BIODIVERSITAS
Volume 24, Number 10, October 2023
Pages: 5808-5819

ISSN: 1412-033X
E-ISSN: 2085-4722
DOI: 10.13057/biodiv/d241063

Carrying capacity of mangrove ecotourism area in Pantai Indah Kapuk, North Jakarta, Indonesia

KEVIN EWALDO[1], MAHAWAN KARUNIASA[1,♥], NOVERITA DIAN TAKARINA[2]

[1]School of Environmental Science, Universitas Indonesia. Jl. Salemba Raya 4, Central Jakarta 10430, Jakarta, Indonesia. Tel.: +62-21-31930251, ♥email: mahawancac@yahoo.com

[2]Department of Biology, Faculty of Mathematics and Natural Sciences, Universitas Indonesia. Jl. Prof. Dr. Sudjono D. Pusponegoro, Kampus UI, Depok 16424, West Java, Indonesia

Manuscript received: 31 July 2023. Revision accepted: 31 October 2023.

Abstract. *Ewaldo K, Karuniasa M, Takarina ND. 2023. Carrying capacity of mangrove ecotourism area in Pantai Indah Kapuk, North Jakarta, Indonesia. Biodiversitas 24: 5808-5819.* Mangroves are crucial in providing various ecological and economic benefits to local communities. This study focuses on the economic aspect of mangroves by analyzing their potential as a tourist attraction in the Mangrove Ecotourism, Pantai Indah Kapuk (PIK). The objective of this study is to analyze the carrying capacity of the mangroves as a tourist attraction to ensure sustainable tourism development. The study was conducted in the Mangrove Ecotourism area, Pantai Indah Kapuk, from January to March 2023, utilizing a quantitative approach. The carrying capacity of the mangrove ecosystem was assessed using the Physical Carrying Capacity (PCC), Real Carrying Capacity (RCC), and Effective Carrying Capacity (ECC) methods. The calculated values for PCC, RCC, and ECC were 107, 16, and 313 visitors/day, respectively. The analysis revealed that the number of visitors at the PIK Mangrove Ecotourism in 2022 had exceeded the PCC and RCC limits, indicating potential ecological impacts. However, the number of visitors had remained within the ECC limits, suggesting that with proper management, the site could accommodate the current visitor levels sustainably. To achieve long-term sustainability, several initiatives are recommended, such as creating zoning in tourist areas to distribute visitor pressure, increasing the number of field officers to monitor the site, and implementing an online ordering system to manage visitor flow efficiently. The findings of this study contribute to the understanding of the carrying capacity concept in ecotourism and provide valuable insights for the management and conservation of mangrove ecosystems as tourist attractions.

Keywords: Carrying capacity, Jakarta, mangrove, sustainable tourism

INTRODUCTION

Mangrove forests are unique coastal plant formations in tropical and subtropical regions, playing a crucial role in the ecosystem's balance (Dang et al. 2020; Sahana et al. 2022; Subramanian et al. 2023). These ecosystems offer a range of ecosystem services that benefit both nature and human communities. These services include provisioning, regulating, supporting, and cultural aspects (Yuliana et al. 2019; Onyena and Sam 2020; Hattam et al. 2021; Suwanto et al. 2021; Edwin-wosu and Dirisu 2022; Palit et al. 2022).

Concerning cultural services, mangroves offer opportunities for recreation, tourism, and environmental education (Moore et al. 2022; Bimrah et al. 2022). Their unique characteristics, such as growing in waterlogged areas and their distinctive aerial roots extending toward the land, make them fascinating. The aesthetic appeal of mangroves significantly enhances tourism activities, bringing substantial economic benefits (Vallecillo et al. 2019; Baskent 2020; Abubakar et al. 2022). Therefore, to ensure the sustainability of mangrove ecosystems, a comprehensive consideration of both ecological and ecosystem aspects is imperative to foster sustainable mangrove tourism.

Globally, the mangrove area is estimated to reach 14.8 million hectares with Indonesia hosting a substantial portion of 3,364,080 hectares (FAO 2020; Ministry of Environment and Forestry 2020). Unfortunately, these vital ecosystems are under constant threat, with the global mangrove area shrinking by approximately 1.04 million hectares from 1990 to 2020 (FAO 2020). Therefore, safeguarding the sustainability of these vital mangrove ecosystems necessitates careful consideration of both ecological and ecosystem aspects, especially in the context of fostering sustainable mangrove tourism.

The Muara Angke Mangrove Forest in Jakarta Province is an example of such an ecosystem. This forest, part of the broader forested area in Jakarta, serves as both a conservation area and a tourism destination, particularly the Mangrove Ecotourism site within Pantai Indah Kapuk. A by Sofian et al. (2020) revealed that in 2018, this mangrove ecosystem suffered from land conversion (272.79 hectares), indicating its degradation. In response, the local government is actively developing the area into a well-structured and sustainable tourist destination to preserve these ecosystems while harnessing their potential for responsible and sustainable tourism.

To achieve sustainable mangrove tourism, it is crucial to consider the carrying capacity of the mangrove ecotourism site (Soria-Díaz et al. 2022). Carrying capacity is fundamental guide for systematically managing tourism activities to minimize negative impacts (Zekan et al. 2022). It includes physical, real, and effective carrying capacities,

emphasizing management capacity (Zacarias et al. 2011; Adrianto et al. 2021; Soria-Díaz et al. 2022). Management capacity focuses on the capability of tourist attraction managers to regulate tourism effectively and maintain sustainable visitor numbers. By adhering to the principles of sustainable tourism, we can provide memorable experiences for tourists and significantly contribute to the preservation of mangrove ecosystems and the rich diversity of flora and fauna they encompass (Forje et al. 2021; Jurkus et al. 2022). Sustainable tourism practices are essential to ensuring these valuable ecosystems thrive for generations to come.

Developing mangrove forests as tourist attractions offers promising solution to address ecosystem degradation, as highlighted in previous studies (Sukuryadi et al. 2020; Purnomo et al. 2022). The post-COVID-19 landscape presents an opportunity for a surge in visitors to natural tourism destinations, known as 'Revenge Travel' (Wang and Xia 2022). In light of the circumstances, it is essential to investigate the carrying capacity of mangrove tourism, which involves determining the optimal number of visitors to maintain the well-being of these ecosystems.

Although a previous study focused on the carrying capacity of mangrove tourism at Mangrove Angke Natural Park, it was limited to the Angke Kapuk Nature Tourism Park in North Jakarta (Eviana and Yusrini 2020). While both sites are part of the North Jakarta mangrove ecosystem, they differ in several aspects, including land area, forest area designation, responsible authorities, and tourism site management. Despite these differences, both are highly popular tourist destinations with significant visitor numbers. Extensive research has been conducted on tourism in the Angke Kapuk Nature Tourism Park, but there is a gap in our understanding of the Mangrove Ecotourism Area. To address this gap, this study focuses on the Mangrove Ecotourism Area, Education Center, Pantai Indah Kapuk. The difference of this study is analyzing the carrying capacity of mangrove tourism by considering its physical characteristics and data collection conducted after the COVID-19 pandemic. This study can offer a more precise understanding of the sustainable tourism capacity of mangrove ecosystems in a post-pandemic scenario, provide recommendations for tourism development after a pandemic, and act as a reference in determining future tourism policies. The novelty of this study is developing the concept of sustainable mangrove tourism after the pandemic. This study aims to analyze the carrying capacity of tourism and compare the number of visitors to the carrying capacity of tourist objects at the Mangrove Ecotourism area, PIK in the pre and post-pandemic COVID-19, and to elucidate the sustainable management of ecotourism program in the mangrove areas.

MATERIALS AND METHODS

Study area

This study was conducted in the mangrove ecotourism area of Pantai Indah Kapuk from January to April 2023. Administratively, the Mangrove Ecotourism is located in the Penjaringan Subdistrict, North Jakarta Municipality, DKI Jakarta Province, Indonesia (Figure 1). This ecotourism area is also part of the Mangrove Angke Kapuk forest area, designated through the Minister of Agriculture's Decree No.161/Kpts/Um/6/1977 on June 10, 1977.

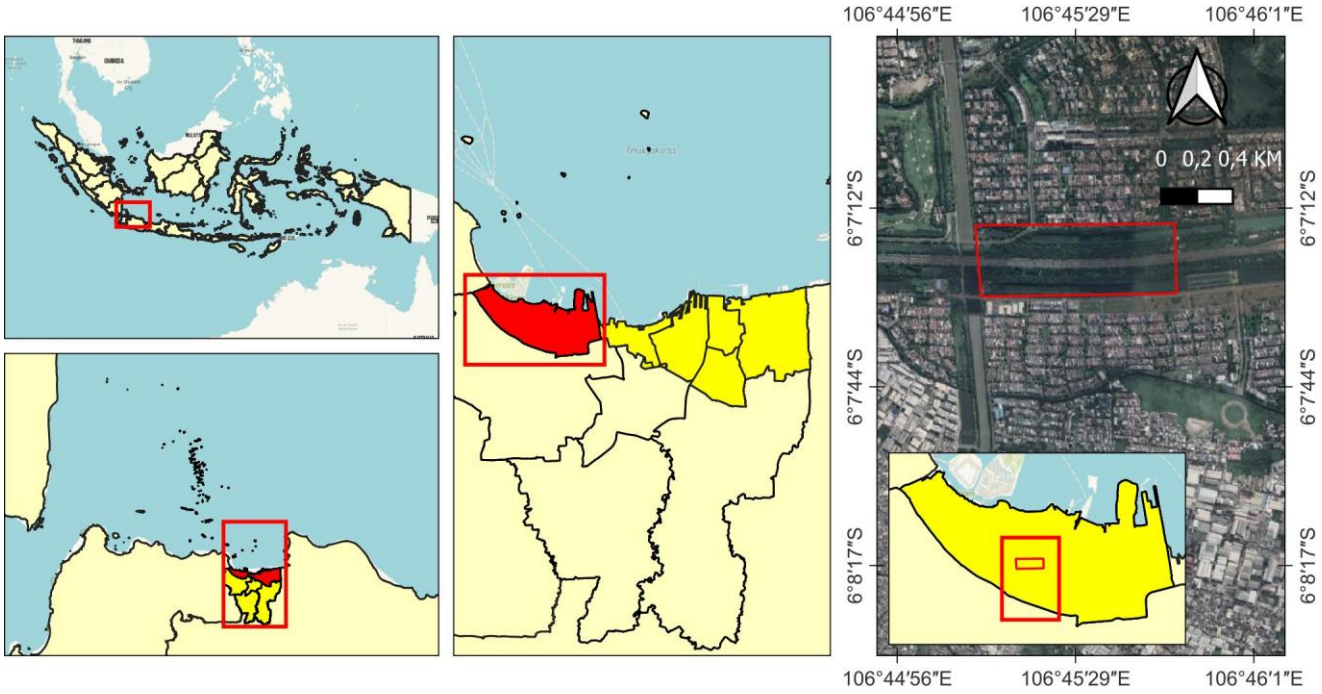

Figure 1. Research site in ecotourism mangrove (Mangrove Education Center), Pantai Indah Kapuk, Penjaringan, North Jakarta, Indonesia

Furthermore, on June 24, 1977, the Regional Government of DKI Jakarta and the Department of Agriculture's Directorate General of Forestry signed the Charter of Cooperation to implement regional autonomy regarding the Angke Kapuk Forest land area. This activity explained that the Angke Kapuk Forest covers approximately 1.144 hectares and is between two subdistricts, Kapuk Muara and Kamal Muara. The classification and management of the Angke Kapuk Mangrove Forest area are divided into four parts. The first area is the Angke Kapuk Nature Tourism Park, managed by PT. Murindra Karya Lestari. The second area is the Muara Angke Wildlife Sanctuary, managed by the Natural Resource Conservation Agency (BKSDA). The third and fourth areas are the Angke Kapuk Protection Forest and Production Forest, managed by the Provincial Parks and Environment Service (Dishut)of DKI Jakarta Province. The Mangrove Ecotourism Area of PIK is part of the Angke Kapuk Production Forest and covers an area of 16.03 hectares. The boundaries of the study area are as follows: *North*: Mayang Permai Cluster Housing Complex, Pinisi Indah, *East*: Kali Adem River, *South*: Prof. Dr. Insinyur Sedyatmo Toll Road, *West*: Pantai Indah Utara Street, East Sector

The selection of this study area was based on the consideration that this tourist attraction is the mangrove ecosystem closest to urban areas and is used for tourism purposes. DKI Jakarta Province has a relatively small mangrove forest, accounting for about 1.66% of its total area (Provincial Parks and Forestry Service 2022). The built-up area, predominantly in the Penjaringan Subdistrict, includes residential areas, industries, and various supporting facilities. Its urban location makes this area vulnerable to environmental damage and land use changes. Therefore, research related to sustainable mangrove tourism destinations is crucial to ensure that existing tourism activities can continue without causing environmental harm. The location map of the study area is presented in Figure 1.

Data collection

The data in this study were categorized into two main types: primary and secondary. Primary data collection involved recording the duration of visitors' stays in the tourism area. Field surveys were conducted to observe the physical conditions of the tourist site, including mangrove species, fauna types, and facility conditions. Interviews with respondents were conducted to determine the average duration of their visits, which was subsequently incorporated into the analysis of physical carrying capacity. The number of respondents in this study was 317 people, calculated using the Slovin method with a degree of accuracy of 5% (Adrianto et al. 2021). The secondary data utilized in this study were sourced from the Parks and Forestry Service of DKI Jakarta Province, results of interviews with tourism site managers, and other relevant scientific literature. Interviews conducted with managers will only be carried out to confirm conditions at the tourist attraction. Secondary data encompassed various factors, including the size of the tourism area, rainfall, wind speed, air humidity, and the monthly count of visitor arrivals.

Data analysis

Physical Carrying Capacity (PCC) is the maximum number of visitors to travel based on physical conditions and time available (Soria-Díaz et al. 2022). The PCC calculation in this study used a formula adapted from previous studies (Hartanti et al. 2018; Soria-Díaz et al. 2022), as follows:

$$\mathrm{PCC} = \mathrm{A} \times \frac{1}{B} \times Rf$$

Where: PCC is Physical Carrying Capacity (of ecotourism area), A is the area of a tourist attraction, B is the length of the area visitors utilize, and Rf is Rotation Factors (visitor rotation factor per day).

The calculation of real carrying capacity in this study is adapted from previous studies (Hartanti et al. 2018; Soria-Díaz et al. 2022) with the following formula:

$$RCC = PCC \times \frac{100 - cfn}{100}$$

Where: RCC is the real carrying capacity, and Cfn is the correction factor. Correction factors considered in this study include rainfall, wind speed, and temperature. The values of each correction factor in sequence are 28%, 56%, and 96%.

Calculation of the effective carrying capacity was done according to Zacarias et al. (2011) and Soria-Díaz et al. (2022), as below:

$$ECC = RCC \times MC$$

Where: ECC is Effective carrying capacity, and MC is Management Capacity. Management capacity in this study is calculated based on the number of officers at the tourist attraction (Adrianto et al. 2021; Soria-Díaz et al. 2022).

The calculation used was an adaptation of previous studies (Zacarias et al. 2011; Soria-Díaz et al. 2022), the formula used is as follows:

$$MC = \frac{Rn}{Rt} \times 100\%$$

Where: MC is Management Capacity, Rn is the officer on duty, and Rt is the officer required to be on duty. The values of Rn and Rt are obtained from information provided by the tourism site management. In addition, the MC in this study was also calculated through the opinions given by visitors. This MC calculation is obtained by converting the satisfaction level of visitors who travel to the PIK Mangrove Ecotourism. Estimating carrying capacity is carried out to prevent environmental damage by considering the number of tourist visitors to a tourist attraction (Long et al. 2022). The calculation of carrying capacity can also be a reference for tourist attraction

managers to develop their sustainable tourism objects (Santos and Brilha 2023)

RESULTS AND DISCUSSION

Mangrove flora and fauna diversity

The diversity of flora in the Mangrove Ecotourism Area is dominated by *Rhizophora mucronata*. This species lives and flourishes in tourist destinations as a result of routine planting efforts by the management. This planting was conducted in collaboration with various stakeholders, including private companies, non-governmental organisations, and academic institutions. However, some mangrove plant species, including api-api (*Avicennia marina*), tancang (*Bruguiera* sp.), pidada (*Sonneratia alba*), and nipah (*Nypa fruticans*), grow natively in this site. Twenty-five plant species reside in this area in addition to the mangrove species themselves, according to information given by Provincial Parks and Forestry Service in 2022 and confirmed again by observing plant morphology and matching it to plant biography books. Moreover, several types that are difficult to identify will be recorded and asked by the experts on this matter. Table 1 lists plant species that grow and thrive in mangrove ecotourism.

The growth of mangroves in ecotourism areas is closely related to the life of existing wildlife species. Several types of fauna found at this area include water birds such as rice shoots (*Phalacrocorax niger*), sea herons (*Ardea sumatrana*), red bambangan (*Ixobrychus cinnamomeus*), king prawn meninting (*Alcedo meninting*), and reptiles, namely lizards (*Mabuya multifasciata*), frogs (*Polypedates leucomystax*), toads (*Limnonectes macrodon*), and monitor lizards (*Varanus rudicollis*). According to data from Provincial Parks and Forestry Service (2022) and field observations, the study area is home to 20 animal species. Field observations were carried out by observing the physical form and behavior of the animal and then matching them with the animal's biography accompanied by tourist site management officers. Table 2 lists the many species of fauna that survive and develop in Mangrove Ecotourism.

However, field observations and direct conversations with management revealed that numerous varieties of snakes in the study area had been transported to protected zones. As a result, no snake species were discovered in the study area (Table 2). This transfer is done to ensure that the lives of the various varieties of snakes are not disrupted by tourism activities and that visitors to these sites are safe.

Mangrove ecotourism visitors in the early period of the pandemic

There was a substantial amount of travel in the early days of the COVID-19 pandemic. Many tourist destinations have seen a decline in visitors, and some have even had to close temporarily. This condition is because the government has implemented a social solution policy to break the virus's chain of transmission. In addition, many nations impose travel restrictions that prevent travelers from traveling abroad or within the country.

Table 1. Types of flora in mangrove ecotourism of Pantai Indah Kapuk, Penjaringan, North Jakarta, Indonesia

Indonesia local name	Common name	Scientific name
Akasia	Acacia	*Acacia auriculiformis* A.Cunn. ex Benth.
Api-api	Grey mangrove	*Avicennia marina* (Forssk.) Vierh.
Kranji	Velvet tamarind	*Dialium indum* L.
Bakau merah	Red mangroves	*Rhizophora mucronata* Lam.
Bakau putih	White mangroves	*Rhizophora apiculata* Blume
Bintaro	Sea mango	*Cerbera manghas* L.
Bungur	Giant crepe myrtle	*Lagerstroemia speciosa* (L.) Pers.
Ciplukan	Cutleaf groundcherry	*Physalis angulata* L.
Dungun	Looking-glass mangrove	*Heritiera littoralis* Dryand.
Kangkung air	Water spinach	*Ipomoea aquatica* Forssk.
Kelapa	Coconut palm	*Cocos nucifera* L.
Kersen	Cherry	*Muntingia calabura* L.
Ketapang	Ketapang	*Terminalia catappa* L.
Kluwih	Breadnut	*Artocarpus camansi* Blanco.
Lamtoro	White leadtree	*Leucaena leucocephala* (Lam.) de Wit
Mangga	Mango	*Mangifera indica* L.
Nangka	Jackfruit	*Artocarpus heterophyllus* Lam.
Nipah	Nipa palm	*Nypa fruticans* Wurmb
Nyiri	Cannonball mangrove	*Xylocarpus granatum* J.Koenig
Pepaya	Pawpaw	*Carica papaya* L.
Pidada	Mangrove apple	*Sonneratia caseolaris* (L.) Engl.
Pisang	Banana	*Musa paradisiaca* L.
Rumput teki	Purple nutsedge	*Cyperus rotundus* L.
Singkong	Cassava	*Manihot esculenta* Crantz
Tancang	Large-leafed Mangrove	*Bruguiera gymnorrhiza* (L.) Lamk

Table 2. Fauna associated in mangrove ecotourism of Pantai Indah Kapuk, Penjaringan, North Jakarta, Indonesia

Indonesia local name	Common name	Scientific name
Kera ekor-panjang	Long-tailed macaque	*Macaca fascicularis* Raffles, 1821
Tekukur biasa	Spotted dove	*Streptopelia chinensis* Scopoli, 1786
Remetuk laut	Golden-bellied gerygone	*Gerygone sulphurea* Wallace, 1864
Cangak merah	Purple heron	*Ardea purpurea* Linnaeus, 1766
Kerak kerbau	Javan myna	*Acridotheres javanicus* Cabanis, 1851
Bondol jawa	Javan munia	*Lonchura leucogastroides* Moore, 1858
Cekakak sungai	White-throated kingfisher	*Halcyon chloris* Boddaert, 1783
Kuntul kecil	Little egret	*Egretta garzeta* Linnaeus, 1766
Raja-udang biru	Cerulean kingfisher	*Alcedo* Linnaeus, 1758
Pecuk-ular Asia	Oriental darter	*Anhinga melanogaster* Pennant, 1769
Cangak abu	Grey heron	*Ardea cinerea* Linnaeus, 1758
Blekok sawah	Javan pond heron	*Ardeola speciosa* Horsfield, 1821
Kokokan laut	Striated heron	*Butorides striatus* Linnaeus, 1758
Kuntul perak	Intermediate egret	*Egretta intermedia* Wagler, 1829
Itik benjut	Sunda teal	*Anas gibberifrons* S.Müller, 1842
Pecuk-padi Hitam	Little cormorant	*Phalacrocorax sulcirostris* Brandt, 1837
Trinil pantai	Common sandpiper	*Tringa hypoleucos* Linnaeus, 1758
Kuntul besar	Great egret	*Egretta alba* Linnaeus, 1758
Bambangan coklat	Von schrenck's bittern	*Ixobrychus eurhythmus* Swinhoe, 1873
Biawak	Water monitor	*Varanus salvator* Laurenti, 1768

Many parties are attempting to adjust to present conditions to ensure the sustainability of the tourism business, such as by instituting tight health procedures in tourist sites (Nguyen 2021). Several tourist destinations also provide virtual travel experiences, allowing tourists to appreciate their attractiveness without physically visiting. However, the tourism industry will require considerable time to recover from the effects of this pandemic. It also occurred at the PIK Mangrove Ecotourism study area. The number of tourists has drastically decreased, and in some months, there has yet to be a single visitor to this place.

At the beginning of the 2020 pandemic, this tourist area was still visited by many tourists. In January, 4,151 visitors still came to this area. However, this tourist attraction had to close temporarily that year due to the high number of COVID-19 virus infections. This condition is also motivated by the implementing of the Indonesian government's policy to suppress the surge in COVID-19 sufferers, which is called large-scale social restrictions or *Pembatasan Sosial Berskala Besar* (PSBB). Figure 2 shows that throughout 2020, this tourist attraction was only crowded with visitors in the first three months and one last month at the end of the year.

The high number of cases of this pandemic has resulted in a drastic decrease in the number of visitors, which, of course, has impacted the tourist attraction's economic sector. The presence of the pandemic has caused the economy in the tourism sector to experience a decline, both in the sale of products and services (Rahimian et al. 2022). Revenue from the tourism economy through entrance ticket and parking fees has also decreased. At the start of the 2020 pandemic, this tour lost income from ticket and vehicle parking fees. This condition lasted for seven months, starting from April to November 2020. The description regarding the amount of tourist object retribution income can be seen in Table 3.

Table 3 illustrates the number of fees (tickets and parking fees) received over a year at the PIK Mangrove Ecotourism, classified into three groups, namely persons, motorbikes, and cars, based on the findings of data processing. The maximum entrance ticket fees were collected in February, totaling IDR 9,000,000, while no fees were collected from April to December. In January, the highest restitution fee for storing a motorcycle was 6,224,000 IDR. In February, the highest restitution fee for the automobile category was IDR 1,872,000. The government has set the price of admission to this tourist attraction at IDR 2,000 per individual, IDR 2,000 per motorbike, and IDR 4,000 per vehicle. The biggest total of retribution in Mangrove Ecotourism in 2020 is from the entrance ticket, which is 25.882.000 IDR.

Based on the available information, it can be determined that February is the month with the maximum number of entrance tickets and parking fees, followed by January. Due to the rapid proliferation of the COVID-19 virus during the first two months of 2020, no restrictions have been placed on tourism activities. The number of tourists and levy revenue at Mangrove Ecotourism will continue to fall until 2021. This tourist destination experienced a decrease in the number of visitors at the onset of the pandemic in 2021. However, this year's statistics showed a little increase when contrasted with the circumstances in 2020. Figure 2 provides information on the number of tourists visiting mangrove ecotourism in 2021.

In Indonesia, the COVID-19 pandemic persisted until 2021. It has significantly altered societal activity patterns, including tourism activities. The Indonesian government continued implementing the PSBB policy from January to February 2021. Nonetheless, in the middle of 2021, the government enacted a new policy, imposing restrictions on community activities or *Pemberlakuan Pembatasan Kegiatan Masyarakat* (PPKM). This policy was issued to prevent the

spread of the COVID-19 virus and preserve the economic stability of several regions in Indonesia.

Implementing the PPKM policy in Indonesia affects various industries, including tourism. Currently, multiple tourist attractions are once again permitted to operate. This policy allows the community to engage in tourism-related activities. This condition increased tourists visiting various tourist attractions, including PIK Mangrove Ecotourism. This tourist attraction has reopened to the public from March to June 2021 (Table 3). Each month for the past four months, more than one thousand individuals have visited this tour.

However, implementing the PPKM policy in Indonesia harmed the proliferation of the COVID-19 virus. The prevalence of a new strain of COVID-19 (type Beta) has increased the number of COVID-19 patients. It resulted in the Indonesian government reimplementing the PSBB policy in society. Some tourist attractions, including PIK Mangrove Ecotourism, have been compelled to close due to deteriorating conditions. This results in a further decline in visitors to this tourist attraction. During the three months from July to September 2021, not a single excursion visitor arrived.

After three months of PSBB implementation, the pathogen COVID-19 was successfully contained. This condition makes the government more accommodating to the community by permitting open-air activities. In October 2021, numerous tourists returned to this tourist attraction. However, the number of visitors was significantly reduced compared to previous months. Beginning in October 2021 and continuing through December 2021, numerous tourists have resumed their tourism activities at PIK Mangrove Ecotourism.

Indeed, fluctuations in the number of tourists affect the local economy, including the tourism industry. Due to the increase in the dissemination of the COVID-19 virus, Mangrove Ecotourism also underwent erratic changes. Ticket fees and parking revenue have also fluctuated in tandem with the implementation of government policies. Table 3 contains a description of the entry fees for PIK Mangrove Ecotourism.

Table 3. Total retribution from mangrove ecotourism

Month	Amount of retribution (IDR)								
	Entrance tickets			Motorcycle parking fees			Car parking fees		
	2020	2021	2022	2020	2021	2022	2020	2021	2022
January	8,302,000	0	11,612,000	6,224,000	0	7,424,000	1,724,000	0	1,780,000
February	9,000,000	0	11,694,000	5,128,000	0	7,648,000	1,872,000	0	2,168,000
March	5,130,000	2,396,000	10,422,000	3,334,000	6,100,000	6,720,000	1,540,000	1,388,000	1,808,000
April	0	2,954,000	6,546,000	0	8,192,000	4,000,000	0	2,136,000	1,288,000
May	0	3,830,000	16,900,000	0	10,872,000	11,536,000	0	2,924,000	3,064,000
June	0	2,668,000	11,038,000	0	8,438,000	7,436,000	0	2,112,000	1,776,000
July	0	0	11,522,000	0	0	7,006,000	0	0	1,972,000
August	0	0	10,452,000	0	0	6,882,000	0	0	2,116,000
September	0	0	6,736,000	0	0	4,276,000	0	0	1,288,000
October	0	804,000	7,994,000	0	2,766,000	5,044,000	0	612,000	1,612,000
November	0	1,852,000	7,754,000	0	6,238,000	4,900,000	0	1,796,000	1,536,000
December	3,450,000	2,534,000	6,602,000	2,800,000	6,472,000	4,016,000	1,000,000	1,928,000	1,300,000
Total	25,882,000	7,038,000	119,272,000	17,486,000	49,078,000	76,888,000	6,136,000	12,896,000	21,708,000

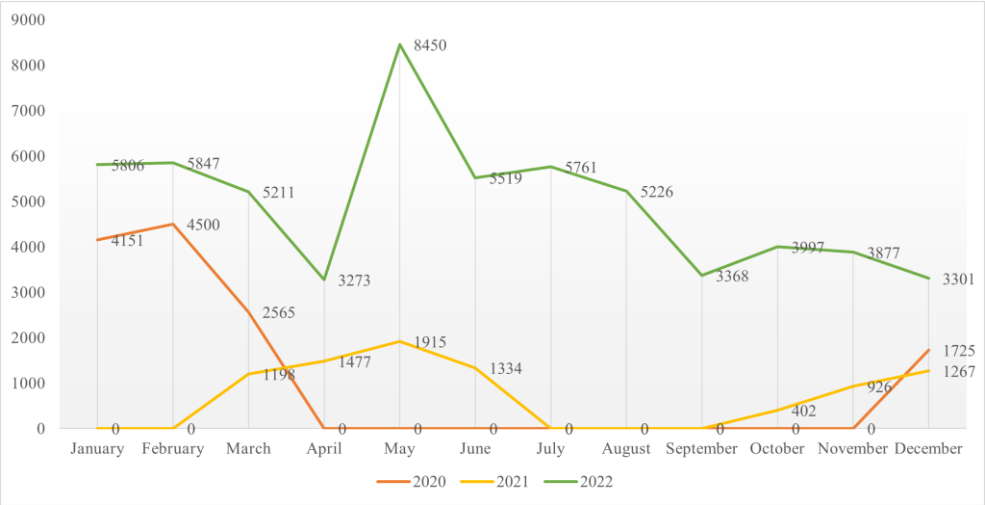

Figure 2. The number of visitors who visited the mangrove ecotourism at Pantai Indah Kapuk, North Jakarta, Indonesia

The conditions that existed in 2021 are different from the conditions that existed in 2020. Compared to the previous year, levy income in 2021 is substantially higher. In 2021, the total revenue from levies was IDR 79,012,000, compared to only IDR 49,504,000 in 2020. This distinction results from the number of visitors and the number of vehicles. However, this value could be more optimal because there are still months of closures of tourist attractions due to government policy implementation. A higher level of levy income in 2021 can indicate the tourism sector's recovery from the impact of the COVID-19 pandemic. However, this condition has only partially improved because government policies that discourage tourism continue to close tourist attractions for months. Furthermore, the tourism sector still faces other obstacles, such as shifting social and health limitations laws, necessitating ongoing efforts to recover this sector optimally.

Mangrove ecotourism visitors in the post period of the pandemic

The cases of COVID-19 pandemic transmission have decreased after two years. The government-provided vaccination program has had a positive impact in reducing COVID-19 virus transmission. The resolution of the COVID-19 cases prompted the government to return the PSBB policy to PPKM with a high tolerance level. The government enabled the community to resume normal operations. Currently, the conditions are safe and entering the "new normal" stage, when every activity may be carried out as usual while living a healthier and cleaner lifestyle. Following the pandemic, many people desire to engage in tourism activities.

The high level of visits to tourist items, notably the PIK Mangrove Ecotourism, demonstrates the community's interest in tourism. Figure 2 depicts the number of visits to the PIK Mangrove Ecotourism. The conditions post-pandemic COVID-19 also had a positive impact on the tourism sector. The public's enthusiasm for tourism may help the industry recover from the effects of the pandemic. However, people must pay attention to hygiene and environmental sustainability when engaging in tourism activities. The government must also optimize the management of tourist attractions so that they can give long-term economic benefits to society and the environment. Thus, tourism in the "new normal" stage can help the community and the environment.

Compared to data from the previous two years, visitor visits to this tourist attraction have increased dramatically. This condition is due to the leeway given by the government in carrying out tourism activities. The increasing number of visitors also has a positive impact on the economy of the tourist attraction (Kamata 2022). The amount of levy income in 2022 has increased quite a lot. The description of the amount of Ecotourism Mangrove PIK levy revenue can be seen in Table 3.

In 2022, the tourist attraction has operated entirely within a year because there is no operational ban from the government. The operation of the tourist object was carried out for 12 months throughout 2022. It certainly helps increase the amount of PIK Mangrove Ecotourism income from retribution fees. Compared to 2020 and 2021, the amount of levies received in 2022 is at its highest, namely IDR 217,868,000.

However, the perceived economic benefits often make tourism object managers forget other aspects, especially environmental conditions. In addition, the high number of visitor visits has the potential to increase. Since the Indonesian government has officially revoked the PPKM policy, activities can be carried out optimally. If ignored, this condition will certainly have the potential to cause negative impacts on the environment. Therefore, efforts are needed to prevent environmental damage from being used as a tourist attraction.

Carrying capacity of mangrove ecotourism PIK

Physical carrying capacity

PIK Mangrove Ecotourism is a mangrove ecosystem that is managed for tourism purposes. This tourist object has an area of 16 hectares, but only half of this area can be used for tourists (8 hectares). Based on the frequency of activities in this area, the average use of space (B) obtained was 5 ha. The rotation factor (Rf) obtained based on the results of interviews with respondents was 2.67 hours. The Rf number is obtained from the average length of visit of visitors at the PIK Mangrove Ecotourism (Zacarias et al. 2011; Hartanti et al. 2018; Soria-Díaz et al. 2022). Therefore, the analysis of the physical carrying capacity of the tourism objects yielded a total of 107 visitors/day. To contextualize this value, it can be categorized as falling within the moderate range. This means that the mangrove ecosystem at this site can reasonably accommodate a moderate number of visitors without causing significant ecological harm.

Real carrying capacity

Calculating the real carrying capacity (RCC) for PIK Mangrove Ecotourism involved considering three correction factors: rainfall, wind speed, and temperature. Based on this, the RCC for this area was determined to be 16 visitors per day. In the context of categorization, this value is relatively low. This suggests that the area may have limitations in accommodating more visitors under certain environmental conditions without adversely impacting the ecosystem.

Effective carrying capacity

The estimated effective carrying capacity (ECC) of 313 visitors per day for the Mangrove Ecotourism site represents a moderate capacity. This value is derived from a calculation considering management capacity and visitor satisfaction with the tourist attraction. To contextualize this value, it can be categorized as falling within the high range. The categorization is specific to the ecological conditions, management practices, and goals of this particular site.

Discussion

The association between carrying capacity and visitor number in PIK mangrove ecotourism

In the post of the COVID-19 pandemic, there has been a notable surge in tourist visits. As pandemic-related travel restrictions gradually eased, many individuals began

planning and booking holiday activities, as evidenced by a notable uptick in flight ticket and hotel reservations across various tourist destinations. Moreover, implementing a government-led immunization program has instilled a sense of confidence among the populace to participate in tourism activities that strictly adhere to robust health protocols. One destination experiencing a notable upswing in visitor numbers is the Mangrove Ecotourism area at Pantai Indah Kapuk. Over the past three years, there has been a consistent upward trajectory in tourist arrivals (Figure 2).

The surge in tourist numbers, driven by the pent-up desire to travel after the pandemic, has given rise to a phenomenon known as "revenge travel," where tourist attractions are experiencing higher visitation rates compared to previous years (Panzer-Krause 2022). While this post-pandemic tourism boom presents opportunities for the industry, it also underscores the need for improved management and responsible stewardship of these destinations.

Increasing tourist visits can undoubtedly have positive economic impacts, benefiting not only tourism operators but also the local communities surrounding these attractions. However, it is crucial to recognize that an upsurge in tourism should be accompanied by enhanced administrative measures and stringent regulations. These measures are essential to ensure the long-term environmental and ecological sustainability of these cherished locations. In this regard, one proactive step is analyzing the environmental carrying capacity of tourist attractions.

Carrying capacity, defined as the maximum number of tourists who can partake in tourism activities without causing detrimental effects on the environment (Sukuryadi et al. 2020), becomes paramount in this scenario. Assessing and understanding the carrying capacity of these destinations can guide sustainable management practices, helping strike a balance between satisfying the appetite for travel and safeguarding the delicate ecosystems, such as mangroves, that are often intertwined with these attractions. In essence, the post-pandemic surge in tourism can be a win-win situation for communities, the environment, and the industry, provided it is accompanied by responsible and sustainable management practices underpinned by sound research and environmental stewardship (Khan et al. 2021).

According to our analysis, the physical carrying capacity (PCC) of Ecotourism Mangrove PIK is 107 visitors per day. This number is relatively lower than the carrying capacity of mangrove ecotourism in Blanakan, West Java, Indonesia. The PCC value of this tourist attraction is 77,000 visitors per day (Hartanti et al. 2018). A similar situation occurred in the study conducted by Sridhar et al. (2016) in Andaman, India, resulting in a PCC value of 400,587 visitors per day. The variation in PCC values can be attributed to differences in the size and utilization of tourist attractions. Ecotourism Mangrove PIK has a smaller area compared to the ecotourism in Blanakan, West Java, Indonesia, or in Andaman, India. Consequently, it can be observed that the differences in PCC values across regions can vary due to differences in size, utilization, and the duration of visitor visits to tourist attractions (Swangjang and Kornpiphat 2021; Aktymbayeva et al. 2023).

If the number of PCCs is aggregated for one month, the maximum number of monthly visitors is 3,210. In 2022, based on the number of visitors to Mangrove Ecotourism, this tourist attraction exceeded its physical carrying capacity every month (Figure 3). Furthermore, this study area has a Real Carrying Capacity (RCC) of 16 visitors per day. This number is relatively lower than the RCC generated by mangrove ecotourism on Tidung Island, Jakarta, Indonesia. The RCC value for this tourist attraction is 634 visitors per day (Adrianto et al. 2021). Similarly, results from the study conducted by Soria-Díaz (2022) in Central Amazonia, Brazil, yielded the highest RCC value of 475 visitors per day.

The corrected RCC values are lower than the previously mentioned PCC values. This variation arises because RCC values are calculated by considering environmental factors. These factors are also responsible for differences in other studies. Each tourist attraction possesses distinct characteristics, leading to varying environmental influences.

Rainfall can affect the ecological environment of a visitor attraction (Adrianto et al. 2021). If the rainfall in the study area is excessive, it will lead to pools and flooding, which can cause environmental damage and annoy tourists (Sunkar et al. 2022). In addition, excessive precipitation can restrict the mobility of travelers, thereby diminishing their travel satisfaction and possibly jeopardizing their safety. In order to determine the permissible number of visitors to a tourist attraction, it is crucial to calculate the real carrying capacity while considering the rainfall factor.

The velocity of the wind can affect the surrounding environment. Extremely high wind velocities can disturb the comfort of visitors, mainly when they are on a family vacation. In addition, if the wind velocity in an ecosystem is excessive, it may cause damage to tourist facilities like gazebos, benches, and garbage cans. Even in severe instances, it can cause several species of trees to fall, thereby endangering the safety of visitors. Therefore, calculating the real carrying capacity that considers the wind speed factor is essential to maintain the comfort of visitors and the sustainability of tourist attractions (Adrianto et al. 2021).

Additionally, the weather is one of the variables that can influence the visitor's environment. If the temperature of the weather at a tourist attraction is too high, it can disrupt the comfort of visitors and cause some to become dehydrated (Adrianto et al. 2021; Li et al. 2022; Steiger et al. 2022). Similarly, if a tourist destination's temperature is too low, it can make visitors feel uneasy and discourage them from engaging in outdoor activities. Therefore, the analysis of the real carrying capacity of a tourist attraction must consider temperature.

Thus, if the resulting RCC values are accumulated within one month, the maximum number of monthly tourist visitors is 480. If analyzed based on the number of visitors to Mangrove Ecotourism at PIK in 2022, the number of travelers has exceeded the real carrying capacity every month. Figure 4 compares the quantity of PIK Ecotourism visitors and RCC visitors.

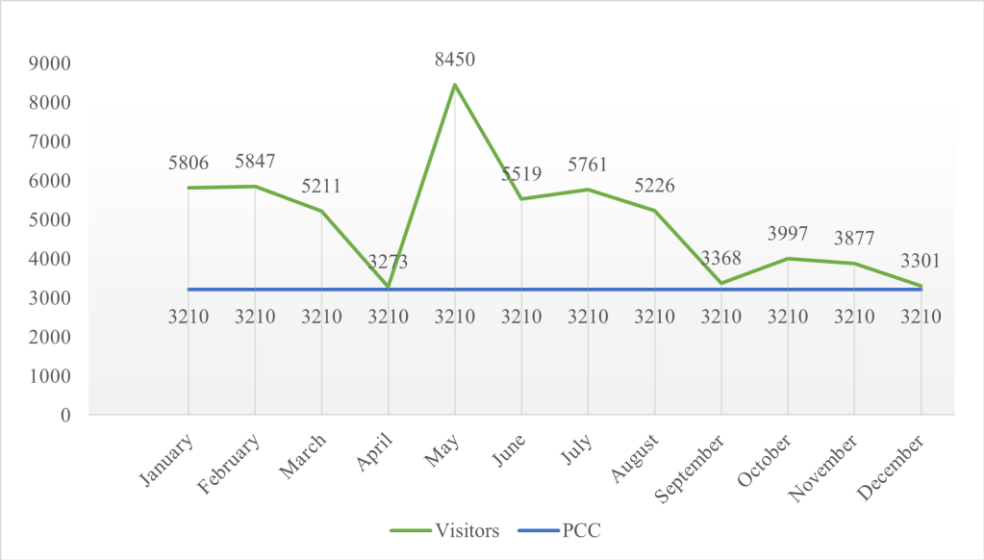

Figure 3. Comparison of the number of visitors to PCC mangrove ecotourism in Pantai Indah Kapuk, North Jakarta, Indonesia

The correction of the PCC values to lower levels compared to the RCC values has a positive ecological impact. It can minimize ecological stress and reduce the potential for environmental damage. However, the concept of sustainable tourism cannot be realized by focusing solely on environmental conditions and factors. Therefore, further calculations involving management capacity are needed to manage tourist attractions effectively. Integrating management capacity calculations is crucial to achieving a harmonious balance between ecological preservation and sustainable tourism. By considering both the environmental constraints and the effectiveness of on-site management, it becomes possible to optimize visitor experiences while safeguarding the natural beauty of tourist destinations and mitigating potential negative impacts on the environment. This holistic approach not only contributes to the long-term ecological health of the area but also enhances the quality of tourism, making it a win-win solution for both nature and travelers.

The total effective carrying capacity determined in this study was 311 visitors per day. The increase in ECC values compared to RCC values demonstrates the significant role of management capacity in determining the carrying capacity of a tourist attraction. If the ECC figures are aggregated over a month, the maximum monthly visitors is 9,330. The increase in the ECC value of the tourist attraction enhances the tolerance for the number of visitors compared to the previous RCC value. This is evident in Figure 5, which illustrates that the number of visitors post-pandemic has remained within the effective carrying capacity. This number is relatively lower than the carrying capacity of mangrove ecotourism in Blanakan, West Java, Indonesia. The ECC value of this tourist attraction is 825 visitors per day (Hartanti et al. 2018).

Management capacity can be optimized to help a tourist attraction attain efficient carrying capacity. In this study, management capacity focuses on the number of site managers responsible for the tourist attraction. The number of staff members operating within the tourist attraction area is a crucial aspect of management capacity because it allows for the monitoring of visitor activities. This monitoring plays a pivotal role in maintaining the sustainability of the mangrove ecosystem, ensuring that the influx of visitors does not disrupt the existing ecological balance. Furthermore, an adequate number of staff members can significantly assist visitors by providing guidance and information about the mangrove ecosystem. In other words, the quantity of site managers directly influences how effectively the tourist attraction can be preserved and managed.

Recommendations for mangrove ecotourism development in PIK based on carrying capacity

In conclusion, the number of visitors to PIK Mangrove Ecotourism has increased during the last three years. The increase in the number of visitors was accompanied by a rise in the revenue generated from tourist attraction entrance fees. In 2020, 2021, and 2022, the annual total numbers of visitors to this tourist attraction were 12,941, 8,518, and 59,601, respectively. The year with the lowest number of visitors was 2021, while the year with the most significant number was 2022. In addition, this tourist attraction earned IDR 49,504,000 in 2020, IDR 79,012,000 in 2021, and IDR 217,868,000 in 2022.

Based on the research findings, the main finding of this study is that the carrying capacity of tourism in the Mangrove Ecotourism area, PIK, is significantly influenced by the pandemic. There was a significant decrease in visitors during the pandemic, indicating a direct impact of the global health crisis on ecotourism. However, in the post-pandemic period, an increase in visitor activities was observed, reflecting the dynamic nature of carrying capacity.

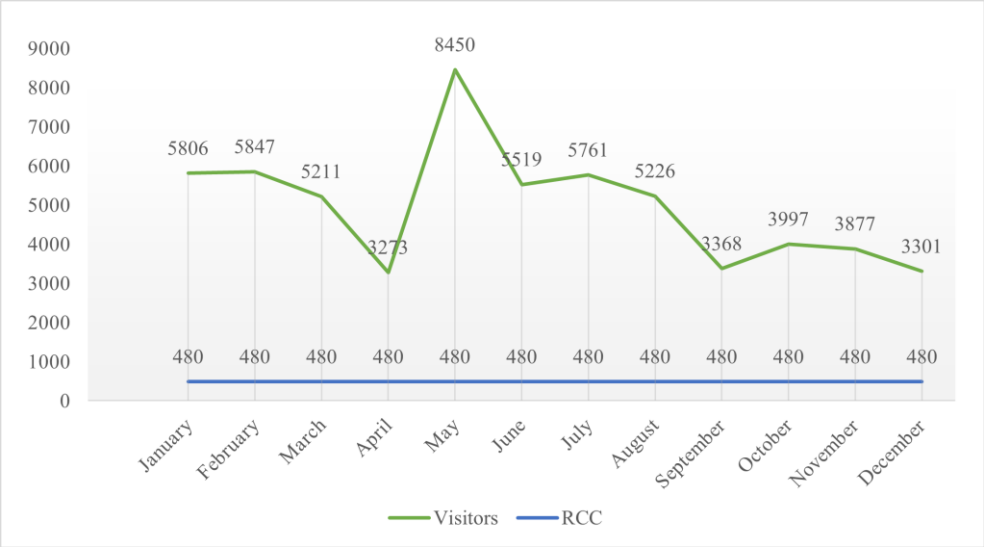

Figure 4. Comparison of the number of visitors to RCC mangrove ecotourism Pantai in Indah Kapuk, North Jakarta, Indonesia

Figure 5. Comparison of the number of visitors to ECC mangrove ecotourism in Pantai Indah Kapuk, North Jakarta, Indonesia

Nevertheless, a limitation of this study is the lack of in-depth and comprehensive discussion regarding the effectiveness of policies implemented from the early stages to the end of the pandemic. Government policies play a crucial role in tourism, significantly influencing the regulation and management of tourist attractions in the future, particularly in emergencies like a pandemic. Evaluating the effectiveness of these policies can serve as an essential foundation for how tourism management can become more adaptive and responsive to changing conditions, thus supporting the long-term sustainability of tourism.

The spread of the COVID-19 pandemic and government policies regarding community activities during the pandemic have caused fluctuations in the number of visitors and payments at this tourist attraction. This increase in visitors and fees may have a positive effect on the revenue of the tourist attraction. However, it may have detrimental effects on the environment. Determining the carrying capacity of tourism in the PIK Mangrove Ecotourism area is an endeavor to prevent this from happening. The physical, real, and effective carrying capacity of the PIK Mangrove Ecotourism is 107, 16, and 311 visitors per day, respectively. This tourist attraction can accommodate 3,210 visitors for PCC, 480 for RCC, and 9,330 for ECC per month. The number of visitors to this tourist attraction has surpassed the physical and real carrying capacity but has yet to be effective. Based on this, the following measures can be taken to maximize the number of visitors while preserving the ecosystem's health.

Several initiatives can enhance the sustainable management of PIK Mangrove Ecotourism. Firstly, a zoning system tailored to the type of tourism offered should be introduced. The site's popularity often results in concentrated visitor gatherings, which, if continuous, can lead to environmental degradation. Zoning based on the

nature of tourism activities is expected to alleviate congestion, a particularly relevant strategy during pandemics, aiding in the path to pandemic recovery (Huynh et al. 2022). Furthermore, the division of visitor activities within the area can enhance tourists' appreciation of the natural beauty of the site, ultimately elevating overall trip satisfaction. Secondly, bolstering the number of personnel at each tourist location is crucial. Increased staff can better cater to the needs of tour-goers and facilitate more efficient monitoring of visitor activities. This proactive approach is expected to mitigate the environmental impact of high tourist volumes. Ensuring an equitable distribution of field officers is equally vital for well-organized tourism operations, enabling visitors to enjoy the natural splendor, acquire knowledge, and prevent disruptions to delicate ecosystems (Burbano et al. 2022). Third, implementing visitor restrictions and reservation systems offers a practical solution to manage visitor numbers, particularly for group travelers. The increased digital adaptability observed during the pandemic among the Indonesian populace presents an opportunity to integrate digital technologies into sustainable tourism planning (Marujo et al. 2021). These technologies, including online ticket booking, not only streamline the ticketing process for visitors but also aid management in establishing visitor quotas, reducing crowding, and enhancing the overall comfort of travelers. Such measures collectively provide a more enjoyable and ecologically responsible tourist experience (Srisawat et al. 2023).

Fourth, local governments and tourism site managers must increase visitor and community awareness of mangrove conservation through educational activities. Raising awareness about the mangrove ecosystem can be achieved through interactive programs, workshops, and information dissemination (Arifanti et al. 2022; Gómez-Ruiz et al. 2022; Gorman et al. 2023). These initiatives not only instill a sense of responsibility for mangrove preservation but also enhance the overall visitor experience. Engaging the local community through educational outreach and involving them in mangrove restoration efforts can foster a sense of ownership and stewardship, creating a stronger connection between the community and the mangrove ecosystem, which is essential for its long-term conservation.

Lastly, to promote mangrove ecological sustainability, local governments should enhance coordination among various stakeholders to carry out monitoring functions for the health of the mangrove ecosystem. In this context, the local government, represented by the Forestry Department of Jakarta Province, should strengthen collaboration with relevant ecosystem experts and academics to conduct routine monitoring of mangrove health. Routine activities, such as, assessing biodiversity, monitoring vegetation density, and analyzing water quality at crucial locations, are essential to achieving mangrove ecological sustainability (Indrajaya et al. 2022; Trialfhianty et al. 2022; Halim et al. 2023). This concerted effort ensures the long-term health and vitality of this vital ecosystem, benefitting both visitors and the environment.

ACKNOWLEDGEMENTS

Our deepest acknowledgments to DKI Jakarta Province Parks and Forestry Service (Dishut), Indonesia, which has supported the study process. Also, to all parties involved during the research process until the completion of this paper. We hope this study can be helpful for many parties to realize the preservation and sustainability of mangrove ecosystems.

REFERENCES

Abubakar S, Kepel RC, Djamaluddin R, Wahidin N, Mingkid WM, Wantasen AS, Montolalu RI, Mantiri DMH. 2022. Suitability and carrying capacity of mangrove ecosystem for ecotourism in Jailolo Bay, West Halmahera, Indonesia. AACL Int J Bioflux Soc 15 (6): 3012-3026.

Adrianto L, Kurniawan F, Romadhon A, Bengen DG, Sjafrie NDM, Damar A, Kleinertz S. 2021. Assessing social-ecological system carrying capacity for urban small island tourism: The case of Tidung Islands, Jakarta Capital Province, Indonesia. Ocean Coast Manage 212: 105844. DOI: 10.1016/j.ocecoaman.2021.105844.

Aktymbayeva A, Nuruly Y, Artemyev A, Kaliyeva A, Sapiyeva A, Assipova Z. 2023. Balancing nature and visitors for sustainable development: Assessing the tourism carrying capacities of Katon-Karagay National Park, Kazakhstan. Preprints. DOI: 10.20944/preprints202310.1040.v1.

Arifanti VB, Sidik F, Mulyanto B, Susilowati A, Wahyuni T, Subarno, Yulianti, Yuniarti N, Aminah A, Suita E, Karlina E, Suharti S, Pratiwi, Turjaman M, Hidayat A, Rachmat HH, Imanuddin R, Yeny W, Darwiati W, Sari N, Hakim SS, Slamet WY, Novita N. 2022. Challenges and strategies for sustainable mangrove management in Indonesia: A review. Forests 13 (5): 695. DOI: 10.3390/f13050695.

Baskent EZ. 2020. A framework for characterizing and regulating ecosystem services in a management planning context. Forests 11 (1): 102. DOI: 10.3390/f11010102.

Bimrah K, Dasgupta R, Hashimoto S, Saizen I, Dhyani S. 2022. Ecosystem services of mangroves: A systematic review and synthesis of contemporary scientific literature. Sustainability 14 (19): 12051. DOI: 10.3390/su14191205.

Burbano DV, Valdivieso JC, Izurieta JC, Meredith TC, Ferri DQ. 2022. "Rethink and reset" tourism in the Galapagos Islands: Stakeholders' views on the sustainability of tourism development. Ann Tourism Res Empirical Insights 3: 100057. DOI: 10.1016/j.annale.2022.100057.

Dang KB, Nguyen MH, Nguyen DA, Phan TTH, Giang TL, Pham HH, Nguyen TN, Tran TTV, Bui DT. 2020. Coastal wetland classification with deep u-net convolutional networks and sentinel-2 imagery: A case study at the Tien Yen estuary of Vietnam. Remote Sens 12 (19): 3270. DOI: 10.3390/rs12193270.

Edwin-wosu NL, Dirisu A-R. 2022. Coastal biodiversity, sustainable livelihood and ecological scenarios in marine wetland of Asarama Andoni in parts of Eastern Niger Delta Nigeria. J Econ Sustain Dev 13 (24). DOI: 10.7176/JESD/13-24-03.

Eviana N, Yusrini L. 2019. Environmental tourism carrying capacity assessment in the Angke Kapuk Mangrove Nature Park (TWA) Jakarta. J Eduturisma 4 (1): 1-20.

FAO [Food and Agriculture Organization of the United Nations]. 2020. Global Forest Resources Assessment 2020 Main Report. In Reforming China's Healthcare System. Rome. Italy. DOI: 10.4324/9781315184487-1.

Forje GW, Tchamba MN, Eno-Nku M. 2021. Determinants of ecotourism development in and around protected areas: The case of Campo Ma'an National Park in Cameroon. Sci Afr 11: e00663. DOI: 10.1016/j.sciaf.2020.e00663.

Gorman D, Wilson MS, Steven ADL. 2023. communicating blue carbon science across the Indo-Pacific region through capacity building fellowships. Sci Commun 45 (3): 402-413. DOI: 10.1177/10755470221143740.

Gómez-Ruiz PA, Betancourth-Buitrago RA, Arteaga-Cote M, Carbajal-Borges JP, Teutli-Hernández C, Laffon-Leal S. 2022. Fostering a participatory process for ecological restoration of mangroves in

Pantanos de Centla Biosphere Reserve (Tabasco, Mexico). Ecosyst People 18 (1): 112-118. DOI: 10.1080/26395916.2022.2032358.
Halim MAR, Soeprobowati TR, Hadiyanto H. 2023. Ecological assessment of the role of mangrove trees in carbon sequestration and biodiversity in Karimunjawa National Park Indonesia. Geogr Environ Sustain 16 (3): 32-43. DOI: 10.24057/2071-9388-2022-2565.
Hartanti U, Patria MP, Utomo SW. 2018. The physical carrying capacity of mangrove ecotourism in Blanakan, Subang Regency, West Java, Indonesia. E3S Web Conf 74: 02001. DOI: 10.1051/e3sconf/20187402001.
Hattam C, Broszeit S, Langmead O, Praptiwi RA, Lim VC, Creencia LA, Hau TD, Maharja C, Wulandari P, Setia TM, Sugardjito J, Javier J, Jose E, Gajardo LJ, Then AY-H, Amri AY, Johari S, Justine EV, Hussein MAS, Goh HC, et al. 2021. A matrix approach to tropical marine ecosystem service assessments in South east Asia. Ecoserv 51: 101346. DOI: 10.1016/j.ecoser.2021.101346.
Huynh DV, Duong LH, Truong TTK, Nguyen NT. 2022. Destination responses to COVID-19 waves: Is "green zone" initiative a holy grail for tourism recovery?. Sustain 14: 3421. DOI: 10.3390/su14063421.
Indrajaya Y, Yuwati TW, Lestari S, Winarno B, Narendra BH, Nugroho HYSHN, Rachmanadi D, Pratiwi, Turjaman M, Adi RN, Savitri E, Putra PB, Santosa PB, Nugroho NP, Cahyono SA, Wahyuningtyas RS, Prayudyaningsih R, Halwany W, Siarudin M, Widiyanto A, et al. 2022. Tropical forest landscape restoration in Indonesia: A Review. Land 11 (3): 328. DOI: 10.3390/land11030328.
Jurkus E, Povilanskas R, Taminskas J. 2022. Current trends and issues in research on biodiversity conservation and tourism sustainability. Sustainability 14 (6): 3342. DOI: 10.3390/su14063342.
Kamata H. 2022. Tourist destination residents' attitudes towards tourism during and after the COVID-19 pandemic. Curr Issues Tour 25 (1): 134-149. DOI: 10.1080/13683500.2021.1881452.
Khan K, Su CW, Xiao YD, Zhu H, Zhang X. 2021. Trends in tourism under economic uncertainty. Tour Econ 27 (4): 841-858. DOI: 10.1177/1354816620909608.
Li S, Luo T, Wang L, Xing L, Ren T. 2022. Tourism route optimization based on improved knowledge ant colony algorithm. Complex Intell Syst 8 (5): 3973-3988. DOI: 10.1007/s40747-021-00635-z.
Long C, Lu S, Chang J, Zhu J, Chen L. 2022. Tourism environmental carrying capacity review, hotspot, issue, and prospect. Intl J Environ Res Public Health 19 (24): 16663. DOI: 10.3390/ijerph192416663.
Marujo N, Borges MdR, Serra J, Coelho R. 2021. Strategies for creative tourism activities in pandemic contexts: The case of the 'saídas de mestre' project. Sustain 13 (19): 10654. DOI: 10.3390/su131910654.
Ministry of Environment and Forestry of the Republic of Indonesia. 2020. Indonesia's Contribution to Achieving Global Biodiversity Targets. Public Relations Bureau of the Ministry of Environment and Forestry. Jakarta. [Indonesian]
Moore AC, Hierro L, Mir N, Stewart T. 2022. Mangrove cultural services and values: Current status and knowledge gaps. People Nat 4 (5): 1083-1097. DOI: 10.1002/pan3.10375.
Nguyen QH. 2021. Impact of investment in tourism infrastructure development on attracting international visitors: A nonlinear panel ARDL approach using Vietnam's data. Economies 9 (3): 131. DOI: 10.3390/economies9030131.
Onyena AP, Sam K. 2020. A review of the threat of oil exploitation to mangrove ecosystem: Insights from Niger Delta, Nigeria. Glob Ecol Conserv 22: e00961. DOI: 10.1016/j.gecco.2020.e00961.
Palit K, Rath S, Chatterjee S, Das S. 2022. Microbial diversity and ecological interactions of microorganisms in the mangrove ecosystem: Threats, vulnerability, and adaptations. Environ Sci Pollut Res (29): 32467-32512. DOI: 10.1007/s11356-022-19048-7.
Panzer-Krause S. 2022. Rural tourism in and after the COVID-19 Era: "Revenge travel" or chance for a degrowth-oriented restart? Cases from Ireland and Germany. Tour Hosp 3 (2): 399-415. DOI: 10.3390/tourhosp3020026.
Provincial Parks and Forestry Service (Dishut) of DKI Jakarta Province. 2022. Preparation of forest management plan for the management of the Angke Kapuk Forest Area, North Jakarta, DKI Jakarta Province. Jakarta.
Purnomo AR, Patria MP, Takarina ND, Karuniasa M. 2022. Environmental impact of the intensive system of vannamei shrimp (*Litopenaeus vannamei*) farming on the Karimunjawa-Jepara-Muria biosphere reserve, Indonesia. Intl J Adv Sci Eng Info Technol 12 (3): 873-880. DOI: 10.18517/ijaseit.12.3.14181.
Rahimian M, Rad MM, Zareei H. 2022. The effect of the Covid-19 pandemic on ecotourism, a study from West of Iran. Front Public Health 10 (2): 1-11. DOI: 10.3389/fpubh.2022.983025.
Sahana M, Areendran G, Sajjad H. 2022. Assessment of suitable habitat of mangrove species for prioritizing restoration in coastal ecosystem of Sundarban Biosphere Reserve, India. Sci Rep 12 (1): 20997. DOI: 10.1038/s41598-022-24953-5.
Santos PLA, Brilha J. 2023. A review on tourism carrying capacity assessment and a proposal for its application on geological sites. Geoheritage 15 (2). DOI: 10.1007/s12371-023-00810-3.
Sofian A, Kusmana C, Fauzi A, Rusdiana O. 2020. Evaluating the condition of Angke Kapuk mangrove ecosystem Jakarta Bay, and its consequences on ecosystem services. Jurnal Kelautan Nasional 15 (1): 1-12. DOI: 10.15578/jkn.v15i1.7722.
Soria-Díaz HF, Graça PMLdA, Solano BS. 2022. Analysis of the carrying capacity of tourist attractions in Central Amazonia, Brazil. Investigaciones Geograficas 108: e60531. DOI: 10.14350/rig.60531.
Sridhar R, Yuvaraj E, Sachithanandam V. 2016. Tourism carrying capacity for beaches of South Andaman Island, India. Tourism - From Empirical Research Towards Practical Application. Intech.
Srisawat P, Zhang W, Sukpatch K, Wichitphongsa W. 2023. Tourist behavior and sustainable tourism policy planning in the covid-19 era: Insights from Thailand. Sustainability 15 (7): 5724. DOI: 10.3390/su15075724.
Steiger R, Knowles N, Pöll K, Rutty M. 2022. Impacts of climate change on mountain tourism: A review. J Sustain Tourism. DOI: 10.1080/09669582.2022.2112204.
Subramanian A, Nagarajan AM, Vinod S, Chakraborty S, Sivagami K, Theodore T, Sathyanarayanan SS, Tamizhdurai P, Mangesh VL. 2023. Long-term impacts of climate change on coastal and transitional eco-systems in India: An overview of its current status, future projections, solutions, and policies. RSC Adv 13: 12204-12228. DOI: 10.1039/D2RA07448F.
Sukuryadi, Harahab N, Primyastanto M, Semedi B. 2020. Analysis of suitability and carrying capacity of mangrove ecosystem for ecotourism in Lembar Village, West Lombok District, Indonesia. Biodiversitas 21 (2): 596-604. DOI: 10.13057/biodiv/d210222.
Sunkar A, Lakspriyanti AP, Haryono E, Brahmi M, Setiawan P, Jaya AF. 2022. Geotourism hazards and carrying capacity in geosites of Sangkulirang-Mangkalihat karst, Indonesia. Sustainibility 14 (3): 1704. DOI: 10.3390/su14031704.
Suwanto A, Takarina ND, Koestoer RH, Frimawaty E. 2021. Diversity, biomass, covers, and ndvi of restored mangrove forests in Karawang and Subang Coasts, West Java, Indonesia. Biodiversitas 22 (9): 4115-4122. DOI: 10.13057/biodiv/d220960.
Swangjang K, Kornpiphat P. 2021. Does ecotourism in a mangrove area at Klong Kone, Thailand, conform to sustainable tourism? A case study using SWOT and DPSIR. Environ Dev Sustain 23: 15960-15985. DOI: 10.1007/s10668-021-01313-3.
Trialfhianty TI, Muharram FW, Suadi, Quinn CH, Beger M. 2022. Spatial multi-criteria analysis to capture socio-economic factors in mangrove conservation. Mar Policy 141: 105094. DOI: 10.1016/j.marpol.2022.105094.
Vallecillo S, Notte AL, Zulian G, Ferrini S, Maes J. 2019. Ecosystem services accounts: Valuing the actual flow of nature-based recreation from ecosystems to people. Ecol Model 392: 196-211. DOI: 10.1016/j.ecolmodel.2018.09.023.
Wang J, Xia L. 2021. Revenge travel: Nostalgia and desire for leisure travel post covid-19. J Travel Tourism Mark 38 (9): 935-955. DOI: 10.1080/10548408.2021.2006858.
Yuliana E, Hewindati YT, Winata A, Djatmiko WA, Rahadiati A. 2019. Diversity and characteristics of mangrove vegetation in Pulau Rimau Protection Forest, Banyuasin District, South Sumatra, Indonesia. Biodiversitas 20 (4): 1215-1221. DOI: 10.13057/biodiv/d200438.
Zacarias DA, Williams AT, Newton A. 2011. Recreation carrying capacity estimations to support beach management at Praia de Faro, Portugal. Appl Geogr 31 (3): 1075-1081. DOI: 10.1016/j.apgeog.2011.01.020.
Zekan B, Weismayer C, Gunter U, Schuh B, Sedlacek S. 2022. Regional sustainability and tourism carrying capacities. J Clean Prod 339: 130624. DOI: 10.1016/j.jclepro.2022.130624.