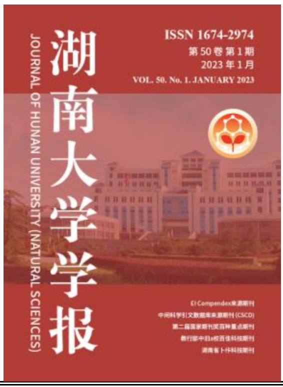

湖南大学学报（自然科学版）
Journal of Hunan University (Natural Sciences)

第 50 卷 第 1 期
2 0 2 3 年 1 月

Available online at http://jonuns.com/index.php/journal/index

Vol. 50 No. 1
January 2023

Open Access Article https://doi.org/10.55463/issn.1674-2974.50.1.16

Economic Valuation of Mangrove Ecosystem Services in Sembilang National Park of South Sumatra, Indonesia

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Received: December 27, 2022 / Revised: January 17, 2023 / Accepted: January 23, 2023 / Published: February 28, 2023

Abstract: An ecosystem services valuation could provide significant improvements for the policy maker to monitor the mangrove ecosystem changes in coastal ecosystems. Therefore, this study aimed to measure the value of ecosystem service in Sembilang National Park (NSP), Banyuasin District, South Sumatra, Indonesia. Data collection used questionnaires and in-depth interviews with the target respondents being fishermen, farmers, and stakeholders who live in the mangrove ecosystem area. The total economic value (TEV) was used as an approach for calculating the various values of the mangrove services. Several methods have been developed to estimate the ecosystem services value. In this study, the market price method, benefits transfer method, replacement method, and travel cost method were applied to estimate the benefit value for provisioning, regulating, supporting, and cultural services. The result showed that the TEV of mangrove ecosystem services with an area of 88,556 ha was IDR 6,961,126,186,194 year^{-1} (US$ 467,974,555.06 year^{-1}) or IDR 78,607,444 ha^{-1}year^{-1} (US$ 5,284.5 ha^{-1}year^{-1}). The annual benefit values for provisioning, regulating, supporting, and cultural services were IDR 267,301,712,200, IDR 6,401,520,094,447, IDR 292,120,962,048, and IDR 183,417,500, respectively. The benefit value of regulating services (coastline protection and carbon sequestration) dominated the TEV of mangrove ecosystems in the SNP. To avoid the lost value of these mangrove services, conservation and restoration should receive a high priority in mangrove management and planning in the future. These research results could be used as baseline data for local governments in managing mangrove ecosystems through the establishment of a mangrove working group in South Sumatra Province. Therefore, the novelty of this research resided in the first economic valuation in the SNP using the TEV approach, as illustrated.

Keywords: cultural services, mangrove, provisioning services, regulating services, supporting services.

印度尼西亞南蘇門答臘森美蘭國家公園紅樹林生態系統服務的經濟估值

摘要: 生態系統服務估值可以為決策者提供顯著改進，以監測沿海生態系統中紅樹林生態系統的變化。因此，本研究旨在衡量印度尼西亞南蘇門答臘 Banyuasin 區森美蘭國家公園

The original article is derived from the ongoing doctoral project in Sriwijaya University.

(NSP)生態系統服務的價值。數據收集使用問卷調查和深入訪談，目標受訪者是居住在紅樹林生態系統地區的漁民、農民和利益相關者。總經濟價值(TEV)被用作計算紅樹林服務的各種價值的方法。已經開發了幾種方法來估算生態系統服務的價值。在本研究中，應用市場價格法、利益轉移法、替代法和旅行成本法來估算供應、調節、支持和文化服務的利益價值。結果顯示，面積為 88,556 哈的紅樹林生態系統服務的 TEV 為印尼盾 6,961,126,186,194 年-1（我们$467,974,555.06 年-1）或印尼盾 78,607,444 哈-1 年-1（我们$ 5,284.5 哈-1 年- 1). 供應、調節、支持和文化服務的年度效益價值分別為 267,301,712,200 印尼盾、6,401,520,094,447 印尼盾、292,120,962,048 印尼盾和 183,417,500 印尼盾。調節服務（海岸線保護和碳封存）的效益價值主導了单核苷酸多态性中紅樹林生態系統的 TEV。為了避免失去這些紅樹林服務的價值，保護和恢復應該在未來的紅樹林管理和規劃中得到高度重視。這項研究的結果可以作為地方政府通過在南蘇門答臘省建立紅樹林工作組來管理紅樹林生態系統的基線數據。因此，本研究的新穎之處在於使用如圖所示的 TEV 方法對单核苷酸多态性進行首次經濟估值。
关键词: 文化服務、紅樹林、供給服務、調節服務、支持服務。

1. Introduction

Sembilang National Park (SNP) is a conservation area of approximately 267,592.42 ha and has the largest mangrove in the western part of Indonesia. The SNP also supports lowland tropical forests, coastal forests, peatlands, and swamps. This park also plays an important role in preserving and supporting the sustainable local use of natural resources [1]. Various of these endangered species are also found at this location such as Malayan Giant Turtle (*Orlitia borneensis*), Indian Elephant (*Elephas maximus*), Storm's Stork (*Ciconia stormi*), and Sumatran Tiger (*Panthera tigris sumatrae*). Sightings of Irrawaddy Dolphins were recorded in the waters around the SNP [2]. The mangrove area in the SNP is a potential habitat for the Asian horseshoe crab a protected marine biota under the Indonesian government [3]-[5].

Mangrove ecosystems provide various valuable services for human well-being such as regulating (water, climate, and natural regulations), provisioning (timber, firewood, charcoal, fiber, and freshwater), habitat (biodiversity, spawning, breeding, and nursery habitat), and cultural (recreation, ecotourism, aesthetic, spiritual and historical information) services [6]-[8]. The term ecosystem services was popularized by the Millennium Ecosystem Assessment [6]. All these services can be expressed through the estimated valu; conversely, they will remain hidden or unappreciated when unrevealed [9]. In other words, mangrove ecosystems are highly potential resources for human well-being and encourage to be massively exploited so these ecosystems are also very vulnerable. Most of the threats to mangrove ecosystems are due to high anthropogenic pressures [10] such as deforestation, overexploitation of natural resources, mining, conversion to other land uses (salt and aquaculture ponds), industrial, and pollution.

However, the mangrove ecosystem services are usually undervalued due to the value of unmarketable services and the difficulty in estimating this value [10]-[11]. In terms of conservation decision-making, knowledge of mangrove ecosystem services remains important [8], [10], [12]. In other words, the lack of understanding and awareness of the values of mangrove ecosystem services can be contributed to ignoring these services' values in decision-making.

Generally, there had been an assessment of the economic valuation for the mangrove ecosystem in several regions of Indonesia, such as in Sungai Apit District, Riau Province [13], Taman Ayu Village, West Lombok Regency [14], Youtefa bay, Jayapura [15], Lansa Mangrove Forest, North Sulawesi [9], and Taman Hutan Raya Ngurah Rai, Bali [16]. Nonetheless, the economic values of mangrove ecosystem services in the SNP of South Sumatra have not been estimated. This research aims to estimate the economic value of mangrove ecosystem services in the SNP, South Sumatra, Indonesia. The results are expected to be used as considered essential for making policy decisions regarding sustainable mangrove management.

2. Materials and Methods

2.1. Study Area

This study was conducted at the SNP located in the Banyuasin coastal waters, South Sumatra, Indonesia (104˚11'-104˚57'E and 01˚38'- 02˚28'S) over the period 2020–2021. The map of the study area is presented in Figure 1.

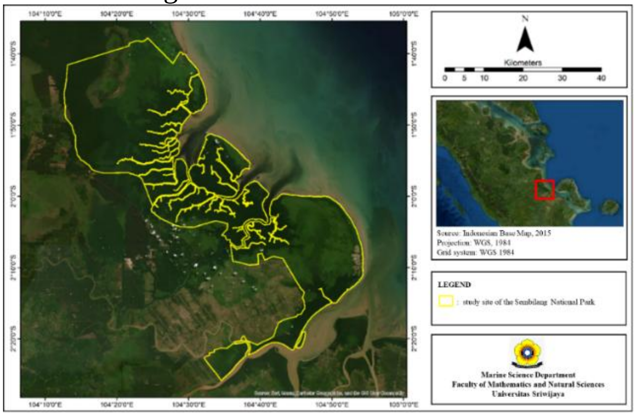

Fig. 1 Study sites of mangrove economic evaluation in Sembilang National Park, South Sumatra, Indonesia

2.2. Data Collection

This study used the desk study and survey methods for collecting secondary and primary data. Secondary data were obtained from the related government departments, scientific publications, and other related data. Primary data were collected directly through direct observation, and interviews with respondents referring to a questionnaire prepared. The respondents (70 respondents) were determined using the methods of Harry King's Nomogram based on 398 household populations with a 10% of error. The respondents represented fishermen, farmers, and stakeholders who resided around mangrove ecosystem areas that represented the direct or indirect beneficiaries.

2.3. Data Analysis

The economic valuation of mangrove ecosystem services was obtained from the assessment of four mangrove ecosystem services namely, provisioning, regulating, supporting, and cultural services [6]. Various analytical methods were used, including the market price method, benefits transfer method, replacement method, and travel cost method.

2.3.1. Provisioning Services

In this analysis, provisioning services were obtained from the benefits value of the mangrove forest products (wood, firewood, honey, and palm leaves), the benefit value of fishery products (fishing and aquaculture), and the benefit value of medicine plants. Both values of fisheries and mangrove products were estimated using market prices [9], whereas the value of the medicine plants was estimated using the benefits transfer method [11]. The calculation formula for the provisioning services is as follows [17]:

$$PS = \sum_{i=1}^{3} PSi \tag{1}$$

$$PS_i = \sum_{i=1}^{s} (Y_i . P_i) - C_i \tag{2}$$

where PS is provisioning services (IDR year^{-1}), PS_1 is the benefit value of mangrove forest products (IDR year^{-1}), PS_2 is the benefits value of fishery products, PS_3 is the benefits value of medicine plants from the mangrove forest, Y_i is the yield of product (kg year^{-1}), P_i is the market price of product i (IDR kg^{-1}), and C_i is the investment cost of products i (IDR year^{-1}).

In terms of the benefit transfer method, established values from past research were used as estimation for new research at other sites, and the time gaps were corrected using an adjustment to the exchange rate or inflation index. Because of money changes over time due to an inflation rate, the compound interest method was used to estimate the current value of money [18]. The medicinal plant value from the mangrove ecosystem in the SNP was estimated from Malik's research [19] in the Takalar district, South Sulawesi (US$ 157 ha^{-1} year^{-1}). The Consumer Price Index (CPI) data were commonly used to convert past values to current values using the following formula [20]:

$$V_c = V_r \left(\frac{CPI_c}{CPI_r}\right) \tag{3}$$

where V_c is the current value (IDR ha^{-1}year^{-1}), V_r is the reference value from the previous study (IDR ha^{-1}year^{-1}), CPI_c is CPI in the current year, and CPI_r is CPI in the reference year.

To estimate the total current value in this study, the current value from the previous study needs to be adjusted to the mangrove area and the proportion of Minimum Wage (MW) between the study location (district) and the reference district/city [18]. The calculation formula is as follows:

$$SS_i = V_c \; x \; M \; x \; \frac{MW_s}{MW_r} \tag{4}$$

where SS_i is the total current value for medical or mangrove biodiversity in SNP per year, M is the mangrove area (Ha), MW_r is Minimum Wage in the reference District/City (IDR), and MW_s is Minimum Wage in the Banyuasin District (IDR).

2.3.2. Regulating Services

These services were obtained from the economic value of mangroves as coastline protection and carbon storage. Both values were estimated using the benefit transfer method. The coastline protection value was estimated by converting the coastline length and the construction cost of the sea dike under the Minister of Public Works and Public Housing Regulation Number 1/PRT/M/2022. Most of the sea dikes were classified as level 2 constructions with an economic life of 20 years

[21]. This regulation was IDR 413,151 per meter per year. While the reference value of the global carbon market (voluntary markets) in 2021 was US$ 6 per ton of CO2e [22]. The calculation formula is as follows [17]:

$$RS = \sum_{i=1}^{2} RSi \tag{5}$$

$$RS_1 = CL.\left(\frac{C_{SD}}{EL}\right) \tag{6}$$

$$RS_2 = CS_r.A_m.P_r \tag{7}$$

where RS is regulating services (IDR year^{-1}), RS_1 is the benefit value of coastline protection (IDR year^{-1}), RS_2 is the benefit value of carbon sequestration, CL is coastline length (m), C_{SD} is the reference cost of sea dike construction (IDR m$_{-1}$ year^{-1}), EL is the economic life of sea dike construction (years), CS_r is the carbon sequestration rate (ton^{-1} ha^{-1}), Am is the total mangrove area (ha), and P_r is the reference price of the global carbon market (USD ton^{-1} CO2e).

To calculate the coastline protection services, equations (3) and (4) were used to justify the price of the sea dike construction in the Banyuasin District in 2022. Equation (3) was used to justify the price of the carbon market in the Banyuasin District (Indonesia) in 2022.

2.3.3. Supporting Services

Due to the limited data available, the value of the supporting service was estimated only from the biodiversity value and the feeding, nursery, and spawning ground value of the mangrove ecosystem. The benefit transfer method was applied to estimating both values. The calculation formula is as follows:

$$SS = \sum_{i=1}^{2} SSi \tag{8}$$

$$SS_1 = A_m.P_{r1} \tag{9}$$

$$SS_2 = A_m.P_{r2} \tag{10}$$

where SS is supporting services, SS_1 is the benefit value from mangrove biodiversity (IDR year^{-1}), SS_2 is the benefit value from the feeding, nursery, and spawning ground (IDR year^{-1}), A_m is the total mangrove area (ha), and P_{r1} is the reference value of the mangrove biodiversity (USD ha^{-1} year^{-1}), and P_{r2} is the reference value of the feeding, nursery, and spawning ground (IDR ha^{-1} year^{-1}).

The biodiversity value (equation 9) was estimated by referring to the mangrove biodiversity value of Ruitenbeek's research in the Bintuni Bay (West Papua) in 1992, which reached US$ 15 ha^{-1}year^{-1}[23]. Whereas the reference value from the feeding, nursery, and spawning ground (equation 10) was based on Maulida's research in Pekalongan City in 2019 that reached IDR 2,068,478 15 ha^{-1}year^{-1}[24]. To estimate this service, equations (3) and (4) were used to justify the price of the mangrove biodiversity in the Banyuasin District in 2022.

2.3.4. Cultural Services

These services were estimated using the travel cost method by calculating transportation costs, consumption, entrance tickets, and other expenses [25]. The calculation formula is as follows:

$$CS = \sum_{i=1}^{5} TCi \tag{11}$$

where CS is cultural services, TC_1 is the entrance ticket cost (IDR year^{-1}), TC_2 is the tour guide cost (IDR year^{-1}), TC_3 is the transportation cost (IDR year^{-1}), TC_4 is the consumption cost (IDR year^{-1}), and TC_5 is the accommodation and other cost (IDR year^{-1}).

2.3.5. Total Economic Value (TEV)

The TEV represented the amount of all economic values obtained from the various services of the mangrove ecosystem [26]. The calculation formula is as follows:

$$TEV = \sum_{i=1}^{4} S_i \tag{12}$$

where S_i represents the estimated value of each mangrove service (provisioning, regulating, supporting, and cultural services).

3. Results

In this study, seven services of mangrove distributed into 4 categories were evaluated, namely: (1) provisioning services, such as fisheries products forest products, and medicine value; (2) regulating services such as shoreline protection and carbon sequestration value; (3) supporting services, such as biodiversity value and the feeding, nursery, and spawning ground value; and (4) cultural services such as recreation value. The overall economic value of mangrove services in SNP that has been evaluated as follows.

3.1. Provisioning Services

The economic value of the provisioning services (Table 1) was IDR. 233,975,319,350 per year (equivalent to US$ 17,969,851 on August 31, 2022) consisting of fishery products (IDR 33,235,782,850 per year), forest products (IDR 90,610,000 per year), and medicine value (IDR 233,975,319,350 per year). Seven fisheries products were categorized as the provisioning service in the SNP, which consists of 5 fishing products (fish, bivalve, mantis, shrimp, crab) and 2 aquaculture products (blood cockle and milkfish). Timber, firewood, Nipa palm crafting, and honey, including medicinal plants were also available from provisioning services of the mangrove ecosystem in the SNP. Medicine's value generated the largest contribution to this service. The highest fisheries product value was obtained from the milkfish harvests, while the mangrove timber had the highest contribution to the forest product value.

Table 1 Provisioning services of the mangrove ecosystem in Sembilang National Park (SNP), Banyuasin District, South Sumatra, Indonesia (Developed by the authors)

Description	Value
A. Fisheries products (PS1)	
Fish catch	817,835,000
Bivalve catch	636,040,000
Mantis catch	963,720,000
Shrimp catch	587,000,000
Crab catch	609,830,000
Blood cockle culture	179,250,000
Milkfish culture	29,442,107,850
Total PS1	33,235,782,850
B. Forest Products (PS2)	
Timber	49,450,000
Firewood	14,520,000
Nypa palm crafting	10,640,000
Honey	16,000,000
Total PS2	90,610,000
C. Medicine (PS3)	
Mangrove Forest Area of SNP (Ha)	88,556
Minimum Wage of the Banyuasin District in 2022	3,194,895
Exchange Rate on August 31, 2022 (1 US$ = IDR)	14,875
Medicines value of SNP in 2022 (US$ per ha per year)	181
Medicine value of SNP in 2022 (IDR per ha per year)	2,642,130
Total medicine value of SNP in 2022 (US$ per year)	16,014,738
Total medicine value of SNP in 2022 (IDR per year)	233,975,319,350
Total PS3	233,975,319,350
D. Provisioning service value (PS1 + PS2 + PS3)	267,301,712,200*

* Equivalent to US$ 17,969,851 as of August 31, 2022

3.2. Regulating Services

The calculated economic value of regulating services (Table 2) reached IDR 6,401,520,094,447 per year (equivalent to US$ 430,354,003 on August 31, 2022). This value was obtained from the coastline protection services and carbon sequestration services, which reached IDR 36,618,827,259 per year and IDR 6,364,901,267,188 per year, respectively. In other words, the largest contribution of the regulating services resulted from carbon sequestration services. The total estimated carbon sequestration was generated from both the amount of carbon stock in the mangrove stand (478.43 ton MgCO2 per ha) and soil carbon (253 ton MgCO2 per ha). Additionally, adjusting the construction price of the sea dike in the Banyuasin District for the current value reached IDR 351,756 per m with a larger foundation of 1.5 m in width and a total sea dike height of 3.5 m.

Table 2 Regulating services of the mangrove ecosystem in Sembilang National Park (SNP), Banyuasin District, South Sumatra, Indonesia (Developed by the authors)

Description	Value
A. Coastline protection (RS1)	
The reference price of the sea dike construction the Minister of Public Works and Public Housing Regulation Number 1/PRT/M/2022 (IDR per m)	413,151
The price of the sea dike construction at the Banyuasin District in 2022 (IDR per m)	351,756
The coastline of SNP (m)	104,103
The estimated value of the sea dike construction at SNP in 2022 (IDR per m)	36,618,827,259
Total RS1	36,618,827,259
B. Carbon sequestration	
Soil carbon (ton $MgCO_2$ per ha)	253.00
Carbon stock (ton $MgCO_2$ per ha)	478.43
The total area of mangrove (ha)	88,556
Price of the global carbon market in 2021 (US$ per ton per ha) **	6
CPI in 2010 for the United States	114.33
CPI in August 2022 for the United States	125.88
Price of the global carbon market in 2022 (US$ per ton per ha)	6.61
The exchange rate on August 31, 2022 (1 US$ = IDR)	14,875
Price of the global carbon market in 2022 (IDR per ton per ha)	98,266
The total value of carbon sequestration (IDR per year)	6,364,901,267,188
Total RS2	6,364,901,267,188
C. The total value of regulating services (RS1 + RS2)	6,401,520,094,447*

* Equivalent to US$ 430,354,003 as of August 31, 2022; ** [22]

3.3. Supporting Services

The supporting service values obtained from this study are shown in Table 3. This service value was assumed to be equivalent to the benefit value generated from the mangrove biodiversity and the feeding, nursery, and spawning ground. The total benefit value of supporting services reached IDR 292,120,962,048 per year (equivalent to US$ 19,638,371 on August 31, 2022). The benefit values of both the mangrove biodiversity and the feeding, nursery, and spawning ground were IDR 27,120,474,004 per year and IDR 265,000,488,044 per year. Accordingly, the feeding, nursery, and spawning ground had the largest contribution to the supporting services.

Table 3 Supporting services of the mangrove ecosystem in Sembilang National Park (SNP), Banyuasin District, South Sumatra, Indonesia (Developed by the authors)

Description	Value
A. Mangrove Biodiversity Value (SS1)	
Price of the mangrove biodiversity in the Banyuasin District in 2022 (IDR per ha per year)	306,254
Mangrove Forest Area of SNP (Ha)	88,556
Exchange Rate in 2022 (1 US$ = IDR)	14,875
Price of the mangrove biodiversity in the Banyuasin District in 2022 (US$ per ha per year)	21
Biodiversity value of SNP in 2022 (US$ per year)	1,823,224
Biodiversity value of SNP in 2022 (IDRper year)	27,120,474,004
Total SS1	27,120,474,004
B. Feeding, nursery, and spawning ground value (SS2)	
The estimated value of feeding, nursery, and spawning ground in the Banyuasin District in 2022 (IDR per ha per year)	2,992,477
Mangrove Forest Area of SNP (Ha)	88,556
The total value of feeding, nursery, and spawning ground in the SNP in 2022 (US$ per year)	17,815,147
The total value of feeding, nursery, and spawning ground in the SNP in 2022 (IDR per year)	265,000,488,044
Total SS2	265,000,488,044
C. Supporting service value (SS1+SS2)	292,120,962,048*

* Equivalent to US$ 19,638,371 as of August 31, 2022

3.4. Cultural Services

In this study, the benefit values of the cultural service were estimated only from tourism services (Table 4). This service value was assumed to be equivalent to the benefit value generated from the travel cost including entrance tickets (IDR 8,025,000 year^{-1}), tour guide (16,650,000 IDR year^{-1}), transportation cost (IDR 101,900,000 year^{-1}), consumption cost (IDR 28,467,500 year^{-1}), as well as accommodation and other cost (IDR 28,375,000 year^{-1}). Accordingly, the total benefit value of the cultural services reached IDR 183,417,500 year^{-1} or equivalent to US$ 12,331 year^{-1} on August 31, 2022. The number of visitors per year was assumed to be equal to the visitor's data based on the Conservation Area Entrance Permits in the SNP during 2019, which reached 167 visitors (160 domestic and 7 foreign visitors). Transportation costs are calculated from Palembang City to the SNP site by car and boat rental. The total travel cost incurred per visitor to the SNP was IDR 1,098,308 (US$ 74 per visitor).

Table 4 Cultural services of the mangrove ecosystem in Sembilang National Park (SNP), Banyuasin District, South Sumatra, Indonesia (Developed by the authors)

Description	Value (IDR per year)
Entrance tickets	8,025,000
Tour guide	16,650,000
Transportation	101,900,000
Consumption	28,467,500
Accommodation and other	28,375,000
Total CS	183,417,500*

* Equivalent to US$ 12,331 as of August 31, 2022

3.5. Total Economic Value (TEV)

The TEV annually obtained from this study was IDR 6,961,126,186,194 or equal to US$ 467,974,555.06 (Table 5). The TEV annually, which covers 88,556 ha, reached IDR 78,607,444 per ha or equal to US$ 5,284.5 per ha. The highest contribution of the TEV came from the benefit value of regulating services (91.96 %). In contrast, the cultural services had the lowest contribution to the TEV of mangrove services (<0.01%). The benefits value of provisioning services accounted for 3.84 % of the TEV whereas the benefits value of supporting services accounted for 4.20 % of the TEV of mangrove services.

Table 5 The total economic value (TEV) of the mangrove ecosystem in Sembilang National Park (SNP), Banyuasin District, South Sumatra, Indonesia

Economic value	Value in the Indonesian rupiah	
	IDR/ha/year	IDR/year
Provisioning services	3,018,463	267,301,712,200
Regulating Services	72,288,178	6,401,520,094,447
Supporting Services	3,298,731	292,120,962,048

Economic value	Value in the Indonesian rupiah	
	IDR/ha/year	IDR/year
Cultural service	2,071	183,417,500
Total	78,607,444*	6,961,126,186,194 **

* Equivalent to US$ 5,284.5 as of August 31, 2022
** Equivalent to US$ 467,974,555.06 on August 31, 2022

4. Discussion

The total benefit values obtained from the mangrove ecosystem in the SNP (South Sumatra, Indonesia) were enormous. Even though some value benefits are not estimated (such as biochemical products, genetic resources, freshwater supply, nutrient cycling, water filtration, as well as spiritual and aesthetic value), the annual TEV resulting from this study was almost five hundred million US dollars per year (significantly higher than the GDP value of South Sumatra Province in 2021). The enormous value of benefits provided by mangrove services for the local communities would be lost when the mangrove ecosystem was destructed. In contrast, these benefits would be sustainable if this ecosystem could be maintained and used responsibly.

Due to the mangrove ecosystem in the SNP being close to the coast, these mangroves will be highly valuable to coastline protection (regulating services) compared to inland mangroves. The results of this study also highlighted that regulating services (the benefits value of coastline protection and carbon sequestration) dominated the TEV of mangrove ecosystems in the SNP. Regulating services are one of the ecosystem services which not be perceived directly by the local community but have enormous value benefits [17], even though most of them are not traded in the market. The conversion of mangrove areas into aquaculture ponds and the irresponsible harvesting of mangrove trees (provisioning services) can seriously threaten the mangrove ability in providing coastal protection services (regulatory services) in the future. The same value was also obtained from research in Sungai Apit, Riau, especially from the value of carbon sinks [13]. The potential for mangrove conservation and restoration to reduce emissions achieve approximately 8% of the 2030 Indonesia Nationally Determined Contribution target from the forestry sector [27]. Additionally, Southeast Asia has the greatest opportunities for blue carbon programs [28].

The TEV annually per ha in this study reached IDR 78,607,444 less than the mangrove valuation in Tanakeke Island of South Sulawesi [29] and Mandah district of Riau [17], In contrast, this TEV was greater than the mangrove valuation in Youtefa bay of Papua [15]. The difference in valuation value was due to differences in the time study, characteristics of the study location, valuation method, and limited data to evaluate all mangrove ecosystem services. Differences in the assessed ecosystem services, the applied valuation technique, as well as the socioeconomic and cultural contexts caused differences in economic values [30]. These findings indicated a significant contribution to the authorities, especially regarding the importance of mangrove ecosystem services for the people's well-being around the NSP and in general, also contributed to mangrove conservation and restoration. Integrating human livelihood requirements in a way that balances conservation goals can provide solutions that lead to the long-term sustainability of mangroves worldwide [31]

For non-economic reasons, preserving the mangrove ecosystem sustainability for supporting marine and coastal biodiversity is important. Finally, it will provis livelihoods and income for local people [32]. SNP is a unique conservation area because some people have been inhibited for a long time before this area was designated as a National Park. The community generally works as fishermen, cultivators, traders, and farmers [33]. Among fishery products (provisioning services), milkfish yields resulted in the highest economic value. Unfortunately, land conflicts due to the mangrove conversion into an aquaculture pond also occurred. In this context, conflict resolution can be carried out by relocating the community from the forest area (resettlement) to the village of origin as well as establishing cooperation between the park authority and the community to restore the conservation area [34]. Other fishery products, which are the main livelihood of fishermen, will continue to generate income if fishing efforts can be controlled to ensure these fish resources' sustainability [35]. However, it is necessary to increase ecotourism as part of the cultural services (contributing < 0.01%), especially in the usage zone as part of the SNP management plan. This condition is supported by the mangrove areas in SNP, which are still well-preserved [36]. Economically, the TEV is encouraged to efforts for balancing economic demands and environmental sustainability [32].

Overall, the research results reveal an important contribution to the management of coastal ecosystem services, particularly the economic valuation of mangrove ecosystem services to local communities around the SNP. Additionally, the results are also expected to provide more awareness to policy decision-makers in the context of ecosystem values and as input for objective and rational decision-making [26].

During the 2021–2024 period, systematic and long-term restoration of mangrove ecosystems has been initiated by the National Agency for Peatland and Mangrove Restoration in collaboration with the Ministry of Marine Affairs and Fisheries as well as the Coordinating Ministry of Maritime Affairs and Investment [26]. For management, restoration, and policy processes at the provincial level of South Sumatra, a Regional Mangrove Working Group has been established. Thus, this study will be very helpful as basic information on mangrove conservation management.

5. Conclusion

This study result estimated the current TEV to the local people around the SNP amounting to IDR 6,961,126,186,194 (US$ 467,974,555.06) year^{-1} or IDR 78,607,444 (US$ 5,284.5) ha^{-1} year^{-1}. Thus, this study demonstrated the highly significant value of mangrove services for the local communities, especially from regulatory services. Increased government participation and strengthening of local communities are urgently needed to maintain the status of conservation areas in providing ecosystem services that impact the welfare of local communities. Additionally, the mangroves in the SNP are also critical for people outside the SNP area. It should be noticed that conservation and restoration should receive a high priority in mangrove management and planning in the future. These results will greatly contribute to the local government, which is currently establishing a regional mangrove working group of the South Sumatra Province and can also be used as baseline data for formulating policies, strategies, programs, and performance indicators for mangrove ecosystem management. Therefore, the novelty of this research resided in the first economic valuation in the SNP using the TEV approach, as illustrated.

Acknowledgments

This original manuscript was supported by Sriwijaya University [No: 0687/UN9/SK.BUK.KP/2020; 0010/UN9/SK.LP2M.PT/2021; and 0109/UN9.3.1/SK/2022]. We express our special appreciation to Mr. Affan Absori, S.T, M.M, Mr. Alex Ridwan from Berbak Sembilang National Park Agency, Mr. Ardani, Mr. Badrun, Banyuasin Team 2020, and Banyuasin Team 2021, especially Ashraffi and Viona, for supporting our research. We would also thank the editor and reviewers for their valuable comments and suggestions to improve our manuscript.

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