The linkage of social-ecological system of Mangrove in Jor Bay, East Lombok Regency, West Nusa Tenggara

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Abstract. The mangrove ecosystem in Jor Bay described as a social-ecological system (SES) that has a multi-purpose function and related to ecosystem services. The mangrove ecosystems have social and ecological dimensions that couldn't be separated. Management based on this approach is social ecology-based management, which is basically the integration between understanding ecology and social values. Therefore, the investigation of the linkage of the mangrove social-ecological system needs to be done in an effort to map the balance of mangrove ecosystem services in Jor Bay. The study was conducted in April-May 2018 in Jor Bay, East Lombok Regency, West Nusa Tenggara. The approaches that used in this research are Burkhard Model. The results obtained are ecosystem services that are most widely used in Jor Bay is provisioning services, especially in non direct extraction use. For example taking some biota that live in mangrove ecosystem. The general condition of ecosystem services in Jor Bay is still in a surplus condition (using a capacity matrix, demand matric and supply matrix).

1. Introduction

Almost along the coast of Jor Bay is spread the mangrove ecosystem starting from Paremas Village to Jerowaru Village. The ecosystem takes the role of providing ecosystem services which broadly grouped into three functions; biological, ecological and economic functions. The biological functions of mangrove ecosystem are as shoreline protection from waves, tidal currents, coastal sediments, and as a habitat for aquatic biota that associated with mangrove ecosystem. The ecological functions include as a place for spawning, nursing and feeding ground of many important aquatic biota. For the economic function, the mangrove is the main sources to provide fish, crabs, shells, shrimps, even the fruit and the wood of mangroves that can be used for food and daily necessities [12].

The mangrove ecosystem in Jor Bay is defined as a social-ecological system that has multi-use function related to the ecosystem services. The ecosystem services according to has been divided into four components; 1) provisioning services, 2) regulating services, 3) cultural services, and 4) supporting services [2], but the have been eliminated the supporting services components and replaced into the habitat services with a reason to prevent double counting in assessing ecosystems [1]. Furthermore The development of terminology of ecosystem services has used the ecological integrity to describe supporting services components [6].

Mangrove ecosystems management in Jor Bay is managed customarily with awig-awig agreed by the society living around the ecosystems. The awig-awig regulates all activities related to management and utilization of resources in Jor Bay, including mangrove ecosystems. Prior the concept of awig-awig was established, some fishermen used mangrove wood as firewood, fishing gear coloring, and other activities to extracting these resources. Several houses of the people around Jor Bay are not far from the mangrove ecosystem, so it indicates that there is interaction between mangrove ecosystems and humans directly or not.

The mangrove ecosystems have social and ecological dimensions that couldn't be separated. The social-ecological system describes the linkage between users (social) and nature (ecology). That a social-ecological system states is defined as an integrated system between the resources and social aspect which has a reciprocal relationship [5]. Meanwhile, according to a social-ecological system is an ecological system that is closely related and affected by more than just one social system [3]. In a social-ecological systems approach, the unit of analysis is the system ecology unit that closely relevant in Jor Bay, East Lombok Regency, West Nusa Tenggara. This is because basically the dynamics of the Jor Bay region are a joint interaction of social and ecological dynamics. Management based on this approach is social ecology-based management, which is basically the integration between understanding ecology and social values. Therefore, the investigation of the linkage of the mangrove social-ecological system needs to be done in an effort to map the balance of mangrove ecosystem services in Jor Bay.

2. Material and Methods

2.1. Time and place

The research was conducted in Jor Bay, East Lombok Regency, West Nusa Tenggara. The research location included two villages; Jerowaru Village and Paremas Village. From those two, there are 6 sub-village directly adjacent to Jor Bay; 4 bub-village in Jerowaru Village (Paton Bako Sub-village, Telong Elong Sub-village, Jor Sub-village, Tutuk Sub-village) and 2 Sub-village in Paremas Village (Permas Sub-village and Keranji Sub-village). Data collection was carried out during April-May 2018. The research location is presented in Figure 1.

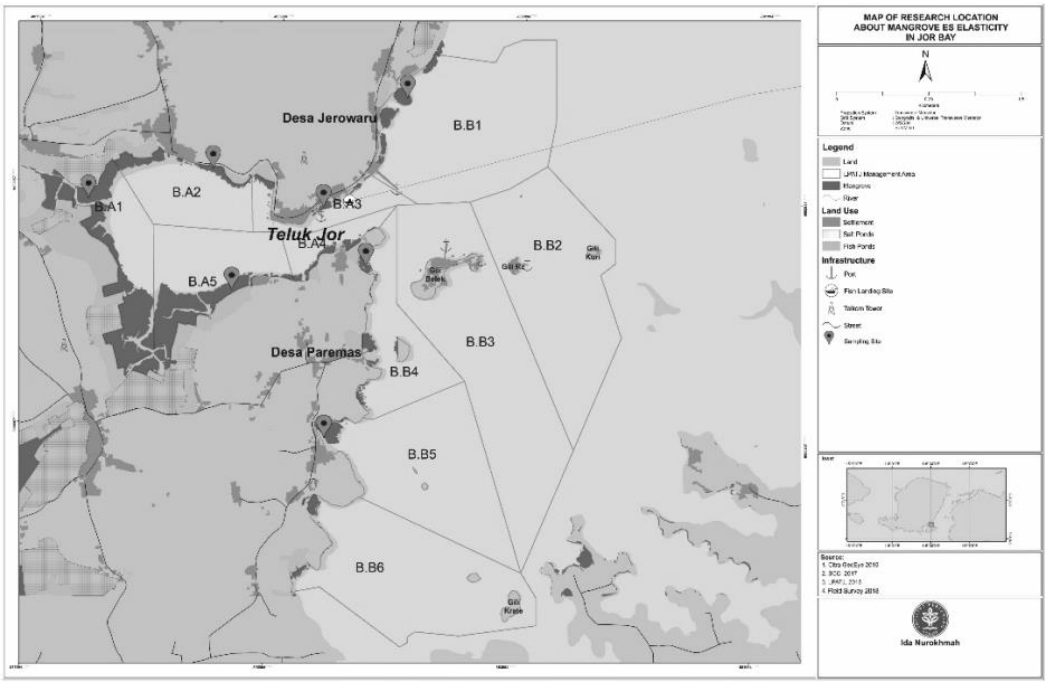

Figure 1. Map of the study area.

2.2. Sampling frame

The sampling of community perceptions was carried out on 30 respondents who were beneficiaries of the mangrove ecosystem. Respondents interviewed consisted of fishermen, collector (middle man), shrimp paste processor, tourists, and the people living around the mangrove ecosystem.

Data collected are the perception of people about the benefits of mangroves and scores (1-5) on the demand matrix, while the capacity matrix was obtained from the FGD results by several community leaders and LPATJ administrators.

Table 1. An example of a capacity matrix.

Mangrove Ecosystem Service	Substrate	Water Column	Mangrove		
			Roots	Steams	Fruits
∑ Ecological Integrity					
IE_1					
.....					
IE_n					
∑ Regulating Services					
RSK_1					
.....					
RSK_n					
∑ Provisioning Services					
PSK_1					
.....					
PSK_n					
∑ Cultural Services					
CSK_1					
.....					
CSK_n					

2.3. Data analysis

Mapping of ecosystem services is modified using a matrix of ecosystem services approached by Burkhard Model [6]. There are 3 steps to mapping the mangrove ecosystem services, namely identification of the type of utilization of mangrove ecosystem services, identification of mangrove ecosystem services and assessment of mangrove ecosystem services.

1. Identification of the type of utilization of mangrove ecosystem services
   Identification of the type of utilization of mangrove ecosystem services is done by identifying the benefits of the mangrove ecosystem. Burkhard Model [6] use satellite-based CORINE from the European Union to find out the type of ecosystem service utilization where the land cover has previously been calculated and divided into 44 types. In this research was not carried out the spatial analysis, because habitat types in mangrove ecosystems were difficult to identify and clearly separated. Therefore the components of habitat type were modified with the type of ecosystem service utilization in each part of the mangrove. Moreover, in this research the mangrove ecosystems as service providers were divided into three components consisting of Substrate, Water Column, and Mangrove Tree (Leaves, Stems and Roots).
2. Identification of mangrove ecosystem services
   Identification of mangrove ecosystem services aims to obtain a mapping of the components of ecological integrity, regulating services, provisioning services, and cultural services.

Identification of ecosystem services is carried out through literature studies and in-depth interviews with beneficiaries of mangrove ecosystem services.

3. Assessment of mangrove ecosystem services
   Assessment of mangrove ecosystem services.is done by mapping the x-axis and y-axis into a matrix form (Table 1). X axis is a type of mangrove ecosystem service utilization, while the y axis is a mangrove ecosystem service. After the matrix is complete, the next step is to assess the three matrices. First, the capacity matrix (supply) with the value ranged from 0 to 5. Zero value means there is no capacity relationship between habitat type and mangrove ecosystem morphology (x axis) with ecosystem services (y axis); value 1 means that the capacity relationship is very weak; value 2 means weak capacity relationship, value 3 means medium capacity relationship, value 4 means high capacitance relationship, and value 5 means very high capacity relationship.

Second, the demand matrix with the value ranged from 0 to 5. To give the value in the demand matrix is based on the results of the questionnaire. The answers from respondents are grouped, then the percentage value is calculated. Furthermore, the percentage value is categorized into four classes with the help of excel software. Third, the availability matrix (budget) with the value ranged from -5 to 5. The value of this matrix is obtained from the result of a reduction between the capacity matrix (supply) and the demand matrix (demand). Negative values mean that demand exceeds inventory (demand> supply), on the contrary positive values mean that inventory exceeds demand (supply> demand). An example of demand and budget matrix are shown in Table 2.

Table 2 An example of demand and budget matrix.

Mangrove Ecosystem Service	Substrate	Water Column	Mangrove		
			Roots	Steams	Fruits
∑ Regulating Services					
RSK_1					
.....					
RSK_n					
∑ Provisioning Services					
PSK_1					
.....					
PSK_n					
∑ Cultural Services					
CSK_1					
.....					
CSK_n					

3. Results and Discussion

3.1. The Utilization of Mangrove in Jor Bay

The social ecological system is defined as an ecosystem unit that is related to or caused by one or more of a social system [3]. The mangrove ecosystem in Jor Bay has a close connection between social and ecological systems. Where if there are changes in the social system it will also affect the mangrove ecological system, and vice versa. In this case the mangrove ecosystem in Jor Bay is considered as a social ecological system that provide benefits to humans directly or not. These benefits can be interpreted as ecosystem services that divided into provisioning services, regulating services, cultural services, and ecological integrity.

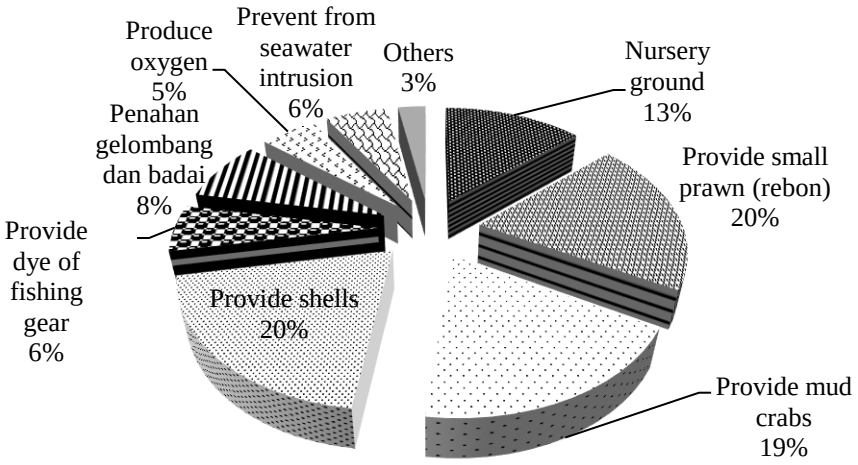

Figure 2. The perception of society in Jor Bay about the benefits of mangrove ecosystem (n = 50).

Many benefits has been felt by the society around Jor Bay. To find out the perception of society about mangrove ecosystem in Jor Bay, the interviews were conducted by questionnaires to 30 sampel (society living around the ecosytem). The perception of society regarding to the benefits of mangrove ecosytems is showed in Figure 2.

Table 3. The components of mangrove ecosystem services in Jor Bay.

Types of Ecosystem services	Details
Ecological integrity	Nutrition provider
	Nursery ground
	Feeding ground
	Habitat of birds, monkeys, and snakes
Provisioning services	Producer of firewood
	Producer of fruits
	Producer of small shrimps (*rebon)* and fish
	Producer of crabs
	Producer of shells
	Producer of larva
	Producer of colouring matters for fishing gears
Regulating services	Sediment traps
	Shoreline protection from currents and waves
	Carbon absorber
	Oxygen produser
	Strom restraint
	Prevention from sea water intrusion
Cultural Services	Recreation
	Shelter

Based on Fig. 2, 65% respondents stated that the benefits of mangrove were to provide small shrimps (well known as *rebon*) and fish, mud crabs, and as coloring substance to fishing-gear. 19% respondents stated that mangroves is regulating services as shoreline protection from waves, storm and

also as a source to produce oxygen, even to prevent from seawater intrusion. And the others stated that the benefits of mangrove ecosytem were as cultural services and ecological integrity. The high perception of society about the benefits of mangrove ecosystem as service provider indicates that the mangrove ecosystem in Jor Bay was closely related to human activities. Furthermore, the relation can have an impact on the high pressure on the ecosystem.

The understanding of the society about the benefits of mangrove, as a service provider, was direct extractive services (means that the society directly utilize the mangrove to take wood and fruit). However, so far what the society has been done in the form of direct extractive services was relatively good enough. On this day the society living in Jor Bay hasn't taken the wood for both fuel and building materials. This is a mark that the LPATJ was successfull to manage Jor Bay, especially in gaining perspective of public awareness against the mangrove ecosystem. The utilization in Jor Bay was largely utilize fisheries resources that have habitat around the mangrove ecosystem.

However, the ecosystem services of mangrove can't only be approached from their perceptions, but also to identify the mangrove ecosystem services needs to be equipped with secondary data, in-depth interviews and field observations. Therefore, the components of mangrove ecosytems services can be seen in Table 3 below.

3.2. Mangrove ecosystem services matrix

The study about the linkage of mangrove social-ecological system in Jor Bay refered to Burkhard Model [6] saying that to know about the linkage can be started by identifying each ecosystem service into three matrices, namely resource capacity matrix (supply), resource demand matrix (demand), and availability matrix (budget). In this study, mangrove ecosystems were divided into several parts; substrate, water column, and mangrove trees (roots, stems and leaves). The X axis is the components utilized from mangrove ecosystem. While the Y axis is types of ecosystem service consisting of ecological integrity, providing services, regulating services, and cultural services.

Capacity matrix and the assessment results are shown in Table 4. The assessment was obtained by conducting a variety of literature studies and in-depth interviews with LPATJ administrators and several society leaders who knew the mangrove ecosystem as a whole. The capacity matrix describes the existing capacity of mangrove benefits for each type of utilization before there is human utilization.

As we can see from the Table 4, the ecosystem services (ecological integrity, cultural services and control services) have a lot of potentials to be utilized in all parts of the mangrove ecosystem. However, for the service provider of mangrove ecosystems only provides high potential value in certain parts. In mangrove ecosystem there are various types of biological resources that can be used for human welfare [10]. Economic benefits obtained from mangrove forests are wood for building materials, firewood, and habitat for various types of biota [4]. Another product is honey. In addition, mangrove forest products can be processed into organic fertilizer, food ingredients, medicines, drinks, household appliances, textile and leather raw materials [9]. The economic benefits of mangroves that have been taken by the society living around Jor Bay are the use of wood as firewood and building materials or ships materials. However, after 2010 when *awig-awig* was appointed that taking the wood was banned. The current use of mangroves nowadays is related to economic benefits in the form of fisheries resources derived from mangrove ecosystems.

Ecologically, mangrove ecosystems take the role as shoreline protection from some kind of threaths like tsunami, abrasion, and as sediment traps, beside, the ecosytems also have some function to recycling nutrients, maintaining fisheries productivity, reducing the rate of seawater intrusion, supporting health, maintaining biodiversity and supporting other coastal ecosystems [8]; [11]. On the other hands, the ecosystems is also used as a supporting component of the stability of coastal ecosystem because each part of coastal ecosystem is very linked, especially between seagrass ecosystems and coral reefs [7]. The other functions of mangroves are as detritus, a source of nutrients and organic matter that can be carried by currents to seagrass and coral reef ecosystems. Seagrass ecosystems function as sediment traps so that the sediments are not carried away or even disturb the life of coral reefs. While the coral reef ecosystem as shoreline protection from waves and sea water.

Table 4. The results of capacity matrix assessment of mangrove ecosystem in Jor Bay.

Types of utilization	Substrate	Water column	Mangrove		
			Roots	Stems	Leaves and Fruits
Ecological integrity					
Nutrition provider	4	4	4	4	5
Nursery ground	4	5	5	4	3
Feeding ground	4	5	4	3	3
Habitat of birds, monkeys, and snakes	0	3	3	5	5
Provisioning Services					
Producer of firewood	0	0	0	5	0
Producer of fruits	0	0	0	0	5
Producer of small shrimps (*rebon)* and fish	0	5	2	0	0
Producer of crabs	3	5	3	2	0
Producer of shells	5	3	4	1	0
Producer of larva	2	5	5	0	0
Producer of colouring matters for fishing gears	0	0	5	5	0
Regulating Services					
Sediment traps	0	0	5	4	0
Shoreline protection from currents and waves	0	0	5	5	5
Carbon absorber	5	4	5	4	5
Oxygen produser	5	1	5	2	0
Strom restraint	0	0	5	5	5
Prevention from sea water intrusion	0	0	5	4	3
Cultural Services					
Recreation	5	5	5	5	5
Shelter	0	0	5	5	5

Most of these benefits have been utilized and felt by the society living around the ecosystems. These utilization occur because of the demand of human needs. The relationship between the level of demand in each part of the mangrove ecosystem is illustrated through the results of an assessment of the demand matrix for mangrove ecosystem services in Jor Bay (Table 5). Assessment of the demand matrix for ecosystem services in Jor Bay is carried out without calculating the demand for ecological integrity services. This is due to the difficulty in quantifying the demand value of ecological integrity services.

The interest parts from the results above is the demand values against the wood is very small amount. Based on the results from in-depth interviews with respondets show that most people know that mangrove wood can be used as fuel or building materials. However, this knowledge is also followed by public awareness not to use mangroves directly. This is also confirmed in the awig-awig regulation which prohibits logging, including the mangrove wood and either to use fruits as a food raw material. Some people know the benefits, but are not balanced with the ability to process fruit into syrup or other products. The government has conducted training to make cakes and mangrove fruit syrup in the PKK group. But the community is lack of enthusiasm to the program, so it is not continuing.

Table 5. The results of the demand matix assessment of mangrove ecosystem services in Jor Bay.

Types of utilization	Substrate	Water column	Mangrove		
			Roots	Stems	Leaves and Fruits
Provisioning Services					
Producer of firewood	0	0	0	0	0
Producer of fruits	0	0	0	0	1
Producer of small shrimps (*rebon)* and fish	0	5	2	0	0
Producer of crabs	2	5	3	1	0
Producer of shells	5	1	3	0	0
Producer of larva	0	2	0	0	0
Producer of colouring matters for fishing gears	0	0	1	0	0
Regulating Services					
Sediment traps	0	0	2	1	0
Shoreline protection from currents and waves	0	0	5	5	1
Carbon absorber	3	2	3	0	1
Oxygen produser	3	0	3	0	0
Strom restraint	0	0	1	1	1
Prevention from sea water intrusion	0	0	5	4	2
Cultural Services					
Recreation	0	0	1	1	1
Shelter	0	0	2	2	4

Furthermore, the capacity matrix and demand matrix are associated with subtracting the two matrices so that an availability matrix is formed. The availability matrix describes the availability of ecosystem services remaining after utilization. The results of the matrix assessment of the availability of mangrove ecosystem services in Jor Bay can be seen in Table 6.

The availability of mangrove ecosystem services in Jor Bay shows surplus value in all types of ecosystem services. This is indicated by the absence of a minus value in the calculation of the availability matrix. From Table 6 it can be seen that only a few ecosystem services are utilized by fishermen and the society living around the ecosystem. There are several ecosystem services that are not utilized by the community, marked by a value in a high availability matrix. Some types of unutilized mangrove ecosystem services are firewood producers, fruit producers, larva producers, fishing gear coloring providers. This cannot be separated from the rules agreed upon by the society in the form of awig-awig. Where one of the regulations is to prohibit logging of mangroves both individually and in groups. Mangrove ecosystem regulating services that have low utilization include sediment traps and storm retention. This is because there is no river in the Jor Bay area so the benefits of mangroves as sediment traps are not needed. Similarly, the benefits of mangroves as a storm barrier are not felt by the society because the position of Telur Jor is sufficiently protected and rarely storms.

Tabel 6. The results of availability matrix assessment (budget) of the mangrove ecosystem services.

Types of utilization	Substrate	Water column	Mangrove		
			Roots	Stems	Leaves and Fruits
Provisioning Services					
Producer of firewood	0	0	0	5	0
Producer of fruits	0	0	0	0	4
Producer of small shrimps (*rebon)* and fish	0	0	0	0	0
Producer of crabs	1	0	0	1	0
Producer of shells	0	2	1	1	0
Producer of larva	2	3	5	0	0
Producer of colouring matters for fishing gears	0	0	4	5	0
Regulating Services					
Sediment traps	0	0	3	3	0
Shoreline protection from currents and waves	0	0	0	0	4
Carbon absorber	2	2	2	4	4
Oxygen produser	2	1	2	2	0
Strom restraint	0	0	4	4	4
Prevention from sea water intrusion	0	0	0	0	1
Cultural Services					
Recreation	5	5	4	4	4
Shelter	0	0	3	3	1

4. Conclusion

The social-ecology connectivity of mangrove between the ecosystem services and habitat types showed that there were linkage between users (social units) and mangrove ecosystems (ecological units). In the service provider, a low surplus (high utilization) was found in order to provide *rebon* and fish, crabs and shellfish. In low surplus regulating services there were a restraining currents and waves, carbon sinks, oxygen producers, and prevention from sea water intrusion. While low surplus in cultural services was found in mangrove services as a shelter.

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