People and Mangroves: Biocultural Utilization of Mangrove Forest Ecosystem in Southeast Asia

Dave Buenavista
Postdoctoral Fellow, Department of Biology,
Universitas Airlangga, Indonesia
Department of Biology, Central Mindanao University, Philippines
f.dave.buenavista@cmu.edu.ph

Hery Purnobasuki (corresponding author)
Department of Biology,
Universitas Airlangga, Indonesia
hery-p@fst.unair.ac.id
https://orcid.org/0000-0002-0562-2058

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Abstract

Mangroves provide diverse benefits for various coastal communities in Southeast Asia. Unfortunately, the same region exhibits the highest global rates of mangrove loss. Whilst studies exploring its value as a biocultural refugia remain lacking, the associated biocultural uses of mangroves are likewise under threat. Using the PRISMA approach, 33 studies passed the eligibility and screening process. The majority of biocultural studies were from Indonesia (60%), Malaysia (9%), Philippines (9%), and Thailand (9%) whilst the least were from Myanmar (6%), Vietnam (3%), and Timor-Leste (3%). We identified seven biocultural lenses for Southeast Asian mangroves; food source, cultural and spiritual use, livelihood source, construction materials, fuelwood and charcoal, medicinal use, and fish poison and fishing material. As a biocultural refugia, management of mangroves are intimately intertwined with traditional practices which stemmed from cultural and spiritual importance of mangroves. However, many Asian cultures remain undocumented and understudied. We, therefore, recommend a more culture-sensitive approach in various community-based mangrove conservation projects that respectfully integrate the indigenous and local knowledge systems (ILKS) and practices. Studies relating to the biocultural values, both tangible and intangible benefits of mangroves, should be further explored to promote the sustainable utilization and conservation of the remaining mangroves in Southeast Asia.

Keywords

mangrove, biocultural, ecosystem services, culture, Asia, indigenous knowledge

Introduction

The Southeast Asian ecoregion harbor the world's most biodiverse mangrove forest ecosystems. In fact, the same region is home to almost a third of all mangroves, with Indonesia alone being home to almost 20% (Spalding & Leal, 2021). Like in any other tropical and subtropical country, mangrove ecosystems provide a wide array of ecological, social, and economic benefits (Sandilyan & Kathiresan, 2012). Ecologically, mangrove forests play a critical role in global climate change mitigation as they hold some of the highest densities of carbon recorded in any ecosystem (Purnobasuki, 2012; Richards et al., 2020). Apart from carbon sequestration, mangroves provide protection for coastal communities against natural calamities such as tropical cyclones and tsunamis (Hochard et al., 2021; Kathiresan & Rajendran, 2005; Sandilyan & Kathiresan, 2015). Mangroves also support the livelihood of various coastal communities in the Asian region. In Myanmar's Ayeyarwaddy Region, for example, forest products collected from the mangrove forest such as firewood, fishes, crabs, and prawn provide 43% of total household income (Aye et al., 2019). Mangrove-forest-dependent communities such as the Peam Krasaop Fishing Community in Cambodia derive approximately 90% of the fishing catch, and 85% of gross their income, from mangrove-associated species (Seary et al., 2020) whilst in the Indian Sundarbans, more than 21% of the households are entirely dependent on mangrove for their livelihood and about 46% earned half of their income from the forest (Bera & Maiti, 2022).

Unfortunately, despite their global importance, the decline of mangrove forest cover continues in many parts of the world (Bhowmik et al., 2022; Friess et al., 2019; Gandhi & Jones, 2019). Southeast Asia, in particular, exhibits the highest global rates of mangrove loss (Bhowmik et al., 2022; Friess et al., 2019; Gandhi & Jones, 2019). Myanmar and Philippines topped the list of "mangrove loss hotspots", followed by Malaysia, Cambodia, and Indonesia (Gandhi & Jones, 2019). The estimated mangrove loss in the Philippines is 0.5% per year, however, Myanmar showed to be the hottest hotspot for mangrove deforestation with the highest rates of loss at 0.5–0.7% per year from 2000–2012, more than four times higher than the global average (Friess et al., 2019; Gevaña et al., 2018; Hamilton & Casey, 2016). Moreover, Indonesia, by far has the largest area of mangrove loss of about 749 km^2 which represents almost half of all global mangrove deforestation (Hamilton & Casey, 2016). Such rates of mangrove loss reflect the pressing global environmental crisis. Several intergovernmental reports indicate that mangrove loss could lead to catastrophic loss and worldwide ecosystem degradation. Available scenarios for nature's contributions to people (NCP) from mangroves and coral alone anticipate losses worth billions of dollars per year, due to sea-level rise and coastal land encroachment (IPBES, 2018). The Intergovernmental Panel on Climate Change (IPCC) likewise highlighted the impacts already observed on habitat area and biodiversity, as well as ecosystem functioning and services due to large-scale mangrove mortality (IPCC, 2019).

As defined by Millennium Ecosystem Assessment, the diverse direct and indirect societal benefits provided by mangroves or any other ecosystem may be broadly categorized into four: 1. provisioning (food, fuel, freshwater, and products obtained from ecosystems), 2. regulating (climate and water regulation, and other benefits obtained from the regulation of ecosystem processes), 3. supporting (necessary for the production of all other ecosystem services), and 4. cultural services (non-material and intangible benefits such cultural diversity, and spiritual and religious values) (Millennium Ecosystem Assessment Secretariat, 2005). Nevertheless, several researches have focused on provisioning services provided by mangroves and their contribution to local livelihoods and food security (Aye et al., 2019; Gnansounou et al., 2021; Mallick et al., 2021; Seary et al., 2020; zu Ermgassen et al., 2021), health and well-being (Arbiastutie & Diba, 2021; Bibi et al., 2019; Islam et al., 2022; Tamalene et al., 2021), protection from natural hazards

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(Hochard et al., 2021; Kathiresan & Rajendran, 2005; Sandilyan & Kathiresan, 2015), as well as their value for blue carbon and climate regulation (Adame et al., 2018, 2021; Gevaña et al., 2018; Song et al., 2021).

Whilst various ecosystem services are relatively well represented in literature, cultural ecosystem services are not yet adequately defined or integrated within the ES framework, and are often under-represented, ignored, or neglected particularly in ecosystem services assessment and even in conservation studies given their subjective and largely intangible nature (Daniel et al., 2012; He & Guo, 2021; Horgan et al., 2021; Martin et al., 2016). Cultural ecosystem services encompass the non-material, immanent, and intangible benefits provided by nature associated with spiritual experiences, cultural expression, or aesthetic inspiration, which are hard to quantify or economically valorised (Onofri & Boatto, 2020). Moreover, many policies and practices failed to meaningfully incorporate indigenous and local knowledge in conservation and development planning. In certain cases, conservation projects were implemented with unclear objectives or merely focused on promoting the recreational or touristic value of the region (He & Guo, 2021). As such, incorporating biocultural perspectives into conservation programmes still presents a global challenge.

The term “biocultural” is a portmanteau of the words “biodiversity” and “culture” which is used to refer to both material and non-material resources provided by nature to sustain our cultural heritage. Biocultural heritage, therefore, encompasses the knowledge, innovations, and traditional practices of indigenous and local communities that are collectively held and inextricably linked to, and shaped by, the socioecological context of communities (Gavin et al., 2015). This also includes the cultural beliefs, values, institutions, knowledge systems, languages and practices that both express and manifest the mutual relationship between humans and the environment (Maffi, 2010). Indeed, in the Southeast Asia, the mangrove forest ecosystem is home to rich biodiversity and local cultures which are both threatened by extinction.

Although many coastal communities have long existed along with the mangrove forest ecosystem, studies exploring its value as a biocultural refugia remain lacking. As defined by Barthel et al. (2013), biocultural refugia are places like mangrove forests in Southeast Asia, that not only shelter species, but also carry knowledge and experiences about the practical management of biodiversity and ecosystem services. As Southeast Asia’s mangrove forests continue to decline, this may likewise lead to the potential loss of various knowledge systems and even the disappearance of ethnic cultures. This global problem is now apparent that a “*Scientists’ Warning to Humanity on Threats to Indigenous and Local Knowledge Systems*” was released in 2021 (Fernández-Llamazares et al., 2021) whilst the International Union for Conservation of (IUCN) also started recognizing the cultural and spiritual significance of nature (Verschuuren et al., 2021).

In this systematic review, we explored the biocultural contribution of mangroves in the Southeast Asian region. Beyond their ecological importance, this study will examine the role of mangroves in local livelihood, food security, health, and culture of ethnic and local coastal communities; specifically, this research aims to answer the following questions:

1. How do the coastal communities in Southeast Asia directly benefit from mangrove forests?
2. What are the biocultural utilizations of mangroves in Southeast Asia?
3. What is the cultural and spiritual significance of mangrove forests for various coastal communities in the Southeast Asian region?

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Methodology

The systematic review and data collection followed the PRISMA (Preferred Reporting Items for Systematic Review and Meta-Analyses) protocol (Moher et al., 2009; O'Dea et al., 2021). We used the Google Scholar database which covers a relatively diverse types of publications such as preprints, published articles, theses, books, and amongst others. We queried the database using the following terms and their combination: "biocultural", "bio-cultural", "Southeast Asia", "Asia", "mangrove", "local knowledge", "ethnic", "cultural use", "traditional use", and "ethnobotanical". In the preliminary screening of relevant publications for review, we set the following eligibility criteria for inclusion:

1. It should be a peer-reviewed research article published in the English language with full text. We excluded non-English publications, review articles, synthesis papers, magazine and newspaper articles, reports, thesis and dissertations, conference presentations, web pages, and inaccessible publications.
2. It should be a study conducted in any of the Southeast Asian countries, namely: Brunei, Myanmar, Cambodia, Timor-Leste, Indonesia, Laos, Malaysia, Philippines, Singapore, Thailand, and Vietnam.
3. Following the publication of the Millennium Ecosystem Assessment in 2005, the data will only cover the last 15 years (2007–2022).
4. Irrespective of the research field (i.e., anthropology, economic botany, human ecology, Asian studies, etc.), the research article must be within the dimensions of "People's connectedness to mangroves" and "Indigenous and local knowledge, skills, practices, cultural and spiritual values and worldviews relevant to mangrove forest ecosystem" modified from Hanspach et al. (2020).

The qualitative data (i.e., cultural and spiritual valorization of mangroves) were categorized in Excel using the concept of "biocultural lenses" described by Hanspach et al. (2020). A chord diagram showing the diverse biocultural utilization of mangroves were then generated using the circlize package in the free statistical software R (Gu et al., 2014).

Results and Discussion

Biocultural research in the last 15 years

In the last 15 years, following the Millennium Ecosystem Assessment, literature relevant to the biocultural uses of mangroves remain scarce and limited. Our consolidated works of literature (n=33) (Table 1) suggest that the surge of research interest on the direct benefits provided by mangroves, in particular, its provisioning and cultural ecosystem services, only emerged in the last decade.

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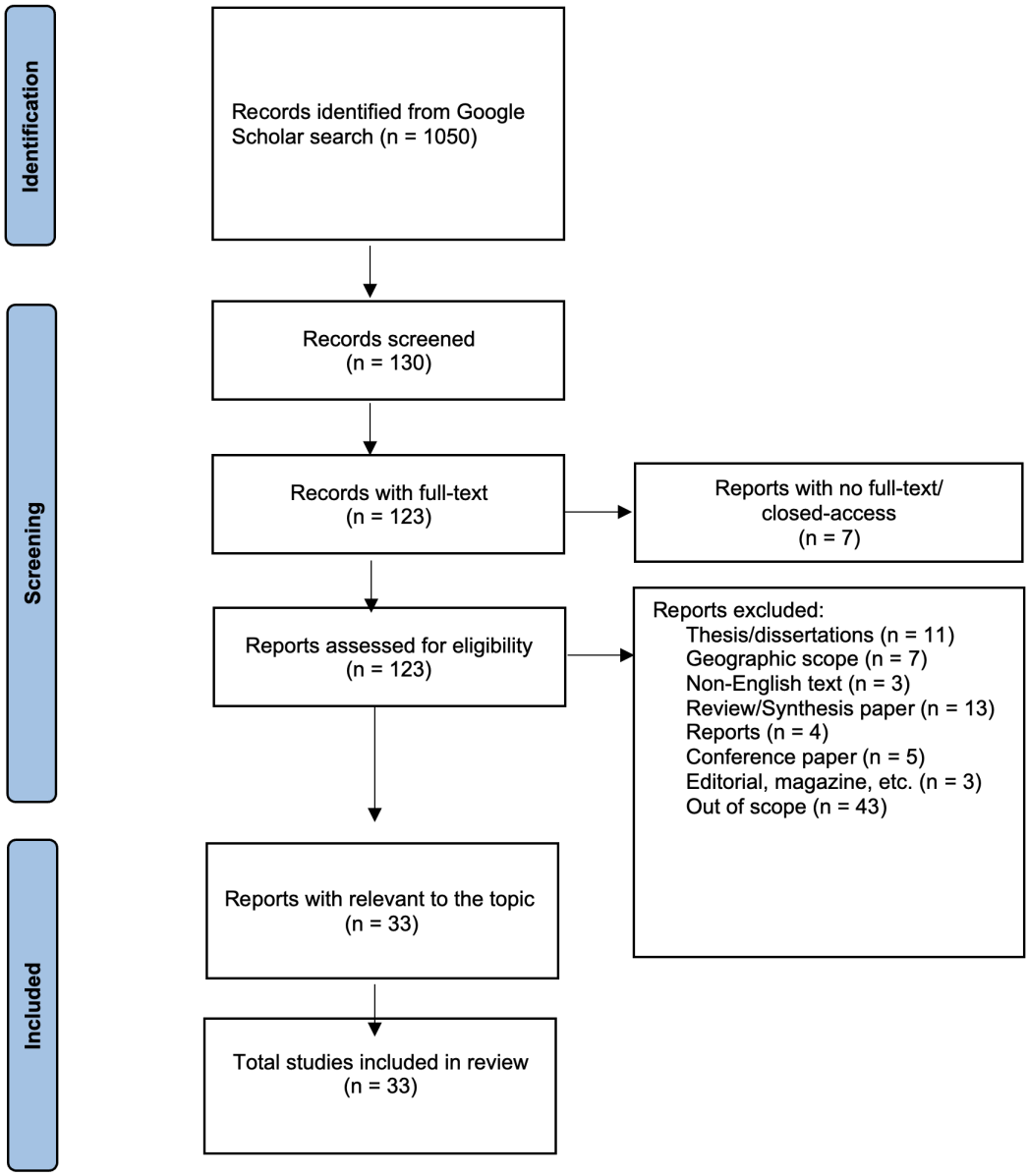

Fig 1. PRISMA flowchart describing the systematic review process

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Table 1. List of publications included in the review after screening (n=33)

No.	Type of Publication	Title	Location	Tribe/Ethnic Groups	Reported Biocultural Usage of Mangrove/Mangrove Forest	Reference
1	Article	Utilization of mangrove plants as a source of Malaria medicine in North Maluku Province, Indonesia	North Maluku Province, Indonesia	Bacan, Buton, Gorap, Maba, Ternate, and Tidore	• Medicinal use of mangrove species for malaria: *Lumnitzera littorea, Rhizophora mucronata, Scyphiphora hydrophyllacea, Sonneratia alba, Xylocarpus granatum*, and *Xylocarpus moluccensis*.	(Tamalene et al., 2021)
2	Article	Assessment of Subsistence Plant Resource of the Mangrove Forest in the Ayeyarwady Delta, Myanmar	Ayeyarwady Delta, Myanmar	Ashe Mayan	• Fuelwood — *Brownlowia tersa, Hibiscus tiliaceus, Cynometra ramiflora, Heritiera fomes, Pongamia pinnata, Ceriops decandra* • Construction — *Heritiera fomes, Bruguiera gymnorhiza, Bruguiera sexangula* and *Rhizophora apiculata, Ceriops decandra* • Crafts — *Heritiera fomes, Aglaia cucullata, Sonneratia* spp. • Tying — *Nypa fruticans, Flagellaria indica, Stenochlaena palustris* • Roofs and walls — *Nypa fruticans* • Food Use — *Sonneratia* spp., *Sarcolobus carinatus* and *Sarcolobus globosus* fruits are snacks for children; fruits of *Dolichandrone spathacea* and the seeds of *Avicennia officinalis* are also eaten. • Medical Use — *Dolichandrone spathacea* for neutralizing a mushroom toxin; *Merope angulata* for easing body pain; *Flagellaria indica* as anthelmintic; burned ash of *Nypa fruticans* fruits as antiodontalgic; *N. fruticans* fruits are used as a substitute for betel nut (*Areca catechu*), chewed daily as a stimulant. • Fish Poison — *Shirakiopsis indica* • Livelihood source — shrimp and fish were smoked using the wood of *Avicennia officinalis* for small-scale business. • Cultural and spiritual use — the stick-like viviparous seeds of *Bruguiera* spp. were used as toys for children. Inflorescences of *Derris* spp., *Phoenix paludosa* and *F. indica* were used as hair accessories, and offerings to Buddhist altars or spirit shrines.	(Ono & Suzuki, 2013)
3	Article	The travelling route for gastronomic tourism via salt in western region of Thailand	Samut Sakhon Province, Thailand	Not mentioned in the study	• Food source — edible plants (i.e., "Cha-Khram") from the mangrove forests are used for traditional cooking.	(Vorasiha, 2018)
4	Article	Social benefits and impacts of mangrove resource utilization in Rio Tuba, Bataraza, Palawan, Philippines	Rio Tuba, Bataraza, Palawan, Philippines	Palaweño, Bisaya, Tagalog, Palao'an, and others	• Charcoal, firewood, and housing — Rio Tuba uses up around 92.2 tons of mangrove charcoal every month.	(Gonzales et al., 2017)
5	Article	Assessment of Sustainable Utilization of Ecosystem Services in Different Stages of Mangrove Forest Restoration at Klong Khone Sub-district, Samut Songkhram Province, Thailand	Klong Khone Sub-district, Samut Songkhram Province, Thailand	Not mentioned in the study	• Food source — fishery resources such as blood cockles, fishes, and krill; • Construction material and fuelwood — mangrove timber was harvested to construct dwellings and fuelwood; recreational area for local people; mangrove forest was increasingly used as a non-formal education learning program for disseminating local knowledge and benefits of ecosystem services to visitors.	(Adulcharoen et al., 2020)

No.	Type of Publication	Title	Location	Tribe/Ethnic Groups	Reported Biocultural Usage of Mangrove/Mangrove Forest	Reference
6	Article	Ethno-bamboo Approaches to the Pala'wan in the Mangrove Area of Palawan Island, the Philippines	Southern Palawan, Philippines	Pala'wan, Molbog, Jama Mapun and Tausug, Illongo and Bicolano, Cuyonon Panimusan	• Construction Material — Bakhaw (*Rhizophora* spp.) is the most commonly used building material; Bangkal (*Nauclea orientalis*) is also common building materials; Saramponay (also called mangkono in Tagalog, *Xanthostemon verdugonianus*) is also used for floors of houses and canoes; nipa (nipa palm, *Nypa fruticans* — building materials.	(Hirota & Tsuji, 2021)
7	Article	Cultural capital of the communities In the mangrove conservation in the coastal areas of Ambon Dalam Bay, Moluccas, Indonesia	Ambon Dalam Bay in the coastal area of Ambon City, Indonesia	Not mentioned in the study	• Food source; cultural and spiritual use — Villages have a view of belief/culture where mangrove is a "tree of life" which is the primary food source for the presence of fish, shrimps and snails which they are harnessing.	(Salampessy et al., 2015)
8	Article	Rendang lokan: history, symbol of cultural identity, and food adaptation of Minangkabau tribe in West Sumatra, Indonesia.	Pesisir Selatan Regency of West Sumatra Province, Indonesia	Minangkabau tribe	• Food source — the mangrove area is the source of Oyster (*Geloina erosa*), a key ingredient of Rendang Lokan. It is not only a local food that has been crowned the best food in the world by CNN, but it also serves as the cultural identity — a marker that distinguishes them from other tribes. • Cultural and spiritual use — Alam Takambang Jadi Guru (learning from the nature) is the philosophy of Minangkabau people in interacting with nature.	(Fatimah et al., 2021)
9	Article	Status and sustainability of mangrove forests: A case study from Merbok Mangrove Reserve, Kedah, Malaysia	Kuala Muda district, Kedah, Malaysia	Malays (94.7%) and few minorities	• Food source — mangroves was regarded as a very important ecosystem for fish habitat, shoreline protection and source of food.	(Hashim et al., 2022)
10	Article	A survey of medicinal plants in mangrove and beach forests from sating Phra Peninsula, Songkhla Province, Thailand	Ranode, Sating Phra, Krasaesin and Singha Nakhon, Songkhla Province, Thailand	Not mentioned in the study	• Medicinal use — 35 species of medicinal plants were only found in the mangrove forests.	(Oratai Neamsuvan, 2012)
11	Article	Community demography and perception towards mangrove exploitation in Jaring Halus village, North Sumatera	Jaring halus village, Secanggang district, Langkat regency, North Sumatera, Indonesia	Melayu, Jawa, Banjar	• Construction material and food source — majority of mangrove resources were harvested for raw material or timbers, followed by other resources, i.e., clams/shells, crabs, shrimps and others to support their living.	(Sahputra et al., 2019)
12	Article	Participatory ecosystem service mapping to enhance community-based mangrove rehabilitation and management in Demak, Indonesia	Two coastal villages, Bedono, and Timbulsloko, in Sayung sub-district, Central Java, Indonesia	Not mentioned in the study	• Food source, fuelwood, and construction — *Avicennia marina* or locally called brayo is harvested for food, either as complementary or substitute of staple food, firewood, and construction material. • Livelihood source — harvesting of mangrove seedlings (*Rhizophora* sp) was an additional source of livelihood that emerged along with the expanding mangrove areas and rehabilitation projects. • Cultural and spiritual use — most of the visitors visited this area for spiritual pilgrimage. However, many visitors also visit the areas to enjoy the beautiful mangrove scenery.	(Damastuti & de Groot, 2019)

No.	Type of Publication	Title	Location	Tribe/Ethnic Groups	Reported Biocultural Usage of Mangrove/Mangrove Forest	Reference
13	Article	Using nexus thinking to identify opportunities for mangrove management in the Klang Islands, Malaysia	Klang Islands, Malaysia	Malay, Chinese and Mah Meri	• Cultural and spiritual use — Mah Meri indigenous community — mask making and leaf origami. • Livelihood and food source — mangrove areas are important area for tourism (local seafood resturant), fishery, mangrove replanting.	(Hattam et al., 2021)
14	Article	Community knowledge and utilization of mangroves in Panabo Mangrove Park, Panabo City, Davao del Norte, Philippines	Panabo Mangrove Park, Panabo City, Davao del Norte, Philippines	Not mentioned in the study	• Food source, fuel resource, and construction and fishing materials.	(Alimbon & Manseguiao, 2021)
15	Book chapter	Mangrove Forests of Timor-Leste: Ecology, Degradation and Vulnerability to Climate Change	Entire coastline of Timor-Leste	Not mentioned in the study	• Food source — on a daily basis, people, cattle, and other domestic animals routinely enter the mangroves to harvest leaves, fruit, fallen wood, and algae growing on root and stem surfaces; goats commonly feed on mangrove tree parts, especially *Sonneratia* pneumatophore. • Cultural and spiritual use — some villages and coastal regions foster some degree of sustainable mangrove resource management. There are customary seasonal prohibitions on harvesting or utilization of designated resources. These customs, known locally as tara bandu (Tetum for 'to raise a prohibition'), represent indigenous practices to limit and manage common resources. Injunctions can include prohibitions on timber cutting and wild food.	(Alongi, 2014)
16	Article	Mangrove and Akit Tribe: Description of Value Orientation and Natural Conservation Effort	Teluk Belitung Village, Riau, Indonesia	Akit Tribe	• Cultural and spiritual use — Akit Tribe Community has local wisdom in protecting nature as a source of life, including the practice of sorting mangroves based on age and the existence of prayers and rituals in responding to natural situations. • Firewood, cigars or house foundation wood, stakes, and charcoal.	(Sugiyanto et al., 2022)
17	Article	Rocking the boat: intersectional resistance to marine conservation policies in Wakatobi National Park, Indonesia	Wakatobi National Park, Sulawesi, Indonesia	Sama-Bajau	• Construction materials — Sama-Bajau use mangroves wood into piles and frames for houses and fish fences. • Fuelwood — mangroves are used daily as a cost-effective cooking fuel.	(Lynch & Turner, 2021)
18	Article	The Local Wisdom in Marine Resource Conservation In Indonesia: A Case Study of Newcomers in Pariaman West Sumatra	Pariaman, West Sumatra, Indonesia	Minang tribe and Malays	• Cultural and spiritual use — Pariaman fishing community believed that the sea, mangrove, river have spirits or souls. This belief signifies their conviction that their economic lives are not merely determined by how well they use their skills, boats and fishing gear in exploiting the sea, but also by how well they interact with the supernatural forces which are an important part of their world.	(Zamzami et al., 2018)

No.	Type of Publication	Title	Location	Tribe/Ethnic Groups	Reported Biocultural Usage of Mangrove/Mangrove Forest	Reference
19	Article	Development of Sustainable Mangrove Areas Based on Empowerment of Coastal Communities in Cemara Beach, Pakis, Banyuwangi, East Java, Indonesia	Cemara Beach, Pakis, Banyuwangi, East Java, Indonesia	Not mentioned in the study	• Food source — Several types of leaves (Deruju type (*Acanthus ilicifolius*) and even mangrove fruit (*Sonneratia caseolaris*) are made into peyek, tea and mangrove syrup by the women's group of the Pantai Cemara community.	(Setyaningrum et al., 2021)
20	Article	Community Forestry for Livelihoods: Benefiting from Myanmar's Mangroves	Ayeyarwady Delta, Myanmar	Not mentioned in the study	• Constructional material and fuelwood — All households use wood for poles and branches for fuelwood. • Food source — mud crab (*Scylla serrata*) which breeds at the roots of the mangroves is one of the most important food products from the mangroves. The palm sap is popular for wine production. The sweet seeds of the fruit are cherished for local consumption. Some of the mangrove areas are generally used for subsistence. These include clams, snails and shrimp, as well as a type of climbing plant, which is used in a local curry dish. • Livelihood source — Poor households' profit from the sale of thatched nypa for roofing. Woven nypa is locally used not only for roofing, but also for the walls of the houses. • Cultural and spiritual use — People also mentioned the cultural and spiritual value of the mangrove forests and their fauna and flora. • Medicinal use — medicinal plants gathered in the forest can be used to treat stomach ache, fever, injuries and snake bites and thus have a positive impact on the local population's health.	(Feurer et al., 2018)
21	Article	The Relation of Cultural Value Orientation to the Poverty of Communities Around Mangrove Forests and Peatlands in Kayan Sembakung Delta	Kayan Sembakung Delta, North Kalimantan, Indonesia	Not mentioned in the study	• Livelihood source — mangrove forest areas and peatlands are the main source of income. • Cultural and spiritual use — For the tribal community in Kalimantan, the meaning of life welfare depends on the availability of nature to fulfil their necessity. The cultural value orientation of surrounding community living near mangrove forests and peatlands tended to be dominant on life is good, work for life, orientation to the future, seeking harmony with nature and depending on others.	(Sutrisno et al., 2022)
22	Article	Need to conservation of mangrove ecosystem in Kotania Bay, District of West Seram, Mollucas: An approach the local wisdom and behavior	Kotania Bay, District of West Seram, Mollucas, Indonesia	Not mentioned in the study	• Cultural and spiritual use — People in the mangrove community follow the rules/tradition known as "Sasi". It is used in the conservation of community-based resource for both land and sea. This customary law provisions on the restriction of entering, taking or doing something in a certain ecosystem and within a specific time period. The "Sasi" to the mangrove ecosystems in the Kotania bay are as follows: not allowed to cut/ take young mangrove trees for any purpose, prohibited to garbage in the mangrove ecosystems; prohibited from using bombs/poison of fish in mangrove ecosystems; prohibited from making mangrove ecosystems as a livestock raising for it may damage the mangrove; prohibited from taking, catching, shooting, killing various types of animals and plants associated with mangrove ecosystems such as birds, soa-soa, snakes, orchids, and so forth in the mangrove ecosystems; prohibited from taking mangrove saplings to be cultivated or planted without permission from Kewang. • The Bajo people believe that mangrove ecosystem, coral reefs, and sea grass ecosystem are guarded by the spirits. The Bajo people believed that if the spirits are being disturbed, the spirits will show their anger. Therefore, the Bajo people treat the ecosystem with caution.	(Nanlohy et al., 2015)
23	Article	Coastal and Marine Resource Policies and the Loss of Ethnic Identity of the Bajo Tribe	Tomini Bay, Indonesia	Bajo Tribe	• Cultural and spiritual use — The Bajo people believe that the destruction of the coastal ecosystem is a disaster for their community. In order to avoid the wrath of the spirits that guards the ecosystems, duata often conduct traditional ceremonies to ward of diseases. They feel that the environment is part of them. They often conduct traditional ceremonies related to the environment.	(Obie & Lahaji, 2020)

No.	Type of Publication	Title	Location	Tribe/Ethnic Groups	Reported Biocultural Usage of Mangrove/Mangrove Forest	Reference
24	Article	Mangrove Forest Utilization for Sustainable Livelihood through Community-Based Ecotourism in Kao Village of North Halmahera District	Kao Village, North Halmahera, Indonesia	Kao	• Food source — the mangrove forest is an important area for fishing and collecting shellfish, eels, shrimp and even the eggs of mamoa bird. • Cultural and spiritual use — The Kao Village have a tradition known as Higaro and Hirono. Through the Hirono tradition, mobility of access to forest resources can be communally optimized, for instance, the cutting down of forests for timber production, which is carried out together as a form of cultural solidarity in helping fellow villagers to establish new settlements. • The Kao also practices the customary law "Sasi", which symbolically has a material form of culture (Matakao) and is spiritually believed to have the ability to punish every act of violation. It is known as the traditional conservation method. • The local tradition known as Bubugo or Mata Kao is used as a cultural symbol and artistic communication to tell everyone that the tree or plantation area had been own and protected by the spirit so that the tree nor the fruits could be cut down or taken. Anyone violating the rules would be subject to sanctions in the form of psychological and physical illness or even death.	(Singgalen, 2020)
25	Article	Local wisdom for mangrove conservation and ecotourism: Case study from Wringinputih, Muncar, Banyuwangi	Wringinputih, Muncar, Banyuwangi, East Java, Indonesia	Not mentioned in the study	• Cultural and spiritual use — Wringinputih are mostly part of the community's local wisdom-based conservation which played an important role in ecotourism and education.	(Purwowibowo et al., 2020)
26	Article	Associating Land With People: Land and Collective Identity Among The Suku Asli of Sumatra	Riau province, Sumatra, Indonesia	Suki Asli	• Food source, Livelihood source, Construction materials — The Suku Asli lived between the mangrove forest and rainforest conducting hunting, gathering and temporary waged labours in the coastal forests employed by the Chinese traders. Their life was totally dependent on coastal resources, such as sago palm, wild boars in the forest, fishes in brackish rivers, shellfishes in the mangrove swamps and mangrove timber.	(Osawa, 2017)
27	Article	Impacts of changes in mangrove forest management practices on forest accessibility and livelihood: A case study in mangrove-shrimp farming system in Ca Mau Province, Mekong Delta, Vietnam	Ca Mau Province, Mekong Delta, Vietnam	Not mentioned in the study	• Livelihood source, Fuelwood, Construction materials, Cultural use — People use decomposed leaves of *Avicennia* as nutrient enrichment to shrimp ponds. *Rizhophora* is mainly used for replanting in this area due to the high commercial value of its timber for firewood and charcoal. Mangrove wood can be used for construction, turned into pit props and walls as well as making chopsticks for tourism trade. Mangrove bark is also rich in tannins used in dying.	(Ha et al., 2014)
28	Article	Pamali, Bajo's Local Wisdom in the Conservation of Marine Resources	Bungin Permai Village, South Konawe District, Southeast Sulawesi, Indonesia	Bajo Tribe	• Cultural and spiritual value — The Bajo people conserve marine resources through the customary rules of pamali and environmental care actions such as planting mangroves in coastal areas. The Bajo believes in the of philosophy "kadampaannu kampo maiga-iga, pugai allou mabunda ana'umputa " (Love the marine environment for the future of our children and grandchildren). The expression is a reflection of the high sense of belonging of the Bajo people to the sea, so they always maintain and preserve the precious source of life.	(Basri et al., 2017)
29	Article	Ethnobotanical Study of Plant Resources in Serangan Island, Bali	Serangan Island, Bali, Indonesia	Not mentioned in the study	• Fuelwood, Livelihood source — source of firewood; mangroves are considered important to support tourism and recreation in the island.	(Putri et al., 2014)

No.	Type of Publication	Title	Location	Tribe/Ethnic Groups	Reported Biocultural Usage of Mangrove/Mangrove Forest	Reference
30	Article	Local indigenous strategy to rehabilitate and conserve mangrove ecosystem in the southeastern Gulf of Kupang, East Nusa Tenggara, Indonesia	Southeastern Gulf of Kupang, East Nusa Tenggara, Indonesia	Not mentioned in the study	• Food source — Source of food like fish, shrimps, and crabs. • Cultural and spiritual use — local indigenous strategy to retain mangrove involved a set of agreement made by local indigenous communities. It consisted of several indigenous rules that bind the member of local communities and outsiders. Every indigenous people who conducting illegal logging in the mangroves would be expelled from the village, while a large fine (in the form of a cattle and money cash around two million rupiah for each logged tree) was applied for outsiders who did the similar action. The member of indigenous communities was permitted to extract the deadwood from mangrove forests using special permits given by the Tumukung (Head of Village). Catching fish, crabs, snails, and shrimps are permitted as long as they did not damage the existence of mangroves.	(Sadono et al., 2020)
31	Article	Mangrove conservation based on local wisdom in North Maluku Province, Indonesia	Tuada on Jailolo Sub District, West Halmahera District, North Maluku Province, Indonesia	Not mentioned in the study	• Construction materials, Livelihood source, Fuelwood, Food source — The locals utilize mangrove wood for the manufacture of the furniture and boats, firewood; the forest is also an important source of fish and crabs. • Cultural and Spiritual use — Local Wisdom on Mangrove Conservation "Siatormawaktuuntukoro hate" refers to the agreement for the timing of mangrove logging based on deliberations by customary leaders. Deliberations between customary leaders discussed logging areas, those responsible for logging activities and communities that could benefit from logging. Historically, communities have complied with the rules, and there have been no logging activities without an agreement. • "Oro hatetapiharussiutoadi" governed the party responsible for mangrove conservation. The conservation rule was that people who use mangroves have to replant in previously logged areas. • "Lahiijinsekolanodesa" contains a rule that before the cutting mangroves to be made fishing boats, the community must first request permission to the customary leaders or community leaders. • "Oro enamalamoenamaicisipelihara" means that people can cut down trees that have large stems, while small trees should be allowed to grow and should not be felled. • "Hakawarosemanciadofu" is governing that before the felling of trees, the community must perform the ceremony as a praying procession. Moreover, after logging, the community should be made a traditional ceremony at the village hall.	(Tolangara & Rasyid, 2018)
32	Article	Contribution of mangrove forest and socio-economic development of local communities in Kudat District, Sabah Malaysia	Kudat and Banggi Island, Kudat District, Sabah, Malaysia	Not mentioned in the study	• Food source, Fuelwood, Medicinal use, Livelihood source — the primary products collected from the mangrove forest are of two main categories namely non-forest products (mud crab (*Scylla serrata*), fishes, 'lokan' (*Geloina coaxans*) and mud creepers (*Cerithidea obtusa*); and the forest products (fuelwood from *Rhizophora*, Tannin (bark), flavourings (Tengar bark), nuts (*Sonneratia*'s), piling poles and medicinal plants). The non-forest products generated the highest income with an average of RM 432.75 per household/month, whilst forest products contributed to an average of RM 40.85.	(Mojiol et al., 2016)
33	Article	Akit Tribe and Existence of Mangrove Forest in Berancah Village, Bengkalis, Indonesia	Berancah Village, Bengkalis, Indonesia	Akit Tribe	• Livelihood source, Fuelwood and charcoal — In Berancah village, mangrove forest is the main source of livelihood from generation to generation. Almost every family from the Akit Tribe is a mangrove seeker or a worker in Panglong Charcoal. Production of wood charcoal is Rhizophoraceae type such as *Rhizophora apiculata*, *Rhizophora mucronata*, and *Bruguiera gymnorrhiza*.	(Rosaliza, 2018)

Recent publications from 2008 (n=5), 2020 (n=5), and 2021 (n=7) largely contributed to this research area (Figure 2). The low number of publications, however, may reflect the global trend which has shown concomitant declines in the abundance of biological and cultural diversity in the past few decades (Lukawiecki et al., 2022). Many rural and indigenous communities face profound cultural, economic, and environmental changes. As such, local and indigenous knowledge is being transformed globally and eroded when pertaining to ecology (Aswani et al., 2018). Moreover, the undervaluation of the "biological" and "cultural" interconnectedness between nature and human culture may have contributed to mangrove forest loss, cultural erosion, and lack of relevant biocultural research across Southeast Asia.

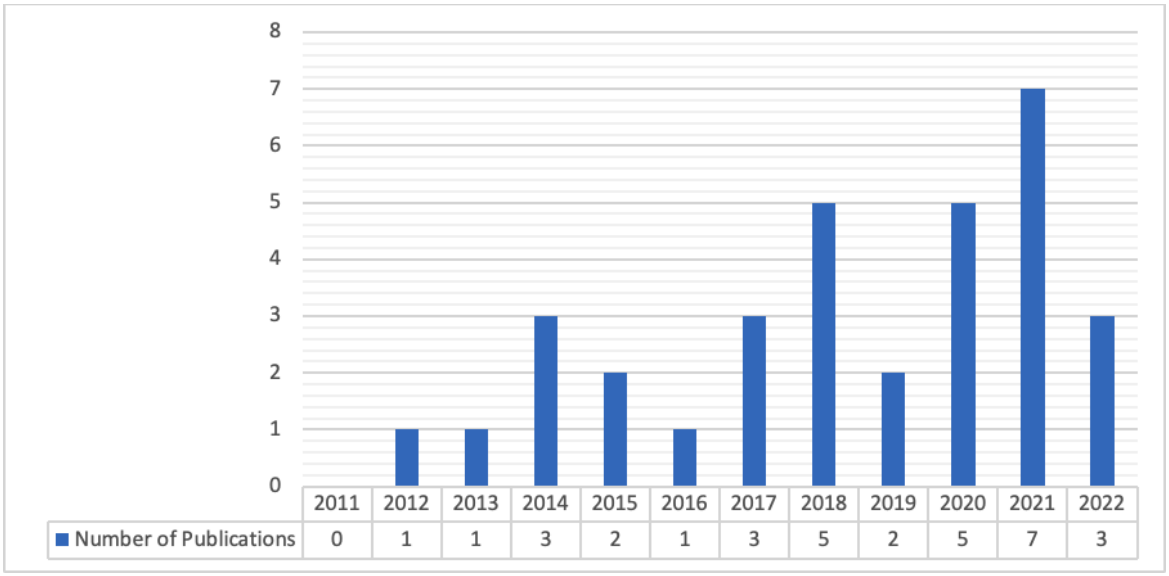

Fig 2. Number of publications in the last decade

The majority of these publications were from Indonesia (60%), followed by Malaysia (9%), Philippines (9%), and Thailand (9%) whilst the least number of publications were from Myanmar (6%), Vietnam (3%), and Timor-Leste (3%) (Figure 3). As predicted, most studies come from the countries with the largest mangrove forest cover; Indonesia (2.24 million ha), Malaysia (Malaysia (521,000 ha), Philippines (356,000 ha), and Myanmar (299,000 ha) (Gevaña et al., 2018). On the other hand, Timor-Leste and Singapore have the smallest mangrove forest cover with only about 3000 ha combined (Gevaña et al., 2018). The aforementioned mangrove-rich countries also exhibit the highest cultural diversity in the region. Indonesia, composed of 1128 groups of indigenous peoples, is the largest in Southeast Asia (Buenavista, 2021; Buenavista et al., 2018). It is followed by Philippines with 110 indigenous groups, Myanmar inhabited by 100 indigenous groups, and Malaysia with 57 indigenous groups (Buenavista et al., 2018).

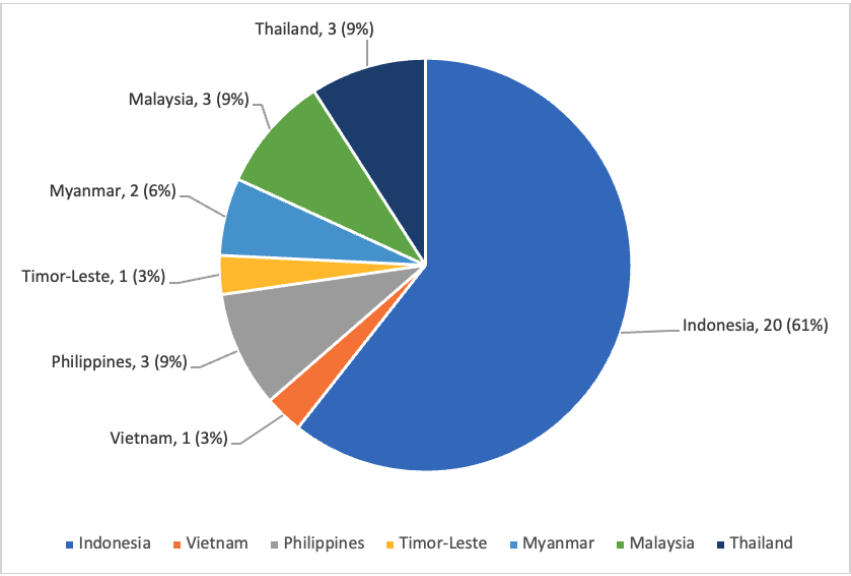

Fig 3. Biocultural studies on mangroves in Southeast Asia

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Three countries were underrepresented in this systematic review, namely, Singapore, Cambodia, and Laos. Based on the historical data of Singapore, the coastal communities at Kampong Mandai Besar, Kampong Mandai Kechil, and Kampong Lorong Fatimah only inhabit the Mandai mangrove and the surrounding area until the late 1980s before their relocation into public housing (Friess et al., 2012). As such, the use of mangroves for charcoal, firewood, artisanal fishing, and subsistence only appeared in historical accounts and is now considered unimportant in modern-day Singapore (Ng & Low, 1994). Currently, Singapore's mangrove is either military or state land designated as nature reserves. Moreover, public interaction with mangroves is restricted mainly to four sites that are managed by the National Parks Board of Singapore; Sungei Buloh Wetland Reserve in the northwest, Berlayer Creek, part of Labrador Park Nature Reserve in the south, Pasir Ris Park in the northeast, and Chek Jawa on the island Pulau Ubin, off the northeast coast (Thiagarajah et al., 2015).

On the other hand, relevant research from Cambodia appeared to be very limited and inaccessible. This knowledge gap is exacerbated by the fact that Cambodia lost approximately 42% of its mangrove forests between 1989 and 2017 (1415 ha/year) (Kozhikkodan Veettil & Quang, 2019). Although the mangrove forest is extremely important for Cambodians, present research into mangrove-fisheries has not yet represented the full complexity of socio-ecological benefits accrued from mangrove-fishery (Seary et al., 2020). Furthermore, the absence of pertinent data from Laos could be explained by its landlocked status.

Human Culture and Mangrove Relations

Mangroves showed to be an integral component of different local and ethnic cultures in Southeast Asia. In the 33 reports screened, we identified seven 'biocultural lenses' or perceived human benefits of mangroves, both tangible and intangible benefits known to the community (Figure 4). Although cited for multiple uses, results showed that mangroves are mainly valued as food sources (24 reports, 72.7%), cultural and spiritual uses (21 reports, 63.6%), and livelihood sources (19 reports, 57.5%). Other reported uses of mangroves include: construction materials (16 reports, 48.4%), fuelwood and charcoal (14 reports, 42.4%), medicinal use (7 reports, 21.2%), and fish poison and fishing material (2 reports, 6.0%).

It can be argued that many coastal and island communities in Southeast Asia depend largely on mangroves as a significant source of food such as fish, shrimps, crabs, snails, and sago palms. In line with this biocultural view, the coastal communities in Ambon Dalam Bay, Moluccas, Indonesia consider mangroves a "tree of life" (Salampessy et al., 2015). Some mangrove plant species were also reported to be edible. In the case Ashe Mayan tribe in Ayeyarwady Delta, Myanmar, for example, the fruits of *Sonneratia* spp. fruits were cooked as ingredients of hinn (Burmese curry) and also eaten raw as snacks similar to fruits of *Sarcolobus carinatus*, and *Sarcolobus globosus* (Ono & Suzuki, 2013). Moreover, some mangrove dishes are also considered a cultural heritage like the laphet-thoke (Burmese tealeaf salad). The ingredient of this national delicacy includes the calyx lobe and flesh of *Sonneratia* spp. fruits, the flowers and fruits of *Dolichandrone spathacea* and the seeds of *Avicennia officinalis* (Ono & Suzuki, 2013). Another edible mangrove is *Avicennia marina* locally known as "brayo" which is harvested for food, either as complementary or substitute for staple food in Demak, Indonesia (Damastuti & de Groot, 2019).

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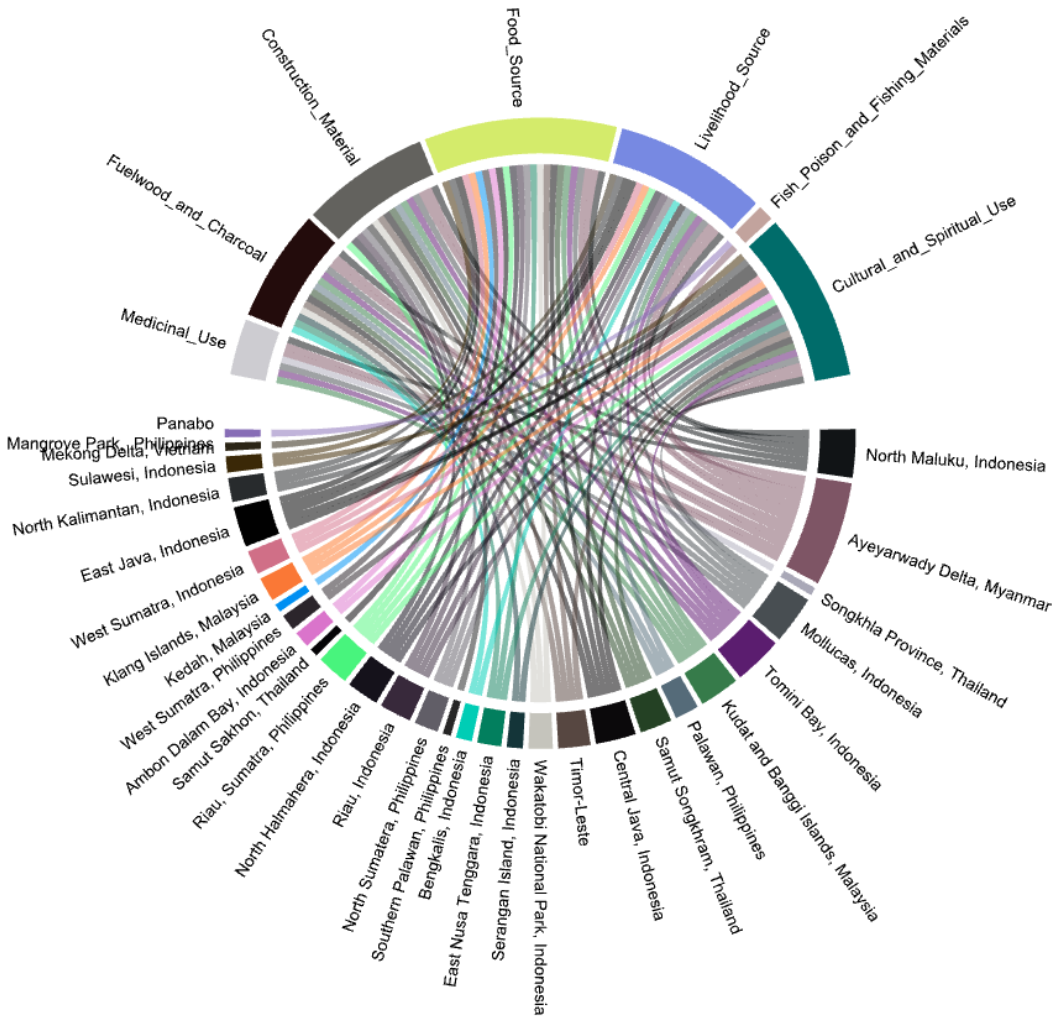

Fig 4. Chord diagram showing the distribution of 33 reports from different provinces in Southeast Asia (shown in the bottom half part of the chord diagram) for the different biocultural uses of mangroves (shown in the top half part of the chord diagram).

As a biocultural refugia, mangroves are also part of various cultural and spiritual beliefs and practices of different indigenous groups in Southeast Asia. It is associated with local wisdom and rituals for various ethnic groups in Indonesia (Sadono et al., 2020; Sugiyanto et al., 2022; Zamzami et al., 2018). It is also used in cultural functions such as in the case of the Mah Meri indigenous community of Klang Islands, Malaysia which utilizes non-timber mangrove forest products for mask and leaf origami traditionally worn by the natives (Hattam et al., 2021). The Ashe Mayan of Myanmar also collects and use inflorescence gathered from the mangrove forests such as those of *Derris* spp., *Phoenix paludosa*, and *Flagellaria indica* for hair accessories, and offerings to Buddhist altars or spirit shrines (Ono & Suzuki, 2013). Apart from material culture, Southeast Asia's mangrove forest is also associated with traditional forest management systems and customary practices. One of the most noteworthy traditions is the "Sasi" in Maluku Islands, Indonesia. "Sasi" is a form of customary law used in community-based resource conservation. "Sasi" provides provisions on the restriction of entering, taking, or doing something in the mangroves within a specific period (Nanlohy et al., 2015). In Kotania Bay, the "Sasi" does not allow the cutting of young mangrove trees for any purpose; it prohibits the throwing of garbage in the mangrove ecosystems; the use of poison and destructive fishing methods is also prohibited; it does not allow the public

from raising livestock for it may damage the mangrove; and most importantly, it also prohibits anyone to take, catch, collect or kill various types of wildlife associated with mangrove ecosystems (Nanlohy et al., 2015).

Moreover, the locals of North Maluku Islands integrate local wisdom in mangrove management. This includes “Oro hatetapiharussiutoadi”, a conservation rule, wherein, locals who use mangroves are obliged to replant in previously logged areas (Tolangara & Rasyid, 2018). The cutting of young mangrove trees is also prohibited under “Oro enamalamoenamaicisipelihara” (Tolangara & Rasyid, 2018). On the other hand, the felling of mature mangrove trees is also highly regulated by customary practice called “Hakawarosemanciadofu”, a traditional ceremony performed by the community (Tolangara & Rasyid, 2018).

In many reports, mangroves are highly valued as a source of livelihood for many rural communities. These profitable mangrove-associated resources include timbers, fish, shellfish (i.e., clams, snails, crabs, shrimps), firewood and charcoal, and various non-timber building materials such as the thatched nipa for walls and roofing (Feurer et al., 2018; Gonzales et al., 2017; Mojiol et al., 2016; Rosaliza, 2018; Sahputra et al., 2019; Singgalen, 2020). Ecotourism is also an important livelihood source for many communities particularly in Indonesia (Purwowibowo et al., 2020; Putri et al., 2014; Singgalen, 2020), Thailand (Vorasiha, 2018), and Malaysia (Hattam et al., 2021). Other uncommon yet, important utilization of mangroves includes their medicinal use for various diseases (Feurer et al., 2018; Mojiol et al., 2016; Oratai Neamsuvan, 2012; Tamalene et al., 2021), and as a source of fish poison and fishing material (Alimbon & Manseguiao, 2021; Ono & Suzuki, 2013).

Conclusion

This systematic review highlights the biocultural utilization of mangroves in Southeast Asia. The publications that mainly contributed in this field were relatively recent, in particular, 2008 (n=5), 2020 (n=5), and 2021 (n=7). Despite the exceptional richness of biocultural diversity in the Southeast Asia, the results indicated a low number of relevant publications (n=33) in the past 15 years. The majority of these biocultural reports were from Indonesia (60%), followed by Malaysia (9%), the Philippines (9%), and Thailand (9%) whilst the least number of publications were from Myanmar (6%), Vietnam (3%), and Timor-Leste (3%). This mirrors the worldwide trend which has shown concomitant declines in the abundance of biological and cultural diversity in the past few decades. Although highly valued for their ecological functions, the consolidated data showed that mangroves are also important for food source, cultural and spiritual use, livelihood source, construction materials, fuelwood and charcoal, medicinal use, and for fish poison and fishing material. Yet, with the rapid and extensive decline of mangrove forest cover across the region, the associated biocultural uses of mangroves are likewise under threat. As a biocultural refugia, mangroves are intimately intertwined with traditional management practices which stemmed from cultural and spiritual importance of mangroves such as the “Sasi” and local conservation wisdom of the people of Maluku Islands, Indonesia. We believed, however, that many Asian cultures remain undocumented and understudied. We therefore recommend a more culture-sensitive approach in various community-based mangrove conservation projects that respectfully integrate the indigenous and local knowledge systems (ILKS) and practices. Studies relating to the biocultural values, both tangible and intangible benefits of mangroves, should be further explored to promote the sustainable utilization and conservation of the remaining mangroves in Southeast Asia.

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