23.214         | 14               | 324.99          |
| Amount                            |                        |                               |                        |                |                        |                | 128              | 3401.63         |
| Service Provider                  |                        |                               |                        |                |                        |                |                  |                 |
| Boat transportation               | 3                      | 8                             | 24                     | 200000         | 4800000               | 342.85         | 40               | 13714           |
| Diving                            | 3                      | 8                             | 24                     | 50000          | 1050000              | 75             | 28               | 2100            |
| Snorkeling                        | 6                      | 8                             | 48                     | 35000          | 1680000              | 120            | 22               | 2640            |
| Swimming                          | 3                      | 8                             | 24                     | 15000          | 3600000              | 25.71          | 35               | 19353.85        |
3.3 Respondent Group's Perspective on Climate Change
Resilience is a parameter to assess ecosystem changes to recover after receiving disturbances. Resilience is observing a disruption in a system that can absorb and maintain the same function, structure, and identity to regulate itself and its capacity to adapt to environmental changes, the socio-ecological system as a complex adaptive system [20,21,22]. Moreover, resilience is a property of a plan. In the Socio-Ecological System (SES), humans have the additional capacity to anticipate change to some degree and influence the future path. Local communities in the study area have adequate knowledge about seagrass services. In this case, they can identify changes in seagrass conditions as an object for assessing the resilience of seagrass and related biota beneficial to the surrounding community's economy. However, resilient things are comprehensive and complex in seagrass ecosystems, so this study uses indicators of seagrass resilience from climate change by using biota types; fish, shrimp, crabs, and mollusks. The indicator of seagrass resilience from the community perspective follows the concept of ecological resilience. Respondents were able to identify the resilience of seagrass to climate change and formulate conservation efforts for its preservation. This, in turn, generates awareness and their social views on management options. It can be said that they want the seagrass area to be protected, especially from the government's efforts to pay more attention to the seagrass ecosystem in the location. One of the strategies in seagrass conservation is through planting, and at the same time, its management is integrated with the local community's needs [11,25]. In addition, they are also expected to use seagrass in an environmentally friendly manner through the development of environmentally friendly cultivation and tourism.

3.4 Seagrass Conservation much needed by the local community
The survey results and interviews with respondents, seagrass conservation efforts have increased the area of seagrass. Furthermore, the results of the respondents' assessment are 1). Respondents from three locations stated that seagrass planted and grew naturally is a way for seagrass to breed and become a place to catch fish, shrimp, crabs, and mollusks, 2). 88.6% of respondents stated that seagrass conservation is an effort to protect livelihoods or restore economic resource wealth from the existence of seagrasses before they are damaged, 3). 78% of respondents stated that seagrass growth and development through planting and natural growth is a principle that must be maintained for seagrass sustainability, and 4.93% of respondents stated that the success of seagrass conservation is a collaboration between the government and the surrounding community. The results of the respondent's assessment described above are a form of the local community's response to the presence of seagrass. In addition, this indicator shows that local communities are an essential component in managing seagrass sustainability at the research site. Meanwhile, the results of interviews, in-depth discussions, and focus group discussions show that the existence of local community institutions has not played an optimal role in seagrass management. However, the values of their Understanding of seagrass individually become the leading force in preserving seagrass in the research location. The behavior of local communities towards the presence of seagrass is a significant social capital for the success of seagrass conservation at the research site. This can be explained, that the people who live near resources and depend on their livelihood can actively protect from threats [20]. The main thing related to this is that livelihoods are the main factor motivating their participation in seagrass restoration and management. However, assistance can be provided for those with low incomes so as not to re-exploit seagrass resources. Seagrass has several benefits for fishermen's livelihoods, namely seagrass as a habitat for fish, mollusks, and crustaceans [18,19,24]. The community is also aware that seagrass provides a habitat for marine life and can treat stomachaches and cosmetics. The part of the seagrass that is used as a treatment for stomach pain is the fruit. The species of seagrass that produces fruit is *Enhalus acoroides* [18]. Based on the results of in-depth observations and interviews, it was found that seagrass beds positively impact the economy around the research location on the south coast of Lombok Island.
4. Conclusion
Climate change has impacted global, regional and local scales, especially for communities in coastal areas, such as in the study sites. However, the existence of coastal ecosystems such as seagrass ecosystems and their environments, such as the diversity of fish, crustaceans, mollusks, and echinoderms associated with seagrasses, has become a source of livelihood for local communities in the study area. The contribution of the economic value obtained by stakeholder groups (fishermen, non-fishing communities, and ecotourism service providers) is significant enough to support the family's financial needs. Therefore, seagrass conservation can be an economical solution for local communities in a global climate change situation.

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