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Valuation of Seagrass Ecosystem Services in Kotania Bay Marine Nature Tourism Park, Western Seram, Indonesia

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ABSTRACT

Economic valuation is basically aimed to help decision makers to estimate economic efficiency of various utilization activities which might be due to the ecosystem in coastal area like seagrass ecosystem and other marine ecosystems, including small islands. Information about the economic value of seagrass ecosystem services is very limited, especially in Eastern Indonesia; therefore, a study which aims to evaluate seagrass ecosystem services in Kotania Bay Marine Nature Tourism Park, Western Seram District, Maluku Province, needs to be done. Seagrass meadows have become a popular topic due to its high productivity in coastal areas and also because of its substantial ability to store carbon. Economic valuation of seagrass ecosystem services in this conservation area covers two types of ecosystem services: Provisioning service (approached by its role as a primary productivity source through consumer surplus) and regulation services (approached by seagrass's ability in storing carbon through the replacement cost method). Estimation of the economic value of seagrass ecosystem services in the waters of Kotania Bay as provisioning service and regulation service are IDR 21,014,755,749. The results are important input for the decision makers in the region in order to maintain the sustainability of the seagrass ecosystem found in Kotania Bay Marine Nature Tourism Park.

Key words: Economic valuation, seagrass ecosystem services, Kotania bay, consumer surplus, replacement cost

INTRODUCTION

Coastal area and small islands which only account 4% of the world's total land area, but the coastal and estuary ecosystem services which dominate this geographical area contributes some of the most important global benefits for mankind (Barbier *et al.*, 2011). Assessing and appreciating coastal and estuary ecosystem services are very important in order to improve the management and better planning policies. The action plan includes collaborative studies between ecology and economy in valuating coastal and estuary ecosystems. Valuation of coastal and estuary ecosystem services is a key step in showing how people's actions change the structure of the ecosystem and its function and therefore its effect towards the ecological production in the form of goods and

ecosystem services which are beneficial for human. Economic valuation is basically aimed to help decision makers in estimating economic efficiency of various utilization activities which might be done on coastal ecosystems and marine areas, including small islands (Adrianto, 2006).

Seagrass is a flowering plant which inhabits shallow seas and estuaries, inhabiting soft substrates (such as mud, sand and corals) and grow up to depths where 11% of surface light can reach the seabed, except for the genus *Phyllospadix* (Duarte, 1991). Seagrass lives in an area protected from waves, hence the sediment is not churned up by currents and/or waves which prohibit its existence (Koch *et al.*, 2006). Seagrass meadows are a highly productive ecosystem, providing important ecosystem services for the coastal zone, including carbon and nutrient store. Organic carbon in the seagrass sediment is known as blue carbon (Greiner *et al.*, 2013). According to Fourqurean *et al.* (2012), seagrass meadows are able to store up to 19.9 Pg of organic carbon. Though as one of the most productive ecosystems in the world and holds an important role in the coastal zone (Duarte, 2002), but this ecosystem is in an unsettling level due to degradation (Orth *et al.*, 2006; Waycott *et al.*, 2009; Fourqurean *et al.*, 2012). Seagrass ecosystem receives very little attention compared to other coastal and estuary ecosystems (Duarte *et al.*, 2008). Seagrass meadows provide various ecosystem services, including raw materials and food, shoreline protection, erosion control, water purification, fishery maintenance, carbon absorption, tourism, recreation, education and research. Estimation of the economic value of all these services are lacking, however. Knowledge on the economic value of the ecosystem and its services is an important asset because it is one of the main demands which support human welfare, sustainability and distribution of justice (Vo *et al.*, 2012).

The seagrass ecosystem is one of the coastal ecosystems found in the Marsegu Island Marine Nature Tourism Park (MNTP) Conservation Area and its adjacent areas of Kotania Bay waters. This area and its adjacent of Kotania Bay covering 11,000 ha had been set aside as Marsegu Island Marine Nature Tourism Park Conservation Area according to the Minister of Forestry and Plantation's decree No. 114/KPTS II/1999, 5 March 1999, which based on the recommendation of the Governor of Maluku Province Number: 525.51/1298/BAPPEDA/97, 14 May 1997. The area is managed by the Department of Forestry, Directorate of Forest Protection and Nature Conservation (PHKA) Cq-Maluku Natural Resource Conservation Station. This conservation area consist of five small islands i.e. Marsegu Island, Osi Island, Burung Island, Buntal Island and Tatumbu Island (Supriyadi, 2009). By these conservation, The Kotania Bay area had been divided into five zones: (1) The corezone, located on Marsegu Island and Burung Island, (2) The utilization zone, mainly on Tatumbu Island, Buntal Island and part of Marsegu Island, (3) The conservation zone, part of Burung Island, Osi Island and the eastern part of Marsegu Island, (4) The traditional utilization zone, Pelitajaya Bay, Buntal Island and Tatumbu Island and Osi Island and (5) The rehabilitation zone, especially the mangrove ecosystemis in Dusun Pelitajaya and Dusun Kotania Bawah and the coral ecosystem.

However, in reality, the utilization activities conducted by the coastal community which resides around the Kotania Bay MNTP conservation area are no longer in line with the zoning set by the study explained. Moreover the sustainability of this MNTP is also strongly supported by three main coastal area ecosystems, the mangrove ecosystem, the coral reef ecosystem and the seagrass ecosystem which are found within the MNTP. These three ecosystems are currently in a degraded condition due to the people's livelihood demands. The area of the mangrove forest ecosystem in the MNTP area has shrunk down to 1,146 ha (Supriyadi, 2000), the coral reef ecosystem, especially from the *Isis* sp. (deep-sea bamboo) kind which is utilized in large amounts,

approximately 10 ton year⁻¹ (DMFA and ORC, 2008); sold as construction material for IDR 150,000 per cubic meter and the area of the seagrass ecosystem has decreased to 1,174.7 ha only (Supriyadi, 2009).

The more degraded the three coastal ecosystems (especially seagrass ecosystem), the less ecosystem services are available. Therefore, the sustainability of the Kotania Bay Marine Nature Tourism Park is threatened too. The global decline in coastal and estuary ecosystems will affect a number of important ecosystem benefits or services (Barbier *et al.*, 2011). This in turn will affect local community livelihood who strongly depend on the ecosystem include seagrass.

Information on the economic value of seagrass ecosystem services is very limited, especially in eastern part of Indonesia, consequently this study with the objectives to value seagrass ecosystem services in Kotania Bay Marine Nature Tourism Park Conservation Area, Western Seram, Maluku Province, needs to be done. The results of this valuation will become an input for the region's decision makers in order to maintain the sustainability of the seagrass ecosystem in Kotania Bay Marine Nature Tourism Park Conservation Area.

MATERIALS AND METHODS

This study was conducted from May to July, 2011, at Kotania Bay Marine Nature Tourism Park Conservation Area, Western Seram District, Maluku Province. The location was determined based on the purposive sampling technique, where the location was selected using a PRA activity with a Community Mapping approach which is related to the utilization activities done by the community on the seagrass ecosystem. Economic valuation of seagrass ecosystem services in that conservation area covering two types of ecosystem services, i.e., provisioning/production service and regulating/regulatory service.

Regulation service: The seagrass ecosystem's regulating service was analyzed through an approach of its ability to store carbon. This service is considered as an indirect use of the seagrass ecosystem; therefore, the assessment method used in valuating this service was the Replacement cost method (Freeman, 2003). The Quadrant transect method was used to sampling the seagrass. This method in same object and location had been presented by Wawo *et al.* (2014).

Provisioning service: The provisioning/production service of seagrass was calculated through its ability as a productive resource which supports the lives of the community living in its vicinity. The approach to estimate the value of the ecosystems in Kotania Bay Marine Nature Tourism Park Conservation Area (the seagrass ecosystem services) based on their role in fishery productivity known as the Effect on Production/EoP approach (Grigalunas and Congar, 1995; Adrianto, 2006). In the EoP technique, the economic value was estimated based on demand analysis. Using the demand function which had been estimated, the analysis could be conducted by using the demand model for estimating change in consumer surplus related to the utilization of seagrass ecosystem resources. This approach is related to direct utilization which is assessed based on the market price (Chee, 2004). The steps in the Effect on Production/EoP approach commences with:

- Developing a demand function for the use of a certain resource:

$$Q = \beta_0 X_1^{\beta_1} X_2^{\beta_2} X_3^{\beta_3} X_4^{\beta_4} X_5^{\beta_5} \quad (1)$$

Where:

Q = Amount of the resources demanded for one year (kg year^{-1})

X1 = Price of the resource demanded (IDR kg^{-1})

X2 = Respondent's age

X3 = Respondent's level of education

X4 = Respondent's annual income level (IDR year^{-1})

X5 = Number of family members who are the respondent's responsibility

- Transforming the demand function to a linear price equation which was then tabulated
- Conducting linear regression according to tabulated result
- Using the Maple 9.5 program to obtain total willingness to pay (U) and Consumer Surplus (CS)
- Obtaining the area's economic value based on utilization activities by multiplying the CS value with the number of people work as utilization actors. Whereas the utilization economic value per hectare was obtained by dividing the area's economic value with the total size of that area

RESULTS

Kotania bay coastal community: Administratively, villages in Kotania Bay Marine Nature Park Conservation Area are part of Piru Sub-district, Western Seram, whereas Wael Village and Kotania Pantai Village are part of Piru Village. Loupessy Village, Tamanjaya Village and Osi Island are part of Eti Village. The small islands which located in Kotania Bay area, inhabited and have more access to livelihoods in the seagrass meadows are the people of village of Osi Island and Buntal Island. The coastal community which was the target respondent was the people living in village of Osi Island, Wael Village and Buntal Island. On Buntal Island, there were 10 households which came from Kotania Pantai Village. Kotania Village was divided into Kotania Pantai Village (the people's livelihood is mostly fishing) and Kotania Atas Village (the people's livelihood is mostly non-fishing). The village on Seram Island whose people mostly have livelihoods in the seagrass ecosystem is Wael Village. The number of people in the village in Kotania Bay and their livelihoods are presented in Table 1.

The coastal community which inhabits the three study locations (Village of Pulau Osi, Buntal Island and Wael Village) is Buton originate (South East Sulawesi) and has lived there for many years and the people are mostly Moslem. They generally have mixed livelihoods according to the yearly seasonal conditions. The reason why the three locations were selected mainly because the coastal community had main livelihoods which were done in the seagrass meadows ecosystem.

Table 1: People's livelihoods and the population of villages of Kotania Bay, west Seram

Description	Piru village		Eti village		
	Wael village	Kotania Pantai village	Loupessy village	Taman Jaya village	Village of Osi island
No. of people	986.00	275.0	600.00	1137.00	895.0
No. of households	228.00	38.0	78.00	297.00	215.0
Livelihood (%)					
Fishermen	92.40	60.0	55.00	22.50	98.0
Farmers	5.00	37.2	43.00	21.50	-
Employees	1.04	0.8	0.57	1.89	0.3
Traders	1.82	2.0	1.43	3.79	0.6
Etc	-	-	-	50.32	1.1

Statistic report for West Seram, 2010 (BPS, 2010)

Table 2: Distribution of people's activities on seagrass meadows

Type of activity	Location		
	Dusun Wael	Dusun Pulau Osi	Buntal island
Gill net	3	5	2
Bameti*	5	15	0
Hand line fishery	16	15	0
Pot fishery	0	5	0
Set net	3	1	0

*Catching small fish trapped in shallow water during low tide

Utilization that damages coastal resources is still undergoes by the people in Kotania Bay in order to fulfill their needs. Explosive fishing method (dynamite), poisonous fishing (potassium cyanide) for ornamental fish and hard coral mining to sell as construction material (PRA results). The coral is sold by the people at IDR 150 thousand per cubic meter. Seventy respondents were chosen, 27 people from Wael Village, 41 people from Village of Osi Island and 2 people from Buntal Island. The distribution of activities conducted by the three communities on the seagrass meadows can be seen in Table 2.

Seagrass ecosystem economic value based on provisioning service: The seagrass ecosystem with its role as a primary productivity source strongly supports the livelihood of the coastal community in Kotania Bay. Using the Effect on Production/EoP approach, an equation was obtained from the results of a regression:

- From the results of the regression analysis, Eq. 2 and 3 were obtained:

$$\ln Q = 30.47 - 2.99 \ln P + 0.11 \ln A - 0.09 \ln S + 0.37 \ln I - 0.02 \ln F \quad (2)$$

$$\ln Q = 38.26 - 3.09 \ln P - 0.41 \ln A - 0.13 \ln S + 0.16 \ln I - 0.11 \ln F \quad (3)$$

Equation 2 is for hand line fishing activities, whereas Eq. 3 is for gill net fishing. Based on the second function (function 2), an estimation of the economic value of hand line fishing was done by calculating the value surplus for consumers (CS). The total value of willingness to pay (U) was IDR 12,638,552 per hand line fisher. The value paid by the consumer (PQ) was IDR 8,421,199. Therefore, the CS value was IDR 4,217,352 per hand line fisheries. The total economic value of hand line fishing was IDR 2,336,413,544 per year with a population of users of 554 people.

Based on function (3), an estimation of the economic value of gill net fishery was done by calculating the value surplus for consumers (CS). The total value of willingness to pay (U) was IDR 103,356,479 per gill net fisher. The value paid by the consumer (PQ) was IDR 69,871,447. Therefore, the CS value was IDR 33,485,032 per gill net fisher. The total economic value of gill net fishery was IDR 18,550,707,805 per year with a population of users of 554 people.

Based on the results of the analysis using Maple 9.5 of the two utilization activities, the seagrass ecosystem's total economic value from provisioning service was IDR 20,887,121,349 per year in seagrass area of 823.6150 ha or IDR 25,360,297 ha year⁻¹.

Seagrass ecosystem economic value based on regulating service: Based on the results of the study of Wawo *et al.* (2014) on seagrass, it was revealed that the carbon stored total on

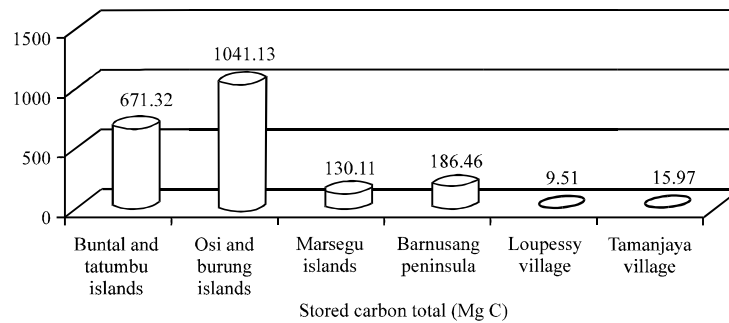


Fig. 1: Stored carbon total in seagrass in Kotania Bay waters

Table 3: Economic value of seagrass ecosystem services

Ecosystem services	Approach	Economic value (IDR)
Provisioning service	Gill net and handline fishing	20,887,121,349
Regulating service	Seagrass' ability to store carbon	127,634,400
	Total	21,014,755,749

seven species of seagrasses at Kotania Bay Waters is 2054.49 mg C. These species are *Enhalus acoroides*, *Thalassia hemprichii* and *Halophila ovalis* from Hydrocharitaceae and 4 species, *Cymodocea rotundata*, *C. serrulata*, *Halodule pinifolia* and *Syringodium isoetifolium* from Cymodoceaceae. The carbon stored total in seagrass at 6 study sites of Kotania Bay Waters is showed in Fig. 1.

According to the Republic of Indonesia's Ministry of Forestry's Regulation year (RoI, 2009), the price of CO₂ is US \$19 t⁻¹ (the current US\$ exchange rate, US\$ 1= IDR 12,000). The estimate of the seagrass ecosystem's regulating service economic value, with the ability to absorb 559.8 t of CO₂ in a seagrass area of 823.6150 ha then was IDR 127,634,400 or IDR 154,968 ha⁻¹.

Economic value of seagrass ecosystem services: The economic value of the seagrass ecosystem services in the waters of Kotania Bay which are in the form of provisioning service and regulating service have an estimated value of IDR 21,014,755,749 (Table 3).

DISCUSSION

Kotania bay coastal community: Social indicators are used on many scales from local to global and can be used to assess changes in societal benefits from changes in ecosystem services (Loomis and Paterson, 2014). People place importance on a wide variety of national, regional and local services provided by marine and coastal ecosystems, including tourism, recreation, fisheries, trade and esthetic and cultural values. In total, all contribute to well-being and a higher quality life. Therefore, the way in which different shorelines and marine environments are managed and what they are managed for, should be a reflection of what society wants from those environments. The Kotania Bay coastal community chose these jobs as fisher because these jobs have been done by many generations in their families. This statement was supported by 94% of the respondents who had a dominant educational level of elementary school (93%).

Seagrass ecosystem economic value based on provisioning service: According to Fig. 2, consumer surplus in Bintan Island (Adrianto *et al.*, 2013) and Waidoba Island (Al Hadad, 2012)

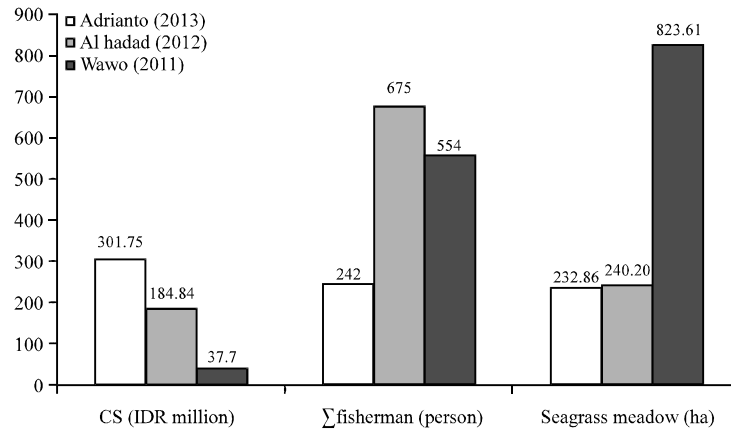


Fig. 2: Consumer surplus for seagrass ecosystem in several locations in Indonesia

were greater than that in the water of the Kotania Bay (the study site). The Kotania Bay water even has an area of seagrass which was larger than the Bintan Island and Waidoba island, but it did not mean that it had a greater consumer surplus. This was caused by the production of fish catch per day per hectare in Bintan Island which was greater than the Kotania Bay water. Besides that, the price of fish in the Kotania Bay followed the price of fish for consumption at restaurants in outside of the Seram Island. Based on interviews with fishermen, it revealed that the fish demand/supplier from several restaurants in outside of the Seram Island derived from the Kotania Bay water. The things mentioned above caused consumer surplus in the Kotania Bay to be small.

Seagrass ecosystem economic value based on regulating service: The greatest of stored carbon was found in Osi Island and Burung Island, because both the islands had an area of seagrass which was greater if it was compared with the other study sites. This was also supported by the study result of Supriyadi (2012) who said that the Kotania Bay water had an average of seagrass cover greater (64%) when it was compared with several locations in Indonesian waters. Seagrasses were involved in carbon sequestration by using carbon dissolved in the seawater (mostly in the form of CO_2 , but also HCO_3^-) to grow (Barbier *et al.*, 2011). Once the plants completed their life cycle, a portion of these materials was then buried in the sediment in the form of refractory detritus. It had been estimated that detritus burial from vegetated coastal habitats contributes about half of the total carbon burial in the ocean (Duarte and Kirkman, 2003). Therefore, the decline in seagrasses could lead to an important loss in the global CO_2 sequestration capacity, although this effect had yet to be valued.

Economic value of seagrass ecosystem services: Seagrass beds provide a wide range of ecosystem services, yet reliable estimates of the economic values of most of these services were lacking. Valuation of ecosystem services is one of the tools that support decision-making in environmental management. It provides useful information for stakeholders and policy makers when making decisions, which often involves choices among different trade-offs (Wakita *et al.*, 2014). Ecosystem Service Valuation (ESV) in marine planning has potential to highlight hidden ecosystem benefits and costs that might be overlooked if only commercial revenues and costs were considered (Borger *et al.*, 2014).

To date, however, the use of ESV in marine planning is still nascent. The time is right to think carefully about how and when ESV could be best used to inform marine planning. Applications of ESV to marine ecosystems arise from decades of research and development of valuation methods for market and non-market goods. Significant efforts have been made to estimate the values of coastal and marine ecosystem services. Understanding the use of non market environmental valuation in policy could help the future successful use of ESV in marine planning. Once planning activities begin, economic valuation estimates can be used to guide scenario plans and provide decision-support data to help stakeholders weigh the economic trade-offs of proposed plans.

It has been identified that seagrasses have been used directly for several purposes in many areas of Indonesia. For examples, the use of seagrass for cattle feeding (cow, sheep) as has been done in Kuta Beach, Lombok and the use of seagrass fruit (*Enhalus acoroides*) that was eaten by most of fishermen of Eastern Indonesia, include Seribu Island in Jakarta for substituting to their breakfast (Dirhamsyah, 2007). Seagrasses are still harvested in Tanzania, Portugal and Australia, where they are used as fertilizer (Hemminga and Duarte, 2000; De la Torre-Castro and Ronnback, 2004). In the Chesapeake Bay, USA, seagrass by-catch or beach-cast is used to keep crabs moist during transport. In East Africa, some species are served as salad, while others are used in potions and rituals (De la Torre-Castro and Ronnback 2004). In the Solomon Islands, roots of the seagrass *Enhalus acoroides* are sometimes used as food, while leaf fibers are used to make necklaces and to provide spiritual benefits such as a gift to a newborn child, for fishing luck and to remove an aphrodisiac spell (Lauer and Aswani, 2010).

Seagrasses also generate value as habitat for ecologically and economically important species such as scallops, shrimp, crabs and juvenile fish. Seagrasses protect these species from predators and provide food in the form of leaves, detritus and epiphytes. The market value of the potential shrimp yield in seagrass beds in Western Australia is estimated to be between US \$684 and US\$2511 ha⁻¹ year⁻¹ (Watson *et al.*, 1993). In Bohol Marine Triangle, the Philippines, the annual net revenue from gleaning mollusks and echinoderms (e.g., starfish, sea urchins, sea cucumbers, etc.) from seagrass beds at low tide ranges from US\$12-120 ha⁻¹ and from fishing US \$8-84 ha⁻¹ (Samonte-Tan *et al.*, 2007). The fish, shrimp and crab yield in southern Australia is valued at US \$1436 ha⁻¹ year⁻¹ (McArthur and Boland, 2006). Based on the latter estimate, a loss of 2700 ha of seagrass beds results in lost fishery production of AU\$235 000. The monetary value of seagrass meadows has been estimated at up to US \$19,000 ha⁻¹ year⁻¹, thus being one of the highest valued ecosystems on earth (Fourqurean *et al.*, 2012).

CONCLUSION

Based on the study conducted, it can be concluded that estimation of the economic value of seagrass ecosystem services in the waters of Kotania Bay Marine Nature Tourism Park which consists of provisioning service and regulating service has a value of IDR 21,014,755,749. This values shows that the role of valuation or economic valuation of seagrass ecosystem services is important in development policies, including in managing the seagrass ecosystem. The loss of the ecosystem or the seagrass ecosystem resources is an economic problem because the loss of the ecosystem means the loss of the ecosystem's ability to provide goods and services to fulfil the needs of the community living around the Kotania Bay Marine Nature Tourism Park.

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