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Research Article
Ecotourism Development Based on the Diversity of Echinoderms Species in Seagrass Beds on the South Coastal of Lombok Island, Indonesia

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Abstract

Background and Objective: The model of utilization of the coastal and marine environment is still dominated by goods products and has not yet moved to ecosystem service products, such as the use of seagrass ecosystem. The purpose of this study was to describe the relevance of ecotourism for seagrass conservation and the economic value of seagrass ecotourism for local communities. **Materials and Methods:** The data in this study were collected through surveys and observations. Fauna data were collected using the transect method. Analysis diversity of Echinoderm species was done using the Shannon-Wiener Index (H') and evenness index (E). In addition, the relationship between bivalve community structure and its environmental parameters carried out using pearson correlation which is processed with SPPS 17 software. **Results:** The results of this study provide information that the ecological aspects of seagrasses that are the choice of tourists to visit seagrass sites are species of Echinoderms associated with seagrasses. However, the tourists who came to the seagrass site, did not know about the attraction at the location of the seagrass. Therefore, evidence of the addition of forms of utilization of seagrass ecological services can be a rational argument for their protection from the threat of destructive exploitation. In addition, local communities have economic benefits from tourism, especially from the provision of transportation services. **Conclusion:** The conclusion is that the choice of utilizing seagrass ecological services can be developed as a policy in overcoming the threat and vulnerability of marine biota and economic solutions for local communities.

Key words: Evidence ecology, seagrass, ecotourism, conservation, livelihoods, local communities, marine biodata, vulnerability

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Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Seagrass is a high-level of plants (Angiospermae), that have adapted to the marine environment and occupies an area of intertidal[1]. The presence of seagrass function is to support the diversity of fauna in the marine environment and can be shown by the discovery of the diversity of fauna associated with seagrass[2]. Group of fauna associated with seagrass are echinodermata, polychaeta, mollusca and crustaceans[3]. The other ecological functions of seagrasses that have been identified are as habitat, feeding grounds and nursery grounds of fish diversity. Ecological services of seagrass an essential to the marine ecology system are on the trophic systems for herbivores and detritus[4-6]. Therefore, seagrass ecological services are not limited to their own environment but can be broader, such as connectivity with other ecosystems on a local and regional scale[7,8].

The other products of seagrass services are for food security and the economies of local communities[9]. It can further be explained that seagrass ecosystem services are provided (food and raw materials), regulation (gas and climate regulation, coastal protection and bioremediation of waste), support (lifecycle maintenance and water conditions) and Cultural adalah research and education, recreation and tourism and cultural heritage and identity. Meanwhile, for the purpose of management of seagrass ecosystem services as a concept boundary are: services between seagrass ecosystems or between seagrass beds that are in one region and seagrass ecosystem services for other coastal habitats such as coral reefs, mangroves and others in the coastal area[10].

The challenges to maintain seagrass ecological services are there sources from exploitation of local communities[11]. Therefore, the management requires the involvement of local communities. The aim is to increase public awareness and can play a role in the educational process of environmental sustainability such as seagrass and its associated biota. One form of management in the sustainable use of seagrass potential is ecotourism. The value of utilization through ecotourism is in accordance with conservation goals to improve the economic status of local communities and education[12]. However, for effectiveness in achieving goals requires guidelines as operational guidance in implementation. One form is the availability of a curriculum that includes the need to increase public awareness and stakeholder skills in ecotourism[13,14].

Ecotourism is a new instrument in the management of coastal resources at the study site. However, the challenge is local people or small fishermen, where they still exploit seagrass resources for the economic needs of the family[15]. Nevertheless, seagrass tours for traveling and snorkeling activities at the study site have a 96% Tourism Suitability Index[16]. Meanwhile, there is no comprehensive research related to integrating the seagrass ecological potential for the development of ecotourism as a management instrument. Seagrass ecological potential (e.g., seagrass beds, rich fauna associations) such as Phylum of Echinodermata has many species as natural attractions in seagrass beds. Therefore, the objectives of this study are: to assess the potential of seagrass and the diversity of species Echinodermata for ecotourism development and 2) ecotourism development is the livelihood solutions of local people and seagrass conservation. The urgency is that regulations and policies are needed in the management of natural tourism on the southern coast of Lombok Island.

MATERIALS AND METHODS

Research location: The location of the study was in the southern coastal area of Lombok Island, which included two districts namely Central Lombok Regency and East Lombok Regency (Fig. 1). The study was conducted from March to October, 2019. Furthermore, the stages in this study were first to establish sampling locations in two coastal areas in the East Lombok Regency (Gili Kere, Lungkak and Poton Bako) and in Central Lombok Regency (Kute, Gerupuk and Awang). The next stage is to conduct an assessment of the development of tourism in each study location. In addition, an assessment of the existing conditions of tourism development was carried out at each sampling location.

Data collection and analysis: The data in this study were collected through surveys and observations. Furthermore, data collection is divided into two stages, first is data collection on echinoderms fauna and environmental conditions, the second is data on local people's perceptions about ecotourism. Fauna data were collected using the transect method in a permanent quadrant with a standard size of 2×2 m. The transect is placed perpendicular to the coastline towards the sea and the interval between transects is 50 m. Echinoderms are observed in quadrants and only living organisms are considered. Echinoderms species identification is carried out directly and unidentified species are stored in 4% formalin and identification is carried out at the University of Mataram biological biology laboratory[17,18]. Meanwhile, an assessment of environmental conditions includes: dissolved oxygen (DO), salinity, pH, temperature, nitrate and phosphate.

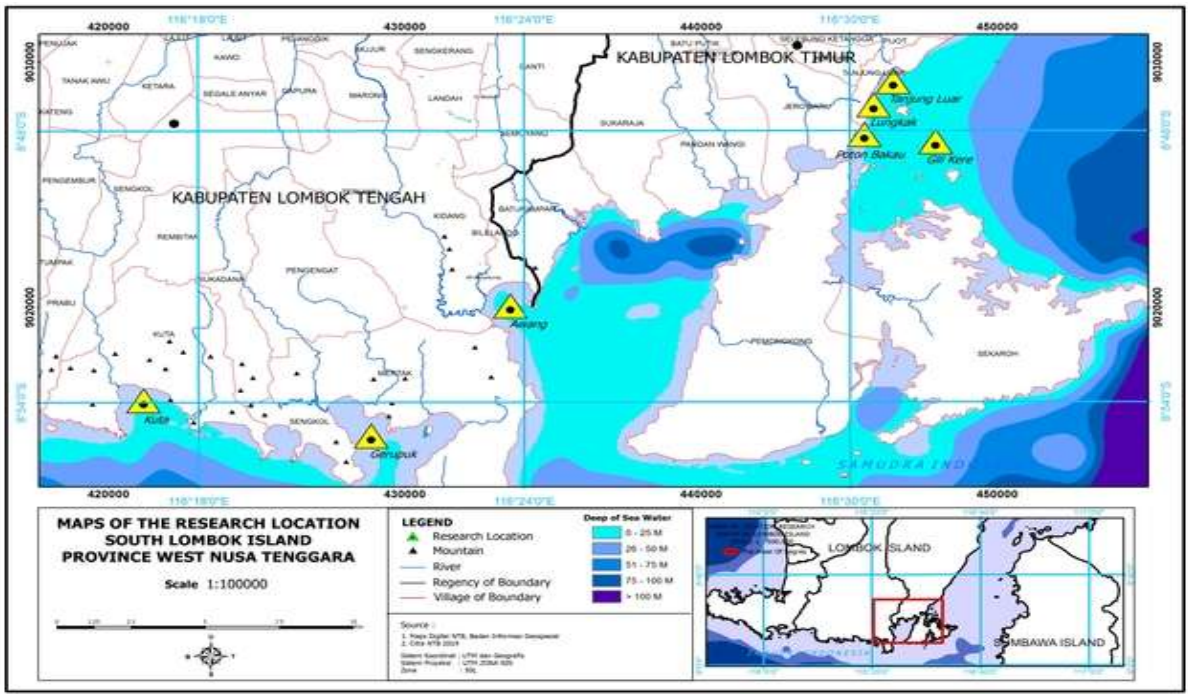

Fig. 1: Research location: (1) Gili Kere, (2) Lungkak, (3) Poton Bako, (4) Kute, (5) Awang, dan (6) Gerupuk

The next data that has been collected is about the perceptions of local people and ecotourism actors (operators and tourists). The assumption is that respondents can come up with opinions and information to fill knowledge needs in the development of seagrass ecotourism. This is according to stakeholder theory as a useful perspective for overcoming several important problems in interpreting the phenomenon across different disciplines. In addition, they as a source of information have relevant and broad experience according to topic and the problem. Therefore, respondents needed in this study are those who have knowledge about the natural environment of seagrass and or seagrass ecosystems.

Respondents criteria as informants in this study are different for each group. Operators as respondents with criteria are those who have experience as beach tourism operators in the study location for at least 5 years. Meanwhile, local people as respondents had the following criteria: (1) Registered as a member of the community and living in the village at each study location and (2) Over 35 years of age. Next, the group of tourist is respondents. In addition to the three groups of respondents, in this study community leaders and/or formal leaders were used as key informants. Researcher's usually collect data, use questionnaires and in-depth discussions. Furthermore, the method used is purposive sampling and the number of respondents from each group is determined proportionally.

Data analysis: All data obtained from respondents were analyzed using descriptive statistics. Furthermore, the abundant species of echinoderms is expressed as the number of individuals per species per square meter. Analysis diversity, species of echinoderm using the Shannon-Wiener Index (H') and evenness index (E). In addition, the relationship between bivalve community structure and its environmental parameters is carried out using Pearson Correlation which is processed with SPPS 17 software[19]. Furthermore, diversity shows the diversity of species or the proportion of the number of species to the number of individuals/species in the community. The formula used for diversity analysis's based Diversity Shannon and Wiener index[20], with Eq:

$$H' = -\sum_{i=1}^{s} pi \log_2 pi$$

where, H' is the Shannon-Wiener diversity index, s is the number of types, pi is the proportion of individuals of type$_i$ to number of individuals of all (pi = ni/N), ni is the number of individuals of a type, N is the total of individuals of all types and Log_2pi is the 3,321928 log pi.

The next analysis is the similarity of individual distribution of each species of echinoderms, in this section using the Evenness index analysis[21], with Eq:

$$E' = \frac{H'}{\log_2 S}$$

where, E' is the evenness index, H' is the value of diversity index and S is the number of species that were successfully taken as examples.

Indicators of the ecological index, in addition to those mentioned above, are abundance of echinoderms. In this study, abundance analysis which shows the number of types of individuals towards the total area of observation[22], with Eq:

$$Di = \frac{ni}{A}$$

where, Di is the abundance of i-type individuals (ind/m^2), ni is the number of individuals of type i obtained and A is the total area of observation area.

RESULTS AND DISCUSSION

Composition species of echinoderms in seagrass areas in study locations: Indicators of seagrass ecology are the discovery of diversity of fauna in seagrass areas. Echinoderms are a group of fauna which have 5 classes, namely Asteroidea (starfish), Ophiuroidea (snake star), Echinoidea (sea urchin) Crinoidea (sea lily) and Holothuroidea (sea cucumbers) and live confined to certain marine environments[17,18,23]. The total numbers of Echinoderms found at the study site are four classes consisting of Asteroidea, Echinoidea, Holothuroidea and Ophiuroidea. The composition of species and percentage of individuals is presented in (Fig. 2). The existence of echinoderms at each study site is evidence of seagrass ecology for the sustainability of marine life. In addition, it can provide information about the wealth of Echinoderm species in the seagrass beds in the South Coastal region of Lombok Island.

The number of species from the 4 Echinoderms classes at the study site was 21 species, with 3783 individuals. The composition of the number of individuals/species in Fig. 3, where the species with the highest number of individuals was *Diadema setosum* (23.95%) and the lowest was *Linckia multifora* (0.43%). The composition species of echinoderms at the study location shows that , Gili Kere is the location with the highest number of species and the location with the lowest number of species is Tanjung Luar/Lungkak and Awang. In the connection with this matter, the species richness of echinoderms (Asteroidea and Echinoidea) shows that seagrass and coral reef cover is relatively good, which is a form of ecological service both ecosystems in providing food and habitat for marine organisms[24,25]. It was further explained that, low abundance species of echinoderms can be associated with different human activities. Meanwhile, compared with the results of other studies, species of echinoderms richness, such as in Marsegu Island Indonesia with a total of 10 species[26], 17 species in Baguala Bay, Maluku, Eastern Indonesia[27], 19 species of echinoderms Mudasalodai and Pazhayar in the Southeast Coastal of India[28,17] species in the islands of the Gulf of Chiriqui Panama[24], 10 species in Babanlagan, Talisayan, Misamis Oriental Philippines[25], 8 species in the intertidal zone of Goso-on and Vinapor, Carmen, Agusan del Norte, Philippines[29].

The overall composition of Echinoderms in the study location is higher than some locations as mentioned above. However, the number of species at each location is lower than 4 locations (e.g., Baguala Bay, Maluku Eastern Indonesia, Mudasalodai and Pazhayar on the Southeast Coast of India,

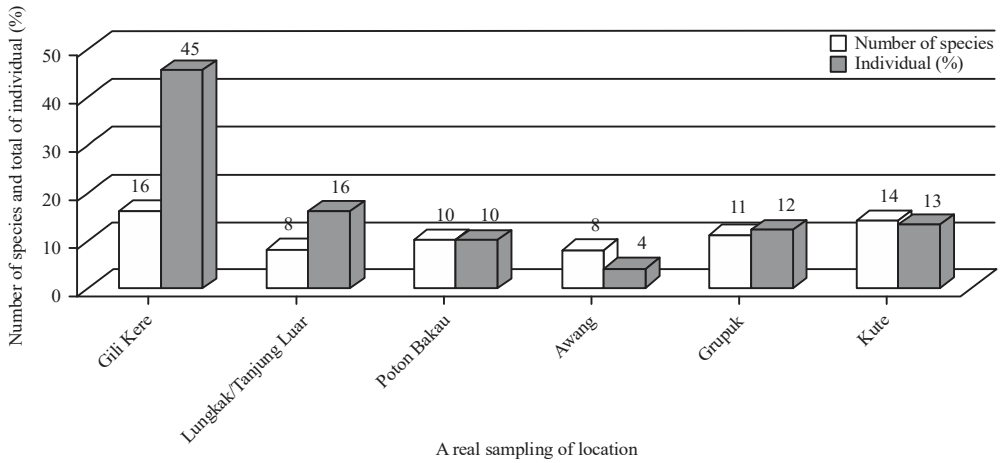

Fig. 2: Number of species and number of individuals/species (%) of echinoderms at each study site

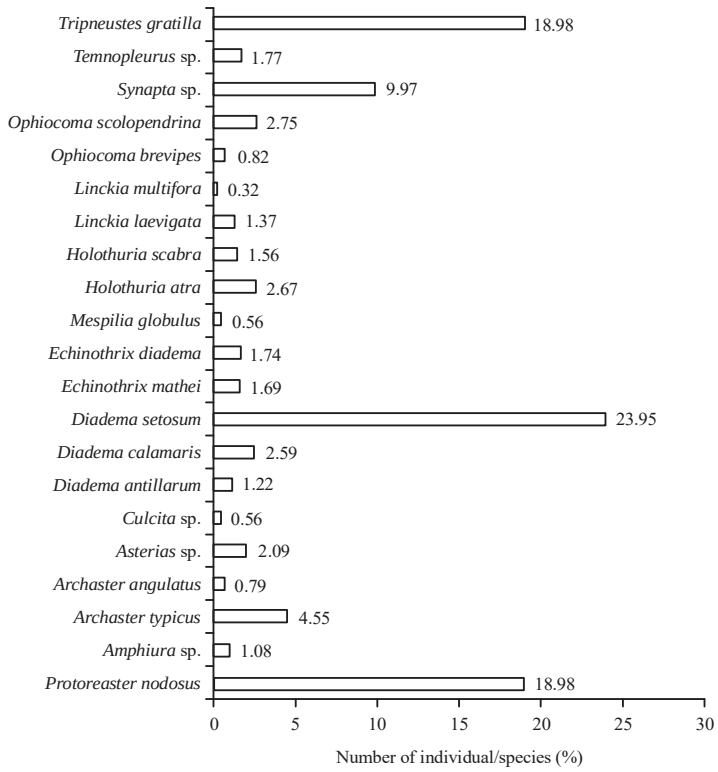

Fig. 3: Individuals/species (%) of echinoderms at all study sites

the Gulf of Chiriqui Panama, intertidal zone of Goso-on and Vinapor and Carmen, Agusan del Norte, Philippines. The wealth of echinoderms in the seagrass area is a very important evidence of seagrass ecology in the marine ecological system. In this case, seagrasses can play a role in providing services as primary producers, habitats and finding food sources such as diversity of marine life such as echinoderms. In addition, the presence of seagrass in the marine environment supports increased productivity of reef fish[30].

Diversity, evenness and abundance of species: Ecological index, namely diversity index (H'), evenness index (E) and abundance (D), species of echinoderms in seagrass areas in the study location are shown in Fig. 4. Echinoderms species diversity index values range between 1.62-2.22 and the location with the highest value (H') is Cute and the lowest is Awang. Meanwhile, the evenness index value ranges from 0.76-0.87 and the location with the highest value is Poton Bakau and the lowest is Gili Kere. Furthermore, the species abundance index of echinoderms ranges from 0.97-4.88 and the highest is Gili Kere and the lowest is the Poton Bakau.

The difference in value (H') between research locations can be sourced from the form of seagrass site utilization by the community. The results of observations during the study, Kute which is a tourist site that has been developed has not found local people who are looking for marine life. Different things are found in Awang and Poton Bakau, where individuals and groups come to the location of seagrass beds to look for marine life. However, the Value (H') on Gili Kere is quite high compared to other locations besides Kute. This can be explained because Gili Kere is a small island and people need transportation tools to reach it. Some research results indicate that the range of echinoderm diversity index values in several other locations is 1.30-2.16, in Baguala Bay, Maluku, Eastern Indonesia[25]. H' = 1.92 in Babanlagan, Talisayan, Misamis Oriental, Philippines[25] and diversity index (H') in the seagrass beds in Tawang ranged from 0.538-1.252 and from 1.041-1.704 in Pidakan Pacitan beaches, East Java, Indonesia[31].

Diversity and distribution of benthic organisms such as species of echinodermata was done where heterogeneity of habitat structures is a significant factor in their distribution and abundance[32]. the results of other studies explain, the spatial distribution and abundance of echinoderms can be explained through habitat structure[33]. In this regard, habitat architecture and depth are a collection of parameters from an abundance of species, such as Asteroidea, Ophiuroidea and Holothuroidea species[34]. Meanwhile, seagrass architecture with a dense and crossed stand has a complex habitat structure, so that it can support the lives of various benthic, demersal and pelagic organisms[35,36].

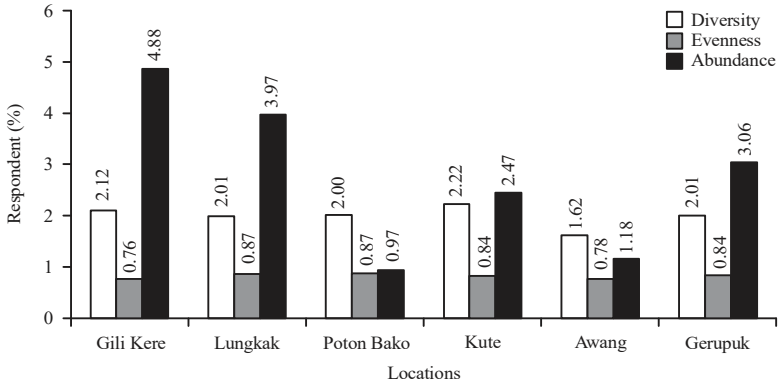

Fig. 4: Diversity, evenness and abundance species of echinoderms in study location

Table 1: Pearson correlation of species diversity indices, evenness and dominancy by environmental parameters

	Pearson correlations								
Parameters	T	S	pH	DO	P	N	H'	E	A
T	1								
S	0.642	1							
pH	0.166	0.622	1						
DO	0.415	0.679	0.499	1					
P	0.168	0.378	0.008	0.359	1				
N	0.189	0.233	0.722	0.064	0.199	1			
H'	0.162	0.125	0.352	0.395	0.636	0.099	1		
E	0.170	0.716	0.912	0.383	0.270	0.821	0.281	1	
A	0.026	0.049	0.067	0.020	0.369	0.619	0.515	0.260	1

T: Temperature (°C), S: Salinity, pH: Degree of acidity, DO: Dissolved oxygen, P: Phosphate, N: Nitrate, H': Diversity index, E: Evenness index, A: Abundance

The difference in the number of species echinoderms at the study site is related to the structure of different seagrass habitats, such as in Gili Kere which is dominated by sand substrate from coral fragments, Kute is dominated by muddy sand, while other locations are dominated by sandy mud substrate. However, seagrass's ability to colonize substrates is evidence of seagrass ecology in providing ecological services for the diversity of marine organisms, such as species of echinoderms. This is very important as an indicator in the rehabilitation of seagrass habitat[37]. In addition, the presence of seagrasses in the marine environment has a similar role to mangroves in creating habitats for the diversity of marine organisms, where their presence has a positive impact as an ecological indicator in conservation for the sustainability of marine organisms[37].

The correlation of species diversity index, evenness and dominance with environmental parameters is presented in (Table 1). The environmental factor that has the highest correlation with the diversity index value (H') is phosphate (r = 0.636) and the lowest is nitrate (r = 0.099). Meanwhile, evenness has the highest correlation with environmental factors pH (r = 0.912) and has the lowest correlation with Temperature (r = 0.170). Furthermore, dominance (D) has the highest correlation with nitrate (r = 0.619) and the lowest is with temperature. The value of the correlation of environmental factors is an important factor to explain the existence of echinoderms at the study site. Environmental factors such as temperature have an effect on decreasing the growth rate of echinoderms caused by falling ocean temperatures, compared to changes in growth from feeding[38]. Further explained that the temperature is not the only factor involved in growth recovery. Meanwhile, the distribution of environmental factors tends to be controlled by complex factors (e.g., sediment type, flow regime, nutrient availability and temperature) which are important factors in echinoderms diversification[39]. In addition, oceanographic conditions, anthropogenic activity and water quality are important factors affecting the density and distribution of sea stars[40].

Ecotourism

Perspectives of respondent on the ecotourism: Exploration of respondent's knowledge according to the research topic is an important step in understanding the respondent's capacity as a representative informant. The results of the study revealed that the group of respondents (e.g., local communities and operators) had limited knowledge about

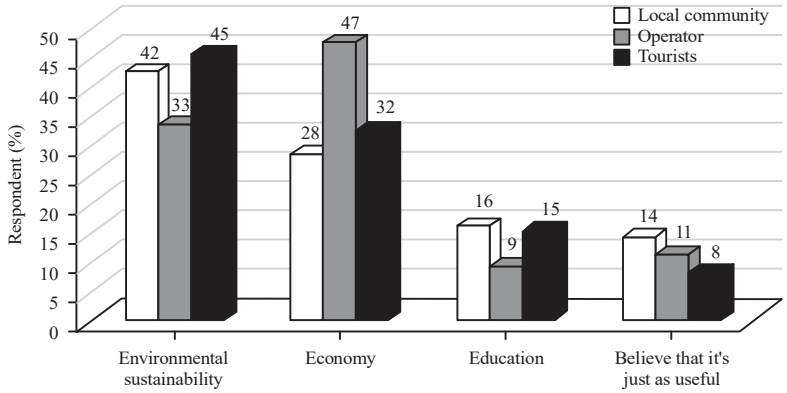

Fig. 5: Results of the respondents' assessment of ecotourism products in the study location

the concept of ecotourism. However, they practically have practiced the concept of ecotourism in activities. For example on what question is the tour?. The two groups stated that tourism activities are tourists who come to the research location for many purposes, such as: for diving, snorkeling, surfing, recreation and fishing. Furthermore, respondents explained that tourists, especially local tourists, enjoyed the beauty of the beach more, while foreign tourists preferred sunbathing on the beach, surfing and snorkeling.

The respondents gave an assessment of tourism in the study location is a natural tourism. Furthermore, respondents' understanding as described above shows that they operationally understood the concept of ecotourism. In addition, respondents have been able to identify ecotourism products. In this case, they have the knowledge to classify ecotourism products which include: (1) Environmental preservation or marine biota, (2) Economy, (3) Education and (4) They believe that the three ecotourism products have the same benefits. The results of the assessment of respondents is 42% choose ecotourism products are for the protection or preservation of marine life, 28% of the economy, 16 education and 14% who believe that have the same benefits. Respondent assessment results. Figure 5 has relevance to ecotourism products which include: (1) Environmental and cultural attractions, (2) Landscape benefits, (3) Accommodation, (4) Equipment, supplies and (5) Education and skills[41]. The ability of respondents about ecotourism products is an indicator to maximize their role in management. This, in accordance with the concept of developing sustainable tourism is to support efforts to preserve the environment (natural and cultural) and increase community participation in management[42].

Preferences of respondents' travelling to seagrass beds in the study site: Seagrass in the intertidal area has a different environment dynamics than other environments, caused by tidal events. The results of surveys and interviews with respondents are natural attractions being the choice of tourists visiting the study location. It was further explained that seagrass beds as a tourist object had differences with the other tourist objects, especially for traveling tourism. This is due to differences in tidal time, such as in April-September when you can see seagrass above sea level between 13.00-18.00 Central Indonesia Time (WITA) and October-March between 06.00-08.00 WITA. The next explanation of respondents is each month on the 14th-17th of the Islamic month (March-September) when the seagrass starts to appear on the surface of the water is different for each day. The 14th was able to enjoy the expanse of seagrass and the diversity of types of associated biota starting ±13.00 WITA. Furthermore, on the next date±1 h 30 min and so on. Meanwhile, the time of seagrass is above the surface ±2-3 h. Therefore, time factor is an important point in the utilization of seagrass ecological services as a tourism object.

The potential of seagrass which was chosen by respondents to visit seagrass sites in the study location. The observation results during the study period the average number of respondents visiting seagrass sites were different for each location. Kute Beach ranges from 75 people-100 people, Gerupuk less than 50 people and Gili Kere on average more than 100 people/day. Other locations (e.g., Lungkak/Tanjung Luar, Poton Bakau and Awang). Regarding the type of tourist object that gives tourists the satisfaction of visiting the seagrass sites is not the same (Fig. 6 and 7).

Fig. 6(a-t): Diversity of species echinoderms in seagrass beds on the study location, (a) *Linckia laevigata*, (b) *B. culcita* sp., (c) *Protoreaster nodosus*, (d) *Diadema setosum*, (e) *Tripneusteus gratilla*, (f) *Diadema calamaris*, (g) *Holothuria scabra*, (h) *Holothuria atra*, (i) *Synapta* sp., (j) *Echinotrix diadema*, (k) *Mespilia globulus*, (l) *Echinotrix* sp., (m) *Synallactes mollis*, (n) *Diadema antilarum*, (o) *Archaster typicus*, (p) *Ophiocoma scolopendrina*, (q) *Holothuria atra* (nobilis), (r) *Histocidaris purpurata*, (s) *Actinopyga miliaris* and (t) *Echinus gilchristi*

The results obtained from the preferences of respondents are 51% for enjoying starfish, especially those with their children and the low ones are for snorkeling and others by 14.14% (Fig. 8). Before making the decision to travel to seagrass sites, a factor that has been identified by respondents as the main thing to visit the study site is the availability of beach tourism. Furthermore, respondents revealed that after they were in a new location, they made a choice to enjoy nature tourism including seagrass location during low tide, snorkeling at high tide, fishing and others.

Ecotourism contributing to local livehoods and seagrass conservation: Tourism has generally been understood as a profitable activity for economic growth, education and environmental preservation. Another aspect is providing employment and entrepreneurship opportunities as a strategy to stimulate economic growth at the local, regional and national levels. The survey results of the activities of tourism in the study location are grouped into three categories: first is the area with advanced categories (e.g., Kute and Grupuk), developing (eg, Gili Kere and Tanjung Luar) and undeveloped

Fig. 7(a-h): (a-c) Tourists with families observing the diversity of species echinodermata, (d) Tourists enjoy the beauty of the beach when seagrasses have appeared on Gili Kere, (e) Mother and child walk while looking at sea biota in seagrasses, (f) Operator explains to tourists the diversity of marine biota, (g) Tourists enjoy the view sea and seagrass beds and (h) Tourists with operators discuss at the Kute beach

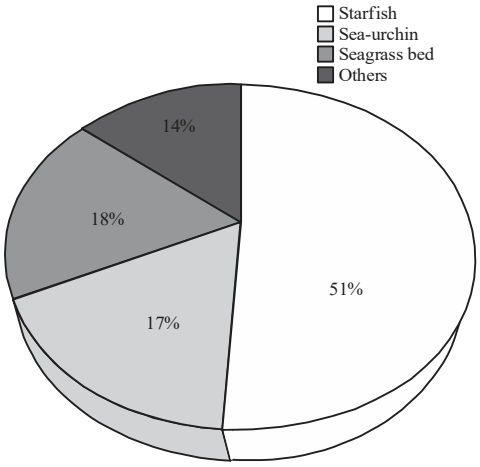

Fig. 8: Reasons why tourists travel to seagrass beds

are Awang and Poton Bako (Fig. 1). The results of in-depth interviews with community leaders and formal leaders (village heads), tourism has contributed to the economy of the local community. For example they can provide food, drinks and equipment rental for snorkeling, buoys and others. In addition, they provide transportation tools such as boats and they directly act as operators such as in East Lombok, namely Tanjung Luar and Lungkak.

Ecotourism, according to respondents, has raised the income levels of local residents. Livelihoods change is a form of adaptation of local communities to take advantage of tourism activities. They get new income from the sale of handicrafts, food ingredients and fish to visitors. In addition, the owner of a coconut plantation receives income from the sale of young coconuts either directly to visitors or indirectly to the sword that provides visitors with drinks. All respondents agreed that ecotourism had increased their livelihoods economically. In this case, ecotourism has brought economic benefits for local people. However, ecotourism is of little benefit to the local population, it is recommended for appropriate benefit sharing mechanisms and increased community participation in ecotourism[43].

Ecotourism is a tourism activity that relies on the preservation of natural resources. In this case, the biodiversity that provides ecosystem services is safe and secure when people protect it. In this regard, biodiversity conservation and its ecosystem have a direct relationship with improving the livelihoods of local communities[44] and the efforts habitat rehabilitation are a solution for the livelihoods of local communities[45]. The results of research on the knowledge of respondents, especially the majority of local communities, namely 57% have knowledge about conservation, 28%

percent are moderate and only 15% have knowledge in the low category. Some of the conservation practices identified by respondents are in protecting the marine environment from the threat of bombing and garbage disposal. The respondent further explained about the application of local norms referred to as "awiq-awiq" in the management of marine natural resources and their ecosystems.

The practice of protection that has been carried out by the community under the coordination of the village government is the application of sanctions for those who carry out activities that have been prohibited in the agreement, for example regarding bombing to catch fish and the use of other fishing gear that damage the environment in coastal waters. This has a significant influence on the conservation of the marine environment, specifically the coastal waters in the study area. Regarding the conservation of the marine environment all respondents agreed, because they had more economic benefits from ecotourism activities. Local people who benefit financially from ecotourism encourage them to comply with conservation measures. Meanwhile, this model is relevant to the concept of ecovillage which confirms that community activities are integrated with natural katrakter. Therefore, ecotourism activities are optimally pursued through community participation programs in ecotourism, so that there is an increase in awareness and education that will affect the livelihood of the local community[46].

CONCLUSION

Seagrass has provided a variety of species of marine life. Echinoderms at seagrass sites in the study location consisted of four classes, namely Asteroidea, Echinoidea, Holothuroidea and Ophiuroidea. Echinoderms in seagrass beds are evidence of the role of seagrass ecology in the marine environment. Potential echinoderms of fauna in seagrass beds are ecological services of seagrass that have economic value. Utilization of seagrass ecological services is for the development of ecotourism in the southern coast of Lombok Island. Ecotourism in the study area has contributed to the livelihoods of local communities. Another thing that is very influential is the growth of local community awareness in environmental conservation. Therefore, strengthening the capacity of local communities needs special attention, so that the development of ecotourism can more quickly achieve goals.

SIGNIFICANCE STATEMENT

This study found the diversity species of echinoderms, is a key factor that has a specific attraction for tourists to visit seagrass location. This can be useful for the development of ecotourism which is a new source of livelihood for local communities and the solutions of seagrass conservation on local and regional scale. Furthermore, this study will help researchers to reveal critical areas of the threat of latent marine biota sustainability, such as exploitation carried out by local communities to meet the needs of family living, which has not been disclosed by other researchers. Thus the new theory about based on ecosystem services and community management can be accepted by scientists and policy makers.

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