ISSN : 1410-5217
Acrredited : 83/Dikti/Kep/2009

Review

CHALLENGING FOR SEAGRASS MANAGEMENT IN INDONESIA

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Received : August, 16, 2011 ; Accepted : December, 20, 2011

ABSTRACT

Seagrasses, one of the important ecosystems in Indonesian coastal waters, have declined mostly due to a variety of multi-sector (i.e. ecology, socio-economy, technology and institution) anthropogenic disturbances. The decline and loss of seagrass meadows will have an effect not only on biodiversity and fisheries productivity within the ecosystems but also on the adjacent ecosystems (coral reef and mangrove forest), and even the effect will spread out far to the outside of the areas where seagrass grow. Seagrass ecosystems management in Indonesia is urgently required as part of fisheries management. However, this concept has not been understood by most of Indonesian people, including some government officials. Consequently, the seagrass ecosystems are still marginalized in the coastal resource management practices in Indonesia. In order to sustain fisheries productivity, knowledge of impact scales of each seagrass-related multi-sector human activities are very important as one of basic requirements in designing an effective seagrass management.

Keywords: anthropogenic disturbance; challenging ; Indonesia ; seagrass decline ; seagrass management.

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INTRODUCTION

Seagrasses have been known as one of the most important marine resources, because they provide a great ecological and economic important marine ecosystem services, including their capacity in sediment stabilization, water quality improvement, and their role in carbon and nutrient cycling, as well as their function to provide habitat for a variety of life forms in coastal waters and they serve as nursery, shelter and feeding area for many species, including numbers of commercially important fish and shellfish (Hemminga and Duarte, 2000). Additionally, seagrass meadows also play an important role in coral reef and other fisheries productivity (Unsworth and Cullen, 2010). The seagrasses are also known as one of the most productive marine ecosystems following the mangrove and coral reefs (Blankenhorn, 2007) because of their relatively high biodiversity and primary productivity.

Although they are important, unfortunately, seagrasses are seldom given the attention or protection they deserves. Seagrass decline and destruction has been commonly experienced by many countries, including Indonesia. The seagrass disturbances are coming from natural causes and the most is due to anthropogenic pressures. Growing population and economic development in the coastal area of Indonesia, especially in the small islands where the communities are dependent upon biodiversity-based livelihoods, will result in high accessibility to the marine living resources and so that increase the anthropogenic threats and disturbances to the coastal biodiversity, where seagrass ecosystems are included.

Hence, seagrass ecosystems management is important. In order to provide biodiversity protection and sustainable use of the

ISSN : 1410-5217
Acrredited : 83/Dikti/Kep/2009

seagrass ecosystems, seagrass management should be a part of integrated coastal management (ICM) practices that is allowing all stakeholders to participate and get benefit from them. To do such management, an understanding of the importance of seagrass ecosystems and the impacts of anthropogenic disturbances on them is highly required. This paper review the importance of seagrass ecosystems in Indonesia and discuss the possible various anthropogenic causes and impacts of the seagrass decline, as well as the challenging for future seagrass management.

THE IMPORTANCE OF SEAGRASS IN INDONESIA

Seagrasses are flowering submerged marine plants that live in coastal waters. The meadow ecosystems they generate have been found in almost all part of the world, except for Antarctic region (Hemminga and Duarte, 2000). Globally, there are only 60 seagrass species distributed worldwide, which of 13 of them are found in Indonesian coastal waters (ISC 2003, Kuo, 2007).

Primary productivity of seagrasses is found highest in the Indo-Pacific (Hemminga and Duarte, 2000) where Indonesian waters is included. The high primary production of the seagrasses provide valuable contribution to marine productivity (Dorenbosch *et al.*, 2005; Unsworth *et al.*, 2009). The primary production is derived not only from tissue of seagrasses themselves but also from epiphytes that grow and attach to the leaves surface of the seagrasses. Consequently, high abundance of fauna species can be found in the seagrass beds. It is supported by several studies in Indonesia (**Table 1**). High abundance of fauna in the seagrass beds is caused by service provided not only for living space, shelter, and protection, but also serve as a basic energy source for the fauna (Hemminga and Duarte, 2000).

Table 1. Fish and invertebrate assemblage in the seagrass beds of some areas in Indonesia

Author	Study results	Study area
Manik (2007)	> 100 fish species	North Sulawesi
Sabarini and Kartawijaya (2006)	212 fish species	Karimun Java National Park, Central Java
Unsworth *et al.*, (2007)	81 fish species	Wakatobi Marine National Park, South-West Sulawesi
Vonk *et al.*, (2008)	38 invertebrate species, 46 fish species	Bone Batang Island, Spermonde Archipelago, South Sulawesi
Rappe (2010)	28 fish species	Barrang Lompo Island
Nadiarti (2011)	63 fish species	Kapoposang Island, Spermonde Archipelago, South Sulawesi

Seagrasses serve as one of nutrient sources in the coastal ecosystems (Connolly *et al.*, 2005; Vizzini, 2009), including as direct source of food for associated organisms (MacArthur and Hyndes, 2007). The same study results in Indonesian seagrass beds have been revealed by Kneer *et al.*, (2008); Liu *et al.*, (2008). These indicate the importance of seagrasses for a food web in tropical seagrass meadows, as identified in the Spermonde Archipelago, South Sulawesi, Indonesia (Vonk *et al.*, 2008). Seagrasses also provide service as a source of food for associated organism indirectly via detritus and epiphytes (Koch *et al.*, 2006; Lepoint *et al.*, 2006). Similar results of experiment done by Kaiser (2008) in Barrang Lompo Island of the Spermonde Archipelago, Indonesia, showed that siganid fishes select epiphytes actively against seagrass and they cannot effectively supply their diet with seagrass material without epiphytes.

Seagrass ecosystems, besides their ecological value, they also have high economic value. In East Bintan, Riau, Indonesia, yearly total economic value of the seagrass beds is about US$ 3 634 796 ha^{-1} yr^{-1}, and this value is contributed by marine tourism, fisheries industry and aesthetic function of US$ 2 447 640, US$ 1

ISSN : 1410-5217
Acrredited : 83/Dikti/Kep/2009

131 600, and US$ 55 556 yr^{-1}, respectively (Dirhamsyah, 2007).

SEAGRASS DECLINE IN INDONESIA, CAUSES AND IMPACTS

Seagrass decline and loss have been widely reported in last decade. For example: at Rottnest Island, Western Australia (Hastings *et al.*, 1995); in Florida Bay, USA (Hall *et al.*, 1999); in South China Sea Region, in Gulf of Thailand, in Vietnam Region (UNEP, 2004); on the Adelaide metropolitan coastline, South Australia (Westphalen *et al.*, 2004); in Bermuda Island, USA (Murdoch *et al.*, 2007); in Kuroshio Region, Japan (Nakamura, 2009). Global seagrass loss between 1879 and 2006 was 27 km^2 yr^{-1} (Waycott *et al.*, 2009). Data from UMCES (2009) showed that 58% of world's seagrass meadows are currently decreasing, including Indonesia lost about 30-40% of its seagrass beds (UNEP, 2004). Banten Bay in Indonesia lost about 26% of its seagrass beds caused mainly by reclamation for port and industrial estate, and at other parts of Indonesia, Grenyeng Bay and Bojonegara, the seagrass degradation is caused by land reclamation for harbours (UNEP, 2004). Seagrass decline is also reported occur in several areas in Derawan Archipelago, East Kalimantan, Indonesia, although the causes of the decline is still remain unknown (Supriadi and Kuriandewa, 2008). Seagrass loss is evidently happen in Gusung Tallang, South Sulawesi, Indonesia. Gusung Tallang was one of the study areas chosen by Erftemeijer and Middelburg (1993) who studied on primary production of seagrass beds in South Sulawesi. There is no one realized that the seagrasses in Gusung Tallang start to degrade and lost, until 2004 when one of the authors, Dr. Harald Asmus, visited the area and found that the seagrass ecosystems could not be reconfirmed anymore.

Although coastal development and poor land management are commonly claimed as the causes of seagrass decline and loss, fisheries over-exploitation may become a serious threat to seagrass meadows in many part of the Indo-Pacific region (Huang *et al.*, 2006; Unsworth and Cullen, 2010). Fauna exploitation activities in the seagrass beds by local people occur in several islands of Spermonde Archiplseago (**Fig. 1**), though little is known about the exploitation level of fauna in the seagrass beds. Dense population in most of the islands of the archipelago who mostly depend on the subsistence and small scale fisheries (Pet-Soede *et al.*, 2001), including the fisheries products from seagrass ecosystems, may leads to high stress of the seagrass ecosystems (Priosambodo *et al.*, 2006).

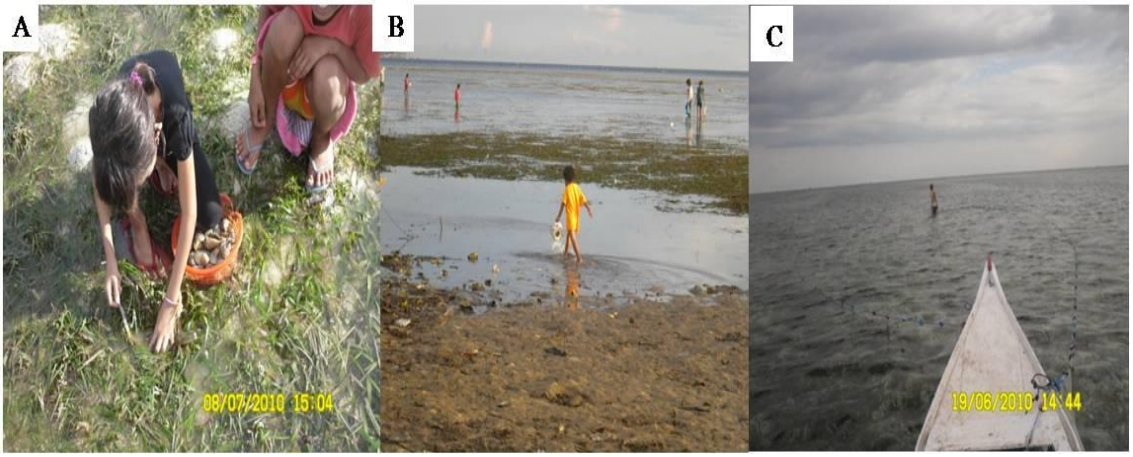

Fig. 1. Seagrass-associated fauna exploitation at low tide in Spermonde Islands of South Sulawesi, Indonesia. (A), (B) collecting shells by mostly kids and women , (C) catching fish with gill-net (Pictures: Nadiarti and Andi Muarrifah).

Boating, commonly found as a part of daily routine activities (**Fig. 2**) of coastal population in Indonesia mainly who lives in small islands, are believed may also contribute negative impacts on seagrass meadows and their associated fauna. Several studies have revealed

ISSN : 1410-5217
Acrredited : 83/Dikti/Kep/2009

the damage of seagrass beds and negative effects on the associated fauna due to boating activities, including boat anchoring (Francour *et al.,* 1999) and propeller scar (Bell *et al.,* 2002; Burfeind, 2004). The seagrass can make self-recovery and regrow in propeller scars, however it takes time and species dependent (Dawes *et al.*, 1997).

Fig. 2. Common boating activities in Indonesia. (A,B) Parking boats in seagrass beds, (C) anchoring in the seagrass beds as a part of boat parking, (D) boats as the only transportation facility for the local coastal communities (Pictures: Nadiarti and Andi Muarifah).

In addition to mechanical damage from anthropogenic activities, the fate of seagrass sustainable services are also determined by knowledge level of the coastal people. Most of them are not realized how important the seagrass ecosystems are. Consequently, there is limited effort to protect the seagrass ecosystems, and eventually, the uncontrolled access to the seagrass beds will result in more threats to the ecosystems.The decline and loss of each seagrass meadow will result in declining of fisheries productivity. This is because the loss of the ecosystem services they provide to the abundance of fauna (including some important economic species) relying on these areas for spawning ground and nursery habitat (Dorenbosch *et al.,* 2006). The impact of the continuing losses of the ecosystems will also expand far beyond the areas where seagrasses grow. Including to both shallow waters and the deep sea, as the export detached seagrass leaves, by currents and waves, has been correlated with high densities of invertebrates and fishes in these areas (Valentine *et al.*, 2002). The impact will also definitely spread out to the neighbouring ecosystems of seagrass, the mangrove forest and coral reefs. It is because as an ecotone between coral reefs and mangrove forests in tropical coasts, the seagrass ecosystems are important in their interaction, including structural and dynamic components of the adjacent ecosystems (UNEP, 2004; Dorenbosch *et. al.,* 2005; Unsworth *et al.*, 2009).

CHALLENGES FOR SEAGRASS MANAGEMENT IN INDONESIA

Seagrass meadows, in several countries including Indonesia, are an important component to their fisheries national production (Unsworth and Cullen, 2010). This is supported by Indonesia's legislations, law 31 of 2004 concerning fisheries and law 27 of 2007 regarding management for coastal area and small islands, in which are stating that seagrass ecosystems are being a part of fisheries management. Based on these laws, several projects (i.e. Marine Coastal Resources Management Project, Coastal Resources Management Project, Coral Reef Rehabilitation

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Acrredited : 83/Dikti/Kep/2009

Management Program) have been implemented with integrated coastal management (ICM) approach, where various use of the coastal ecosystem is managed to provide various requirements, including both biodiversity protection and sustainable use. All stakeholders (including government, NGOs, different economic sectors, and local communities) are then allowed to participate and get benefits.

Through these projects, unfortunately, many issues established with regard to just mangrove and coral reefs management without including seagrasses. Majority of the marine protection areas, as part of those projects, are established to protect coral reef only and have included minimal protection of seagrass meadows. This is not only occur in Indonesia, but is a common phenomena worldwide (Orth *et al.*, 2006). Besides, transfer of knowledge to local coastal community through those projects are also limited just on coral reef ecosystems (**pers. obs**.). A bigger new program, namely Coral Triangle Initiative (CTI) in the Indo-Pacific region that involved six countries (including Indonesia), is a conservative program that again only focusing on coral reefs (www.cti.org), and yet the seagrasses are again still marginalized in the marine coastal resources management practices.

Education and monitoring programs of seagrasses in Indonesia, particularly in Komodo National Park (Pedju, 2004) have been initiated by volunteer programs, namely SeagrassWatch (www.seagrasswatch.org) and SeagrassNet (www.seagrassnet.org). Additionally, various threats (including physical destruction, reclamation, dredging, demersal fishing, sand-mining, waste disposal, land based runoff, eutrophication, water clarity and hotel building) which identified as potentially to damage Indonesian seagrasses, are suggested to be concerned through more effective legislation over education and management planning (Cole and McKenzie, 2005). However, these are not enough to guarantee the sustainable function and services of seagrass ecosystems without knowing what are seagrass-related human activities from any dimensions (such as ecology, socio-economy, technology and institution) and what are their impact scales on the sustainability of seagrass ecosystems. It is because, human activities have interconnection with coastal resource system (Scura *et al.,* 1992 *in* Cicin-Sain and Knecht, 1998, **Fig. 3**) and have a great contribution to the seagrass decline and loss. Accordingly, seagrass management should be a part of ICM.

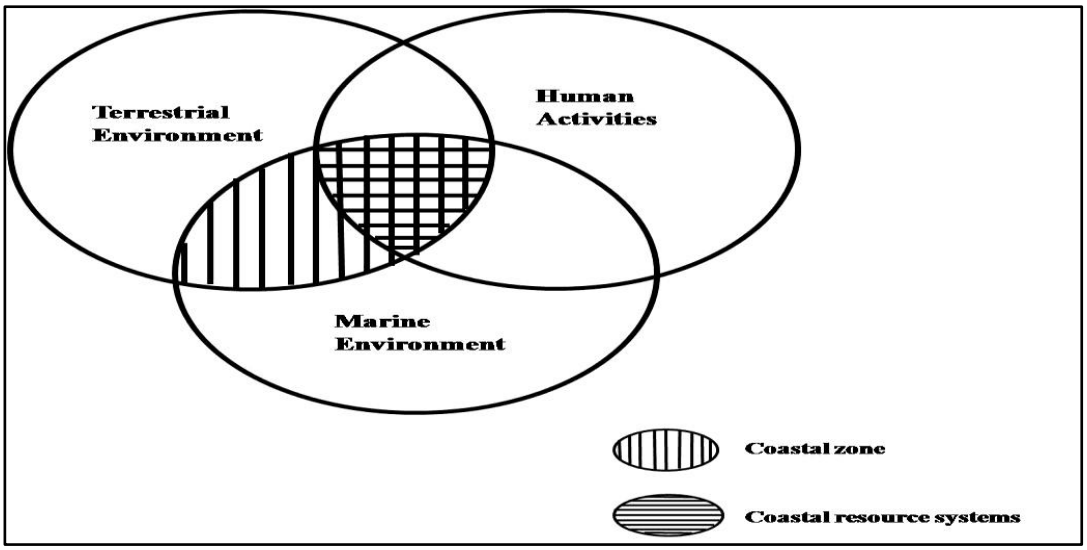

Fig.3. Relationship of human activities and coastal resource systems (redrawn from Cicin-Sain and Knecht, 1998).

The impact scale will tell us, how bad or good the human activities to the sustainable function of seagrass ecosystems. Recognizing various human activities from each dimension (socio-economy, ecology, technology, or institution) and their impact scale to the seagrass ecosystems, will provide a clear figure of which activity have most influence to the existing condition of seagrass ecosystems. The challenge is to search for ways to ensure the continued

ISSN : 1410-5217
Acrredited : 83/Dikti/Kep/2009

function and service of seagrass ecosystems through improvement and control of the most influenced human activities. This is not an easy way to be applied because the understanding of the importance of seagrass ecosystems by most of Indonesian people, including government officials are still very limited. So, another challenge has to be faced is how to improve knowledge and awareness of these people regarding to the importance of seagrass ecosystems. Overall, the most challenging is how these people realize on the importance of the seagrass ecosystems and to obtain their willingness to engage in the management of the ecosystems.

CONCLUDING REMARKS

To some extent, managing seagrass is an essential part of managing the fisheries, especially in nursery stage, and the impact scales of each seagrass-related human multi-sector activities are very important to be identified and to be included in ICM practices. By knowing this, alternative strategies of seagrass integrated-management may be designed in advance to support sustainable fisheries productivity.

ACKNOWLEDGMENTS

The authors thank to Prof. Jamaluddin Jompa, Prof. Budimawan and Dr. Khusnul Yaqin for their constructive comments on earlier drafts of this manuscript. Authors also thank to Andi Muarifah for some of photographs in this paper. Some supporting references were kindly provided by coordinator and staffs of Centre for Coral Reef Research (CCRR) within Hasanuddin University of Indonesia. Review on Challenging for Seagrass Management In Indonesia by Nadiarti was a part of PhD Thesis within the SPICE (Science for Protection of Indonesian Coastal Ecosystems) Project and financed in part by the Indonesia Directorate General of Higher Education.

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