

Building Resilience for Communities in the Face of Damaged Coastal Ecosystems: A Case Study in Gerokgak Village, Buleleng Regency, Bali, Indonesia

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Abstract. The condition of Indonesia's coastal ecosystems is experiencing considerable degradation and the average coastal damage in Indonesia shows that almost 50% severely damaged. Healthy ecosystem services can support human life and well-being both in terms of health, food security, and provision of employment opportunities. However, due to the considerable pressure on the coast, and irrational anthropogenic factors, the services of the coastal ecosystem experience disruption which lead to less optimal services. Based on these problems, the authors examined how much influence the coastal ecosystem services have on the society. This study aims is to achieve the goal of improving the management of mangrove ecosystems, coral reefs, estuaries, seagrass beds through integrated ecosystem restoration activities that are environmentally sustainable. The method is using "Ecosystem-Based Management" (EBM). Such approach is integrated with coastal village restoration plan (REDP) in Pejarakan village – Buleleng – Bali to create community resilience. The results of the study are expected to provide a model of community institutional resilience to cope damaged ecosystem conditions. Further, the model is expected to be used for assessing coastal ecosystem services elsewhere.

Keywords: Ecosystem damaged, Ecosystems services, EBM, Community Building

1. Introduction

Coastal communities currently face very complex problems related to ecological, socio-economic and socio-cultural factors. Ecological problems faced by coastal communities are related to the reduced quality of coastal ecosystems due to the decreasing of mangrove forest, damage of coral reefs. Loss of seagrass beds due to land conversion, intensive sedimentation and siltation, micro-climate change, marine pollution due to heavy metal content from domestic waste and factory waste along the coastal area. Socio-economic problems of coastal communities are due to exploitation by the authorities, investors which resulted in increasingly poor coastal communities. Examination of social and cultural dimensions in the coastal region is related to changes in the pattern of fisheries management from traditional to modern, which together with increasingly intensive anthropogenic factors. The imposition of this paradigm shift is in line with the occurrence of climate change, food availability and poverty traps.



These ecological, socio-economic and social cultural problems are caused by human factors that exploit coastal ecosystems irrationally. Based on this background, this study aims to achieve the goal of improving the management of mangrove ecosystems, coral reefs, estuaries, seagrass beds through integrated ecosystem restoration activities.

2. Methods

To achieve the research objectives, approaches are used by using the interaction between ecosystem components and their processes which are closely related to the performance of ecosystem services and their relationship with human use pressures which result in degradation of the coastal environment. The three components are interrelated with one another. Therefore, ecosystem-based Management approach (EBM) is employed to overcome the problem and application of the concept of Coastal Village Ecosystem Restoration or called REDP. [1]

2.1. Review of Previous Research

Review of previous research was carried out with the rationale that the potential ecosystem in Pejarakan village includes: mangrove forests, coral reefs, seagrass beds. The existence of these three ecosystems has decreased in their performance which is caused by destructive human activities. The impact of these destructive human activities decreases the ecosystem's ability to provide services. Review of previous studies that has had carried out in the research area is needed as baseline data. The research review was conducted to four studies conducted by: [2], [3], [4], and [5]. Pejarakan village in West Bali had a change in the distribution area of mangrove forests from 21.97 ha in 2000 to 19.74 ha in 2005. This condition declined to 19.74 ha in 2010 [2]. However this area increased dramatically to 23.97 ha in 2015. Mangrove tree density monitored in the Putri Menjangan Nature Conservation Forum (NCF). It is estimated that there are 7 types of mangrove species found, namely *Osbornia octodonta*, *Sonneratia alba*, *Avicenia marina*, *Rhizophora stylosa*, *Rhizophora apiculata*, *Ceriops tagal*, and *Ceriops decandra*. 7 species were found at three points with a total density of mangrove trees around 900 ind ha⁻¹; Belta 4,400 ind ha⁻¹; and seedlings 26,667 ind ha⁻¹[3]. There are six types of mangroves found in Pejarakan village, namely the *Sonneratia alba* type which has the ability to absorb and store high carbon. *Sonneratia alba* species have carbon uptake and storage values of 57.60 tons C ha⁻¹ and 15.71 tons C ha⁻¹[4] Furthermore, the *Rhizophora stylosa* type with uptake and deposits of tons C ha⁻¹ and 11.67 tons C ha⁻¹, for the type of *Rhizophora apiculata* capable of absorbing and storing carbon at 33.62 tons C ha⁻¹ and 9.17 tons C ha⁻¹. Estimation of the total value of sequestration in the mangrove forest of Pejarakan Village, Buleleng Regency, Bali is known that the mangrove forest sequestration value is 179.11 tons C ha⁻¹ and has a carbon stock value of 727.52 tons C ha⁻¹ sourced from sediment, litter and the upper surface of mangrove living.

2.2. Data Analysis Method

Data analysis method uses a qualitative approach. To manage changes both short and long term that need to be managed are human activities that cause irrational activities. The impact will disrupt conservation and sustainable development efforts [6]. Therefore, the Ecosystem Based Management (EBM) approach and an institutional approach and as institutional approach with the concept of Coastal Village Ecosystem Restoration (REDP) were used to analyze data in this research.

2.3. Ecosystem Based Management

Ecosystem-based management (EBM) is an approach that focuses on managing the number of human activities that affect the sea and the coastal environment. This approach is to maintain the health and resilience of ecosystems and the complete range of coastal ecosystem services provided (Environmental law Institute, 2009). This means managing human activities appropriately across time, space and sector to minimize cumulative impacts that reduce human health and service ecosystem functions. This approach will help identify and strive for sustainable outcomes, avoid destructive actions, and achieve adaptive management based on comparative experience of critical areas to achieve effective ecosystem-based management solutions [7-10]

2.4. Organization Concept of Coastal Village Ecosystem Restoration Plan (REDP)

EBM will produce ecosystem values from ecological, economic and social aspects to implement EBM results. The organization will be the main mover implementing the EBM results with the community and the private sector. The organizational structure and process for compiling and implementing EBM are described as follows: Based on [1] research, the institutional concept is called Coastal Village Ecosystem Restoration Plan (REDP).

3. Results

3.1. Condition of The Study Area

According to [11], West Bali National Park (TNBB) has an area of 19,002.89 ha, consisting of a terrestrial area of 15,587.89 ha, and the Selaus water area of 3,415 ha. TNBB has 4 mountains that are quite well-known in the region, namely Mount Prapat Agung as high as 310 meters above sea level, Mount Banyuwedang 430 meters above sea level, Mount Klatakan 698 meters above sea level and Mount Sangiang which is the highest of 1002 meters above sea level. Based on Schmidt and Ferguson, the TN area of West Bali has a climate type classification D, E, C with an average rainfall D: 1,064 mm/year, E: 972 mm/year, and C: 1,559 mm/year. The average air temperature is 33° C with the average number of months of rain in one year is 3 months. In some locations, the humidity in the forest is around 86%. The rivers in the park include river Labuan Lalang, river Teluk Accept, river Trenggulun, river Bajra / Klatakan, river Melaya, and river Sangiang Gede. Pejarakan Village, Gorakgak Sub district is included in the TNBB with a total of 7,524 people in 2009. The width of Pejarakan Village, 3,170.15 Ha or 73.50% is State forest.

3.2. Mangrove Ecosystems

Several studies were conducted by several researches to measure the location of mangroves in Pejarakan village. They can be seen in Figure 1 below.



Remarks:
 Station reserach Rizky (2006): St1, St2, St3 (●)
 Station reserach Pitaloka (2017) StA, StB, StC (●)
 Station reserach Putra (2018) Sta, Stb (●)

Figure 1. Location of Mangrove Research

The area of mangroves in Pejarakan Village is based on data that the mangrove forest in 2005 was 19.74 ha. This area decreases in 2010 to 17.43 Ha. However, in 2015 mangrove forest area increased to 23.87 [2]. The decrease in the area of mangrove forests from 2005 to 2010 was caused by the widespread

use of mangrove wood by various purposes such as firewood, building materials, net reinforcement from mangrove bark, natural dyes, and brick industry. The expansion of mangrove forests is also increasingly threatened because of the conversion of mangrove land into ponds owned by individuals that began in 1998 and the worst expansion of pond land was in 1999 to 2011. This made the mangrove area in the Putri Menjangan area experience a change in area. However, the area of mangroves increased from 17.43 ha in 2010 to 23.87 ha in 2015ha.

Table 1. Carbon Sequestration on Various Species of Mangrove

Species of Mangrove	St 1		St 2		St 3		St 4	
	SC	Sq CO ₂	SC	Sq CO ₂	SC	Sq CO ₂	SC	Sq CO ₂
	Ton C/ha		Ton C/ha		Ton C/ha		Ton C/ha	
Rhizophoa Stylosa	4.6	17.05	0.51	1.85	6.52	23.90	-	-
Osbornia Octdonta	1.52	5.56	-	-	-	-	-	-
Soneratia alba	4.27	15.67	3.31	12.13	5.87	21.52	2.26	8.28
Ceriops tagal	2.13	7.83	0.80	2.93	1.58	5.79	0.44	1.61
Avecenia marina	3.28	12.04	1.65	6.06	0.59	2.17	0.30	1.09
Rizopora apiculata	-	-	0.84	0.84	3.43	12.57	5.51	20.22
Total	15.86	56.16	7.11	23.82	17.96	65.94	8.51	31.19

Source: [4]

Remarks: St: Station, SC : Stock Carbon; Sq CO₂ : Sequestration

3.3. Coral Reefs Ecosystems

Based on the survey results of the Coral Triangle Center obtaining data on the condition of coral reefs at a depth of 3 meters, the percentage of live coral cover is an average of 60.7 percent. The same percentage of cover also occurred at a depth of 10 meters which ranged from 14 percent - 90.3 percent with an average of 60 percent.[12]. According to Marthen (in [12]) other results of fish data showed that fish density ranged from 145 ind ha⁻¹ to 9,602 ind ha⁻¹ with an average density of 2,395 ind ha⁻¹. Meanwhile, fish biomass on the coast of Bali is between 8.2 kg ha⁻¹ - 1,119.1 kg ha⁻¹ with an average of 286.7 kg ha⁻¹. The largest group of fish was found on the coast of Bali from the families Achanturidae and Caesionidae.

3.4. Seagrass ecosystems

Seagrass is a one-seeded (angiosperm) flowering plant (monocot) that lives in shallow seas, has rhizome roots, leaves, flowers and fruit, and breeds generatively (flower pollination) and vegetative (shoot growth). Therefore, seagrass is very different from seaweed(algae) which has no clear roots, stems and leaves [13]. Seagrass bed is formed by one or more species in a particular location. Seagrass Padang is a habitat for several marine organisms. Animals that live in seagrass beds are permanent residents and some are visitors. Animals that come as visitors are usually to spawn or care for their children like fish. In addition, there are also animals that look for food such as sea cows (Dugong) and sea turtles eat seagrass Syriungodium isoetifolium and Thalassia hemprichii [14].

4. Discussion

4.1. The Assessment of Ecosystem Services with EBM

To evaluate how strong an ecosystem component affects others, a qualitative scoring system is developed. Partial scores related to several hierarchical criteria are summed to determine the total score of effects (influences). Variable of human drivers that influence the service of the Pejarakan village ecosystem and have a significant influence include: deforestation activities, coral reef destruction, pond construction, recreation area development, and land use change. Whereas, natural drivers that affect ecosystem services include damage to coral reefs. Natural Drivers that are very influential on ecosystem services in Pejarakan village include: coral reefs, mangroves, ecosystem habitats, biodiversity, and the presence of white starlings. Ecosystem services that are strongly influenced by the cumulative impacts of human activities include: habitat, biodiversity, mangroves, and coral reefs. While ecosystem services that are

affected by cumulative impacts include: religious values, the presence of white starlings, environmental aesthetic, climate regulation and recreational value. Indirect impact scores that indicate which ecosystems are affected have the greatest impact such as the results of human activities throughout the ecosystem. The four most powerful ecosystem services provide indirect impacts including coral reefs, mangroves, diversity, habitat and the presence of white starlings.

4.2. EBM Approach Through REDP Institution

Based on the results of EBM ecosystem services the activities that need to be stopped immediately are deforestation, destruction of coral reefs, construction of ponds, development of recreation areas, and changes in land use. For that reason, based on [1] to conduct mangrove restoration, the most responsible institution is the village government.



Figure 2: Ranking of ecosystem components in Pejarakan Village as a driver of ecosystem changes

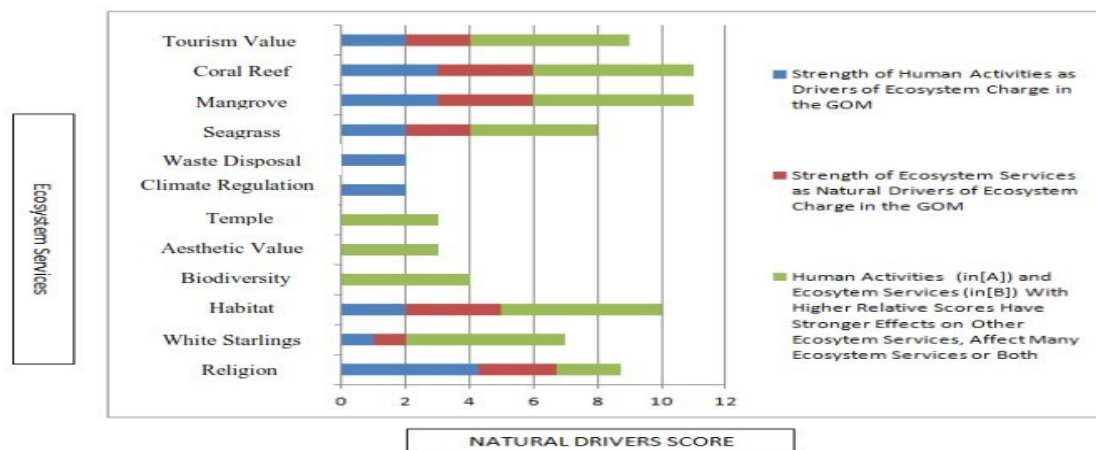


Figure 3: Relationship between Ecosystem Services and natural Drivers scores

To achieve the goal of improving the management of mangrove ecosystems, coral reefs, estuaries, seagrass beds through integrated ecosystem restoration activities that are environmentally sustainable and the priority strategies formulated include: a) Ecosystem restoration approaches in the coastal areas that are most addressed are mangroves, coral reefs, estuaries and seagrass beds. Priority for handling is very necessary given the limitations of financing; b) Restoration planning is carried out first per ecosystem by referring to coastal spatial planning (if any), and if there is no direct map of the coastal spatial plan, sectoral planning is then prepared which is then integrated into an ecosystem integration map; c) The provincial government makes general guidelines for restoration which are then elaborated in more detail by the

district government according to the natural and coastal conditions of each region; d) Management of restoration must involve the community in various levels of society.

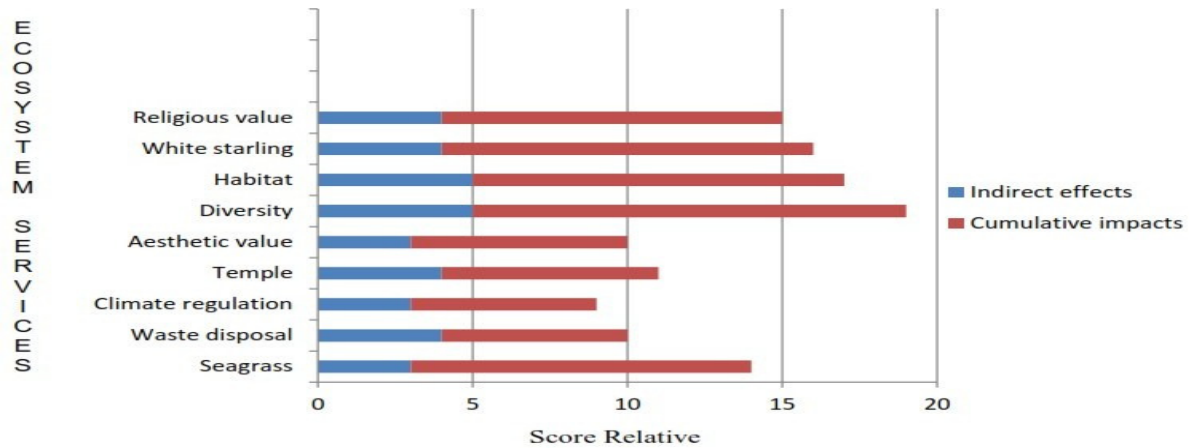


Figure 4: Relative score of the influence of human activities on ecosystem services in Pejarakan Village

Table 2. The Role of Institutions to Cope With Human Driver and Natural Driver

No	Handle Items	Local Device Organization Buleleng Regency	Institutions that Handled Local Gerogak Village Government	Companion team from universities
1	Natural Driver a. coral reef ecosystem; b. mangrove ecosystem; c. ecosystem habitat; d. the presence of white starlings	Ecosystem planning rehabilitation and restoration phase. Implementation and monitoring and evaluation	Rehabilitation and joint restoration of community groups	Preparation of Coastal Village Restoration Plans and supervision of implementation
2	Human Driver a. deforestation; b. destruction of coral reefs; c. making ponds; d. recreation area development; e. changes in land use	Prohibit and not issue permits for every investor that threatens the existence of the ecosystem	Recommending to the district government through the Local Devised Organization related not to allow activities that would threaten the existence of the ecosystem	Conducting counselling related to coastal rehabilitation and restoration programs including training and education

5. Conclusions

Based on the EBM analysis and institutional concepts related to REDP, the conclusion which can be drawn are: (a) Coastal ecosystem rehabilitation or restoration includes: coral reef ecosystems, man- grove ecosystems, and ecosystem habitats; biodiversity including the presence of white star- lings must be restored to their habitat and become an inseparable part of the government policies of Buleleng Regency and Pejarakan village government; (b) For this reason, ecosystem assessment supporting the Gerogkak village ecotourism area with the EBM approach and its integration with REDP has been carried out comprehensively and integrated and includes coral reef ecosystems, mangrove ecosystems, ecosystem habitats, and biodiversity including the presence of white starlings. Rehabilitation and restoration must be carried out every fiscal year by allocating funds from the Buleleng Regency and supplementary funds from the Pejarakan village budget; (c) Human drivers such as: logging activities, coral reef destruction activities, pond construction activities, development of recreation areas, and all activities that cause changes in land use are not played out or do not need to be allowed to engage in activities in Pejarakan village.

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