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Review

Ecotourism and mangrove conservation in Southeast Asia: Current trends and perspectives

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ABSTRACT

Mangroves in Southeast Asia provide numerous supporting, provisioning, regulating, and cultural services that are crucial to the environment and local livelihoods since they support biodiversity conservation and climate change resilience. However, Southeast Asia mangroves face deforestation threats from the expansion of commercial aquaculture, agriculture, and urban development, along with climate change-related natural processes.

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Mangrove ecotourism sites
Ecotourism impacts on mangroves
Mangrove ecosystem services
Mangrove mapping
Conservation and restoration initiatives

Ecotourism has gained prominence as a financial incentive tool to support mangrove conservation and restoration. Through a systematic literature review approach, we examined the relationships between ecotourism and mangrove conservation in Southeast Asia based on scientific papers published from 2010 to 2022. Most of the studies were reported in Indonesia, Malaysia, Philippines, Thailand, and Vietnam, respectively, which were associated with the highest number of vibrant mangrove ecotourism sites and largest mangrove areas compared to the other countries of Southeast Asia. Mangrove-related ecotourism activities in the above countries mainly include boat tours, bird and wildlife watching, mangrove planting, kayaking, eating seafood, and snorkeling. The economic benefits, such as an increase in income associated with mangrove ecotourism, have stimulated infrastructural development in ecotourism destinations. Local communities benefited from increased access to social amenities such as clean water, electricity, transportation networks, schools, and health services that are intended to make destinations more attractive to tourists. Economic benefits from mangrove ecotourism motivated the implementation of several community-based mangrove conservation and restoration initiatives, which attracted international financial incentives and public-private partnerships. Since mangroves are mostly located on the land occupied by indigenous people and local communities, ensuring respect for their land rights and equity in economic benefit sharing may increase their intrinsic motivation and participation in mangrove restoration and conservation initiatives. Remote sensing tools for mangrove monitoring, evaluation, and reporting, and integrated education and awareness campaigns can ensure the long-term conservation of mangroves while sustaining ecotourism's economic infrastructure and social amenities benefits.

1. Introduction

Mangroves are salt-tolerant trees and shrubs that grow in saline waters of deltas, estuaries, lagoons, and sheltered shores along tropical and subtropical coastlines around the globe. These plant communities provide essential ecosystem services (such as supporting, provisioning, regulating, and cultural services) that are of critical importance for human well-being and the maintenance of biodiversity (MEA, 2005a,b; FAO, 2020; FAO & UNEP, 2020; Leal and Spalding, 2022). Mangrove forests serve as permanent habitats and nurseries for both invertebrate and vertebrate species due to the high abundance of food and shelter, and low predation pressure. The soft substrate within mangrove ecosystems serves as a habitat for diverse infaunal and epifaunal species, with interstitial spaces between roots offering both shelter and sustenance for mobile fauna, including prawns, crabs, and fish (Nagelkerken et al., 2008). Mangrove forests are capable of storing the highest densities of carbon in their below- and above-ground biomass recorded in any ecosystem, highlighting their conservation, restoration, and sustainable use importance for enhanced carbon sequestration and climate change mitigation (Kauffman et al., 2020; Hagger et al., 2022; Richards et al., 2020). In addition, mangroves extend flood protection benefits by regulating water flow, annually safeguarding 15 million people worldwide (Menéndez et al., 2020). Mangrove root systems stabilize shorelines, reduce erosion, and act as natural filters, thus serving as a protective barrier against marine pollution by trapping sediments and pollutants (Alongi et al., 2016). They help maintain groundwater levels and prevent saltwater intrusion into coastal areas, preserving freshwater resources and avoiding water scarcity (Giri et al., 2011).

Globally, mangrove forests exist in 123 tropical and sub-tropical nations and territories, and in 2020, they covered a total area of 14.7 million ha (Bunting et al., 2022). The greatest extent of mangroves is found in Asia (6.37 million ha), and Southeast Asia mangroves are the most biologically diverse globally and cover the largest area (about 4.9 million ha and 4.82 million ha) (Area from MODIS: FAO, 2020; Area from JERS-1 SAR, ALOS PALSAR and ALOS-2 PALSAR-2: Bunting et al., 2022). Indonesia has 2,953,398 ha of mangrove area, and alone comprises about 20% of the global total and 61.25 % of the mangrove area in Southeast Asia, according to 2020 data (Bunting et al., 2022; FAO, 2020). The global area of mangrove forests has decreased by 524,500 ha (3.4%) from 1996 to 2020 (Leal and Spalding, 2022). Southeast Asia has experienced the greatest net losses of mangroves, which totalled about 245,700 ha (4.85%) from 1996 to 2020 (Bunting et al., 2022; Leal and Spalding, 2022).

Increases in mangrove loss have been largely attributed to anthropogenic drivers, that specifically include conversion and expansion of commercial aquaculture, agriculture (rice and oil palm) plantations, and rapid urban expansion as a result of the implementation of economic incentives and policies aimed to enhance food security. Poorly executed development of tourism infrastructure has also resulted in adverse effects on mangrove ecosystems (Singgalen, 2022; Singgalen and Manongga, 2022). In addition, tourist activities such as scuba diving, yachting, and anchoring degrade marine systems, and in particular movement through mangrove ecosystems (foot, canoe, boats) disturbs the system (Pernot et al., 2017). Indirect stressors from natural processes (which are often exacerbated by human actions) have also caused losses, and these include changing sedimentation rates, rising sea levels, changes in temperature and precipitation levels, and increases in harmful pollutants (Bunting et al., 2022; Leal and Spalding, 2022; Hagger et al., 2022; Richards and Friess, 2016; Richards et al., 2020). Losses in global mangrove area remain high, though it was more than halved during the period from 1990 to 2020, that is, 47,000 ha per year from 1990 to 2010 to 21,000 ha per year from 2010 to 2020 (FAO, 2020; FAO & UNEP, 2020; Leal and Spalding, 2022). Halting anthropogenic induced global losses of mangroves would save approximately 16,800 ha of area by the end of 2030 (Leal and Spalding, 2022).

The data for country-level mangrove area and loss reported for the same period (1990–2020) by the different studies (e.g., Bunting et al., 2022; FAO, 2020; Leal and Spalding, 2022) showed some discrepancies. Differences in methodological approaches can result in high variability in mangrove area statistics between sources. In particular, differences in the spatial resolution, type and date of acquisition of satellite images, mapping methods, the scope and scale of the studies, and mangrove classification approaches can result in high variability in the estimation of mangrove cover and distribution between studies (Rondon et al., 2023). Similarly, trends in mangrove cover change exhibited large standard deviations due to high variability in national estimates, resulting in several contradictory trends (Friess and Webb, 2013). This could result in low confidence in mangrove area dynamics, negatively affecting ecosystem functional loss estimates, biodiversity threat assessments, and science-based conservation policies (Friess and Webb, 2013).

Notwithstanding these discrepancies, applications of remote sensing and the use of alternative technologies in mapping mangroves and land use change can inform the impact of ecotourism on mangroves. Remotely sensing technologies such as satellite, light detection and ranging (LiDAR), and unmanned aerial vehicles (UAVs) have been used to map and detect spatial and temporal changes in mangrove area, cover, and distribution (Rondon et al., 2023; Pham et al., 2019; Lucas et al., 2017; Alongi et al., 2016; Heumann, 2011). In particular, UAVs or drones have emerged as an essential tool for the management and promotion of mangrove ecotourism (Yang et al., 2022) and for deriving near real-time early warning metrics to inform and guide sustainable forest

management, including mangrove ecosystems (Ewane et al., 2023a). Remotely sensed data can also be used for ecosystem and productivity assessments, field survey planning, and water-quality analysis (Kuenzer et al., 2011).

Ecotourism is defined as "responsible and purposeful travel to natural areas that provide and sustain social and economic benefits to local livelihoods while conserving the environment" (International Ecotourism Society - TIES, 2015). Mangrove ecosystem services are important and unique ecotourism attractions for a wide range of tourist groups. Specifically, mangrove ecotourism attractions are linked to ecosystem services including recreation and leisure, aesthetic value, educational opportunities, cultural heritage, folklore medicines and extracts, and spiritual and religious contributions (Saranraj and Sujitha, 2015; MEA, 2005a,b). Terrestrial/aquatic plants and wildlife species are important attractions to tourists. Thus, the identification of suitable mangrove ecotourism locations considers ecological, economic, and social indicators and components that encompass biodiversity, endemic species, conservation status, fragile ecosystems, water quality, sustainable practices, local community involvement, accessibility, infrastructure, and environmental education (Kiper, 2013). Thus, mangroves provide ample opportunities for sustainable ecotourism (Nelly et al., 2020).

Ecotourism provides another pathway for mangrove conservation, as well as for the management or reduction of the stressors noted earlier. Mangrove ecotourism has gained widespread prominence and is an important form of tourism to many people around the world, with approximately 3945 attractions in 93 countries (Spalding and Parrett, 2019). Mangrove ecotourism in Southeast Asia offers a range of enriching experiences. Travelers can enjoy enriching guided eco-tours in places like Langkawi Mangrove Kilim Geoforest Park (Malaysia), Bohol Mangrove Forest (Philippines), and Bintan Mangrove (Indonesia). These nature-based tours allow travelers to experience the breathtaking natural beauty of mangrove ecosystems while simultaneously offering insights and support into conservation efforts. In Southeast Asia, ecotourism has emerged as a promising approach for mangrove conservation and restoration, offering socio-economic advantages to local communities and enhancing awareness of mangroves' significance in biodiversity conservation and climate change resilience.

Mangrove ecotourism has important environmental benefits, such as offering a potentially important source of financing for mangrove conservation and restoration initiatives that should contribute to the financial and sustainable management of mangrove-protected areas visited by tourists. Governments in Southeast Asia have traditionally used a variety of methods such as user fees, concessions, sales and royalties, taxation, and donations to capture and retain revenue from ecotourism (Brandon, 1996). These economic tools which can be categorized as Corporate Social Responsibility (CSR), Payments for Ecosystem Services, Contingent Valuation Method, and Choice Experiment via willingness to pay, have been used to assign a financial value to mangrove forests in Southeast Asia. Thus, mangrove ecotourism can support conservation and restoration efforts aimed at safeguarding and enhancing responsible and sustainable practices that can help conserve and restore mangrove habitats. This is achieved through providing financial support, raising awareness among tourists and local communities, and adhering to environmental regulations. A sudden and large source of tourism income providing alternative livelihoods to local communities may divert locals away from mainstay livelihood activities such as aquaculture, fishing, and agriculture and promote the conservation of mangroves to earn more economic benefits (Friess, 2017).

Mangrove ecotourism also has invaluable social and economic benefits that help provide sustainable livelihoods to local communities, and thus are increasingly acting as important financial incentives for national governments and local communities to conserve and restore mangroves. Ecotourism enhances sustainable livelihoods and increases environmental awareness and knowledge among the local people living adjacent to mangrove communities, safeguarding biodiversity conservation while protecting and shielding local communities against more frequent natural disasters associated with climate change (WWF, 2017). Community-based mangrove ecotourism can enhance the socio-economic status of indigenous peoples and local communities (IPLCs) that rely upon mangrove ecosystems and can also contribute to mangrove conservation. Thus, ecotourism could be seen as a neo-liberal conservation tool to support mangrove conservation and restoration activities in a sustainable manner that benefits and strengthens links between the environment, mangroves, and people (Friess, 2017). Mangrove ecotourism activities contribute directly or indirectly towards global efforts to achieve related UN sustainable development goals (SDGs), such as SDGs 1 (No poverty), 2 (Zero hunger), 11 (Sustainable cities and communities), 12 (Responsible consumption and production), 13 (Climate action), 14 (Life below water), and 15 (Life on land).

Ecotourism comes with its set of challenges, such as environmental, social, and cultural impacts from disputes concerning benefit-sharing distribution and potential disruptions to traditional livelihoods (Brandon, 1996). Due to the prominence of mangrove ecotourism in Southeast Asia, many IPLCs are experiencing increased tourist numbers, boat traffic in the mangrove canals, pollution, mangrove destruction, and conflicts in ecotourism benefit sharing, which directly and indirectly impact the environment, local economy, culture, and society (Friess, 2017; Swangjang and Kornpiphat, 2021; WWF, 2017; Swangjang and Kornpiphat, 2021). As ecotourism results in both positive and negative short- and long-term impacts on the environment and IPLCs, it is regarded as both a solution and a threat. Thus, it is also critical to develop metrics to identify, understand, measure, and mitigate the envisaged direct and indirect environmental, economic, and socio-cultural impacts of increased tourism in different countries (Friess, 2017). It is important to understand the significant knowledge gaps related to the spatial extent of mangrove ecotourism activities and how important their contributions are to biodiversity conservation, habitat protection, and the national, regional, and local economies of Southeast Asia countries (Friess, 2017).

The aims of this paper are to 1) examine the geographical distribution of key mangrove ecotourism sites, 2) identify key mangrove ecotourism activities in the various ecotourism sites, 3) examine the impacts of ecotourism on mangrove ecosystems, economy, and society, and the ongoing mangrove ecotourism conservation initiatives (highlighting case studies), and 4) examine the trends and growth factors in mangrove ecotourism in Southeast Asia. We highlight the importance of integrating state-of-the-art technologies like remote sensing and deep learning to improve monitoring, evaluation, and reporting (MER) of mangrove cover change due to ecotourism. We discuss ecotourism-driven mangrove conservation and restoration initiatives in the region in relation to the UN SDGs in Southeast Asia. We highlight the need to use UAVs for real-time monitoring of mangroves and identify early warning metrics that would guide the development of sustainable pathways and solutions to mitigate the associated negative impacts of mangrove ecotourism activities in Southeast Asia. Finally, we discuss the limitations of the study, future research directions and policy implications.

2. Methods

Our literature review process focused specifically on English-language results from January 2010 through December 2022. Relevant articles were searched in Google and Google Scholar search engines and Scopus and Web of Science (WoS) databases. Because the rise of ecotourism activities is a recent phenomenon, our search focused specifically on the years from January 2010 through December 2022 to obtain the important scientific developments in the field of ecotourism and mangrove conservation in Southeast Asia. For this study, we adopted the Preferred Reporting Items for Systematic Reviews and Meta-analysis (PRISMA) (Moher et al., 2009). Using the search expressions in Table 1, we examined the first 10 Google and Google Scholar pages with

100 results per page giving a total of 1000 articles. We limited the search to the first 1000 articles in the Google Scholar search after a pre-test screening of the literature search results, where no additional relevant articles are usually retrieved through examining 500 more articles (Ewane et al., 2023b). Articles were then assessed for eligibility according to the search expression for inclusion evaluation criteria in Table 1 and in addition to the article being scientifically peer-reviewed. Laos was excluded from the search countries of Southeast Asia because it is landlocked and has no mangrove cover.

Articles were identified as potentially relevant by first reading the title and abstract and later verified by reading the entire paper. The workflow representing the systematic literature review process is presented in Fig. 1. The list of primary articles from the manual review included 298 results, of which 88 were removed after filtering for duplicates. The remaining 210 articles were assessed for eligibility by excluding a further 120 results that were not in English, were related to mangroves and ecotourism in regions irrelevant to the purpose of this paper, or focused on elements of mangroves that did not take into account the effects of tourism or ecotourism.

Following manual filtering, we conducted a code-based search using Python (https://serpapi.com/search?engine=google_scholar) to confirm these results, utilizing the keywords outlined in Table 1. The code-based search returned 122 results from Google Scholar, of which 120 were removed as duplicates or as sources that did not focus on ecotourism and mangroves in Southeast Asia, resulting in an additional 2 articles. Finally, 7 articles were added throughout the literature search process from the citation network and complementary studies using the snowballing technique (Badzmierowski et al., 2021; Ewane et al., 2023b). The full systematic review process, described in Fig. 1, resulted in a final list of 100 peer-reviewed sources (Supplementary Information). Gray literature, such as blog posts, online newspapers, theses, dissertations, and conference abstracts were excluded from the systematic review process, except for peer-reviewed conference series proceedings due to their focus on the subject of mangrove ecotourism and conservation.

There was a positive relationship between the area of mangroves in each country and the number of publications per country. Among the 100 selected articles, 67 mentioned Indonesia (2,953,398 ha), followed by Malaysia (n = 17; 524,575 ha), collectively constituting 83.8% of the reviewed articles. The Philippines (284,798 ha), Thailand (252,799 ha), and Vietnam (187,147 ha) were mentioned 9, 6, and 6 times, respectively, while Brunei (11,497 ha), Myanmar (543,539 ha), Cambodia (62,692 ha), and Singapore were mentioned 1 or 2 times (Fig. 2A and B).

There was an increase in the number of publications between 2011 (N = 1) and 2018 (N = 16), followed by a slight drop in 2019 (N = 12), and an increase in 2020, which together with 2022 had the highest number of articles among the publications reviewed (N = 20 - 21). There was then a slight decrease in 2021 (N = 15) (Fig. 3). Of the 100 papers surveyed, 84% were published over the last five years (2018–2022), underscoring the growing consideration of the importance of mangrove conservation for ecotourism development.

Primary ecotourism sites were identified via a literature review, with emphasis on the frequency of mentions. Specific case studies representing Indonesia, Malaysia, Thailand, and the Philippines have been described to highlight the ecotourism-driven mangrove conservation and restoration initiatives. In addition, the trends and growth factors impacting mangrove ecotourism in Southeast Asia were examined.

Table 1
Search expressions considered for the systematic literature search.

Criteria	Search Expression
What	"Mangroves"
AND	"Southeast Asia" OR "Brunei" OR "Burma" OR "Myanmar" OR "Cambodia" OR "Timor-Leste" OR "East Timor" OR "Indonesia" OR "Malaysia" OR "Philippines" OR "Singapore" OR "Thailand" OR "Vietnam"
How	"Ecotourism" OR "Tourism"
When	January 2010 to December 2022

3. Results and discussion

3.1. Geographical distribution of key mangrove ecotourism sites

Almost 46% of the world's mangroves are distributed over South Asia, Southeast Asia, and Asia-Pacific, with Indonesia having about 20% of the global mangrove area. Thus, mangroves represent key ecotourism attractions in Southeast Asia. Mangrove ecotourism in Southeast Asia represents a diverse set of attractions and activities that range in geographical distribution and level of attraction. The spatial distribution of mangroves and the location of 14 identified key mangrove ecotourism sites as key attractions in countries of Southeast Asia are presented in Fig. 4. These include the Ha Long Bay (Vietnam); Khao Sok National Park (Thailand); Langkawi Mangrove Kilim Geoforest Park, Matang Mangrove Forest Reserve, Klang Island and Tulai Island (Malaysia); Bintan Mangroves, Karangsong Village, Pantai Pasir Kadilangu, Nusa Penida Island, Komodo National Park, and Tongke-Tongke Mangrove Forest (Indonesia); and Olango Island Wildlife Sanctuary and Bohol Mangrove Forests (Philippines). Thus, most of the mangrove ecotourism sites and key attractions were reported in Indonesia (N = 6), Malaysia (N = 4), and the Philippines (N = 2) which were three countries with large areas of mangrove cover (Fig. 4 and Table 2). This suggests that there is a positive relationship between the number of ecotourism sites and the size of mangrove cover per country in Southeast Asia. These ecotourism attractions are increasing in popularity and are known to influence destination choice by tourists (Avau et al., 2011; Spalding and Parrett, 2019).

Therefore, the spatial distribution of the published articles and the popularity of mangrove ecotourism in Southeast Asia is diverse and dependent on the country's mangrove area cover. It also depends on specific ecotourism activities, available recreation opportunities, and tourist interests (Ginantra, 2022). For activities related to natural environments (such as hiking, bird watching, and kayaking), the temporal scale is usually a day trip or an overnight stay. However, for non-mangrove ecotourism activities related to cultural heritage properties (such as visiting a historic site or museum), the temporal scale may be shorter, such as a few hours.

The development of mangrove tourism villages in these key ecotourism sites is an increasingly popular way to expand mangrove ecotourism in Southeast Asia. The potential of the tourism village can be divided into several zones; zoning is intended to cluster the tourism village and classify its various features. Mangrove tourism villages generally have local potential due to their attractive local features (Suyanto et al., 2019). Therefore, it is necessary to develop a tourism village strategy by empowering local communities, exploring the physical potential and local wisdom as an attraction to be "sold" as environmental services.

3.2. Mangrove ecotourism activities in the various ecotourism sites in Southeast Asia countries

Mangrove ecotourism activities are broad and diverse, ranging from ecological, social, and cultural activities, with varied attractions to tourists in the form of recreation and leisure (Table 2). Social recreational and leisure activities involving boat tours were the most popular. Bird and wildlife watching, kayaking, eating seafood, snorkeling, trekking, fishing, photography, and research and education were also important ecotourism activities. Most of these diverse ecotourism activities were reported in Indonesia and Malaysia with the largest areas of mangrove cover, suggesting an appreciable relationship between the diversity of ecotourism activities and the size of mangrove cover per country in Southeast Asia. Tree planting following various voluntary mangrove rehabilitation and restoration projects involving tourists is a

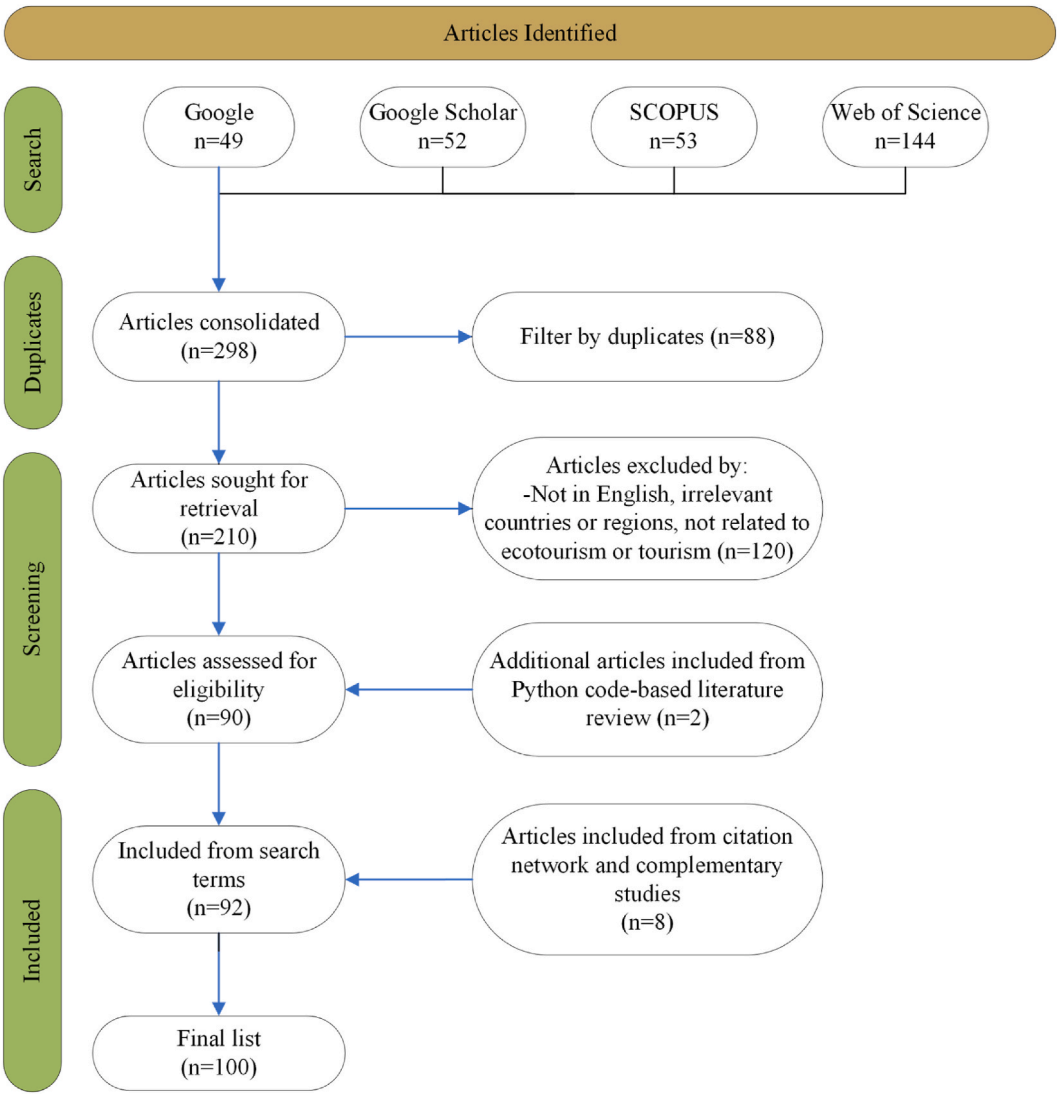

Fig. 1. Workflow representing the systematic literature review process.

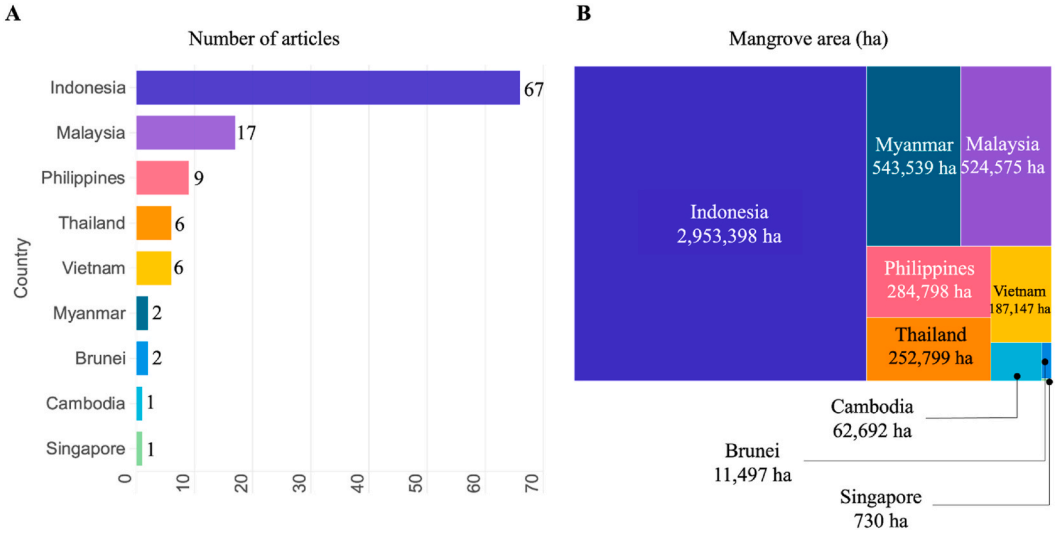

Fig. 2. A) Number of published articles for each country from Southeast Asia focused on mangrove ecotourism (2010–2022). B) Mangrove area (ha) for each country from GMW 3.0: Bunting et al. (2022).

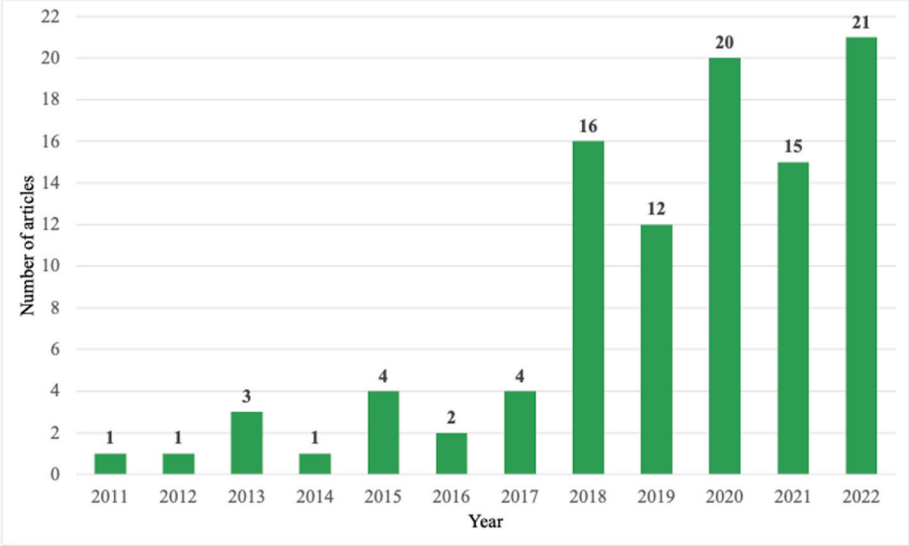

Fig. 3. Temporal variation in the number of peer-reviewed publications (English) focused on mangrove ecotourism in South Asia (2010–2022).

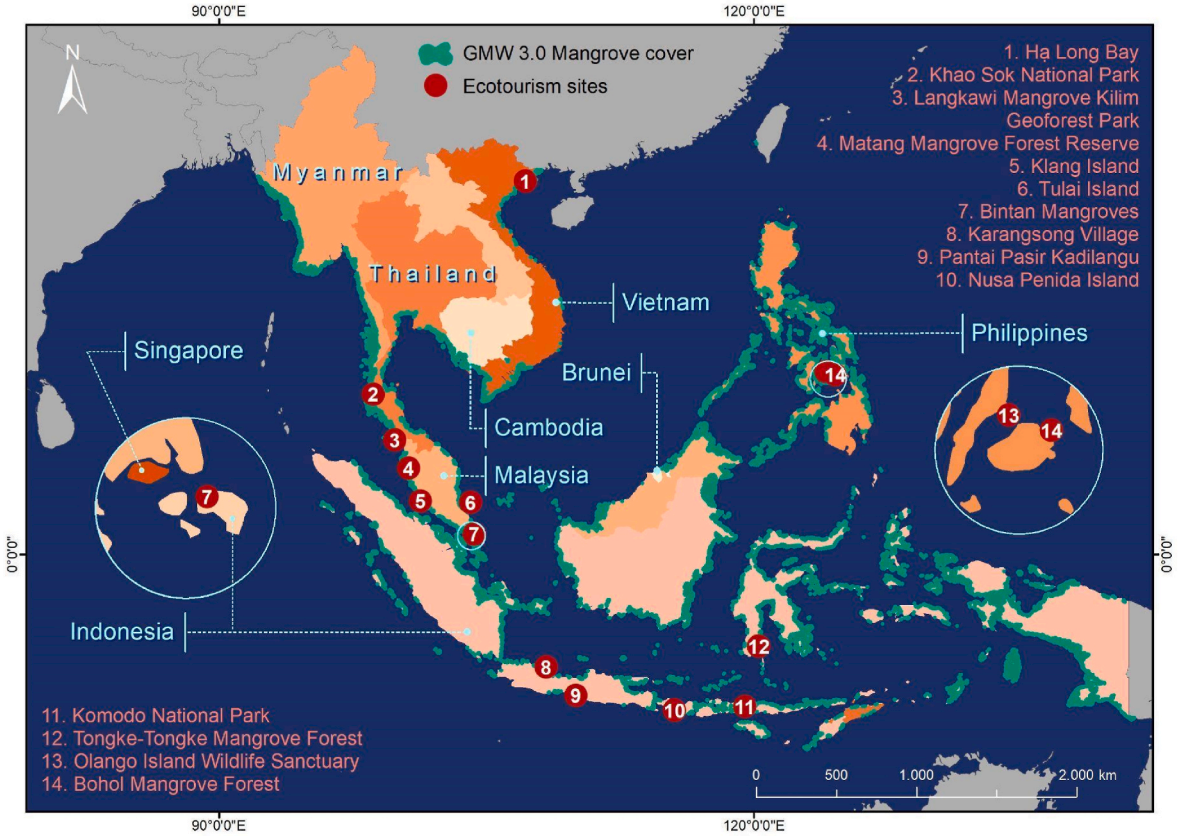

Fig. 4. Distribution of mangroves and locations of key mangrove ecotourism sites in Southeast Asia. Mangrove area for each country from GMW 3.0: Bunting et al. (2022).

common ecological activity in Southeast Asia.

Ghermandi and Nunes' (2013) analysis of 253 coastal shoreline recreational activities showed that only 11 activity evaluations were attributed to mangrove ecosystems (4.6%). There are still significant knowledge gaps concerning the cultural value of mangroves today, with spiritual and ceremonial uses present in locations like Singapore (Friess, 2017). The economic impact of these ecotourism activities, in terms of contribution to GDP for individual countries and local tourism economies, should be quantified in future studies to provide context on the profitability of mangrove ecotourism and the proportion of re-investment in community-led mangrove conservation and restoration projects.

Table 2
Mangrove ecotourism activities in the various mangrove ecotourism sites in countries of Southeast Asia (identified via a literature review, with emphasis on the frequency of mentions).

#	Country	Mangrove ecotourism site	Key ecotourism activities/attractions	Reference examples
1	Vietnam	Ha Long Bay	Visiting and mangrove planting	Zhang and Jiang (2011)
2	Thailand	Khao Sok National Park	Mangrove planting and kayaking	Treephan et al. (2019)
3	Malaysia	Langkawi Mangrove Kilim Geoforest Park	Mangrove boat tours, mangrove kayaking and jet ski tours, visits to bat caves, eating seafood on floating restaurants, monkey viewing, and an eagle-watching point along one of the rivers	Mohamed (2012); Thompson et al. (2018)
4	Malaysia	Matang Mangrove Forest Reserve	Charcoal factory visit, bird and dolphin watching, fishing	Mahmud et al. (2015)
5	Malaysia	Klang Island	Island tours in boats, cruise ships and eating seafood in floating restaurants	Hattam et al. (2021)
6	Malaysia	Tulai Island	Kayaking, snorkeling, scuba diving, nature trail, research, and education tour and tracking, photography, bird watching, and mangrove planting	Saad et al. (2015)
7	Indonesia	Bintan Mangroves	Eating seafood on floating restaurants, island tours on boats	Harahap & Absah (2022a); Khairunnisa et al. (2021)
8	Indonesia	Karangsong Village	Nature hiking, bird watching, mangrove forest tours either by path or boat, and photography	Garsetiasih et al. (2021); Novianti et al., 2022
9	Indonesia	Pantai Pasir Kadilangu	Boat tours and eating of seafood on floating restaurants	Fistingrum and Harini (2021)
10	Indonesia	Nusa Penida Island	Boat tours, snorkeling or diving, bird watching	Vipriyanti et al. (2024)
11	Indonesia	Komodo National Park	Boat tours, snorkeling, bird watching, kayaking and trekking to view the Komodo Dragons	Hidyarko et al. (2021)
12	Indonesia	Tongke-Tongke Mangrove Forest	Boat tours	Dahliah (2020)
13	Philippines	Olango Island Wildlife Sanctuary	Bird watching, mangrove planting	Ancog and Ruzol (2015)
14	Philippines	Bohol Mangrove Forests	Boat tours and mangrove planting	Carandang et al. (2013); Miranda et al. (2013)

3.3. Mangrove ecotourism impacts and conservation initiatives

3.3.1. Benefits of ecotourism to the environment, economy and society

Mangrove ecotourism promotes and contributes to direct and indirect ecological, economic, and social benefits to the host countries and local communities through the various ecotourism, recreation, and leisure activities and opportunities offered by the key ecotourism sites (Table 3). From the economic dimension, the primary objective of mangrove ecotourism management is to have a positive impact on the national and local economy, by utilizing the potential of mangroves to attract tourists. This may lead to increased business opportunities, income, and positive impacts on other economic sectors (Harahap and Absah, 2022), while boosting intrinsic motivations for community-based mangrove restoration and conservation to sustain the economic benefits of ecotourism activities.

Table 3
Benefits associated with mangrove ecotourism activities in countries in Southeast Asia.

Category of benefits derived from mangrove ecotourism activities	Description
Ecological benefits (Mangrove restoration, conservation and protection actions)	Mangrove reforestation/tree planting Community-based mangrove management/protection Promotion of sustainable/responsible ecotourism activities
Economic benefits	Increase in country-regional level Gross Domestic Product Increase in tourism industry income Increase in tourism household/family income Increase in individual income Increase in infrastructural development investment across related sectors Creation of new and alternative jobs/employment
Social benefits	Poverty reduction Improvement in quality of life Increased access to basic amenities (clean water, sanitary, electricity, transport network, schools, health service, etc.) by the local population

Mangrove ecological benefits come from community-led mangrove planting, mangrove ecosystem projection initiatives, and the promotion of sustainable mangrove ecotourism activities. Global and local concern to enhance ecotourism and mangrove conservation is motivating and attracting the expansion of mangrove reforestation activities involving seedling planting across Southeast Asia, where mangroves are highly vulnerable to anthropogenic stressors. For example, tree planting to conserve and restore mangroves and support ecotourism activities is widely practiced by local communities and tourists in the Philippines (Ancog and Ruzol, 2015; Carandang et al., 2013; Miranda et al., 2013), Malaysia (Saad et al., 2015), Vietnam (Nguyen, 2016) and Thailand (Treephan et al., 2019).

Mangrove forests along the Mekong River protect its ecological function of bringing sediment downstream and fish to spawn, thereby sustaining the livelihoods of the adjacent and downstream communities, and helping to ensure their continued existence (WWF, 2017). These connections between mangrove ecosystems and community livelihood sustenance mean that mangrove conservation and protection should be considered a priority (Singgalen, 2020). Thus, the ecological benefits of mangrove ecotourism activities is motivating the expansion of mangrove restoration and conservation initiatives in Southeast Asia countries.

The ecological, economic, and social benefits of mangrove ecotourism are interconnected with many other complementary industries. Designated protection sites for mangroves also draw attention from tourists, giving further rise to the "development of a massive tourism industry and all other complementary industries which contribute to the country's socio-economic development" (SEARCA KC3, 2018). Tourists benefit from the socio-cultural services of mangrove habitats while providing direct and indirect income benefits to tourism operators and local communities (Friess, 2017). Mangrove ecosystems provide wood and seafood for both tourists and the host local communities, which helps to increase both tourists and household

food security and nutrition diversity and stimulate economic growth and a higher standard of living in nearby communities (Musa et al., 2020). Ecotourism improved lives in Vietnam by creating new job opportunities, not just for the family directly involved, but for nearby families as well (WWF, 2017). The UNESCO-designated Langkawi Global Geoparks in Malaysia were designed as both a conservation site for mangroves and as a tool to support sustainable ecotourism (Asri and Musa, 2021).

Mangrove ecotourism activities have significant impacts on the local economy and household livelihoods, as they can create jobs, generate revenue, and promote economic growth, with each one having its unique economic aspects. Kayaking and trekking to view the Komodo Dragons in Indonesia offer a unique travel opportunity, but also generate employment for local communities. Tour operators, guides, and support crews require manpower to help deliver the excursion package to travelers. This means that the industry provides a livelihood for people within the vicinity of Komodo National Park, where the dragons reside, and ecotourism helps to raise local living standards (Hidyarko et al., 2021).

Thus, mangrove ecotourism may generate millions of dollars in visitor expenditure and act as an alternative economic livelihood for coastal communities that can increase community income (Kissinger and Np, 2020). For instance, the contribution of Tongke-Tongke mangrove forest in Indonesia tourism to the regional revenue in the tourism sector of Sinjai Regency was low, at 25.7%. The government's efforts to increase tourism contributions to the local revenue in 2018 were successful, resulting in a 43.7% absolute increase over the previous year, to 69.4% (Dahliah, 2020). Similarly, Sri Lanka's ecotourism has almost doubled as a percentage of GDP over the past decade, and over 2.7 million people depend on mangrove fisheries for their livelihood (Camisani, 2018).

The management of mangrove ecotourism in the Pasir Mendit and Pasir Kadilangu hamlets of Indonesia has a significant impact on the social conditions of the community (Fistingrum and Harini, 2021). This is because mangrove ecotourism leads to changes in the pattern of community activities around mangrove ecotourism sites, such as new income-generating activities, with 90% of them currently related to mangrove ecotourism. Similarly, the existence of mangrove ecotourism in Karangsong Village, Indonesia, gave rise to several activities, such as trading around mangrove ecotourism (Setiyawan and Saraswati, 2017). The community's income-generating activities mostly relate to mangrove ecotourism, stimulating jobs as ecotourism managers, traders, and parking attendants. Ecotourism in mangrove forests on the East Coast of Surabaya (Pamurbaya) has a total economic value of approximately US$ 3.8 million per year or US$ 8101.8 per ha per year (Kusumawardani, 2019).

Moreover, mangrove ecotourism revenue can be invested in tourism infrastructure development and other socio-economic ventures. Ecotourism finance can be used to support infrastructural development projects such as the improvement or construction of lodges, transportation networks, schools, and health facilities, as well as increased access to basic amenities such as clean water and electricity. These types of economic development benefits and improvements can be integral in lifting people out of poverty, elevating the quality of life of local people living in the region, and stimulating national and local economic growth. The revenue generated from tourism can also lead to the creation of new jobs and business opportunities, contributing to poverty alleviation and economic development. By investing in such activities, ecotourism can finance mangrove restoration and conservation projects, preserve natural mangrove habitats, and protect the environment for future generations. By promoting sustainable and responsible tourism, the local economy and community can benefit in the long term as the increased revenue from tourism is invested back into the community, leading to an overall improvement in the quality of life for residents.

Tourist motives to travel in any country or destination are usually multifaceted, involving interests to visit not just areas of natural attractions but also areas with high and diverse cultural attractions. Exploring the ancient temple complex through guided tours or bicycle rides in Cambodia has significant economic benefits as it helps to drive tourism and encourages local economic development (Rawlins et al., 2020). As tourists flock to explore the historical and cultural sites, the local economy reaps the benefits of increased revenue from tourism-related activities, such as food and beverage services, souvenir sales, and transportation services. Additionally, hiring local guides and utilizing local businesses for bicycle rentals helps to support the growth of the local economy.

3.3.2. *Negative impacts of ecotourism-related activities on mangroves and tourism industry*

The negative impacts of mangrove ecotourism activities vary depending on context and management practices. The negative impacts of ecotourism on mangrove ecosystems result from physical exploration of the environment, which harms not only mangroves but also the ecosystem services they provide (Novianti et al., 2022). Damage from human interaction, including litter, light pollution, sewage, and other disturbances, occurs easily to the natural vegetation and fauna in the mangrove ecosystem (Giles et al., 2022). Abandoned waste and litter by tourists can pollute estuarine waters, negatively affecting the health of marine life reliant upon mangrove ecosystems (Sucharitakul and Hardy, 2021). The noise and presence of people affect sensitive species of wildlife, unlike tolerant species (Garcia et al., 2014). The examples below demonstrate the common challenges faced with water pollution and resource availability resulting from mangrove loss (Table 4).

The damage or even removal of mangroves as a result of ecotourism has significant impacts on water pollution and water access. The large influx of tourists to tropical coastal areas can affect economic and ecological resources, which in turn can affect coastal ecosystems through land conversion and waste generation activities (Swangjang and Kornpiphat, 2021). Mangroves are negatively affected by unsustainable and irresponsible ecotourism activities such as clearance for lodges and restaurants; this will in turn reduce carbon storage and sequestration rates, considering that mangroves are excellent carbon sinks. When mangroves are cleared, water pollution increases, negatively affecting aquatic ecosystems, marine life, and communities relying on clean water. Boat tours along river channels in mangrove ecosystems can result in negative effects on shoreline mangroves, such as riverbank erosion from boat wakes, which could result in the uprooting of mangrove trees (SEARCA KC3, 2018).

3.3.3. *Ecotourism-driven mangrove conservation and restoration initiatives*

Ecotourism must account for these unwanted consequences, lest the institution become more harmful than helpful to the countries and communities that utilize mangroves for tourism, require them for their livelihoods, and/or rely on them for the protection and services they provide. The responsibility for managing and governing sustainable ecotourism is distributed among various stakeholders, including government authorities, tour operators, hoteliers, local communities, conservation organizations, tourists, researchers, and accreditation bodies. For ecotourism to effectively contribute to mangrove conservation and restoration in Southeast Asia, all these stakeholders must collaborate and work together towards a common goal.

Many Southeast Asian countries promote mangrove conservation and sustainable management practices to mitigate negative impacts and protect valuable coastal ecosystems (UNEP, 2019). The countries have committed to mangrove conservation and rehabilitation initiatives involving tree planting and management through various stakeholder organizations to sustain the provision of valuable ecosystem services, including safeguarding and promoting the ecotourism industry. Several countries around the world have developed mangrove ecotourism and conservation initiatives. The following are four prominent examples from Southeast Asia.

Table 4
Negative impacts of ecotourism-driven mangrove deforestation activities in selected countries of Southeast Asia.

Country	Ecotourism-driven deforestation activities	Negative impacts	Proposed mitigation and ecosystem-based management strategies
Indonesia	Mangrove deforestation for shrimp aquaculture and coastal development	Increased sedimentation, water pollution, and saltwater intrusion affect freshwater availability in coastal areas	Effective design and management of the tourist areas by enhancing mangrove conservation and rehabilitation for biodiversity while balancing economic demands through selective wood harvesting, re-planting harvested areas, and revitalizing aquaculture to deter new pond expansion (Ali et al., 2021; Malik et al., 2019; Yuwanti and Setiawan, 2018)
Thailand	Conversion of mangroves into tourist attractions and industrial zones	Water pollution (heavy metals/ metalloids and pesticides). The removal of mangroves has also disrupted natural water flow patterns and exacerbated water shortages in some regions	To conserve mangroves, policies should prioritize urban planning measures, promote awareness of ecotourism's environmental benefits among stakeholders, and ensure comprehensive monitoring of mangrove changes stored in a local database (Swangjang and Kornpiphat, 2021)
Vietnam	Mangrove removal for agriculture and shrimp farming	Increase sedimentation that reduces water quality and affects aquatic habitats, including those of commercially important fish species	Establishment of national and international policies for mangrove conservation to address deforestation drivers. Prioritize mangrove replanting and existing conservation through technical support (Pham et al., 2022)
Philippines	Coastal development, illegal logging and conversion to fishponds	Increased water pollution from sediment runoff, loss of natural water filtration, and regulation that impact water quality and availability	Enhancing mangrove conservation through bolstered educational programs, heightened awareness campaigns on their ecological and socio-economic significance, and implementing management zonation that encompasses strict protection, and designated ecotourism areas (Quevedo et al., 2020)
Malaysia	Clearing mangroves for palm oil plantations and coastal infrastructure	Increased water pollution through the release of sediment, nutrients, and agrochemicals, affect both coastal ecosystems and communities relying on these water sources	Safeguarding mangroves as multifunctional resources for communities and stakeholders, by integrating all relevant parties including the private sector through awareness and economic opportunities, and refining policies to close gaps that threaten this ecosystem (Hattam et al., 2021)

3.3.3.1. Case studies: Indonesia, Malaysia, Thailand, and the Philippines. Indonesia is the world's largest archipelago, with over 17,000 islands, and is home to some of the most extensive mangrove ecosystems in the world. The country has several national parks and reserves that protect these areas, including Papua Islands, which is one of the largest mangrove areas in Southeast Asia. Ecotourists can visit these areas to observe wildlife, take boat tours, and learn about the traditional livelihoods of local communities. For example, on Nusa Penida Island, over two hundred thousand people visit each year as tourists, while the island itself is designated for conservation - they balance the two, cultivating ecotourism and managing it for the safety of the wildlife, mangrove habitats included (Vipriyanti et al., 2024). In Indonesia, the effectiveness of mangrove ecosystem rehabilitation efforts for ecotourism development in four coastal villages (Sriwulan, Bedono, Timbul Sloko, and Surodadi) in Central Java was assessed (Damastuti et al., 2022). Through resource mapping and interviews, it was found that Bedono, Indonesia, had achieved greater success due to its longer-term funding, protection legislation acceptance, public support, etc. (Damastuti et al., 2022). Consequently, this resulted in higher mangrove and macroinvertebrate diversity compared to other villages. This research identified key components for successful mangrove restoration, which can serve as a guide for biodiversity conservation moving forward (Damastuti et al., 2022).

Malaysia is a Southeast Asian country that is home to several important mangrove ecosystems, including the Matang Mangrove Forest Reserve, located in the state of Perak. The reserve covers over 40,000 ha and is home to a variety of wildlife, including monkeys, crocodiles, and numerous bird species. Ecotourists can take boat tours of the reserve and visit traditional fishing villages to learn about the local culture. On Tulai Island, the Mangrove Bay area is home to many businesses that appeal to tourists by offering services including diving, snorkeling, and cruises. This is just one area of Tulai Island with mangroves that can be explored via ecotourism, many of which have different mangrove species for an appealing, diverse experience in mangrove ecotourism (Saad et al., 2015). In Malaysia, by studying the Klang Islands and conducting stakeholder workshops and focus group discussions over two years, it was determined that locals recognized the benefits of mangroves beyond simply its goods and services, and their lives were impacted by losing mangrove access. Although fishing was still seen as important, participants favored ecotourism as a possible alternative livelihood option (Hattam et al., 2021). Various cases across Southeast Asia show that local individuals, families, and organizations play key roles in conserving mangrove forests. Mangrove rehabilitation strategies should be centered on local people's differential adaptive capacity and multiple needs (Carrie et al., 2022).

In Thailand, successful community-based mangrove management (CBMM) has enabled researchers to study what factors have helped other CBMM initiatives achieve success. Collective action coupled with NGO support in response to degradation crises was followed by

increased cooperation between local and government authorities. Internal and external factors such as leadership within the community, changing occupations, experience, and capacity for organization were all contributing elements to successful CBMM.

The Philippines is an archipelago of over 7000 islands that is home to several important mangrove ecosystems, including the Olango Island Wildlife Sanctuary, which is located in the central part of the country. The sanctuary covers over 1000 ha and is home to over 40,000 migratory birds that visit the area each year. Ecotourists can visit the sanctuary to observe the birds and learn about the local culture. Mangroves provide much economic value to the Philippines, thus many conservation strategies have been implemented to properly protect them. For instance, within Banacon, Bohol, Philippines (83,079 ha), and Kamuning, Palawan, Philippines (2769 ha), the preservation of mangrove ecosystems is facilitated by the revenue generated through mangrove ecotourism activities (Carandang et al., 2013).

3.3.4. Ecotourism as an integral part of social-ecological resilience

As evidenced through this review, sustainable and responsible ecotourism can have complex associations with different elements of a much larger social and ecological system, such as feedback from both social and ecological factors in a specific system like an estuary wetland (Choi et al., 2021). In the face of major global challenges such as climate change and population growth, ecotourism development should consider the impact it has on this complex social-ecological system to mitigate negative impacts on human well-being and ecological resilience. The ability of the social-ecological system to function without shifting to a new regime with a different set of processes and structure, in the face of change and disturbance, is referred to as social-ecological resilience (Garmestani et al., 2019; Walker and Salt, 2012). Therefore, improving social-ecological resilience would ensure the sustainability of the complex system in which ecotourism activities function.

With more than 70 million people dependent on mangrove ecosystems in the Bay of Bengal and Southeast Asia (Landesa, 2022), the cultural, spiritual, and ethical values of IPLC should be integrated into the decision-making process. These values constitute the social dimensions of resilience and, along with key ecological resilience attributes, can assist in developing ecotourism endeavors. As powerful drivers of human behavior, it is important to recognize these values as fundamental to modern conservation efforts and their ability to simultaneously preserve biodiversity and human well-being (Infield and Mugisha, 2010; Kareiva and Marvier, 2012). Due to its mutual reinforcement and dependence, ecotourism development should always happen within a strategic framework responsive to the underlying social-ecological system and is recommended to be developed following a value-focused thinking approach (Keeney, 1996; Martin et al., 2023).

The balance between construction and conservation poses significant challenges when it comes to mangrove ecosystems in Southeast Asia. These unique and biodiverse habitats are critical for local communities as well as the flora and fauna that rely on these ecosystems. They also play a vital role in mitigating climate change and protecting coastal areas from natural disasters. However, the rapid pace of economic development in the region often clashes with the need to conserve these valuable ecosystems. Mangroves are often locally viewed as wastelands or obstacles to progress, leading to their destruction for urban development, aquaculture, agriculture, and infrastructure projects. The conversion of mangrove forests into shrimp farms or tourist resorts has been a persistent issue, particularly in countries like Vietnam, Indonesia, and Thailand (Boyd et al., 2021). These activities result in the loss of important wildlife habitats, increased vulnerability to storms and erosion, and a decline in the natural services mangroves provide.

In response to the pressing need for mangrove conservation, several initiatives have been launched across Southeast Asia. Government authorities, with support from international organizations, have established protected areas and implemented regulations to limit mangrove destruction. Community-based conservation programs have empowered local communities to actively engage in mangrove restoration and management, allowing them to benefit from sustainable resource use and ecotourism (Purwanti et al., 2021). Efforts to strike a balance between construction and conservation have also emerged. Innovative approaches, such as "building with nature" concepts, are gaining traction (Garmestani et al., 2019). These strategies integrate mangroves and other natural habitats into coastal infrastructure projects, providing ecological benefits while meeting the needs of development. For instance, mangrove restoration and conservation have been incorporated into the design of coastal protection systems, such as breakwaters and embankments, to enhance their effectiveness in protecting shorelines, mitigating storm surges, and promoting ecosystem resilience (Damastuti et al., 2022; Mulyadi and Hamidy, 2021).

Education and awareness campaigns are essential components of conservation efforts (Ewane et al., 2023b). By raising public awareness (national parks are the pioneers of mangrove-based recreation) about the value of mangroves, the threats they face, and the benefits they provide, communities and decision-makers can make informed choices that prioritize their long-term conservation (Hakim et al., 2017; Sulistyorini et al., 2018). Additionally, promoting sustainable alternatives to destructive practices, such as promoting sustainable aquaculture or eco-friendly tourism, can help alleviate pressure on mangrove ecosystems (Friess et al., 2019; Pham et al., 2022; Situmorang, 2018). The challenge of balancing construction and conservation in mangrove ecosystems in Southeast Asia requires a multidimensional approach. It entails recognizing the intrinsic value of these ecosystems, involving local communities in conservation efforts, and exploring innovative solutions that integrate ecological considerations into development projects. By adopting a sustainable and collaborative approach, long-term preservation of mangroves can be ensured while still meeting the region's economic and infrastructure needs.

3.3.5. Interrelationships with indigenous peoples and local communities (IPLC)

Ecotourism initiatives in Southeast Asia often involve indigenous communities due to their profound connection with nature. Similarly, involvement in ecotourism can bring benefits and challenges for non-indigenous peoples. Indigenous people constitute an appreciable share of the total population among countries of Southeast Asia (Fig. 5). Indigenous people and local communities have a large influence on mangrove restoration, conservation, and ecotourism development activities. In Karangsong Village, West Java, Indonesia, the effect the community had on mangroves was examined. It was found that "sustainable ecotourism development needs to involve local communities in its management", as local communities influence environmental services through positive thoughts about and concerns for the mangroves in the area (Garsetiasih et al., 2021). This is needed in order to maintain a positive mindset when managing the mangroves. Karangsong Village was not alone in this phenomenon; in North Sumatra, Indonesia, community groups also supported mangrove conservation, and "the involvement of the local community is important for implementing sustainable mangrove management practice" (Basyuni et al., 2018).

Certain strategies for mangrove conservation rely on community benefit. In fact, it is argued that "the success of managing the natural environment by involving the community is strongly influenced by the local social conditions" (Situmorang, 2018). The Muara Baimbai Mangrove Area, Sei Nagalawan Village, Perbaungan District, Serdang Bedagai Regency in Indonesia were studied as an example of this; in the area, mangrove rehabilitation has been strong, with many trees along the coast and at the mouth of rivers. The local community manages the trees, and this effort has been successful in promoting tourism and the local economy. In addition to other benefits from their participation in mangrove participation, the community management works to increase residents' social capital (Situmorang, 2018).

Local governments and authorities also play a role in mangrove conservation. The Department of Environmental and Natural Resources

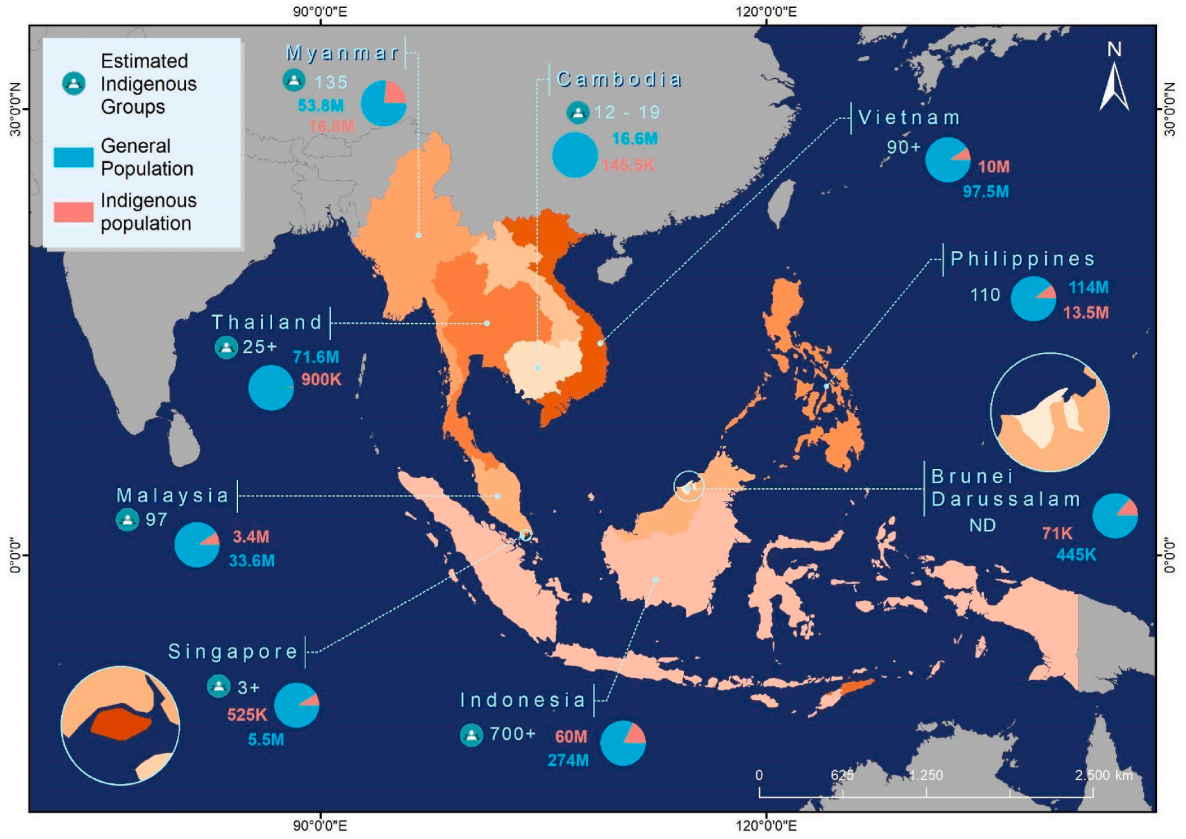

Fig. 5. Indigenous population and share of total population among countries of Southeast Asia.

in the Philippines is particular in its implementation of no illegal cutting of mangroves; this rule is strictly followed by the locals, which demonstrates their awareness of local laws, and indicates that local government efforts to prevent illegal cutting have been effective (Quevedo et al., 2020). On the other hand, mangroves can suffer when the community and local authorities or governments clash, or when overlapping regulations and responsibilities, poor governance, and social or land-based conflicts arise. For example, in Karansong, West Java, Indonesia, the Decree of Regional Government Indramayu changed the management of a section of mangroves, placing the regional government in charge. In turn, through tickets and parking prices, the number of tourists decreased, impacting the local economy negatively. In addition, community participation in mangrove management decreased following the transfer of leadership, creating tension (Fatimatuzzahroh et al., 2018).

In summary, community involvement has benefits in the management of mangroves from both environmental and economic perspectives. Only a small percentage of the initial articles used in this review referred to the implications of ecotourism on IPLCs. Their involvement in ecotourism can bring multiple benefits. Responsible and sustainable ecotourism projects developed in collaboration with indigenous peoples - such as in the Cengkrong mangrove area of Indonesia - generate economic benefits, preserve cultural values and community empowerment, strengthen land rights and visitor education, and enhance resource management and nature conservation (Purwanti et al., 2021; Moscardo et al., 2018).

3.4. Trends and factors influencing ecotourism growth in Southeast Asia

3.4.1. COVID-19 impacts

The ecotourism sector in Southeast Asia has been significantly impacted by the COVID-19 outbreak. The arrival of foreign tourists was reduced to 65% of its previous total during the first quarter of 2020, according to the United Nations World Tourism Organization, 2020 (UNWTO). To reduce the spread of the virus, the vast majority of countries implemented border restrictions or travel advisories; thus, the number of foreign visitors fell dramatically. The significant drop in tourism led to the loss of 440 million potential foreign visitors and roughly US $460 billion in potential tourism revenue, which is five times the loss of international tourism revenues during the financial and global economic crisis of 2009 (Khairunnisa et al., 2021).

The tourism industry in Asia and the Pacific was most affected by this issue; foreign arrivals decreased by 72% over six months in 2020. The fall in tourism particularly impacted Indonesia, which registered a drop in visitor arrivals of 89.22% from August 2019 to August 2020 (UNWTO, 2020). The Riau Islands are one of the entry points for foreign tourists in the country. In the Riau Islands, there was a 99.92% decline in tourist numbers (Khairunnisa et al., 2021). Given that the Riau Islands are one of the Indonesian provinces whose primary source of income is tourism this reduction in tourism had a significant negative impact on the area (Khairunnisa et al., 2021). Mangroves are one of the many tourist attractions on the Riau Islands. In addition to other countries in the region, Thailand, Indonesia, and Vietnam rely on tourism as a major source of income and jobs, with ecotourism representing a developing subsegment of the sector.

The COVID-19 pandemic forced many ecotourism operators to close temporarily or permanently; this has had a significant impact on local communities and small businesses that rely on ecotourism for their livelihoods. The loss of income has also affected conservation efforts in the region, as many ecotourism operators contribute a portion of their profits to support conservation initiatives. Moreover, the pandemic highlighted the vulnerability of Southeast Asia's ecotourism sector to global crises and the need for more resilient ecotourism practices. Some ecotourism operators have adapted to the situation by focusing on

domestic tourism and developing new products and services that cater to changing customer preferences and safety concerns. For instance, some operators have shifted from traditional group tours to private tours or have introduced more outdoor and nature-based activities to promote social distancing (Beery et al., 2021). Despite the challenges, the pandemic has also presented opportunities for innovation and collaboration in the ecotourism sector. For example, some operators and conservation organizations have collaborated to develop new ecotourism products and services that support conservation and community development. The pandemic has also highlighted the importance of building more resilient ecotourism practices that can better withstand future crises.

However, the decrease in tourist numbers and widespread lockdowns also had a positive impact on the restoration of ecosystem health in Southeast Asia. Due to a decline in boat traffic and factory emissions, river water quality in Malaysia experienced a decrease in total suspended solids as well as an increase in dissolved oxygen levels. There was also a significant improvement in air quality in the region, particularly in countries such as Singapore, Brunei, Malaysia, and the Philippines, due to a reduction in emissions from factories, vehicles, and open garbage burning (Praveena and Aris, 2021; Suriyankietkaeq and Nimsai, 2021).

3.4.2. Factors influencing the growth in demand for ecotourism

Southeast Asia is experiencing a surge in ecotourism due to its unique natural and cultural attractions. Tourists are increasingly interested in experiencing native traditions and natural environments while supporting sustainable and responsible tourism practices (Honey, 2008). Additionally, there is growing awareness of the negative impacts of traditional mass tourism on the environment and local communities, which may lead many travelers to seek more sustainable alternatives, like ecotourism (WWF, 2017). The widespread availability of information on the internet and social media has made it easier for people to learn about ecotourism and its consequences (Miller, 2020).

Several behavior change models apply to travelers transitioning to ecotourism. While the causal relationship between ecotourism and environmental self-identity is noteworthy, it is not solely restricted to those with pro-environmental concerns (Blamey and Braithwaite, 1997). The Value-Belief-Norm model can also be applied to understand how ecotourism can be a conspicuous symbol of a desired social norm or identity (Beall et al., 2021). This model predicts pro-environmental behavior by examining an individual's values, beliefs, and norms (Stern et al., 1999; Stern, 2000). Additionally, several recent studies suggest that tourists' decision-making can be significantly influenced by the desire to project their social status to others (Boley et al., 2018; Ekinci et al., 2013; Gazley and Watling, 2015; Jordan et al., 2018; Moran et al., 2018; Todd, 2001).

One model unexplored in the literature is the Transtheoretical Model (TTM), which suggests that individuals progress through a series of behavior changes, including precontemplation, contemplation, preparation, action, and maintenance (Prochaska and DiClemente, 1983). It is recommended that an experiment be set up to test the effectiveness of TTM in the context of mangrove ecotourism in Southeast Asia. The hypothesis is that individuals may move through these stages as they become more aware of the impacts of traditional mass tourism and consider more sustainable alternatives. Applying the TTM model suggests that awareness-raising activities and education can move people from the precontemplation stage to the contemplation stage. Training and capacity-building programs can help individuals move from the contemplation stage to the preparation stage, and well-designed ecotourism activities and programs can encourage people to move from the preparation stage to the action stage. Finally, monitoring, evaluation, and continued education and outreach can help people maintain sustainable ecotourism practices. Other behavior change models that may be applicable in this context are the Health Belief Model (Rosenstock, 1974), the Theory of Planned Behavior (Ajzen, 1991), and the Social Cognitive Theory (Bandura, 1986). However, there is no one-size-fits-all answer to which model is most effective in maintaining ecotourism. Various factors must be considered, such as the specific context, target audience, and behaviors targeted. Nevertheless, studies have shown that combining different models can lead to more significant and sustained behavior change. In the case of ecotourism, a comprehensive approach combining various models may be more effective in promoting sustainable and responsible tourism.

3.4.3. Current tradeoffs

As mangrove conservation is associated with socioeconomic demands on the coastal zone, such as the development of fisheries, ecotourism activities, and other services, the balance between socioeconomic and environmental demands is complicated. Multiple government agencies in Southeast Asia are responsible for managing and conserving mangroves. The aims and responsibilities of government agencies often overlap, conflict, or are unclear. Mangrove conservation in Southeast Asia is carried out by the establishment of private-public partnerships and through financial incentives for conservation. Ecotourism has emerged as a highly effective approach for conserving mangroves in various Southeast Asian locations. This strategy leverages the cultural significance of these ecosystems and provides economic and political incentives to support local communities.

Ecotourism generates income for the local population while conserving and restoring the natural resources of the mangroves. This activity promotes local culture and traditions, encourages the participation of external specialist organizations, and creates a climate of cooperation among community members in dealing with problems. For example, in Thailand, traditional culture and lifestyle are linked with the natural environment. Rural identity is promoted through activities by the national government and the Ministry of Tourism and Sport (Treephan et al., 2019); as a result, traveling to rural areas and interacting with local people is one of the current attractions in Thailand.

One of the current trade-offs involves maintaining both ecotourism viability and the integrity of the mangrove ecosystem, which can be achieved by effective combinations of ecotourism products. The products are necessary to facilitate both the economic and conservation development of the mangrove ecosystem. For Malaysian visitors, both activities and physical products are particularly influential (Azis et al., 2018), whereas in Indonesia, policy intervention regarding the conservation of the mangrove has improved in recent years at all levels (Richards and Friess, 2016). These interventions have contributed to the creation of rehabilitation programs focusing on the preservation of the mangrove area, prevention of coastal erosion, and improvement of fish capture. Thus, the enhancement of mangrove biodiversity is absolutely necessary due to its huge contribution to ecotourism (Malik et al., 2019).

3.4.4. Mangrove ecotourism in relations with UN SDGs

Mangrove ecotourism activities contribute substantially towards global efforts to achieve related United Nations Sustainable Development Goals (SDGs), such as SDGs 1 (No poverty), 2 (Zero hunger), 11 (Sustainable cities and communities), 12 (Responsible consumption and production), 13 (Climate action), 14 (Life below water), and 15 (Life on land). Ecotourism is related to SDG 1 (No poverty) and SDG 8 (Decent work and economic growth), as it fosters economic growth of local communities helping to alleviate poverty while promoting inclusive and sustainable economic growth. By fostering local communities and their relationships with their members, ecotourism can also help preserve cultural heritage as tourists learn about and interact with local traditions (UN, 2015). Ecotourism can also promote sustainable urban development by creating economic opportunities as defined in SDG 11 (Sustainable cities and communities). In addition, ecotourism could be related to SDG 12 (Responsible consumption and production) because it can promote sustainable practices by discouraging visitors from littering (UN, 2015). Through responsible waste management and energy conservation, ecotourism contributes to SDG 14 (Life below water) by

protecting and restoring marine and coastal ecosystems (UN, 2015).

4. Opportunities to scale monitoring initiatives for mangrove conservation and future research directions

4.1. State-of-the-art technologies to scale monitoring of mangrove ecosystems

Traditional field methods used to characterize mangroves are costly and time-consuming, as mangroves are often located in inaccessible regions or temporarily inundated due to tides, and may bring dangers such as crocodiles and other wildlife, unsafe working conditions (e.g., heat exhaustion), or risk of criminal activity. The use of remotely sensed data can overcome these obstacles and can be used to accurately map their distribution as well as detect spatial and temporal changes in mangroves (Ewane et al., 2023a; Rondon et al., 2023; Heumann, 2011; Lucas et al., 2017; Pham et al., 2019). Several products such as Digital Terrain Models (DTMs) and satellite images or drone images have been used to detect changes in mangroves over the last half century (Alongi et al., 2016). Habitat inventories have been created from current and historic imagery acquired from satellites, aircraft, or drones, as well as DTMs and canopy height models derived from Light Detection and Ranging (LiDAR) data. Remotely sensed data can also be used for ecosystem and productivity assessments, field survey planning, and water-quality analysis (Kuenzer et al., 2011).

UAVs or drones have emerged as an essential tool for the management and promotion of mangrove ecotourism (Yang et al., 2022). Drones are used for diverse mangrove management purposes, providing information on the state of mangroves and their environment in near real-time within remote areas. However, laws regarding the use of drones in Southeast Asia vary with each country and regulations change frequently. Regarding country variation, the use of drones is regulated by different organizations: in Thailand by the National Broadcasting and Telecommunications Commission, in Indonesia by the Ministry of Transport, in Malaysia by the Malaysian Civil Aviation Authority, in Singapore by the Singapore Civil Aviation Authority, and in the Philippines by the Civil Aviation Authority of the Philippines. All drones must be registered with these organizations, and operators must be licensed before flying in certain areas.

In addition, restrictions for drone use vary by country or region. For example, in the Philippines, the use of drones in protected areas is regulated through guidelines by the Department of Environment and Natural Resources. In Thailand and Malaysia, there are certain areas designated as no-fly zones, and the use of drones in wildlife reserves and national parks requires a permit from the Department of Wildlife and National Parks. Therefore, the use of drones for ecotourism activities in Southeast Asia has several limits which are subject to regulations and permits. Despite this, in recent years the use of drones in mangrove ecotourism in Southeast Asia has become more diverse. Drones are used to map mangroves to identify changes in vegetation and monitor the health of mangrove ecosystems (Baloloy et al., 2020).

The Google Earth Engine Mangrove Mapping Methodology (GEEMMM) as a mangrove detection tool can be readily applied by non-specialist coastal managers to map and monitor mangrove cover, and the use of the tool has been demonstrated for the detection of mangroves throughout coastal Myanmar (Yancho et al., 2020). The Australian Geoscience Data Cube can be used to accurately determine the extent of mangroves in northern Australia, classifying mangroves into five zones with an accuracy of 82%, which can provide a basis for future studies to develop fast and consistent mangrove mapping techniques in Southeast Asia (Rogers et al., 2017). Remote sensing tools can also be used to identify appropriate locations for ecotourism. Additionally, geo-information tools used in combination with multi-criteria decision analysis can support ecotourism planning and development (Wong and Fung, 2016).

Artificial Intelligence (AI) can be used to analyze data collected from drones, satellite imagery, and remote sensors. Machine learning algorithms can be trained to identify patterns and anomalies in the data, which can help identify potential threats to mangroves. Mobile applications can be developed for local communities living near mangroves. These apps can be used to report any potential threats such as illegal logging or fishing and provide information important to mangrove conservation. Finally, a blockchain can be used to create a secure and transparent database of all the conservation efforts and data collected. This can help with accountability to help ensure that mangrove conservation efforts are effective.

4.2. Ecosystem valuation

Ecosystem valuation in mangrove ecotourism is essential for informed decision-making, policy formulation, sustainable management, and promotion of conservation efforts in maximizing economic benefits while simultaneously safeguarding ecosystem integrity. The estimation of the value of mangrove ecosystem services can be used as a basis for management and can lead to significant implications for policy-making related to conservation, social welfare, and claims related to environmental degradation (Arkham et al., 2023).

4.3. Mangrove management through stakeholder engagement

Mangrove management can be framed as a nexus challenge (Hattam et al., 2021). Stakeholders highly interested in mangrove ecosystems often lack influence, particularly without involvement from influential private sector actors. Future mangrove management efforts should prioritize the integration of stakeholders, especially by engaging high-influence entities (i.e., the private sector) (Hattam et al., 2021). As mangrove ecotourism is linked with associated fauna, it is recommended that assessments be conducted of the potential fauna that may enhance tourist attraction in the region (Vipriyanti et al., 2024). Further, a community-based tourism (CBT) approach to assessing the potential development and challenges in mangrove ecotourism management should also be further researched (Prihadi et al., 2024).

5. Policy implications

Policies should aim to maximize socio-economic benefits for local communities while minimizing negative environmental impacts to ensure the long-term sustainability of mangrove ecotourism. Future research findings have the potential to be translated into policy recommendations targeted at regional policymakers, particularly in rural settings. Through harnessing the capacity of local communities to access various forms of capital through mangrove ecotourism, livelihood sustainability can be improved. In the context of mangrove ecotourism, the utilization of prospective analysis can provide stakeholders with forward-looking policy frameworks aimed at ensuring environmental sustainability.

In certain scenarios, the intervention of the government in the management of mangrove ecotourism may reduce community participation. Therefore, co-management is preferred, which enhances community engagement and thus reduces the potential conflicts between the government and the local community (Feti et al., 2020).

6. Limitations of the study

Our research encountered several limitations. The primary constraints include the exclusion of gray literature (such as blog posts, online newspapers, theses, dissertations, and conference abstracts), and the restriction of the review to sources published solely in English. These constraints may have resulted in the omission of relevant studies published in other languages or gray literature, potentially introducing gaps in the literature review. In addition, the identification of key important geographical ecotourism sites/activities was based on the mentioned

frequency in the final reference list. Thus, these results may be geographically biased as they were based on regions where there was mangrove ecotourism research. In addition, this study may be susceptible to publication bias, where only articles with significant findings regarding mangrove ecotourism were published, which may have reduced the scope of the study.

7. Conclusion

The mangroves in Southeast Asia offer important provisioning, supporting, regulating, and cultural ecosystem services that benefit the environment and people. Ecotourism and associated recreation and leisure activities are important components of the cultural services provided by mangrove ecosystems. This critical ecosystem is highly vulnerable to deforestation associated with the expansion of commercial aquaculture, agriculture, plantations, and urban growth. Ecotourism serves as a significant financial incentive to support community-based mangrove restoration and conservation initiatives. We used a systematic literature review approach to examine ecotourism and mangrove conservation interrelationships in Southeast Asia based on scientific papers published from 2010 to 2023.

Indonesia, Malaysia, Philippines, Thailand, and Vietnam, have the most ecotourism and mangrove conservation studies associated with their highest number of vibrant mangrove ecotourism sites and largest mangrove areas compared to the other countries of Southeast Asia. Mangrove ecotourism activities are dominated by boat tours, bird and wildlife watching, mangrove planting, kayaking, eating of seafood, and snorkeling, mostly in the vibrant ecotourism sites in these countries. The economic returns of ecotourism in these countries have provided support for ecosystem-based management strategies including mangrove conservation and restoration activities. The economic benefits of mangrove ecotourism are associated with increases in income at the national, household (tourist families), and individual levels. Most importantly, local peoples' desire to sustain their benefits from mangrove ecotourism motivated the implementation of several community-based mangrove restoration and conservation initiatives involving tree planting. This action drew international financial incentives and public-private partnerships to support mangrove conservation initiatives. Local communities benefited from increased access to social amenities such as clean water, electricity, transportation networks, schools, and health services driven by mangrove ecotourism to make destinations more attractive to tourists.

Since mangroves are mostly located in the land occupied by IPLCs, good governance that ensures total respect for their rights can provide more economic benefits to them while acting as intrinsic motivation to increase their participation in mangrove restoration and conservation initiatives to promote and sustain mangrove ecotourism. State-of-the-art remote sensing technologies combined with machine learning techniques can improve mangrove mapping, monitoring, evaluation, and reporting at scale to provide benchmark information to support mangrove ecotourism planning and development. Finally, the delicate balance between ecotourism construction and mangrove conservation can be addressed by innovative approaches and education and awareness campaigns that ensure the long-term conservation of mangroves while meeting the economic and infrastructure needs associated with ecotourism activities in the region.

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Declaration of competing interest

The authors declare that they have no potential real or perceived conflict of interest. Authors Ewane Basil Ewane, Jorge F. Montenegro, Redeat Daneil, Austin Blanton, Freddie McTavish, Luisa Fernanda Valasquez-Camacho, Pavithra S. Pitumpe Arachchige, G.A. Pabodha Galgamuwa, Shalini A.L. King, Shruthi Srinivasan, Meshal M. Abdullah, Wan Shafrina Wan Mohd Jaafar, Tarig Ali, and Midhun Mohan are affiliated with Ecoresolve Inc. Ewane Basil Ewane, Jorge F. Montenegro, and Midhun Mohan were also employed by BlueForests Inc. The remaining authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Data availability

Data will be made available on request.

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