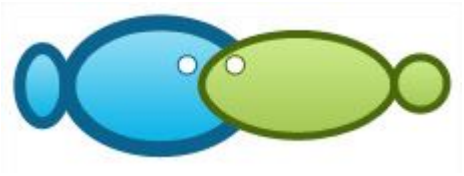

Economic value of seagrass ecosystem in Nain Island, South Minahasa Regency, North Sulawesi, Indonesia

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Abstract. Seagrass is an ecosystem that plays important role for other marine biota living in the coastal waters. Nain Island is highly dependent upon surrounding natural resources, including seagrass resources. This study aims to know the economic value of the seagrass ecosystem in Nain Island. Data were collected through interviews using questioners. The seagrass ecosystem valuation used total economic value, i.e. total of use-based economic value of direct use, indirect use, and optional use, and non-use-based economic value comprising existence value and bequest value. The direct use value obtained from fisheries was IDR. 20,514,110,400 yr^{-1}, whereas the indirect use was gained IDR. 458,883,961 yr^{-1} as fish nursery value and carbon sink, IDR. 5,113,171,200 yr^{-1} as biodiversity value, IDR. 323,270,400 yr^{-1} as existence value, and IDR. 2,051,411,040 yr^{-1} bequest value, respectively, so that the total economic value of the seagrass ecosystem in Nain Island was IDR. 28,460,847,001 yr^{-1}. These economic values indicate the contribution of the seagrass ecosystem to the communities living around Nain Island area.

Key Words: economic valuation, direct use, indirect use, optional use.

Introduction. Seagrasses are flowering plants that possess the ability to adapt to the aquatic environment with high salinity fluctuation, living submerged in the water, having rhizome, leaves, and root. These plants mostly grow in the mud or sand and dominate shallow coastal waters (Fitrian et al 2017).

Seagrass ecosystem is one of the marine resources that possess great role in providing biodiversity, fish abundance, and environmental services. Its occurrence has similar role and function to coral reef and mangrove ecosystems, either ecological or social economic aspects, so that it is able to increase the food security, coastal community's livelihood, and support local or national economy (Arkham 2015). According to Cullen-Unsworth & Unsworth (2013), seagrass ecosystem has important roles, in which seagrass habitat takes the third place of ecosystem services and world natural resources. It is known that there are 360 species of fish, 117 species of macroalgae, 24 species of mollusks, 70 species of crustaceans, and 45 species of echinoderms living in the seagrass bed of Indonesia (Sjafrie 2016).

Furthermore, Sjafrie (2016) stated that the ecosystem services of seagrass are similar to other ecosystems to give benefits for human prosperity as supplying service, supporting service, regulating service, and cultural service. Seagrass ecosystem also prepares resources that can be used as fishing ground. It also becomes spawning ground, nursery ground, and feeding ground for various marine biota. As cultural services, this ecosystem can be used for nature tourism area as well. Seagrass ecosystem makes regulations by catching and storing carbon (Wahyudin et al 2019).

Nain Island is one of the small islands that have seagrass ecosystem resources and has been benefitted by fishermen communities to get fish and other marine animals for their own consumption and sale. The presence of activity concentration in the coastal area and direct dependence on the seagrass ecosystem resources in the form of fishing around the island has influenced the ecological function of the seagrass ecosystem in

Nain Island. Based on previous finding (Schadow 2018), decline in the percent cover of seagrass ecosystem in Nain Island results from human population, tourism development, and household's need fulfilment. One of the efforts to have an appropriate management is to estimate the economic value of the benefits in the seagrass ecosystem. To increase the decision maker's awareness of the necessity to protect the seagrass ecosystem, a clearer economic argument needs to be done in order to conserve the ecosystem (Dewsbury et al 2016). Thus, this study was aimed at determining the economic value of the seagrass ecosystem in Nain Island, North Minahasa Regency, North Sulawesi.

Material and Method

Research operations. This study was carried out in Nain Island (Figure 1), North Minahasa Regency, North Sulawesi Province, for two months, March-April, 2020. Nain Island group is located at the geographic position of 1º35'41'' - 1º35'16'' N and 124º50'50'' - 124º49'22" E, consisting of Nain Island with an area of 118.16 ha and uninhabited Small Nain Island with an area of 2.5 ha. The former has 3 definitive villages, Nain, Nain Satu and Tatampi. The area has hilly topography with a slope of about 20-40° and a position of 139 m above sea level. The residential area is located at the flat land of about < 4 ha, the slant area, and pole-supported houses above the sea water. Nain Island is dominantly inhabited by Bajo and Sangeress communities with total population of 3,376 people and 1,004 families. The major livelihoods of Nain Island people are fishermen and seaweed farmers, in which Nain Island has become the center of seaweed farming in North Sulawesi Province. Therefore, several water quality parameters were recorded on temperature, turbidity, pH, and salinity.

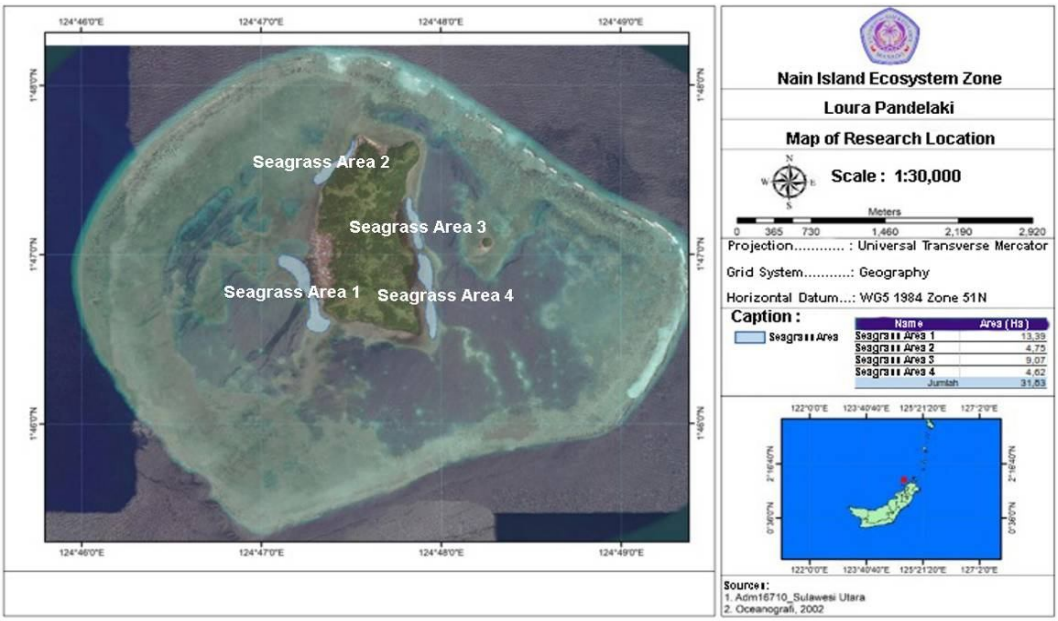

Figure 1. Nain Island.

Data collections employed purposive sampling method. Data were obtained through direct interviews to fishermen communities in Nain Island, whereas other information was taken from literatures or scientific publications and other related government institutions. A theoretical framework is shown in Figure 2.

The economic value of seagrass ecosystem in Nain Island was assessed using a total economic value, addition of use value consisting of direct use value, indirect use value, optional value, and non-use value consisting of existence value and bequest value. Direct use value was estimated using productivity approach; indirect use value and optional value used benefit transfer valuation; the existence use value was calculated using contingent valuation method; and bequest value was determined through estimation approach.

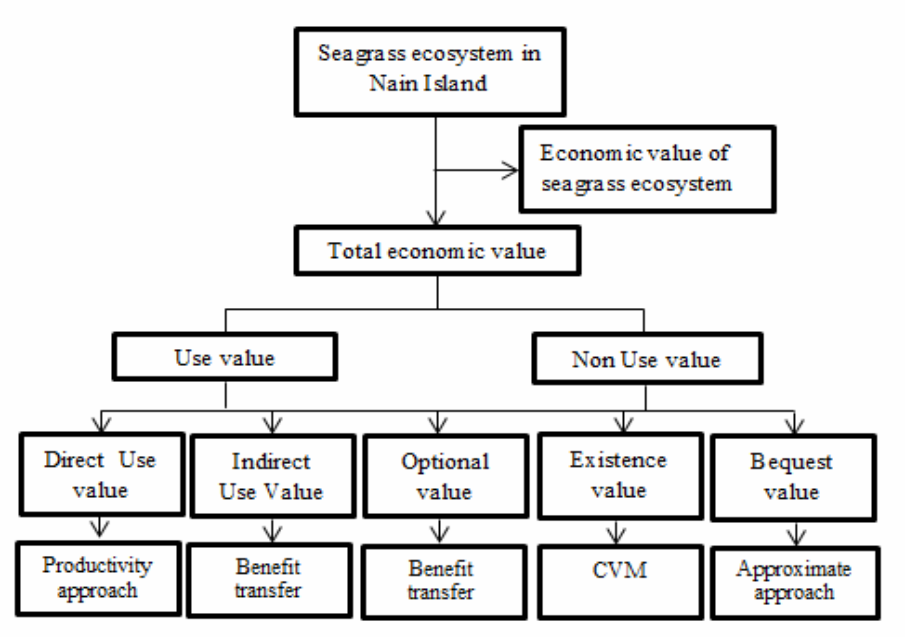

Figure 2. Research theoretical framework.

Data analysis. Valuation on the use value and non-use value of the seagrass ecosystem in Nain employed economic valuation analysis.

Direct use. This value is obtained from direct use of the resources estimated from the productivity approach, such as fish and non-fish catches. It was calculated following Darutaqiq (2017):

$$DUV = \sum_{i=1}^{n} DUV_i$$

where: DUV = direct use value, DUVi = fishing benefit (fish, crabs, sea cucumbers), n = number of use types, i = type of use – i.

Indirect use. This value is the benefit obtained from the use of goods without direct use (Humphreys & Fowkes 2016). This estimation is the biological supporting function value as fish nursery ground and the environmental service function as carbon absorption. The valuation uses the benefit transfer approach through benefit estimation from other place where the resources are available, then it is transferred to obtain a rough estimation on the environmental benefit (Fauzi 2004). The benefit transfer valuation was done by transferring the data from previous valuation study (Mehvar et al 2017). Determination of fish nursery value in the seagrass ecosystem in Nain Island utilized benefit transfer method with fish nursery value assumption in rabbitfish culture per Ha in pond (Kordi 2010), the multiplication of monoculture system of juvenile rabbitfish of 130-170 g and the price of individual fish, divided by 5-year investment costs with pond age (Suparmoko 2004), and multiplied by the seagrass bed area. Indirect use of carbon absorption was based on the assumption of total seagrass ecosystem area in Indonesia, 30,000 km^2, that can absorb carbon as much as 56.3 million ton yr^{-1} (Said 2012).

Optional use value. This estimation is obtained using the diversity value of seagrass ecosystem with benefit transfer method. According to Wahyudin et al (2019), the economic value of coastal and marine biodiversity is based on estimation value with resource type, averagely IDR. 160.64 million ha^{-1} yr^{-1}. The biodiversity value of seagrass ecosystem of Nain Island was got from the multiplication of seagrass bed area in Nain Island and mean economic value of the seagrass ecosystem:

Option Value = seagrass bed area (Ha) x mean economic value of seagrass ecosystem

Existence value. The existence value functions to know whether there is impact of the seagrass bed occurrence in the area or not. This value was measured from the benefit of

seagrass bed existence directly felt by the community using willingness to pay method based upon the Contingent Valuation Method (CVM) method. This method is a valuation method through direct survey on individual response to willingness to pay for an environmental commodity or non-marketable resource. The CVM approach was conducted in 5 phases as follows (Fauzi 2004) by:
1. making a market hypothesis;
2. obtaining the auction value;
3. estimating the auction value;
4. determining the auction curve;
5. aggregating data by multiplying mean WTP with number of fishermen's households.

Bequest use value. This value is estimated from the seagrass ecosystem resources that can be used in future by the next generation in the condition as present state (Fauzi 2004). The bequest value of seagrass ecosystem was calculated using an estimation approach, in which the bequest value (BV) was estimated as:

$$BV = 10\% \times \text{total of direct use value}$$

Total economic value. This value was determined following Rizal & Dewanti (2017) as:

$$TEV = UV + NUV = (DUV+IUV+OV) + (XV+BV)$$

where: TEV = total economic value;
UV = use value;
NUV = non-use value;
DUV = direct use value;
IUV = indirect use value;
OV = optional value;
XV = existence value;
BV = bequest value.

Results and Discussion. Measurements of water physico-chemical parameters showed that the water condition of Nain Island had unideal turbidity and salinity conditions based on the seawater quality standard for marine biota of the Living Environmental Minister's decree numbered 51/2004 (Table 1). Water turbidity has reached the upper threshold due to boat activities on the surface. High water turbidity will inhibit the sunlight into the water and could influence the photosynthesis of the seagrass. Water salinity was also below the optimal range that could influence the optimum growth of the seagrass. Nevertheless, water temperature and pH are categorized to be in suitable range for the seagrass growth. This condition still supports the local communities to run their seaweed farming activities.

Table 1

Water quality of Nain Island

No.	*Parameter*	*Unit*	*Measurement*	*Standard quality (MLE No. 51/2004)*	*Quality criteria*
1.	Temperature	^{o}C	29.67	28-30	Suitable
2.	Turbidity	NTU	5.94	< 5	Unsuitable
3.	pH		8.14	7-8.5	Suitable
4.	Salinity	‰	29.33	33-34	Unsuitable

The seagrass bed area was identified using georeferenced Google Earth Satellite Image and it was estimated as much as 31.83 ha. The seagrass bed condition in Nain Island, based upon mean percent cover, was 26.4% in average. Referring to the Living Environmental Minister's decree numbered 200/2004 concerning the status and the degradation of seagrass bed, the condition of Nain Island seagrass bed belonged to poor condition. Seagrass ecosystem degradation will alter the social-ecological system in the coastal area, ecological health, habitat function, human prosperity (Karlina et al 2018).

The seagrass species in Nain Island were *Enhalus acoroides, Thalassia hemprichii, Cymodocea serulata, C. rotundata,* and *Halodule pinifolia.* Nevertheless, the seagrass was generally dominated by *E. acoroides,* and the species with the lowest distribution was *T. hemprichii.*

Economic value of seagrass ecosystem in Nain Island. Economic valuation is intended to determine the amount of total economic value of the natural resources utilization. The information will be beneficial for the decision makers in formulating the sustainable management policy. Seagrass ecosystem is difficult to measure and to grade because its benefit for people is hard to measure. For accurate valuation of the seagrass ecosystem, the spatial and temporal variations in service supply and the synergy of inter ecosystem functions need to be understood and evaluated (Nordlund et al 2016).

Seagrass ecosystem in Nain Island has given direct or indirect benefit to the surrounding communities. Total economic value, the total of use and non-use value, obtained becomes information on the economic benefits provided by the seagrass resources in Nain Island (Table 2).

Direct use value. Fishing activities used net, speargun, and line. The fish species caught were rabbitfish (Siganid), parrotfish (Scaridae), anchovy (Stolephorus sp.), grouper (Epinephelinae), and emperorfish (Lethrinidae). Fishing activities are done averagely 20 days a month in 9 months a year. The direct use was IDR. 2,930,587,200 yr^{-1} from rabbitfish, IDR. 2.930.587.200 yr^{-1} from parrotfish, IDR. 2,197,940,400 yr^{-1} from anchovy, IDR. 3,663,234,000 yr^{-1} from grouper, and IDR. 2,930,587,200 yr^{-1} from emperor fish, respectively. The direct use from non-fish removals was IDR. 2,930,587,200 yr^{-1} from crabs and IDR. 2,930,587,200 yr^{-1}. Thus, total economic value of direct use was IDR. 20,514,110,400 yr^{-1}.

Table 2

Total economic value of seagrass ecosystem in Nain Island

No.	*Benefit category*	*IDR. yr^{-1}*	*Proportion of total economic value (%)*
1	Direct use:		72.08
	- fish catch,	14,652,936,000	
	- non-fish catch	5,861,174,400	
2	Indirect use:		1.61
	- fish nursery,	381,960,000	
	- carbon absorption	76,923,961	
3	Optional use	5,113,171,200	17.97
4	Existence use	323,270,400	1.14
5	Bequest use	2,051,411,040	7.21
	Total	28,460,847,001	100.00

Source: Processed data 2020.

Indirect use value. This value was obtained from fish nursery value of IDR. 381,960,000 $ha^{-1}\,yr^{-1}$. The calculation of fish nursery ground is presented in Table 3.

Table 3

Fish nursery ground in seagrass ecosystem in Nain Island

Fish seed	*Weight (g)*	*Price (IDR. gr^{-1})*	*Monoculture rearing system*	*Five year-investment (60,000,000/5)*	*Seagrass area (ha)*	*Economic value (IDR. $ha^{-1}\,yr^{-1}$*
Rabbitfish	130-170	2,000	30,000	12,000,000	31.83	381,960,000

Source: Processed data.

The estimation of carbon absorption value is shown in Table 4. The economic value of seagrass ecosystem in Nain Island as carbon storage was IDR. 76,923,961 yr^{-1}. The correction factor is also involved to avoid overestimation.

Table 4

Carbon value of seagrass ecosystem in Nain Island

Seagrass ecosystem (ha)	*Carbon absorption potency (Ton ha^{-1} yr^{-1})*	*Carbon value (IDR. ton^{-1})*	*Correction factor*	*Carbon value (IDR. yr^{-1})*
31.83	18.77	143,060	90%	76,923,961

Source: Processed data.

Optional use value. The amount of biodiversity reserve was obtained by multiplication between seagrass ecosystem area in Nain Island (31.83 ha) and mean economic value of seagrass resource of IDR. 160.64 million ha^{-1} yr^{-1} (Wahyudin et al 2019). Based on the assumption, the amount of economic value of seagrass bed biodiversity in Nain Island was IDR. 5,113,171,200 yr^{-1}.

Existence use value. Mean existence value was IDR. 39,733 mo^{-1} or IDR. 357,600 yr^{-1} multiplied with number of fishermen's households, 904, so that the existence value of the seagrass ecosystem in Nain island was IDR. 323,270,400 yr^{-1}.

Bequest use value. The estimation approach is used to know the bequest value that cannot be measured with market value. The analysis indicated that the bequest value of seagrass ecosystem in Nain Island was IDR. 2,051,411,040 yr^{-1}.

Total economic value of seagrass ecosystem of Nain Island. Total economic value of seagrass ecosystem in Nain Island was IDR. 28,460,847,001 yr^{-1}. Direct use value has the highest proportion with an average of 72.08% covering fish and non-fish catches. The lowest proportion was recorded in indirect use value, 1.61%. This value could also be considered as an opportunity cost if the seagrass ecosystem in Nain Island suffered from degradations. The real use value and non-use value of the seagrass ecosystem in Nain Island could become a quantitative basic information in determining the sustainable management policy strategy.

Conclusions. Total economic value of the seagrass bed ecosystem in Nain Island was IDR 28,460,847,001 yr^{-1}, covering direct use of IDR. 20,514,110,400 yr^{-1}, indirect use of IDR. 458,883,961 yr^{-1}, optional use value of IDR. 5,113,171,200 yr^{-1}, existence use value of IDR. 323,270,400 yr^{-1}, and bequest value of IDR. 2,051,411,040 yr^{-1}. To anticipate future shift in the seagrass ecosystem condition, the economic valuation of this ecosystem should be regularly updated to have suitable guide to developing the public policy in order to minimize the external costs of goods and service given by the natural resources for human needs.

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