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Economic Value of Mangrove Forest Ecosystem in Unit XXXIII Kubu Raya Forest Management Unit

(Nilai Ekonomi Ekosistem Hutan Mangrove di KPH Unit XXXIII Kubu Raya)

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ABSTRACT

Mangrove forest ecosystems resources could serve as income sources for the surrounding communities. However, the total economic value of these resources has yet to be recognized, calculated, and considered in managing and conserving mangrove forest ecosystems. This research aimed to estimate the direct economic value (timber, charcoal, aquatic biota, processed products, honey, and Nypa roof), indirect economic values (abrasion prevention, carbon stock, oxygen production, intrusion barrier), and optional economic value (biodiversity) of mangrove forest ecosystems. This research used two assumptions to calculate the total economic values: with and without timber utilization activities for charcoal production in the Unit XXXIII Kubu Raya Forest Management Unit (FMU). The results indicated that the indirect economic value had the highest percentages compared to the direct and optional economic values in both assumptions.

INTISARI

Sumberdaya ekosistem hutan mangrove berpotensi menjadi sumber pendapatan bagi masyarakat sekitar. Namun demikian, saat ini nilai ekonomi total dari sumberdaya alam tersebut belum dikenali, dihitung, dan digunakan sebagai bahan pertimbangan dalam pengelolaan dan konservasi ekosistem hutan mangrove. Penelitian ini bertujuan untuk mengetahui nilai ekonomi langsung (kayu mangrove, arang bakau, biota perairan, hasil olahan, madu, dan atap daun nipah), nilai ekonomi tidak langsung (pencegah abrasi, penyimpan karbon, penghasil oksigen, dan penahan instrusi air laut), dan nilai ekonomi pilihan (keanekaragaman hayati) dengan asumsi terdapat kegiatan pemanfaatan ekosistem hutan mangrove (kayu mangrove) dan tanpa kegiatan pemanfaatan ekosistem hutan mangrove (kayu mangrove untuk produksi arang) di KPH Unit XXXIII Kubu Raya. Hasil perhitungan menunjukkan bahwa nilai ekonomi tidak langsung mempunyai persentase tertinggi dibandingkan dengan nilai ekonomi langsung dan nilai ekonomi pilihan pada kedua asumsi yang digunakan dalam perhitungan.

Introduction

The mangrove forest ecosystems have high productivity, decomposition of organic matter, and a crucial ecological chain for living organisms in the surrounding waters (Imran 2016). Mangrove forest ecosystems are unique, diverse, and complex ecological systems that function as protectors, buffers, and supporters of life on land and in water (Karlina et al. 2016). They have physical, biological, and economic functions for the coastal areas. The physical functions of the mangrove forest ecosystem include abrasion prevention, seawater intrusion barrier, windbreaker, and CO2 sequester. The mangrove forest ecosystems become the spawning and nursery ground for aquatic biota (fish, shrimp, and shellfish), bird nesting ground, and other aquatic biotas' natural habitat (biological functions). Using mangrove wood as building materials, firewood, plywood, pulp, piles, and handicrafts also creates relatively high economic values (Prayogi et al. 2017).

Mangrove forest ecosystems have an essential economic role in fulfilling human needs. On a local scale, the mangrove forest ecosystems could provide materials for firewood, building, medicine, bark, food, and charcoal. Meanwhile, industries also used materials from mangrove forest ecosystems for plywood, pulp, paper, charcoal, and leather tanning (Mulyadi 2017). The lucrative economic benefits of mangrove forest ecosystems have led to extensive exploitation, severe deforestation, and ecosystem degradation, such as in the coastal areas of Unit XXXIII Kubu Raya Forest Management Unit (FMU). The lucrative economic benefits of mangrove forest ecosystems have led to extensive exploitation, severe deforestation, and ecosystem degradation, such as in the coastal areas of Unit XXXIII Kubu Raya Forest Management Unit (FMU). The communities in Batu Ampar Sub-district (Batu Ampar Village), Kubu Sub-district (Kubu Village), and Teluk Pakedai Sub-district (Teluk Pakedai Hulu Village) used mangrove wood primarily as raw material for charcoal and other commercial uses.

However, the planning and development of coastal often exclude the mangrove forest ecosystems because their direct, indirect, and optional economic values are not easily recognized. The economic values of mangrove forest ecosystems depend on their existence. Continued utilization puts pressure on mangrove forest ecosystems and their surroundings, leading to deterioration in the ecosystem and the surrounding communities' livelihood. Therefore, communities need to participate in maintaining the mangrove forest ecosystems through conservation and sustainable utilization (Santri et al. 2020).

Many goods and services of the mangrove forest ecosystems are nonmarketable, and most people indirectly benefit from their economic values (Fadhila et al. 2015). The consumption of some goods and services of mangrove forest ecosystems, such as hydrology, biology, and aesthetics, is through non-market mechanisms. People only realize the economic value of mangrove forest ecosystems when they become increasingly scarce and human welfare is compromised. Local communities also traditionally utilize the mangrove forest ecosystems for their subsistence and not for sale. This form of utilization fulfills their daily needs, meaning those goods and services are nonmarketable (Siregar 2012). Therefore, assessing the direct, indirect, and optional economic values of the mangrove forest ecosystems is necessary. Economic valuation gives a quantitative value to the goods and services produced by natural resources and the environment based on the market and non-market values (Hasibuan 2014). The economic value measures the maximum amount a person is willing to give up in terms of goods and services to obtain other resources (Anna 2005 in Rusmiyati et al. 2016). This research aimed to determine the direct (timber, charcoal, aquatic biota, processed products, honey, and Nypa roof), indirect (abrasion prevention, carbon stock, oxygen production, intrusion barrier), and optional (biodiversity) economic values of mangrove forest ecosystems in Unit XXXIII Kubu Raya FMU.

Materials and Methods

Time and Location

This research was conducted from November to December 2021 in the protected forest area (HL) of Unit XXXIII Kubu Raya FMU. The Unit XXXIII Kubu Raya FMU covered 80,324 ha areas based on the 2020 land cover map, consisting of namely Protected Forest or HL (48,080 ha), Production Forest or HP (6,428 ha), and Limited Production Forest or HPT (25,816 ha). Batu Ampar, Kubu, and Teluk Pakedai Hulu villages in the coastal areas of the mangrove forest ecosystems became the locus of this research. The communities of these villages primarily worked as fishermen and charcoal makers (Table 1). These villages were selected because they hosted the Temporary/ Permanent Sample Plots (TSP/PSP) and communities that utilized the mangrove forest ecosystems as their primary income sources (Figure 1).

Table 1. Description of the research locations in the Unit XXXIII Kubu Raya FMU

No.	District	Village	Forest Function	Mangrove Forest Ecosystem Area (ha)
1.	Batu Ampar	Batu Ampar	HL	24,354
2.	Kubu	Kubu	HL	3,652
3.	Teluk Pakedai	Teluk Pakedai Hulu	HL	247
		Total Area		28,253

Source: Spatial data analysis, 2021.

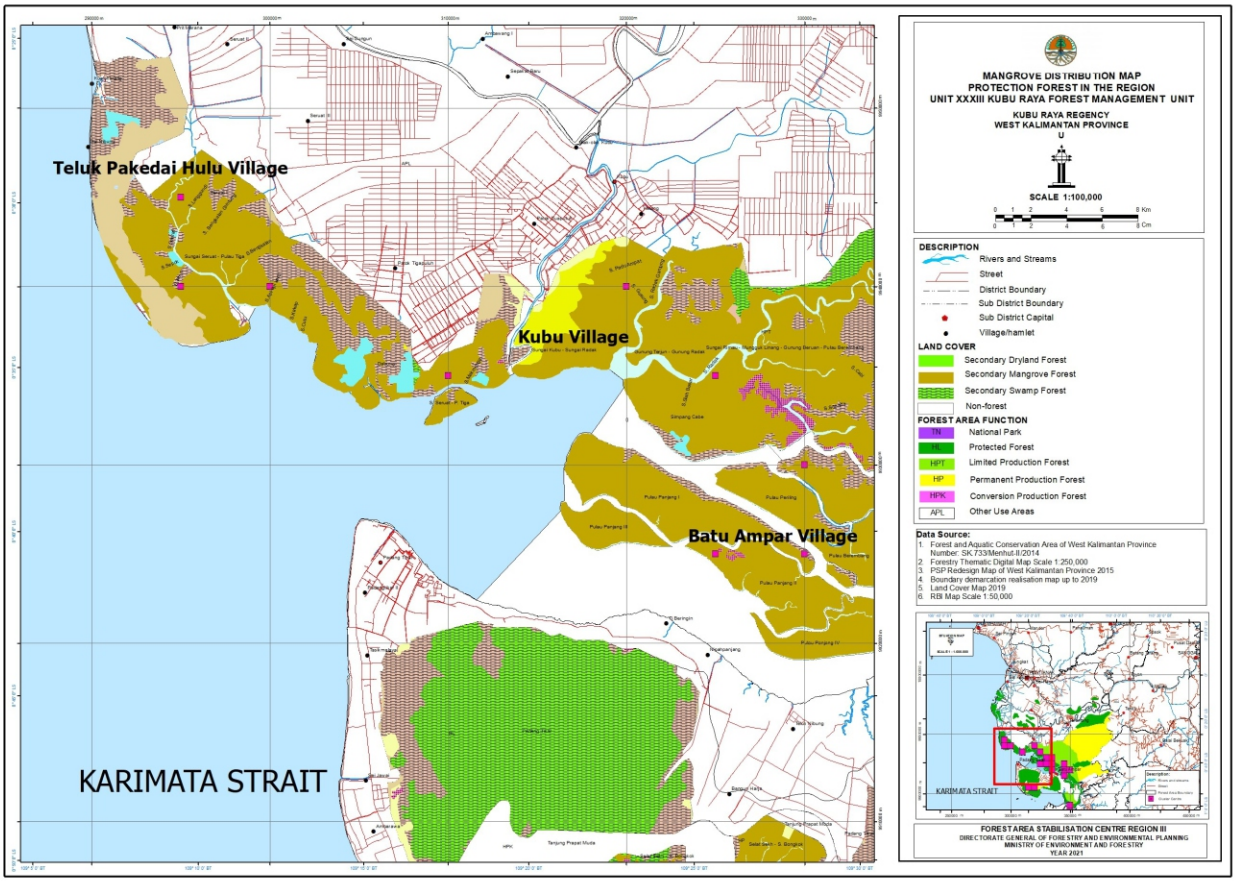

Figure 1. Mangrove Forest Ecosystems in Protected Forest (HL) of the Research Locations in Unit XXXIII Kubu Raya FMU (BPKH Region III Pontianak, 2020)

Data collection

Primary data

Direct economic values data collected include wood, charcoal, aquatic biota (fish, shrimp, and crabs), honey, crab crackers, and Nypa roof. Indirect economic values data collected include abrasion prevention, carbon stock, oxygen production, and seawater intrusion barriers, while the optional economic value data was biodiversity. This research used a survey with interviews using a list of questions to collect primary data on the sources of household incomes, types of mangrove forest resources utilization and their price, and the values of the utilization. The research team also observed community and protected forest conditions during the survey.

The communities in Batu Ampar, Kubu, and Teluk Pakedai Hulu villages, whose primary incomes were from using mangrove forest ecosystems, became the population of this research. Respondents were purposively selected to serve the research objectives. The respondents should be able to provide data and information and explain the economic activities related to mangrove forest ecosystem utilizations. The Village officials facilitated the determination of the number of respondents based on the best available data and information (Table 2). The tools and materials used in this research include laptops, writing tools, cameras, and questionnaires.

Secondary data

Secondary data could include spatial data, books, literature, notes, and reports related to the research topic (Yusuf et al. 2020). In this research, the secondary data included land cover data in 2015 and 2020 from BPKH Region III, reports on the results of measuring TSP/PSP enumeration of the mangrove forests ecosystem by BPKH in 2019, village potential data (PODES) from BPS, theses, dissertations, and publications from scientific journals.

Data analysis

The spatial analysis determined the land cover changes in the research area between 2015 and 2020, using spatial analysis tools (Arc GIS 10.8 software) to produce a land cover change map from 2015 to 2020. The economic valuation could estimate the quantitative value of goods and services produced by the environment and natural resources regardless of their market value availability (Fadhila et al. 2015). This research quantified the environmental services of the mangrove forest ecosystem to obtain their direct, indirect, and optional economic values.

Direct economic values

Kalitouw et al. (2015) suggested that direct economic value included benefits from the mangrove forest ecosystem. The valuation of the direct economic value estimated the economic value of each resource

Table 2. Number of populations and respondents in KPH Unit XXXIII Kubu Raya

No	Livelihood	Total Population (People or KUPS)	Number of Respondents		
			Batu Ampar Village (People or KUPS)	Kubu Village (People)	Teluk Pakedai Hulu Village (People)
(1)	(2)	(6)	(3)	(4)	(5)
1	Mangrove Charcoal Maker	200*	30	10	-
2	Fishermen	750*	45	30	30
3	Aquaculture Fishermen	50	1 KUPS*	3	1
4	Shellfish Collector	50	5	5	5
5	Honey Collector	3	1	1	1
6	Crab Cracker Maker	1 KUPS*	1 KUPS*	-	-
7	Nypa roof Maker	30	3	3	3

Source: Respondent data, BPS 2021, *Information from village officials, KUPS = Social Forestry Bussiness Group of the mangrove forest ecosystems, resulting from the multiplication of production and its market price. This research calculated the direct economic value of mangrove wood, charcoal, aquatic biota (shrimp, fish, and crabs both caught and cultivated), crab crackers, honey, and Nypa roof. The calculation of direct benefits used formula (1).

TML = ML1 + ML2 + ML3 + ML4 + ML5 + ML6 + ML7 + ML8 --(1)

Remarks:
TML = Total direct economic value
ML1 = Direct economic value of wood
ML2 = Direct economic value of mangrove charcoal
ML3 = Direct economic value of aquatic biota (collected)
ML4 = Direct economic value of aquatic biota (cultivated)
ML5 = Direct economic value of shellfish
ML6 = Direct economic value of Crab Crackers
ML7 = Direct economic value of Mangrove Honey
ML8 = Direct economic value of Nypa roof

The calculation of direct economic value of mangrove wood used formula (2)

Economic value of mangrove wood = Vha x H = $1/2\pi D^2 TK \times H - B$ ---------------------------------------(2)

Remarks:
Vha = Volume of mangrove wood (m^3/ha)
H = Mangrove wood price (IDR)
T = Average wood height (m)
K = Average stand density (stems/ha)
D = Average diameter (cm)
B = Operating costs (IDR)

The calculation of direct economic value of mangrove charcoal used formula (3).

Economic value of mangrove charcoal = (P X H) - B ---(3)

Remarks:
P = Production (kg)
H = Selling price (IDR)
B = Operational cost (IDR)

The calculation of direct economic value of aquatic biota (collected and cultivated), and shellfish used formula (4).

Aquatic Biota Value = (T X H) - B ---------------------(4)

Where:
T = Catch (Kg)
H = Selling price (IDR)
B = Operating costs (IDR)

The calculation of direct economic value of processed products (crab crackers), mangrove honey, and Nypa roof used formula (5).

Economic value of processed products = (P X H) - B ---(5)

Where:
P = Production (Kg)
H = Selling price (IDR)
B = Operating costs (IDR)

Indirect economic values

The community indirectly received economic value from the goods and services produced by natural resources and the environment (Fauzi 2002), such as ecological services from mangrove forest ecosystems. The calculation of indirect economic value used a benefit transfer approach because they had no market value. The value estimation used the results from previous research, including abrasion prevention, carbon stock, seawater intrusion barrier, and oxygen production.

The economic value of the mangrove forest ecosystem as abrasion prevention used a breakwater construction approach (Suryono 2006). Kalitouw et al. (2015) suggested that the replacement costs could estimate the value of breakwater benefits. Replacement cost indicates the amount required to build a breakwater to replace the function of the mangrove forest ecosystems as a breakwater. The calculation used formula (6).

Replacement cost = Pgp x H - U ----------------------(6)

Remarks:
Pgp = Shoreline Length (Km)
H = Price or Cost (IDR/Km)
U = Economic Life of breakwater embankment (year)

Mangrove forest ecosystems contribute significantly to the global carbon cycle as carbon sequesters and oxygen producers. The carbon stock and oxygen production calculation used a benefit transfer approach and estimated values from previous research (Johnston et al. 2015).

Seawater intrusion could occur naturally through abrasion and sedimentation and induced by human activities such as coral extraction, mangrove forest logging, pond construction, land clearing for new settlements, and uncontrolled groundwater extraction (Alfian 2004). The economic value estimation of the mangrove forest ecosystem as intrusion prevention was equivalent to decreased quantity and quality of rice production due to seawater intrusion into rice fields (Mahyudin 2012). Rice became the primary commodity in the Kubu Raya Regency. Mahyudin (2012) revealed that the seawater intrusion reduced rice production by 419.4 tons/year or IDR1446,400,000/year in Labakkang, Segeri, and Mandalle Sub-districts with a size rice field area of 361.6 ha. The calculation estimated the indirect economic value of the mangrove forest ecosystems in the Labakkang, Segeri, and Mandalle Sub-districts of IDR 1,446,400,000/year. The indirect economic value estimation of intrusion barrier used the formula (7). The calculation of total indirect economic value of mangrove forest ecosystems used formula (8).

Economic value of seawater intrusion barrier = (P x L X H) - U ---(7)

Remarks:
P = Potential of rice production (kg/ha)
L = Rice Field Area (ha)
H = Rice Price (IDR/kg)
U = Economic Age of Rice Farming Business (year)

MTL = MTL1 + MTL2 + MTL3 + MTL4 ---------------(8)

Remarks:
MTL1 = Indirect economic value of mangrove forest ecosystem as abrasion prevention
MTL2 = Indirect economic value of mangrove forest ecosystem as carbon stock
MTL3 = Indirect economic value of mangrove forest ecosystem as an oxygen producer
MTL4 = Indirect economic value of mangrove forest ecosystem as a seawater intrusion barrier

Optional economic values

The optional economic value indicates the willingness of a person to pay to preserve the mangrove forest ecosystems' future use, such as biodiversity (Fahrudin 1996). The calculation used a benefit transfer approach with the value estimation from the mangrove forest ecosystem benefits from the biodiversity value based on the mangrove forests in Indonesia of US\$ 1,500/km^2/year or US\$ 15/ha/year (Ruitenbeek 1991).

Total economic value

Total economic value (TEV) consists of direct, indirect, and optional economic values. The management policy formulation of mangrove forest ecosystems should consider TEV to determine their allocations and alternative use appropriately. This research calculated the TEV by summing the direct, indirect, and optional benefit results using formula (9) as follows (Bakosurtanal 2005).

TEV = DEV + IEV + OEV ------------------------------(9)

Remarks:
TEV = Total economic value
DEV = Direct economic value
IEV = Indirect economic value
OEV = Optional economic value

Results and Discussion

Land Cover Changes and Perceived Benefits of Mangrove Forest Ecosystem

The spatial analysis indicated changes in land covers in Unit XXXIIII Kubu Raya FMU between 2015 and 2020 (Table 3). The secondary dryland forest, primary swamp forests, and non-forests decreased, while secondary mangrove and swamp forests increased within those five years. Abrasion induced by over-exploitation of mangrove wood for mangrove charcoal production and house constructions led to deforestation and primary swamp forests loss (Umayah et al. 2016). Deforestation also accelerated the abrasion in the region, reducing 0.17 km of the coastline (Rumalean 2018). The mangrove forest ecosystems in Unit XXXIIII Kubu Raya FMU played a crucial role in supporting sustainable development in the region. However, the stakeholders were unaware of their economic values because data and information related to their functions and economic values were unavailable.

The utilization and perceived benefits of mangrove forest ecosystems in Unit XXXIIII Kubu Raya FMU included direct, indirect, and optional economic values (Table 4). The direct values comprised the utilization of wood and non-wood mangrove forest products. Meanwhile, the community encountered difficulty recognizing the indirect and optional economic values because they needed market prices.

The economic value of the mangrove forest ecosystem

Direct Economic Value

This research used two assumptions to calculate the total economic values: with and without timber utilization activities for charcoal production in the Unit XXXIII Kubu Raya FMU. The first calculation assumed mangrove wood utilization by the community for charcoal production. The potential

Table 3. Land cover change from 2015 – 2020 in KPH unit XXXIIII Kubu Raya

No	Land Cover	Area (ha) in HL Function		Changes	Percentage
		2015	2020		
(1)	(2)	(3)	(4)	(5)	(6)
1	Secondary Dryland Forest	4,233	4,116	(117)	2.76%
2	Primary Swamp Forest	1,310	-	(1,310)	100%
3	Secondary Mangrove Forest	48,073	48,080	7	0.01%
4	Secondary Swamp Forest	51,557	53,946	2,389	4.63%
5	Non-Forest	34,890	33,921	(969)	2.78%
	Total	140,064	140,064		

Source: Spatial data analysis, 2021

Table 4. Identification of the mangrove forest ecosystem economic values at Unit XXXIII Kubu Raya FMU

No	Types of economic value	Area (ha) in HL Function			Percentage
		Batu Ampar	Kubu	Teluk Pakedai Hulu	
(1)	(2)	(3)	(4)	(5)	(6)
A	Direct economic value				
	1. Mangrove wood	Yes	Yes	-	Utilized by the community*
	2. Charcoal	Yes	Yes	-	Utilized by the community
	3. Fishing (fish, shrimp, crab, shelfish)	Yes	Yes	Yes	Utilized by the community
	4. Aquaculture (crab)	Yes	Yes	-	Utilized by the community
	5. Aquaculture (fish)	Yes	Yes	Yes	Utilized by the community
	6. Honey	Yes	Yes	-	Utilized by the community
	7. Crab crackers	Yes	-	-	Utilized by the community
	8. Nypa roof	Yes	Yes	Yes	Utilized by the community
B	Indirect benefit value				
	1. Abrasion prevention	-	-	-	Perceived by the community
	2. Carbon stock	-	-	-	Perceived by the community
	3. Oxygen production	-	-	-	Perceived by the community
	4. Sea water intrusion barrier	-	-	-	Perceived by the community
C	Optional benefit value (biodiversity)	-	-	-	Perceived by the community

Source: Questionnaire Data, 2021, *part of which is used for raw materials for mangrove charcoal

economic value of mangrove wood at the location was IDR 2,480,800,000/year, obtained from the number of existing charcoal kilns (443 units) multiplied by the required raw material of 2 m^3/kiln/pyrolysis process, the number of pyrolysis process/year (8 times/year), and the mangrove wood selling price (IDR 350,000/m^3). The second calculation assumed no existing mangrove wood utilization activities. The measurement conducted by BPKH region III Pontianak revealed that the wood stock of *Rhizophora* sp was 15.63 m^3/ha for 30 years, or an average growth of 0.512 m^3/ha/year, and the average market price of mangrove wood was IDR 350,000/m^3. The economic value estimation was IDR 154,558,036,500 for 30 years or IDR 5,151,934,550/year, obtained by multiplying the potential, price, and area size of 28,253 ha.

The proximity of the mangrove forest ecosystems to the community encourages them to utilize mangrove wood, especially for charcoal production. In addition, the community also had limited alternative jobs due to the low level of education, making charcoal production a viable source of income (Miswadi 2017). The economic value estimation of charcoal was IDR 11,075,000,000/year, obtained from the multiplication of the number of the kiln (443 units), the net benefits from each pyrolysis process (IDR3,125,000/pyrolysis process), and the number of pyrolysis process/year (8 times/year). The charcoal yield from each pyrolysis process was 5 tons/pyrolysis process.

The existence of mangrove forest ecosystems could impact fisheries production by 30% (Rangkuti 2017). Participatory mangrove forest management that involves communities could facilitate synergy between business and conservation activities, such as developing crab (*Scylla serrata*) silvofishery (Paruntu et al. 2016). The yields of aquatic biota collection activities depended on seasons, such as the east season (May-June), south season (July-November), and west season (December-April). In the low tide season (Juli-November), fishermen can catch 5 kg of fish (*Rasbora sp*), 2 kg of shrimp (*Metapenaeus sp*), and 10 kg of crabs (*Scylla serrata*) in one working day, while in the high tide season (December-April), they can catch up to 20 kg each. The net economic value estimation of the fish, shrimp, and crab collection was IDR 19,445,400,000/year. Women carried out shellfish collection activities in groups. They collected shellfish from beaches adjacent to settlements and mangrove vegetation. The species collected are clams (*Anadara* sp), ale-ale (*Meretrix* sp), kepah (*Polymesoda* sp), tengkuyung (*Sulcospira testudinaria*), and snails (*Limnaea* sp). In one month, they collected shellfish eight times with an average yield of 50kg/one collection. The average selling price of shellfish was IDR 15,000/kg, and the production cost was IDR 2,050,000/month. The economic benefit estimation of shellfish collection was IDR 3,950,000/month or IDR 47,400,000/year. One KUPS cultivated crab (*Scylla serrata*) and swim bladder fish in Batu Ampar village using net pens of 17 m x 17 m for crab and 10 m x 10 m for swim bladder fish. The KUPS reported that this crab cultivation generated a total net economic value of IDR 229,200,000/year/net pen. Swim bladder fish cultivation generated a total net economic value of IDR 391,220,000/year/ net pen.

The honey collection from mangrove trees (*Rhizophora* sp) was uncommon in Unit XXXIIII Kubu Raya FMU. The economic value estimation of the honey collection was IDR 5,400,000/year, calculated by multiplying the net economic benefit (IDR 450,000/month), the collection frequency (1/month), and the number of months in a year. The yield was approximately 5 kg/collection, with revenue of IDR 650,000 and costs of IDR 200,000.

The SAMPAN NGO assisted one KUPS in producing crab crackers every week or four times a month with a production yield of about 12 kg per production. With the selling price at IDR 80,000/kg and production costs of ID R960,000/month, the net economic value generated was IDR 2,880,000/month or IDR 34,560,000/year.

The community around Unit XXXIIII Kubu Raya FMU also utilized the Nypa (*Nypa sp*) as raw material for making roofs. The Nypa roof production reached 600 pieces/month for 12 days/month. With a selling price of IDR 5,000/piece and a production cost of IDR 1,350,000/month, the net economic value was IDR 1,650,000/month or IDR 19,800,000/year.

Indirect Economic Value

The abrasion prevention economic value calculation involved the costs of establishing breakwaters construction along the coast protected by mangrove forest ecosystems. The calculation assumed that each 100-meter width of the mangrove forest ecosystem could reduce 60% or more inundation during high tides. The establishment and maintenance costs for 30 years of breakwater facilities in West Kalimantan Province was IDR 9,000,000,000/km (Bapedalda West Kalimantan Province 2012). The spatial analysis estimated around 14.52 km of the coastline for mangrove forest ecosystems in the research location. Therefore, the net economic value estimation of mangrove forest ecosystems to prevent abrasion was IDR 4,356,000,000/year.

The carbon stock estimates in mud substrates could become a reference in assessing the economic value of mangrove forest ecosystems as carbon sequesters (Purnomobasuki 2012). The carbon stock of the mangrove forest ecosystems in Unit XXXIIII Kubu Raya FMU was 72.16 tons/ha for 30 years or 2.41 tons/ha/year (LPP Mangrove 2008). The area of the mangrove forest ecosystems was 28,253 ha, and the carbon price in Europe in January 2020 was IDR 311,581/ton C. The Regency Minimum Wage (UMK) Index of Kubu Raya Regency was 1.44 compared to Pontianak City in 2021. The net economic value of the carbon stock of mangrove forest ecosystems was IDR30,550,271,274/year.

Mangrove forest ecosystems could produce oxygen of about 3.65 m^3/ha/year (Siregar 2012). The area of the mangrove forest ecosystem in the research location was 28,352 ha, producing 103,484.8 m^3/year of oxygen. The estimated price of oxygen in Kubu Raya District was IDR900,000/m^3, and the Regency Minimum Wage (UMK) Index of Kubu Raya Regency was 1.44 compared to Pontianak City in 2021. The economic value of the mangrove forest ecosystems as an oxygen producer was IDR 134,116,300,800/year.

The rice fields in Unit XXXIIII Kubu Raya FMU became the most vulnerable to decreased production due to seawater intrusion. Therefore, the decline in rice production could become a meaningful estimate of the economic value of mangrove forest ecosystems as seawater intrusion barriers. The average rice production before the seawater intrusion was 1.8 tons/ha/year and 0,64 tons/ha/year after the seawater intrusion. The size of the rice fields in the research location was 4.0 ha, and the prevailing rice price was IDR4,200/kg. The decrease in production was 4.64 tons/year, equivalent to IDR 19,488,000/year.

Optional Economic Value

The optional benefit value of biodiversity was estimated using the benefits transfer approach and values from previous research (Osmaleli 2014). Previous research reported an estimated optional value of US$27/ha/year for the Batu Ampar mangrove forest ecosystems (Jabbar 2021). With an ecosystem area of 28,253 ha and an IDR to the US$ exchange rate of IDR 14,356/US$, the net optional economic value was IDR 10,951,201,836/year.

Total Economic Value

The total economic value (TEV) calculation of the mangrove forest ecosystems (28.253 ha) in Unit XXXIII Kubu Raya FMU used two assumptions to calculate the total economic values: with and without timber utilization activities for charcoal production (Table 5). The calculation results indicated that the indirect economic value had the highest percentages compared to the direct and optional economic values in both assumptions (79.09% with charcoal production and 82.33% without charcoal production). Comparing the calculation with both assumptions was necessary because communities utilized mangrove wood for charcoal production during the

Table 5. The value of the total economic benefits of mangrove forest ecosystems with and without charcoal production

No	Types of Use	Values			
		With charcoal production		Without charcoal production	
		IDR/year	%	IDR/year	%
(1)	(2)	(5)	(6)	(3)	(4)
A	**Direct**				
	1. Timber	2,480,800,000	1.16%	15,151,934,550	2.51%
	2. Charcoal	11,075,000,000	5.18%		
	3. Fishing (fish, shrimp, crab)	19,445,400,000	9.10%	19,445,400,000	9.47%
	4. Fishing (shellfish)	47,400,000	0.02%	47,400,000	0.02%
	5. Aquaculture (crab)	229,200,000	0.11%	229,200,000	0.11%
	6. Aquaculture (fish)	391,220,000	0.18%	391,220,000	0.19%
	7. Honey	5,400,000	0.00%	5,400,000	0.00%
	8. Crab crackers	34,560,000	0.02%	34,560,000	0.02%
	9. Nypa roof	19,800,000	0.01%	19,800,000	0.01%
	Subtotal 1	**33,728,780,000**	**15.78%**	**25,324,914,550**	**12.33%**
B	**Indirect**				
	1. Abrasion prevention	4,356,000,000	2.04%	4,356,000,000	2.12%
	2. Carbon stock	30,550,271,274	14.29%	30,550,271,274	14.88%
	3. Oxygen production	134,116,300,800	62.75%	134,116,300,800	65.32%
	4. Intrusion barrier	19,488,000	0.01%	19,488,000	0.01%
	Subtotal 2	**169,042,060,074**	**79.09%**	**169,042,060,074**	**82.33%**
C	**Alternative**				
	Biodiversity	10,951,201,836	5.12%	10,951,201,83	5.33%
	Subtotal 3	**10,951,201,836**	**5.12%**	**610,951,201,836**	**5.33%**
	Total Economic Value	**213,722,041,910**	**100.00%**	**205,318,176,460**	**100.00%**

Source: Primary data analysis, 2021

field observation.

This indirect economic value in Unit XXXIII Kubu Raya FMU dominated the economic values of mangrove forest ecosystems. The management of Unit XXXIII Kubu Raya FMU and the communities should have optimally utilized this considerable potential of mangrove forest ecosystems. This result aligned with similar research showing that the indirect economic values contributed the most to the total economic values of the mangrove forest ecosystems in Indonesia (Siregar 2012, Rospita et al. 2017). The direct economic benefit value percentage ranged from 51.8% to 94% (Mangkay et al. 2013; Malik et al. 2015; Suharti et al. 2016; Rizal et al. 2018). However, the economic values obtained in this research might change due to changes in the types of utilization, especially the direct economic value (Setyowati 2016).

Conclusion

The total economic value calculation of the mangrove forest ecosystem in the protected forest of Unit XXXIII Kubu Raya FMU, with the size of 28,253 ha, used two assumptions to calculate the total economic values: with and without timber utilization activities for charcoal production. The total economic value with timber utilization activities for charcoal production was IDR 213,722,041,910/year or IDR 7,564,579/ha/year with a direct benefit value of IDR 33,728,780,000 (15.78%), indirect benefit value of IDR 169,042,060,074 (79.09%), and optional benefit value of IDR 10,951,201,836 (5.12%). The total economic value without timber utilization activities for charcoal production was IDR 205,318,176,460/year or IDR 6,843,939,215,33/ha/year with a direct benefit value of IDR 25,324,914,550 (12.33%), indirect benefit value of IDR 169,042,060,074 (82.33%), and optional benefit value of IDR 10,951,201,836 (5.33%).

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