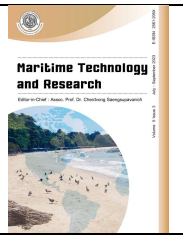
Maritime Technology and Research

https://so04.tci-thaijo.org/index.php/MTR



Review Article

Mangrove ecosystem management in Indonesia: Review, limitation, gap, and knowledge

Angga Kurniawansyah*, Dewi Susiloningtyas and Masita Dwi Mandini Manessa

Department of Geography, University of Indonesia, UI Campus, Depok 16424, West Java, Indonesia

Article information

Received: November 30, 2022
1st Revision: January 23, 2023
2nd Revision: March 1, 2023
Accepted: March 2, 2023

Keywords
Management,
Mangrove,
Review,
Limitation,
Gap,
Knowledge

Abstract

This study examines the past and summarizes the main findings of 35 studies on managing mangrove ecosystems in Indonesia published between 2018 and 2022. The systematic use of the Preferred Items for the Systematic Review and Meta-Analysis (PRISMA) method showed that, in the last five years, mangrove ecosystem management had had a trend that led to the themes of deforestation and natural resource management, as well as to the themes of sustainable development, ecosystems, coastal zones, and forestry, which were the main topics of discussion in 2019. In addition, the words that have become dominant are ecosystem, forestry, and biodiversity. The limitations and gaps identified include aspects of tourist areas, the use of remote sensing, and quantitative and qualitative approaches that can provide knowledge for advancing mangrove ecosystem management studies in the future.

1. Introduction

Mangroves are one of the coastal ecosystems in addition to coral reefs, seagrasses, and small islands (Asyiawati & Akliyah 2017), and are types of plants in the tree and shrub group that have developed their adaptation to the tidal zone environment (Jamili et al., 2021) in tropical and subtropical climates (Arulnayagam et al., 2021). Mangroves are also used to describe a variety of tropical coastal communities dominated by several species of typical trees or shrubs that can grow in salty waters (Martuti et al., 2019). In Indonesia, this mangrove ecosystem grows on around 3.36 million ha (Ministry of Environment and Forestry, 2022). Mangroves, coastal ecosystems, have a variety of functions, and aid in maintaining the balance of other ecosystems (Kurniawansyah et al., 2022), such as recreation areas, land plantations, and conservation areas (Saparinto 2007), carbon sequestration (Zhu & Yan, 2022), elemental cycles, in fighting climate change (Liu et al., 2020; Yu et al., 2020), and reducing the impact of natural disasters of tsunamis and typhoons (Nurdin et al., 2015), erosion and abrasion prevention, biota nutrition sources, and resource providers for humans and marine tourism (Prihadi et al., 2018; Tufliha et al., 2019).

In addition, according to Barbier (2016), mangroves have been used as natural protectors of coastline from wind and waves, for fisheries cultivation, for ecotourism, and in research and education. The richness and usefulness of the mangrove ecosystem attract the community to take advantage of it, both from agencies that regulate its use and from the community as the driving

*Corresponding author: Department of Geography, University of Indonesia, UI Campus, West Java, Indonesia
E-mail address: angga.kurniawansyah11@ui.ac.id

force (Kurniawansyah et al., 2021). Ecologically, coastal ecosystems such as mangroves are related to human behavior and activities (Utina et al., 2017). Therefore, in the context of human activities, some activities can have a negative or detrimental impact and damage the mangrove ecosystem or components that make up other ecosystems (Dahuri et al., 1996). This is also known as the pressure of anthropogenic factors that can cause mangrove ecosystems extinction (Valiela et al., 2001; Alongi, 2002; FAO, 2007; Duke et al., 2007). However, a lack of awareness or perseverance in conservation and management strategies have been implemented or proposed (Farnsworth & Ellison, 1997; Primavera, 2000; Kovacs, 2000; Armitage, 2002; Dahdouh-Guebas & Koedam, 2002; Dahdouh-Guebas et al., 2005; Feagin et al., 2010; Satyanarayana et al., 2013). Romanach et al. (2018) suggest that adding human populations threatens mangrove ecosystems because their activities can interfere with their function and role as ecosystem components. This indicates that mangrove ecosystems have a direct or indirect impact (Cormier-Salem, 2006). Therefore, the existence of mangrove ecosystems is a separate concern so that the benefits and positive impacts can continue to be felt by the surrounding community and other living things. There is a need for a study on mangrove ecosystem management as a preventive and countermeasure measure for the later occurrence of ecosystem damage.

In the last 5 years, the management of mangrove ecosystems in Indonesia has been carried out by academics, including in the aspect of tourist areas (Erlinda et al., 2022; Fatimatuzzahroh et al., 2020; Fistiningrum & Harini, 2021; Kurniawan et al., 2020; Massiseng et al., 2020; Prasetya et al., 2018), in the aspect of utilization of remote sensing instruments (Arfan et al., 2021; Asyiawati & Hindersah, 2020; Christian et al., 2021; Rahadian et al., 2019; Yusran & Patience, 2020; Rihulay & Papilaya, 2022), in the aspect of quantitative approaches (Arfan et al., 2021; Basyuni et al., 2018; Damastuti et al., 2022; Fistiningrum & Harini, 2021; Indah et al., 2018; Teak & Personal, 2018; Marlianingrum et al., 2019; Melo et al., 2020; Melo et al., 2019; Nanlohy & Ruban, 2021; Nanlohy et al., 2019; Paembonan et al., 2020; Prasetya et al., 2018; Puryono & Suryanti, 2019; Sahputra et al., 2022; Salminah et al., 2020; Santoso et al., 2019; Wahyurini et al., 2021; Yusran & Sabar, 2020), and the aspect of qualitative approaches (Erlinda et al. 2022; Fatimatuzzahroh et al. 2020; Firdaus et al. 2021; Hasnanda et al. 2018; Idajati & Widiyahwati, 2018; Kurniawan et al., 2020; Majesty & Fadmastuti, 2018; Massiseng et al., 2020; Nawari et al., 2021; Rahadian et al., 2019; Roziqin, 2018; Yonvitner et al., 2020). This research was conducted to present a discussion of research carried out in the context of managing mangrove ecosystems in Indonesia, including knowing the context of limitations, gaps, and new knowledge in managing the mangrove ecosystem. This can be helpful for academics and the government as a reference for research development and as a basis for creating a policy for managing mangrove ecosystems to create natural and social sustainability.

2. Materials and methods

This research uses the systematic review guideline method described in the framework report Preferred Items for Systematic Review and Meta-Analysis, or PRISMA (Liberati et al., 2009; Moher et al., 2009; Azizan et al., 2021; Page et al., 2021). In principle, a systematic review is a research method that summarizes the results of primary research to present more complex and balanced facts. At the same time, meta-analysis is a way to synthesize results statistically (quantitatively), or is said to be part of the systematic review method with a quantitative approach (Siswanto, 2010). This method is widely used to produce systematic literature (Koutsos et al., 2019) to identify, select, and analyze relevant research documents from a series of formulations already carried out (Moher et al., 2009). Through this PRISMA review, unknown components of the study can be analyzed cumulatively according to the understanding of the field under study (Shamsollahi et al., 2021). All resources available in this PRISMA method are used to search for documents that intersect or are related to research, thus minimizing the potential for document selection bias (Pae, 2015).

This approach provides a descriptive literature review with relevant research contexts (Lyu et al., 2022). This PRISMA method assists the author in accurately describing what has been done, what has been discovered, and what plans there are (Sarkis-Onofre et al., 2021). A review-type article is a type of interpretation, synthesis, and assessment of a scientific study or research by experienced authors (Yilmaz, 2006), which cannot be reviewed using an analogy approach because the clarity is not detailed enough, not comprehensive, and is likely written in line with the author's opinion, resulting in bias or misinterpretation by accident (Selcuk, 2019). So, the PRISMA method was chosen to help avoid these problems by using different criteria that the author will set. The reporting of the PRISMA method is also said to be more optimal in terms of the quality of the literature review process (Sarkis-Onofre et al., 2021). This review approach has been taken several times, such as for bibliometric reviews (Dabić et al., 2020; Donthu et al., 2021; Manesh et al., 2021) and meta-analysis reviews (Rosck et al., 2017; Rana & Paul 2020; Bhowmik et al., 2022; Bimrah et al., 2022). Meanwhile, other approaches related to this review have also been carried out, including the hybrid narrative approach (Paul et al., 2017; Kumar et al., 2020), theme-based synthesis (Kahiya, 2018; Christofi et al., 2021), and theory-based reviews (Hassan et al., 2016; Gilal et al. 2019). From the literature data obtained later, if it meets the established criteria, the literature will then be extracted and synthesized (Azizan et al., 2021) using the R (4.4.2), and then run in RStudio and also the Bibliometrix packages, according to Aria (2023).

Data search

Literature data is identified from the search engine and Scopus *database* using the *article title*, *abstract,* and *keywords* searches in the form of "*management*" and "*mangroves*" as in **Table 1**. From the search results, 347 pieces of literature will be filtered. In the literature screening, the researcher chooses the title and abstract separately, as Mugi et al. (2022) did. The results of the literature screening are only relevant to the management of mangrove ecosystems, and they only look at the last five years, from 2018 to 2022, so that data can be kept up to date.

Table 1 Scopus database search keywords.

Article Title, Abstract, Keywords	Article Title
Management, mangrove	Management, mangrove

Source: Data Recapitulation (2022).

Table 2 Scopus database keyword query.

Database	Query Keyword
Scopus Index	(TITLE-ABS-KEY (management, AND mangrove) AND TITLE (management, AND mangrove))) AND (LIMIT-TO (PUBSTAGE , "final") OR LIMIT-TO (PUBSTAGE , "aip")) AND (LIMIT-TO (OA , "all") AND (LIMIT-TO (PUBYEAR , 2022) OR LIMIT-TO (PUBYEAR , 2021) OR LIMIT-TO (PUBYEAR , 2020) OR LIMIT-TO (PUBYEAR , 2019) OR LIMIT-TO (PUBYEAR , 2018) AND (LIMIT-TO (DOCTYPE , "ar") OR LIMIT-TO (DOCTYPE , "cp") AND (LIMIT-TO (EXACTKEYWORD , "Mangrove") OR LIMIT-TO (EXACTKEYWORD , "Ecosystems") OR LIMIT-TO (EXACTKEYWORD , "Mangroves") OR LIMIT-TO (EXACTKEYWORD , "Forestry") OR LIMIT-TO (EXACTKEYWORD , "Forest Management") OR LIMIT-TO (EXACTKEYWORD , "Sustainable Development") OR LIMIT-TO (EXACTKEYWORD , "Management") OR LIMIT-TO (EXACTKEYWORD , "Environmental Protection") OR LIMIT-TO (EXACTKEYWORD , "Coastal Zone Management") OR LIMIT-TO (EXACTKEYWORD , "Mangrove Forest") OR LIMIT-TO (EXACTKEYWORD ,

Table 2 (continued) Scopus database keyword query.

Database	Query Keyword
Scopus Index	"Sustainability) OR LIMIT-TO (EXACTKEYWORD , "Mangrove Ecosystems") OR LIMIT-TO (EXACTKEYWORD , "Sustainable Management") OR LIMIT-TO (EXACTKEYWORD , "Environmental Management") OR LIMIT-TO (EXACTKEYWORD , "Ecosystem Service") OR LIMIT-TO (EXACTKEYWORD , "Ecosystem Services") OR LIMIT-TO (EXACTKEYWORD , "Wetlands") OR LIMIT-TO (EXACTKEYWORD , "Conservation Management") OR LIMIT-TO (EXACTKEYWORD , "Ecosystem Management") OR LIMIT-TO (EXACTKEYWORD , "Mangrove Management") OR LIMIT-TO (EXACTKEYO, "Ecosystem") OR LIMIT-TO (EXACTKEYO, "Local Participation") OR LIMIT-TO (EXACTKEYO, "Coastal Zones") OR LIMIT-TO (EXACTKEYO, "Stakeholders") OR LIMIT-TO (EXACTKEYO, "Indonesia") OR LIMIT-TO (EXACTKEYO, "Wetland") OR LIMIT-TO (EXACTKEYO, "Coastal Communities") OR LIMIT-TO (EXACTKEYO, "Avicennia") OR LIMIT-TO (EXACTKEYO, "Environmental Monitoring") OR LIMIT-TO (EXACTKEYO, "Livelihood") OR LIMIT-TO (EXACTKEYO, "Management Strategies") OR LIMIT-TO (EXACTKEYO, "Perception") OR LIMIT-TO (EXACTKEYO, "Restoration") OR LIMIT-TO (EXACTKEYO, "Coastal Management") OR LIMIT-TO (EXACTKEYO, "Exactkeyo") OR LIMIT-TO (EXACTKEYOSE, "Mangrove Forests") OR LIMIT-TO (EXACTKEYO, "Participatory Approach") OR LIMIT-TO (EXACTKEYO, "Remote Sensing") OR LIMIT-TO (EXACTKEYO, "Resource Management") OR LIMIT-TO (EXACTKEYO, "Community Participation") OR LIMIT-TO (EXACTKEYWORD , "Community Resource Management") OR LIMIT-TO (EXACTKEYWORD , "Natural Resources Management") OR LIMIT-TO (EXACTKEYWORD , "Co-management") OR LIMIT-TO (EXACTKEYWORD , "Forests") OR LIMIT-TO (EXACTKEYWORD , "Nature Conservation") OR LIMIT-TO (EXACTKEYWORD , "Anthropogenic Effect") OR LIMIT-TO (EXACTKEYWORD , "Coastal Zone") OR LIMIT-TO (EXACTKEYWORD , "Comanagement") OR LIMIT-TO (EXACTKEYWORD , "Community") OR LIMIT-TO (EXACTKEYWORD , "Environmental Degradation") OR LIMIT-TO (EXACTKEYWORD , "Forest") OR LIMIT-TO (EXACTKEYWORD , "GIS") OR LIMIT-TO (EXACTKEYWORD , "Mangrove Ecosystem") OR LIMIT-TO (EXACTKEYWORD , "Planning") OR LIMIT-TO (EXACTKEYWORD , "Sustainable Forest Management") OR LIMIT-TO (EXACTKEYWORD , "Avicennia Marina") OR LIMIT-TO (EXACTKEYWORD , "Conservation Planning") OR LIMIT-TO (EXACTKEYWORD , "Environmental Policy") OR LIMIT-TO (EXACTKEYO, "Habitat Restoration") OR LIMIT-TO (EXACTKEYO, "Human Activity") OR LIMIT-TO (EXACTKEYO, "Coastal Engineering") OR LIMIT-TO (EXACTKEYO, "Community-based") OR LIMIT-TO (EXACTKEYWORD, "Ecotourism Management") OR LIMIT-TO (EXACTKEYO, "Forest Ecosystem") OR LIMIT-TO (EXACTKEYWORD") OR LIMIT-TO (EXACTKEYO") OR LIMIT-TO (EXACTKEYO") OR LIMIT-TO (EXACTKEYO, "Natural Resources") OR LIMIT-TO (EXACTKEYO, "Satellite Imagery") OR LIMIT-TO (EXACTKEYO, "Coastal Ecosystems") OR LIMIT-TO (EXACTKEYO, "Coastal Protection") OR LIMIT-TO (EXACTKEYWORD, "Ecosystem Health") OR LIMIT-TO (EXACTKEYWORD, "Environmental Planning") OR LIMIT-TO (EXACTKEYWORD, "Geographic Information Systems") OR LIMIT-TO (EXACTKEYWORD, "Information Systems") OR LIMIT-TO (EXACTKEYWORD, "Integrated Approach") OR LIMIT-TO (EXACTKEYWORD, "Local Community") OR LIMIT-TO (EXACTKEYWORD , "Mangrove Restoration") OR LIMIT-TO (EXACTKEYWORD , "Monitoring") OR LIMIT-TO (EXACTKEYWORD , "Protected Area") OR LIMIT-TO (EXACTKEYWORD , "Resource Use")) AND (LIMIT-TO (AFFILCOUNTRY , "Indonesia"))

Source: Data Recapitulation (2022).

All of the literature found by the search was looked over to ensure there were no duplicates or documents that did not meet specific criteria. This criterion was used to eliminate bias in the literature during the literature feasibility screening process (Koutsos et al., 2019; Tricco et al., 2016; Mortensen et al., 2017), whose criteria reflect the objectives of the literature review (Azizan et al., 2021). Using predetermined criteria will reduce errors, biases, and inconsistencies when selecting related literature (Frampton et al., 2017). The criteria in question include "*Open Access*: All, *Year*: 5 years (2018 - 2022), Document Type: Article, Conference *Paper, Publication stage: Final* and *Article in Press, Language: English Source Type: Journal* and *Conference Proceedings, Country*: Indonesia, and *Query* on *keywords*" (**Table 2**). The literature obtained after this step is 41, which will be carefully reviewed to decide whether the literature meets the predetermined criteria after the extraction process. Detailed literature will be extracted, which includes *citation information, bibliographical information,* and *abstracts & keywords.*

Descriptive analysis

The descriptive analysis used the PRISMA framework (**Figure 1**), which identified 41 articles of literature potentially relevant to this research review. Furthermore, six articles were omitted because the abstract contents were less relevant to the research. The search resulted in a final total of 35 articles as literature for full-text review that met the designation criteria and was ready for further synthesis in this review, which will be integrated with the RStudio and Bibliometrix packages, according to Aria (2023).

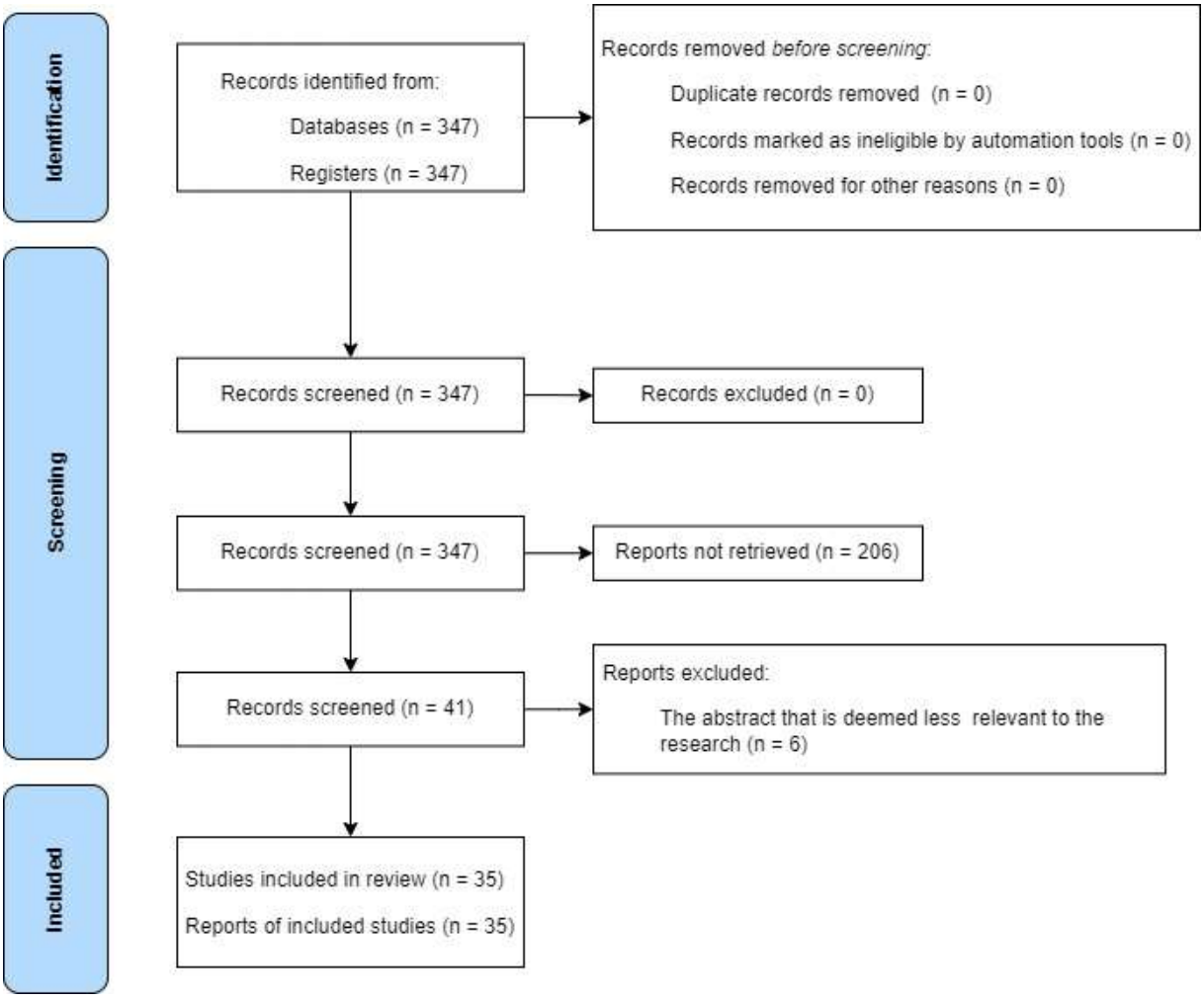


Figure 1 PRISMA method literature review.
Source: Data Recapitulation (2022).

Literature extraction

All literature retrieved in the last search (35 articles as literature) was stored in Bibtex format (.Bib). The literature extraction (.bib format) takes place by running the bibliometric packager, according to Aria (2023), in R software using the Rstudio platform. The formula is shown in **Table 3**. Furthermore, literature extraction will be performed in stages, as shown in **Table 4**. This bibliometric will discuss the *Thematic Map, Co-occurrence Network,* and *Trend Topics* literature.

Table 3 RStudio Software Formulas.

Software	Formulas
RStudio R (4.4.2)	install.packages("bibliometrix") library(bibliometrix) biblioshiny() Ctrl+A and Run

Source: Data Recapitulation (2022).

Table 4 Steps of bibliometric literature extraction.

R Packages	Steps
Bibliometrix	Data Load Data Choose "import raw file(s)" on Import or Load Choose "Scopus" on the Database Choose file .bib Click Start

Source: Data Recapitulation (2022).

3. Results and discussion

3.1 Literature extraction details

Based on the identification results that have been carried out, 35 articles as literature meet the eligibility criteria for further review. Furthermore, the extraction was carried out using the Bibliometrix package under the biblioshiny function, and the results of the extraction can be seen in the figure below regarding *Thematic Map, Co-occurrence Network,* and *Trend Topics.*

Figure 2 and **Table 5** show the Thematic Map analysis, a collection of words describing the themes in each quadrant. Quadrant I consists of *Motor Themes (trending themes),* Quadrant II consists of *Niche Themes (special themes),* Quadrant III consists of *Emerging or Declining Themes (abandoned themes),* and Quadrant IV consists of *Basic Themes (basic themes).* From the literature reviewed, Quadrant I concerns trending themes in mangrove ecosystem management, namely *deforestation* and *natural resources management*, which are included in *the deforestation cluster* as much as 11.43 % of the total occurrence of themes. This indicates that the literature on mangrove ecosystem management based on *deforestation* and *natural resource management* is not too much of a focus in the extraction results, but that it is becoming a trend. Quadrant II deals with specific themes in managing mangrove ecosystems, including *coastal zones, coastal ecosystems, community empowerment, information systems, information use, surveys, aquaculture,* and *food supply*. Quadrant II is divided into 3 clusters: *the coastal zones, information systems,* and *aquaculture cluster* themes. *The coastal zones cluster* accounted for 25.71 % of the incidents, *the information*

system cluster accounted for 17.14 %, and *the aquaculture cluster* accounted for 11.43 % of the total themes. From Quadrant II, it can be understood that quite a lot of literature on managing mangrove ecosystems based on the theme of the coastal zone has been extracted in which the specifications include *coastal zones, coastal ecosystems,* and *community empowerment.*

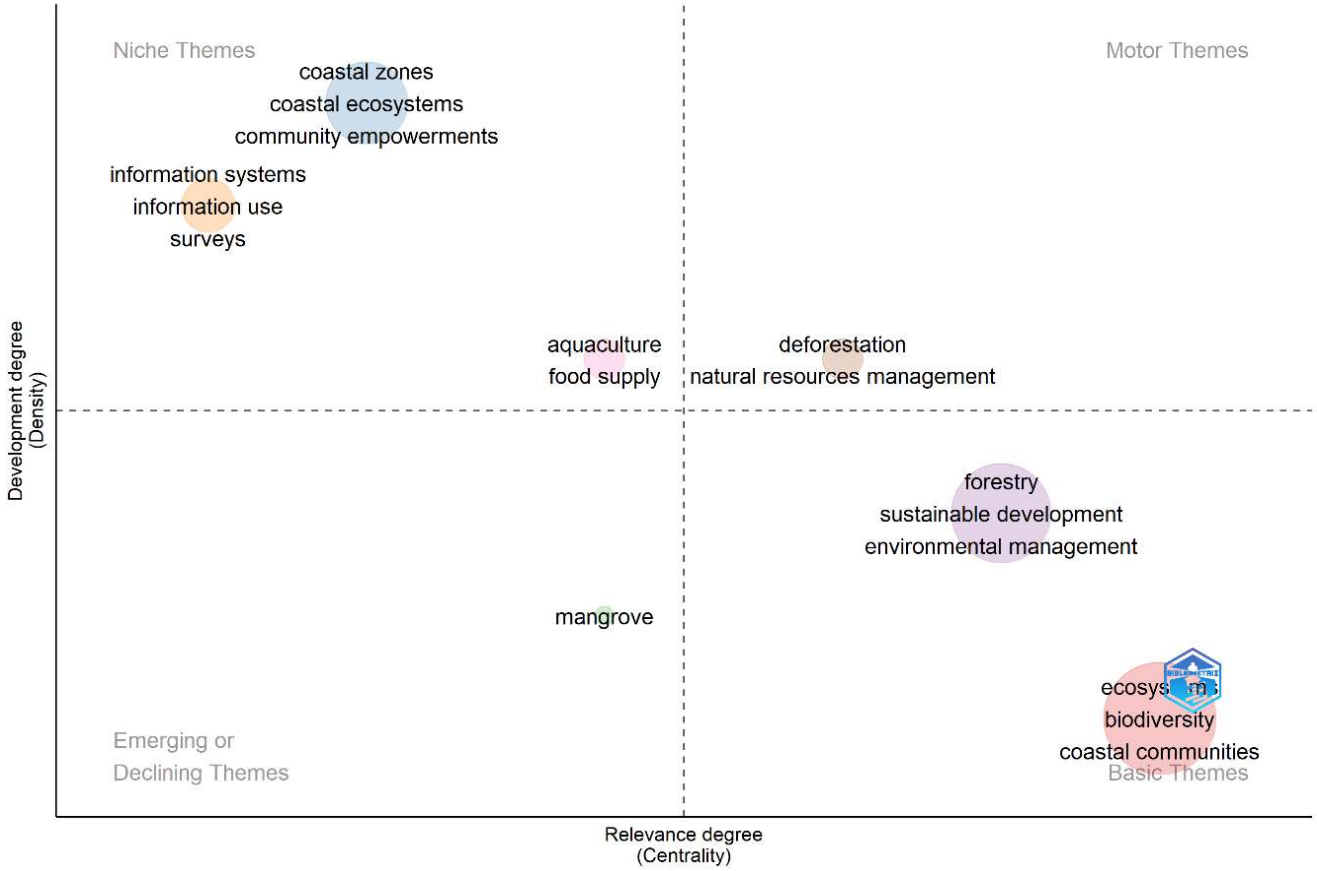


Figure 2 *Thematic Map* of literature.
Source: Data Processing (2022).

In Quadrant III, themes starting to be abandoned or that are declining in managing mangrove ecosystems are presented, related to the *mangrove* themselves, as much as 5.71 % of the total themes extracted. The *mangrove* theme event in Quadrant III is the most minor compared to the other theme events. If we look more specifically at literature extraction, this happens because the research on the mangrove theme focuses on the mangroves studied, or it can be said that it is unrelated to other themes in the title. This incident originates from the research of Paembonan et al., 2020) and Santoso et al. (2019) with the titles *"Sustainable Forest Management Through Natural Mangrove Regeneration…"* and *"Analysis of Sustainability Ecosystem Mangrove Management In…"*. Quadrant IV deals with the primary themes in managing mangrove ecosystems, namely *forestry, sustainable development, environmental management, ecosystems, biodiversity*, and *coastal communities*. Like Quadrant II, this quadrant is divided into several clusters, namely the *forest* and *ecosystem cluster* themes. *The forestry cluster* accounts for 48.57 % of the events, and *the ecosystem cluster* accounts for 94.29 % of the themes. *The ecosystem cluster* theme has the highest occurrence among other themes in the other quadrants. This also indicates that the literature on managing mangrove ecosystems based on the *ecosystem* theme is heavily extracted, and whose specifications include *ecosystem, biodiversity,* and *coastal communities*.

Table 5 Word clusters on thematic map.

Occurrence	Words	Cluster Label
2	*deforestation*	*deforestation*
2	*natural resources management*	*deforestation*
5	*coastal zones*	*coastal zones*
2	*coastal ecosystems*	*coastal zones*
2	*community empowerments*	*coastal zones*
2	*information systems*	*information systems*
2	*information use*	*information systems*
2	*surveys*	*information systems*
2	*aquaculture*	*aquaculture*
2	*food supply*	*aquaculture*
2	*mangrove*	*mangrove*
8	*forestry*	*forestry*
5	*sustainable development*	*forestry*
4	*environmental management*	*forestry*
18	*ecosystems*	*ecosystems*
7	*biodiversity*	*ecosystems*
5	*coastal communities*	*ecosystems*

Source: Data Recapitulation (2022).

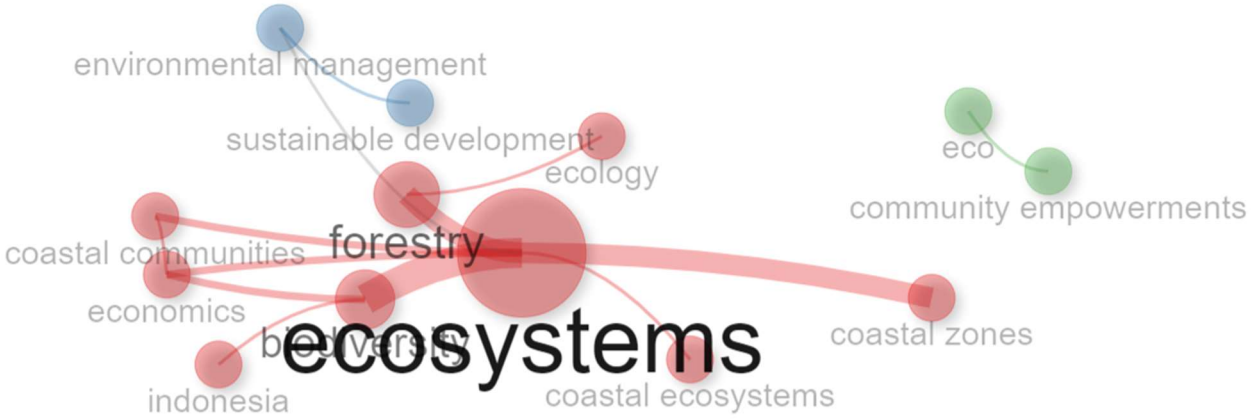


Figure 3 *Co-occurrence Network* Literature.
Source: Data Processing (2022).

Figure 3 provides information related to a network that has a relationship between one word and another, or that is related together. The literature extraction results show a higher linkage between words with a more significant circle symbol and thicker writing on the network. It can be seen in the picture that the word *ecosystem* is a word that looks very thick compared to other words. In addition, the word *ecosystem* is also the center of a network of words around it, such as

biodiversity, forestry, ecology, coastal communities, economics, Indonesia, coastal zone, coastal ecosystem, and *environmental management.*

It is possible to say that the outcomes of the literature extraction show that there has been a reciprocal link between the word *ecosystem* and the scope of the words *coastal zone, forestry, ecology, coastal communities, economics, Indonesia, biodiversity,* and *coastal ecosystem*. Meanwhile, the words *environmental management* and *sustainable development* are linked together with the word *forestry*, which is one of the words that have a high connection with the word *ecosystem* besides the word *biodiversity*. Then, for the words *community empowerments* and *eco*, there is no mutual connection with other words, either those that have a big circle like the words *ecosystem*, quite big like the words *forestry* and *biodiversity*, or those that are as big as the words *ecology, coastal communities, economic, Indonesia, coastal zone, coastal ecosystem,* and *environmental management*. It is possible because the two words are too specific in the context of society or social aspects of mangrove ecosystem management.

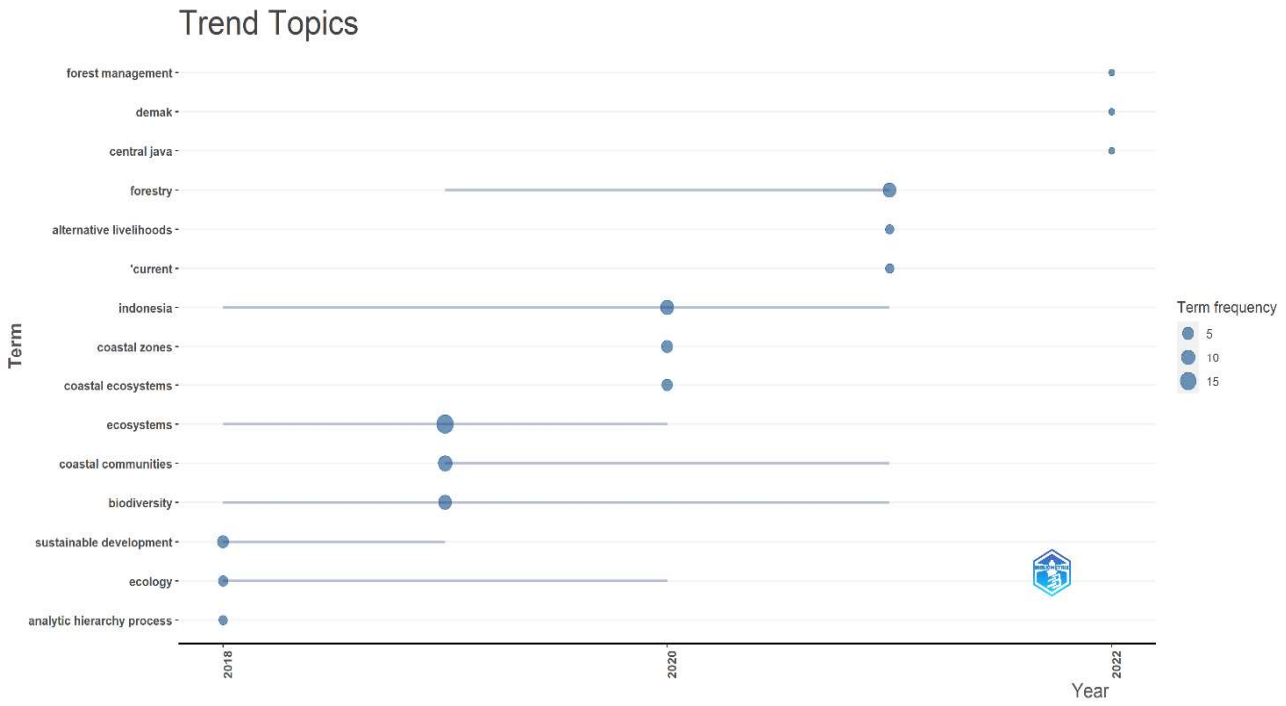


Figure 4 *Trending topics* of literature.
Source: Data Processing (2022).

Furthermore, **Figure 4** gives information on trending topics from extracted literature on managing mangrove ecosystems annually. Regarding this trend, parameters are set, namely, three most words each year and at least one word each year. In 2018, the topic with the highest trend in managing mangrove ecosystems was *sustainable development,* accounting for 14.29 % of the total literature. A year later, the trend toward managing the mangrove ecosystem shifted, accounting for 51.43 % of the total literature. The trend shifts to coastal zones by 2020, accounting for up to 14.29 % of total literature. The trend in 2020 does not point to *Indonesia* because it describes the research location. Also, the trend of managing mangrove ecosystems means that forestry will make up 22.86 % of all literature in 2021. There is no trend information for 2022 because *Demak Regency* and *Central Java*, which have one and two topics, respectively, are research places for trend information in 2020.

The *analytic hierarchy process* was mentioned in 2018 (5.71 %), *biodiversity* was mentioned in 2019 (22.86 %), *coastal ecosystems* were mentioned in 2020 (11.43 %), and *current issues* were mentioned in 2021 (5.71 %). This shift in topic trends regarding mangrove ecosystem

management is made possible by the specific scope of research, which began with the topic of *sustainable development*, moved to the topic of *ecosystems*, and has recently ended on the topic of *coastal zones* and *forestry*. The changes in topic trends that have occurred in the last five years will have implications for research in the following years, namely with a more in-depth specification of the scope of the topic. An example is the management of mangrove ecosystems on topic trends *in tourism areas, conservation zones, aquaculture regions,* and the like. The context of mangrove management may be a particular reason for this type of research on mangrove ecosystem management, which has many meanings, and meanings from several theories.

3.2 Mangrove ecosystem management in tourist areas

In the last five years, research on mangrove ecosystem management in Indonesia was carried out in tourist areas, one of which was by Erlinda et al. (2022) in producing alternative priority strategic choices in the Rawa and Barembang River ecotourism areas, Siak Regency. His research considered several things: potential, attractiveness, activities, and tourism policies. The results of his research are strategies for managing mangrove ecosystems in tourist areas. These strategies include promoting ecotourism more, opening up investment opportunities for ecotourism development, improving facilities and infrastructure, giving ecotourism business training, promoting ecotourism more, getting the government and stakeholders to work together, and keeping mangrove ecosystems in good shape.

Then, Fatimatuzzahroh et al. (2020) made a list of strategic priorities for the Karansong ecotourism area in Indramayu based on ecosystems, joint management, regime property rights, and adaptive management. Some of the things considered in his research are management policies, management impacts, policies, and stakeholder/government-based management. His research findings are that changes in policies or regulations between local governments and communities affect ecosystem management, which impacts reducing the number of tourist visits. The management transfer from the community to the private sector resulting from existing policy changes decreases community involvement and participation in mangrove ecosystem management.

According to Fistiningrum and Harini (2021), community participation has a socio-economic impact on managing mangrove ecosystems in the Pasir Mendit and Kadilangu tourist areas in Kulonprogo Regency (Yogyakarta Province). The findings were that community-based mangrove ecosystem management has several effects, including the emergence of activities that generate additional income related to tourism, the same level of social interaction in the form of voluntary work before and after the existence of mangrove ecotourism, rules that bind the community and are obeyed together, and social conflicts related to management because this benefits some parties.

Kurniawan et al. (2020) researched the Lantebung ecotourism area, Makassar City (South Sulawesi), which underlined the role of several parties, the government and the surrounding community, in ecosystem management. Several things are considered, namely the condition of the ecosystem, identification of roles (fishermen, Heads of Bira Village, and tourism services), interests (the existence of green belts, biodiversity, educational facilities, and tourism), and mapping of actors. The result of their findings is that the involvement of both the government and the surrounding community in ecosystem management means they have their respective roles, with their main interests in the form of tourism activities and educational interests.

Massiseng et al. (2020) and Kurniawan et al. (2020) worked together to make a model for managing mangrove ecosystems. The management model is obtained by considering policy scenarios in 2020 and 2050, namely scenario one, by carrying out a policy strategy to increase community empowerment by 10 %, and scenario two, by carrying out a policy strategy to increase tourism promotion by 10 %. The results are that the scenario model in mangrove ecosystem management is considered more optimal, with a strategic policy scenario to increase tourism promotion by 10 %, which increases the ecosystem area by 25.25 ha and revenue from these

tourism activities by 620.25 million rupiahs in the next 30 years. This happens because tourists visiting will add insight, and the community can manage the mangrove ecosystem well. Idajati et al. (2016) believe that the success of mangrove ecosystem management, starting from planning, development, and supervision, must involve more people than just a small group, so that the participation rate is maximized. Promoting nature tourism supports information on alternative natural tourism destinations that tourists can visit, where natural tourism significantly influences visitor satisfaction.

Prasetya et al. (2018) also researched the Jangkaran ecotourism area in Kulon Progo to help make plans for managing ecosystems. Some things that are considered are how institutions are run, the potential for ecotourism, the facilities and infrastructure, and how easy it is to get to the location. Their findings are that some things that need to be considered in developing ecotourism (strategies) in ecosystem management are the potential of mangrove ecotourism, mangrove ecotourism facilities, and infrastructure, access to mangrove ecotourism locations, and mangrove ecotourism management institutions. To help with this, we need to improve our ability to manage human resources, take care of the natural zoning of ecosystems, and keep biodiversity. From these explanations, it is clear that managing mangrove ecosystems in tourist areas focuses on developing a plan or strategy for implementing sustainable tourism that still considers improving the ecosystem and the economy.

3.3 Mangrove ecosystem management using remote sensing

Research related to mangrove ecosystem management in Indonesia in the last five years was carried out by remote sensing, one of which was by Arfan et al. (2021) with Landsat 8 satellite imagery to determine the area and distribution of mangrove ecosystems on the coast of Luwu Regency. However, this did not show or explain the use of remote sensing instruments in data processing and research results. Likewise, Asyiawati and Hindersah (2020) only show existing land use using image recording in the coastal area of Muara Gembong with a combination of spatial pattern plan maps. The same thing happened in the research of Christian et al. (2021), who used aerial photos to see. This study only talks about satellite imagery because the area has changed the potential of nature in Bukit Batu District, Riau. Only a few points are needed to explain what nature can do, and aerial photos have nothing to do with data collection or processing.

Yusran and Sabar (2020) used satellite images from Landsat 7 ETM and Landsat 8 OLI to find sample points for field surveys to determine the types of mangroves, the number of mangroves, and the land cover. The data collection and processing of the two Landsat satellite images are not explained in general or detail, nor are they explained in the context of figuring out the type and number of mangroves. As is well known, Landsat satellite imagery requires radiometric and geometric corrections to eliminate errors in the recording of satellite imagery data caused by the distance or altitude of the satellite, the atmosphere, the satellite's motion, and the rotation of the earth. Rihulay and Papilaya (2022) also researched ecosystem management by looking at the mangrove area from 1999 to 2020 on a 5-year basis using Landsat 5, Landsat 7, and Landsat 8 OLI satellite images in Ambon Bay. As for aerial photographs, these have shortcomings in the form of the need for more data on large areas (Heumann 2011) and in considering cloud shadows (Santos & Bitencourt, 2016), although they are suitable and are recommended for detailed mapping in coastal environments (relatively small and narrow areas) and mapping evaluation (Kuenzer et al., 2011).

3.4 Mangrove ecosystem management with a quantitative approach

Research related to mangrove ecosystem management in Indonesia in the last five years has been carried out with a quantitative approach, one of which is by Arfan et al. (2021) with scoring

from the results of *Strengths, Weaknesses, Opportunities, and Threats* (SWOT) analysis, where the sample was based on *proportional stratified random sampling*. The sample is based on the stratification of the types of community activities around the mangrove area. The results are aggressive strategies that could be used instead of developing sustainable mangrove resources that have economic value to create profitable business opportunities. Segmentation and the number of samples were not explained in this study, which is a shortcoming of the study. Prasetya et al. (2018) also scored the assessment of priority elements from experts/experts/academics/stakeholders in mangrove ecosystem management from the *Analytic Hierarchy Process* (AHP) analysis results. Their research results show that the essential parts of managing mangrove ecosystems are: potential, facilities and infrastructure, access, and ecotourism institutions. Ecotourism is an excellent way to make coastal areas more sustainable and less vulnerable to natural disasters like tsunamis.

In their research, Nanlohy and Ruban (2021) used random sampling to figure out how to manage the mangrove ecosystem. They did this by weighing and scoring the internal and external factors of the surrounding community. Their findings said that the analysis of community perceptions, behaviors, and participation shows the importance of mangrove ecosystem management remaining sustainable, and the type of management recommended must involve all local communities. There is also a need for cooperation between the government and the community. For better management, local communities must understand the condition of mangrove ecosystems and participate in their management programs. Local governments must involve coastal communities in mangrove ecosystem management programs so that communities can take full responsibility for conserving mangrove ecosystems.

Fistiningrum and Harini (2021) also conducted a score in their research to determine community participation and the impact of ecosystem management on the social and economic conditions of the community. The scoring began with an interview conducted on a Likert scale, and a statistical test was carried out in the form of a Spearman Correlation Test and a T-Test on internal factors with community participation, where the sample was obtained through *purposive sampling*. The study's results indicate that community participation has a moderate level at the planning stage, community participation has a very high level both at the implementation and benefit-taking stages, and community participation has a high level at the evaluation stage. According to their findings, mangrove ecotourism management has various impacts, including (a) the emergence of additional income-generating activities related to mangrove ecotourism, (b) the same level of social interaction in the form of voluntary work before and after the existence of mangrove ecotourism, (c) binding rules that are sufficiently obeyed by the community, (d) social conflicts related to mangrove ecotourism management, and (e) the average income of the community after the existence of mangrove ecotourism being more significant than before mangrove ecotourism.

Indah et al. (2018) also conducted a statistical test in the form of a regression test with a Likert scale based on interviews conducted by *multistage random sampling* and *proportional sampling*. Their research used statistical tests to determine how society affects ecosystem management and management models (both internally and externally). The findings are in the form of a management model involving the role of the community (people and *people figures*), and government supports through a strategy model of mangrove forest management, a pond cultivation management model by including mangroves as *an input* source for production facilities, and ecotourism to increase community income. The influencing factors of ecosystem management come from age, education, and family burdens.

Puryono and Suryanti (2019) also performed statistical tests, namely, the Chi-Square, Correlation, and Bivariate Correlation tests- by random sampling. The statistical test aims to observe people's perceptions of conditions and degradation, related activities, knowledge, and desire to participate in conservation. The results show that local people and tourists do not know much about mangrove ecosystems, their benefits, or how their loss affects the environment. In

addition, both local communities and tourists have a low interest in participating in mangrove conservation efforts, although the interest of tourists in participating is higher than that of local people. A solution that can be applied to maintain the sustainability of the mangrove ecosystem in Karimunjawa is to use mangroves as an ecotourism attraction. The study's shortcomings were that it did not explain the results of the observations in detail, only the final results conclusion.

Salminah et al. (2020) used nonprobability sampling to conduct Spearman Correlation tests, similar to Fistiningrum and Harini (2021), to assess local communities' understanding of mangrove management programs. The results show that the awareness-raising campaign about the mangrove program has not reached everyone in the Mahakam Delta. However, the program has the potential to help support policies that try to stop climate change. There are still some problems with how management programs are put into place. For example, local communities are more likely to get management programs if they are helped by long-term mentoring, intensive awareness-raising programs, and SilvoFishery demonstrations that are good for the environment and the economy. Also, because local communities benefit economically from mangrove management programs, the government needs to make it easier for local communities to access money and markets; so that people will be more likely to protect mangrove ecosystems, programs that take care of mangroves need to think about the long-term economic benefits of rehabilitated mangroves for nearby communities. Wahyurini et al. (2021) also conducted statistical tests in the form of the SEM *Warp Partial Least-Square* method, the Innel model, the reliability test, the *Convergent Validity* Outer Model test, and the *linear validity* test of the structural model *(Outer Model)* with WarpPLS software to determine the influence of *Co-Management* as mangrove ecosystem management. The findings say that *Co-Management* can affect the economic improvement of coastal communities, such as increasing incomes, new job opportunities, and mangrove sustainability.

Then, the research of Nanlohy et al. (2019) also used statistical tests, in the form of multiple regression analysis with *disproportional sampling.* The analysis determines the interconnectedness of people's attitudes toward Sasi, one of the natural resource management instruments used by local communities to maintain the quality of nature or the biodiversity of natural resources. The findings say that the community has a positive attitude towards mangrove ecosystem management through the Sasi approach, and more than 60 % of the community supports the implementation of Sasi as a way of achieving sustainable mangrove ecosystem management. Basyuni et al. (2018b) conducted a transect method and sample plots for flora and fauna analysis to determine the level of suitability of mangrove ecotourism, producing strategies for developing ecotourism that can improve efforts to manage mangrove ecosystems. Their research showed that the main reason for deforestation in Lubuk Kertang is that mangrove ecosystems are being turned into aquaculture and oil palm plantations. The information will likely help with planning and practices for coastal management and mitigating actions for scenarios in which emissions are cut down. This study uses the transect method and sample plots and does not discuss analyzing plant and animal life.

Damastuti et al. (2022) also carried out the same method as Basyuni et al. (2018c) but combined it with calculating the mangrove species wealth index in each coastal village in the study area. It is aimed at analyzing the effectiveness of ecosystem management on biodiversity. The results of their research mention essential factors that contribute to the effectiveness of CBMM for biodiversity conservation, namely (a) long-term funding and maintenance, (b) greater local acceptance of protection legislation, (c) higher levels of public support, (d) the use of more mangrove species, (e) much more extensive spatial-scale mangrove restoration, and for highly eroded areas, and (f) the presence of additional measures to reduce wave energy. Natural environmental changes should be considered when choosing a site for rehabilitation, planning for rehabilitation, planting species and techniques, and continuing to care for the site.

Paembonan et al. (2020) used the same method: transects and sample plots (Purposive Line Sampling Plots) that were 20×20 m^2. In addition, calculations were also carried out with the formula *Based Area* (BA) for the base area of the tree, the *importance value index* (IVI). This is

based on the understanding that one of the success factors for mangrove ecosystem management can be seen from the potential of natural stands and youth produced in the mangrove ecosystem. The findings say that the natural regeneration potential of mangroves on Pannikiang Island is dominated by *Brugueira gymnorhiza, Rhizophora mucronata, Sonneratia alba,* and *Rhizophora stylosa*. These species can ensure the continuity of natural regeneration for mangrove communities on Pannikiang Island, while other species require intervention through artificial regeneration.

Meanwhile, Jati and Pribadi (2018) took a quantitative approach using the *Total Economic Value* (TEV) formula to determine the utilization of mangrove ecosystems from the aspects of direct, indirect value, and choice/option value. Their findings result in using mangrove resources in Baros Hamlet, which the community can directly perceive as fisheries utilization (*Scylla sp., Mugil sp., Macrones sp., Oreochromis*) and the use of mangrove seedlings. In addition, the total economic value of mangroves in Baros Hamlet was obtained at Rp 1,390,233,258 per year, calculated from direct benefits of Rp 90,648,258 per year, indirect benefits of Rp 1,099,335,000 per year, and optional benefits of Rp 200,250,000 per year.

The formula, which consists of provisioning services (PS), supporting services (SS), regulatory services (RS), and cultural services (CS), was also used in the research of Marlianingrum et al. (2019). This is used to identify, map, and assess the mangroves' economic use, investigate ecosystem services in mangrove conservation, and understand the mangrove ecosystems' role, which serves as the management policies foundation. The result of the findings is that the mangrove ecosystem has a high economic value, so it must be maintained and appropriately managed. Cultural services and mangrove ecosystem regulation services must be improved by providing awareness of the importance of mangroves to the community, so that the role of mangrove ecosystems can be the basis for making management policies in Tangerang Regency.

Melo et al. (2020) conducted several quantitative approaches in the form of *multidimensional scaling* (MDS) analysis, the Rap-Mforest approach, scoring, the *Alternating Least Square Scaling* (ALSCAL) algorithm with SPSS software, *leverage* analysis, and *Monte Carlo* analysis. This approach considers several dimensions, namely the ecological, economic, and social sustainability conditions. The result of the sustainability value produces two values with an interval of 0 to 2: a wrong value that reflects the most unfavorable conditions, and a good value that reflects the most favorable conditions for sustainable ecosystem management. In the previous year, the research of Melo et al. (2019) also used a quantitative approach in the form of quantitative stakeholder analysis (local and district governments, academics, non-governmental organizations, and local communities) with a snowball *sampling* matrix. This analysis is used to explain stakeholder involvement in the program, its strengths, and its importance in supporting the goals of sustainable mangrove ecosystem management. The matrix of power and interests shows that key players and stakeholders play significant roles in sustainable mangrove management initiatives. Stakeholders are essential to the program's success, so keeping good relationships with them is vital. Increasing the awareness of these actors on the importance of mangrove ecosystems as a life support system can be done by involving them in sustainable initiatives. These actors can collaborate to empower subject stakeholders to achieve program objectives. The actors who fall into this quadrant are considered critical players because they have power and are of high importance to the successful implementation of management.

Sahputra et al. (2022) also used dimension assessment (MDS analysis) to determine how well the mangrove ecosystem was managed. They identified indicators using Rap-Mangrove Forest (RMF) and scoring, a modified version of the Rapid Appraisal for Fisheries (RAPFISH). The findings of their study demonstrate that, in order to achieve sustainable mangrove management in the coastal region of Jaring Halus Village, it is preferable to raise stakeholder awareness and knowledge about the significance of managing the mangrove ecosystem by holding seminars, dialogues, and offering free education or training to the community about the principles of sustainable mangrove use. Santoso et al. (2019) also used RMF and Monte Carlo analysis to do

MDS analysis, but they added technological dimensions to study a broader range of dimensions and to look at the sustainability of mangrove ecosystem management. The study's findings indicate that the sustainability status of mangrove ecosystem management in Pangkah Wetan Village and Pangkah Kulon Village is mainly entirely sustainable. Based on the analysis results, faunal diversity and coastline changes are susceptible to the sustainability status of mangrove ecosystems for the ecological dimension. The economic dimension is a type of direct utilization of the mangrove ecosystem for the community and the contribution of the mangrove ecosystem to the increase in labor.

Meanwhile, the social dimension is the mangrove ecosystem damaged by the community and community access to utilize the mangrove ecosystem. In the institutional dimension is the involvement of dimension; there are institutions related to mangrove ecosystem management and sanctions for violations of regulations in mangrove ecosystems. Furthermore, the technological dimension is the technique of processing mangrove forest products and capturing biota in the mangrove ecosystem. The sustainability of the mangrove ecosystem depends on the community utilizing and managing it.

Yusran and Sabar (2020) use technological dimensions in their research to calculate the NDVI formula in obtaining mangrove density information as material for identifying mangrove damage and formulating sustainable management cooperation that still considers aspects of mangrove function and role as a means of natural coastal protection and security. Based on image interpretation results showing that the total area of the mangroves in 2009, 2014, 2016, and 2019 is 105.85, 101.07, 92.06, and 100.06 ha, respectively, the findings only explain the mangroves area, and do not explain their density. Between 2009 and 2014, 5.83 to 6.82 ha of dryland agriculture and mangrove conversion of forests into ponds changed the land's topography. The destruction of mangrove forests contributes to abrasion, seawater intrusion, and habitat loss for animals such as birds, mammals, reptiles, insects, and various marine life. From some of the explanations above, the quantitative approach in mangrove ecosystem management is intended as a calculation method for identifying or knowing the value and multi-faceted connectedness studied.

3.5 Mangrove ecosystem management with a qualitative approach

Research related to mangrove ecosystem management in Indonesia in the last five years is carried out with a qualitative approach, one of which is by Arfan et al. (2021) with interviews, *Focus Group Discussion* (FGD), *External Strategic Factors Analysis Summary* (EFAS) matrix, and *Internal Strategic Factors Analysis Summary* (IFAS), as well as SWOT analysis. The results of their research are in the form of several alternative strategies that can be carried out for mangrove ecosystem management while still improving the community's economy in the form of environmentally friendly cultivation/fishing businesses and ecosystem development as ecotourism, as well as empowering fishermen/farmers to realize household-scale industries. The IFAS and EFAS matrices, as well as SWOT analysis, were also carried out by Basyuni et al. (2018a) in looking at the potential of ecotourism and alternative community-based management strategies. The results show that the presence of community groups supports other ways to manage mangrove ecotourism, such as ecotourism activities, keeping the number of mangroves within the area's carrying capacity, and using the internet and social media to attract tourists to ecotourism. However, the carrying capacity aspect was not explained in detail in this study. Firdaus et al. (2021) also conducted interviews and focus groups with a combination of *Willingness To Pay* (WTP) analysis to assess perceptions of mangrove restoration programs in the context of ecosystem management. Their level of perception makes fishing communities realize the importance of mangroves as a support for their livelihoods. The value of money that fishing communities can donate to forest restoration programs demonstrates their willingness to do the restoration. The WTP value of mangrove restoration between fishermen and farmers is different. The average WTP value for fishermen is IDR 118,440 per year (8.46 USD/year) and, for shrimp farmers, it is IDR 220,500 per

year (15.75 USD per year). Individuals with higher educational backgrounds are more likely to participate in WTP because they may know the benefits of restoration programs. These results imply the importance of prioritizing the educational aspects of local communities living around mangroves to create a mutually beneficial relationship between humans and mangroves. Deficiencies in this study are seen in information about the characteristics of family members (income of family members, work). Income information in this study is limited to fishing activities, and there is a possibility that respondents may have income from other activities.

Indah et al. (2018) also used the IFAS and EFAS matrices and a SWOT analysis of community-based management strategies supported by local governments. Interviews and FGDs were also conducted by Nanlohy et al. (2019) in the identification of institutions that are determinants of the cultural way of managing ecosystems. Asyiawati and Hindersah (2020), in their research, conducted interviews and analysis descriptively. The study results show related policies that can be carried out in managing mangrove ecosystems through spatial plans, increasing community participation, and developing ecotourism by providing facilities and infrastructure. Interviews and descriptive analysis were also conducted by Basyuni et al. (2018c) related to the development of *SilvoFishery* as an implementation of mangrove ecosystem management that is beneficial in improving the community's economy and fauna diversity. Christian et al. (2021) also talked to people who manage mangrove ecosystems and the Pertamina RU II Sungai Pakning *Corporate Social Responsibility* (CSR) about *Essential Ecosystem Areas* (EEA), which are divided into four groups: wetlands, animal corridors, biodiversity parks, and high conservation value areas. This is intended to grant status that will add benefits in protecting mangrove areas as protected areas in regional spatial plans. Besides that, it also gives benefits as an integration of local efforts with national targets, building a positive image for the actors involved, both community and local government, supporting the private sector to expand tourist areas publicly, improve the quality of regional biodiversity, and strengthen protection from the threat of abrasion and flooding.

Interviews and participatory mapping methods were used in the research of Damastuti et al. (2022) for the identification of *community-based mangrove management* (CBMM), which has characteristics in the form of community governance, joint strategies, and supporting regional regulations), as well as management impact components (mangrove cover and diversity of mangrove flora and fauna). Interviews with the combination of SWOT and AHP were also conducted by Erlinda et al. (2022) in formulating sustainable ecosystem management strategies, including increasing ecotourism promotion, opening investment opportunities for ecotourism development, improving facilities and infrastructure, providing ecotourism business training, establishing cooperation between the government and stakeholders, and maintaining mangrove ecosystems. The study's findings stated that, in terms of policy, funding is an essential factor that the government and stakeholders must realize to improve the welfare of local communities and the sustainability of mangrove ecosystems in Siak Regency.

This combination was also carried out by Nanlohy et al. (2019) and IFAS and EFAS to develop perceptions, behaviors, and community participation in local natural resource management practices. Nawari et al. (2021) identified *community-based mangrove forest management* (CBMFM) in Bukit Batu District through qualitative descriptive and gap analysis. The findings state that management in Bukit Batu District is still not optimal, and management's human, natural, and financial resources aspects still need to be improved. This can be done by implementing specific strategies, namely (a) increasing the capacity of mangrove managers and institutions by participating in the training of carbon credit system standards and comparative studies in the field of management, (b) implementing multistakeholder management by collaborating intensively with local governments, the private sector, NGO facilitators, and international donor agencies to register carbon credit projects, as well as developing program plans and budgets, (c) developing a transparent and accountable budgeting system that leads to independence in maintaining management credibility, (d) developing an integrated plan for a CO_2 emission reduction program

according to carbon credit system standards, and (e) creating development innovations that follow local wisdom in managing mangrove forests as other ecosystem service providers follow the carrying capacity of their environment to support continuous improvement.

AHP analysis was also used in the research of Prasetya et al. (2018) for the development of ecotourism as ecosystem management. Qualitative descriptive analysis was also used by Rahadian et al. (2019); Roziqin (2018); Wahyurini et al. (2021); and Yusran and Sabar (2020), based on interviews related to mangrove rehabilitation activities, environmental policies (*masterplan*) by local governments, mangrove co-management (*co-management),* and identification of cooperation in ecosystem management. In the meantime, Fistiningrum and Harini (2021) conducted a structured interview with the help of questionnaires about social and economic factors, internal factors, and community involvement in managing mangrove ecosystems. Massiseng et al. (2020) used Powersim Studio 10 Express software, a structured interview, and a dynamic system approach for modelling scenarios in ecosystem management.

Hamzah et al. (2020) also conducted interviews with questionnaires to analyze the form of importance and degree of influence of each actor in mangrove management. The results obtained show ecosystem management carried out in mangrove rehabilitation programs with the involvement of government actors as decision-makers, community actors as program implementers, and private actors as companions and funders. Hasnanda et al. (2018) also did interviews with descriptive analysis using the Social Network Analysis (SNA) software method and stakeholder mapping analysis with an attractive matrix to find all parties involved in mangrove management in the Forest Management Unit (FMU) area. Idajati and Widiyahwati (2018) conducted in-depth interviews, AHP analysis, and qualitative descriptive analysis to determine the priority of ecosystem management factors: conservation activities, education, community participation, the economy, and institutional management. In-depth interviews were also conducted by Majesty and Fadmastuti (2018); Sahputra et al. (2022); and Salminah et al. (2020), related to *Community-Based Mangrove Management* (CBMM), sustainability dimensions (ecological, economic, and social), and the sustainability of management programs. Melo et al. (2019) did the same as Idajati and Widiyahwati (2018), who emphasized local institutions or governments, because institutions' strengths and qualities play essential roles in sustainable mangrove management as a component of management goals.

Jati and Pribadi (2018) use descriptive analysis to talk about how to take care of mangrove ecosystems in good ways for the economy and the environment, like aquaculture and planting mangrove seedlings. Kurniawan et al. (2020) also use this analysis, along with an actor analysis that shows how vital each actor's role is in ecosystem management. Melo et al. (2020) interviewed how to make sustainable policies for managing ecosystems from an ecological, economic, and social point of view. Santoso et al. (2019) also used descriptive analysis to look at this sustainability, but they added technological dimensions to their study. Fatimatuzzahroh et al. (2020) conducted interviews and descriptive analysis focusing on stakeholder policies, including management policies, impacts, policies, and stakeholder/government-based management. Due to the findings, a policy change, and declining community involvement and participation, the mangrove ecosystem management was transferred from the community to the private sector. Puryono and Suryanti (2019) conducted a door-to-door interview with a questionnaire about people's perceptions of mangrove ecosystems. From some of the explanations above, a qualitative approach in mangrove ecosystem management underlies the explanation, decryption, and description of the research data collection obtained to provide further understanding as a basis or reference for making a policy.

3.6 Limitations, Gaps, and Knowledge in Mangrove Ecosystem Management

Research related to mangrove ecosystem management has been carried out several times by academics, one of which is by Arumugam et al. (2021), which links the role of the government in its management other than local communities in the delta/estuary area with a correlation matrix and

interviews. The finding is that there is polarization between policymakers and the community in the context of mangrove ecosystem management, which says that the community cannot only blame the local government for its activities. Nevertheless, there were flaws in their research. For example, some samples were left out of the analysis because of differences in the educational background that made the arguments and statements of relevant stakeholders not match up. It should be possible to limit the sample to people with a certain level of education, such as those with a bachelor's degree or higher.

Handayani (2021) relates socio-ecological aspects to management in education levels, knowledge, community participation, and alternative livelihoods for the community. The method used was interviews with questionnaire guides with communities around the mangrove ecosystem at random, with a minimum number of respondents of 30 people. The questionnaire uses a Likert scale with a specific value. However, the context of the ecosystem management studied is limited to rehabilitation activities. Mangrove ecosystem management also uses the *causal loop* and *participatory rural appraisal* (PRA) diagram to formulate a mangrove conservation implementation strategy based on social capital development (Santoso et al., 2021). Moreover, in this study, the context of ecosystem management studied is only limited to conservation activities, which can be further added to concerning protection aspects in the context of management in the form of activities or actions that the community or local community can carry out.

Setiawati (2019) did the same research by linking community attitudes, knowledge, and participation with segmentation based on age, gender, length of stay, education, occupation, and income to find the essential strategies for managing mangrove ecosystems. The method used is interviews with door-to-door questionnaires in communities around the mangrove ecosystem at random and descriptive analysis. The results obtained are a priority strategy for mangrove ecosystem management in the form of protection and improvement of mangrove ecosystems through planting mangroves on the coastal border and planting with *SilvoFishery* techniques, routine maintenance on mangroves that have been planted, creating zone boundaries for conservation areas, and law enforcement related to tolerance limits for physical development on the coast. The problem with this study is that it does not explain the data collection results in the field. Instead, it only shows the final results of processing the data.

Ely et al. (2021) use internal and external factors in mangrove ecosystem management. There are strengths and institutions on the inside, while opportunities and threats are on the outside. The *purposive sampling* method is used for the surrounding community, and a respondent is a person who often carries out activities around the ecosystem and benefits from the mangrove ecosystem. Descriptive and SWOT analyses were also used in this study. The findings say there are five forms of utilization, including mangrove ecosystem management, fishing, sea cucumber collection, bameti behavior, tourism (recreation), and research. Nevertheless, this study has problems, such as not explaining the questionnaire or the indicators that respondents were asked to provide. It made it hard to determine the research results from the available data.

From some of the literature we have talked about so far, it is clear that remote sensing instruments used to manage mangrove ecosystems have limitations when it comes to science that cannot be explained or seen. However, Santos and Bitencourt (2016) say that they are an essential tool to be considered when managing mangrove and coastal ecosystems. In other words, remote sensing instruments must be linked or integrated with other disciplines in mangrove ecosystem management to obtain more complete results. Although the integration is a form of an obstacle for remote sensing, this corresponds to the statement by Dahdouh-Guebas (2002) that the integration of disciplinary data that is not directly related to remote sensing, such as demography, sociology, economics, and others, is a challenge in itself for remote sensing. Also, some remote sensing instruments cannot be used because there is not enough information about the area they cover, the level of spatial resolution, and the advanced correction stages. Therefore, these challenges are gaps

that must be filled in remote sensing-based mangrove research in the future. Similarly, the spatial levels of urgency for remote sensing range from low to medium to high.

Meanwhile, in the scope of tourist areas, the gap is in the form of choosing locations that have the potential for, or value in, tourism, not only carried out at locations that have been inaugurated or already have mangrove tourism status. Tourism development is a reference that needs to be studied and identified (Nugroho et al., 2019), emphasizing the naturalness, peculiarity, and authenticity of natural resources (Yulianda, 2007). This is the gap in ecosystem management from the perspective of tourist areas.

As for quantitative and qualitative approaches, an obvious limitation is the existence of a combination of two methods to obtain a complementary field data result, for example, scoring and weighting for participant identification obtained from the results of SWOT, AHP, or EFAS and IFAS analysis. It is also the knowledge of both approaches to managing mangrove ecosystems. The implementation of each approach, or separate approaches, which are qualitatively and quantitatively carried out independently or separately, may be a gap between these two approaches, although it appears impossible to separate them from them. Also, segmentation and the number of samples measure how well, and the data on these two ways to get valid research results is presented. This is because variations from segments and samples will enrich findings in the field and provide more complex information.

The author recommends several things for future research needs regarding mangrove ecosystem management knowledge in order to fill limitations and gaps, namely: (1) determining specific methods (quantitative, qualitative, or mixed) in each type of regional scope, both in tourist areas and non-tourism areas, and mangroves in general; (2) further studies on the integration of spatial and non-spatial data (remote sensing instruments with social discipline); and (3) planning carefully to take primary data in the field, such as the amount of data, questionnaires, segmentation of respondents, and others.

4. Conclusions

In the last five years, research on the management of mangrove ecosystems in Indonesia has led to trends in deforestation and the management of natural resources, which make up as much as 11.43 % of the total literature extracted. Topic trends in mangrove ecosystem management include *sustainable development* in 2018, *ecosystems* in 2019, *coastal zones* in 2020, and *forestry* in 2021, with 14.29, 51.43, and 22.86 %, respectively, of the total literature extraction. Meanwhile, research that has been abandoned in the last five years related to managing mangrove ecosystems, namely the *mangroves* themselves, is because these studies are not linked to other themes in the title and account for 5.71 % of the total literature extraction. Then, the trending topics with the least number are *the analytic hierarchy process* in 2018, *biodiversity* in 2019, the *coastal ecosystem* in 2020, and urban ecology in 2021, with 5.71, 22.86, 11.43, and 5.71 %, respectively, of the total literature extraction. Research in 2022 does not have themes or trending topics because the extraction results show time information, and the frequency is only for each extraction result. Research on managing mangrove ecosystems relates to many other topics, such as *biodiversity, forestry, ecology, coastal communities, economics, Indonesia, coastal zones, ecosystems,* and *environmental management.* Words that dominate the extraction results include *ecosystem, forestry, and biodiversity*, which can be seen in the visualization of the size of the circle. The findings of this study indicate that using remote sensing technology, which can integrate other disciplines to provide information or a visual understanding, is essential for managing ecosystems effectively. This is especially true for the humanities. Of course, a combination of quantitative and qualitative methods must be used to determine segmentation and the overall sample size. It will be a step towards reducing limitations and gaps in research on mangrove ecosystem management.

Acknowledgments

We would like to thank the Geography Postgraduate Study Program at the Faculty of Mathematics and Natural Sciences at the University of Indonesia for consistently supporting research publications in all forms. A word of gratitude is also given to Lembaga Pengelolaan Dana Pendidikan (LPDP) for assisting the first author with time and material to allow the taking of further studies at the Postgraduate Program in Geography at the University of Indonesia. According to this study, it is essential to disseminate other literature related to research themes to enrich reviews other than Scopus.com databases, such as Web of Science (WoS), Harzing's Publish or Perish, or Google Scholar.

References

Alongi, D. M. (2002). Present state and future of the World's mangrove forests. *Environmental Conservation, 29*(3), 331-349. http://dx.doi.org/10.1017/S0376892902000231

Arfan, A., Maru, R., Side, S., Abidin, M. R., & Sideng, U. (2021). Mangrove forest management strategy as a sustainable production forest area in Luwu district, South Sulawesi province, Indonesia. *Journal of Physics: Conference Series, 1752*, 012089. http://dx.doi.org/10.1088/1742-6596/1752/1/012089

Arfan, A., Nyompa, S., Rakib, M., & Juanda, M. F. (2021). The analysis of mangrove area as a marine eco-fisherytourism area in Luwu Regency South Sulawesi, Indonesia. *Journal of Physics: Conference Series, 2123*, 012009. http://dx.doi.org/10.1088/1742-6596/2123/1/012009

Aria, M., & Cuccurullo, C. (2023). *Comprehensive science mapping analysis*. https://cran.r-project.org/web/packages/bibliometrixData/bibliometrixData.pdf

Armitage, D. (2002). Socio-institutional dynamics and the political ecology of mangrove onservation Indonesia. *Global Environmental Change,* 12, 203-217.

Arulnayagam, A., Khim, J. S., & Park, J. (2021). Floral and faunal diversity in Sri Lankan mangrove forests: A systematic review. *Sustainability, 13*(17), 1-22. https://doi.org/10.3390/su13179487

Arumugam, M., Niyomugabo, R., Dahdouh-Guebas, F., & Hugé, J. (2021). The perceptions of stakeholders on current management of mangroves in the sine-saloum delta, Senegal. *Estuarine, Coastal and Shelf Science, 248*, 106751. https://doi.org/10.1016/j.ecss.2020.107160

Asyiawati, Y., & Akliyah, L. S. (2017). Identifikasi dampak perubahan fungsi ekosistem pesisir terhadap lingkungan di wilayah pesisir kecamatan muaragembong. *Jurnal Perencanaan Wilayah Dan Kota, 14*(1), 2551. https://doi.org/10.29313/jpwk.v14i1.2551

Asyiawati, Y., & Hindersah, H. (2020). Sustainable mangrove ecosystem management policy in muaragembong coastal area, Bekasi district, Indonesia. *Journal of Physics: Conference Series, 1469*, 012124. https://doi.org/10.1088/1742-6596/1469/1/012124

Azizan, F. A., Kiloes, A. M., Astuti, I. S., & Aziz, A. A. (2021). Application of optical remote sensing in rubber plantations: A systematic review. *Remote Sensing, 13*(3), 1-36. https://doi.org/10.3390/rs13030429

Barbier, E. B. (2016). The protective service of mangrove ecosystems: A review of valuation methods. *Marine Pollution Bulletin, 109*(2), 676-681. https://doi.org/10.1016/j.marpolbul.2016.01.033

Basyuni, M., Bimantara, Y., Siagian, M., Wati, R., Slamet, B., Sulistiyono, N., Nuryawan, A., & Leidonad, R. (2018). Developing community-based mangrove management through eco-tourism in North Sumatra, Indonesia. *IOP Conference Series: Earth and Environmental Science, 126*, 012109. https://doi.org/10.1088/1755-1315/126/1/012109

Basyuni, M., Fitri, A., & Harahap, Z. A. (2018). Mapping and analysis land-use and land-cover changes during 1996-2016 in Lubuk Kertang Mangrove Forest, North Sumatra, Indonesia.

IOP Conference Series: Earth and Environmental Science, 126, 012110. http://dx.doi.org/10.1088/1755-1315/126/1/012110

Basyuni, M., Yani, P., & Hartini, K. S. (2018). Evaluation of mangrove management through community-based silvofishery in North Sumatra, Indonesia. *IOP Conference Series: Earth and Environmental Science, 122*(1), 012109. http://dx.doi.org/10.1088/1755-1315/122/1/012109

Bhowmik, A. K., Padmanaban, R., Cabral, P., & Romeiras, M. M. (2022). Global mangrove deforestation and its interacting social-ecological drivers: A systematic review and synthesis. *Sustainability, 14*(8), 1-24. http://dx.doi.org/10.3390/su14084433

Bimrah, K., Dasgupta, R., Hashimoto, S., Saizen, I., & Dhyani, S. (2022). Ecosystem services of mangroves: A systematic review and synthesis of contemporary scientific literature. *Sustainability, 14*(19), 12051. https://doi.org/10.3390/su141912051

Christian, Y., Budiman, M. K., Purwanto, W., & Damar, A. (2021). Supporting community-based mangrove forest management as essential ecosystem area in Sungai Pakning, Riau. *IOP Conference Series: Earth and Environmental Science, 744*, 012007. https://doi.org/10.1088/1755-1315/744/1/012007

Christofi, M., Vrontis, D., & Cadogan, J. W. (2021). Micro-foundational ambidexterity and multinational enterprises: A systematic review and a conceptual framework. *International Business Review, 30*(1), 101625. https://doi.org/10.1016/j.ibusrev.2019.101625

Cormier-Salem, M. C. (2006). *Mangrove: Changes and conflicts in claimed ownership, uses and purposes* (pp. 163-176). In Proceedings of the International Conference on Environment and Livelihoods in Coastal Zones: Managing Agriculture-Fishery-Aquaculture Conflicts, Bac Lieu, Vietnam. https://doi.org/10.1079/9781845931070.0163

Dabić, M., Maley, J., Dana, L. P., Novak, I., Pellegrini, M. M., & Caputo, A. (2020). Pathways of SME internationalization: A bibliometric and systematic review. *Small Business Economics, 55*(3), 705-725. https://doi.org/10.1007/s11187-019-00181-6

Dahdouh-Guebas, F. (2002). The use of remote sensing and GIS in the sustainable management of tropical coastal ecosystems. *Environment, Development and Sustainability, 4*(9), 93-112. http://dx.doi.org/10.1023/A:1020887204285

Dahdouh-Guebas, F., & Koedam, N. (2002). *A synthesis of existent and potential mangrove vegetation structure dynamics from Kenyan, Sri Lankan and Mauritanian case-studies*. Bulletin Des Séances, Brussels.

Dahdouh-Guebas, F., Jayatissa, L. P., Nitto, D. D., Bosire, J. O., Seen, D. L., & Koedam, N. (2005). How effective were mangroves as a defence against the recent tsunami? *Current Biology, 15*(12), 443-447. https://doi.org/10.1016/j.cub.2005.06.008

Dahuri, R., Rais, J. M., Putra, S., Ginting, & Sitepum, M. J. (1996). *Pengelolaan sumber daya wilayah pesisir dan lautan secara terpadu*. Jakarta: Pradnya Paramita.

Damastuti, E., de Groot, R.. Debrot, A. O., & Silvius, M. J. (2022). Effectiveness of community-based mangrove management for biodiversity conservation: A case study from central Java, Indonesia. *Trees, Forests and People, 7*(120), 100202. https://doi.org/10.1016/j.tfp.2022.100202

Donthu, N., Reinartz, W., Kumar, S., & Pattnaik, D. (2021). A retrospective review of the first 35 years of the International Journal of Research in Marketing. *International Journal of Research in Marketing, 38*(1), 232-269. https://doi.org/10.1016/j.ijresmar.2020.10.006

Duke, N. C., Meynecke, J. O., Dittmann, S., Ellison, A. M., Anger, K., Berger, U., Cannicci, S., Diele, K., Ewel, K. C., Field, C. D., Koedam, N., Lee, S. Y., Marchand, C. & Dahdouh-Gebas, F. (2007). A world without mangroves? *Science, 317*(5834), 41-43. https://doi.org/10.1126/science.317.5834.41b

Ely, A. J., Tuhumena, L., Sopaheluwakan, J., & Pattinaja, Y. (2021). Strategi pengelolaan ekosistem hutan mangrove di negeri amahai. *Jurnal Manajemen Sumberdaya Perairan,*

17(1), 57-67. https://doi.org/10.30598/tritonvol17issue1page57-67

Erlinda, S., Mulyadi, A., Zulkarnain, & Suwondo. (2022). Policy strategy for sustainable management of mangrove ecotourism in Siak Regency, Riau province, Indonesia. *International Journal of Sustainable Development and Planning, 17*(1), 173-183. https://doi.org/10.18280/ijsdp.170117

FAO. (2007). *The World's Mangroves 1980-2005*. Rome.

Farnsworth, E. J., & Ellison, A. M. (1997). *The global conservation status of mangroves* (pp. 328-334). The Food and Agriculture Organization.

Fatimatuzzahroh, F., Hadi, S. P., Purnaweni, H., & Sudarno. (2020). Does the intervention of regional authorities contribute to sustainable mangrove ecotourism? Case study on mangrove management at Karansong, West Java, Indonesia. *Ecological Questions, 31*(3), 7-14. https://doi.org/10.12775/EQ.2020.017

Feagin, R. A, Mukherjee, N., Shanker, K., Baird, A. H., Cinner, J., Kerr, A. M., Koedam, N., Sridhar, A., Arthur, R., Jayatissa, L. P., Seen, D. L., Menon, M., Rodriguez, S., Shamsuddoha, M., & Dahdouh-Guebas, F. (2010). Shelter from the storm? Use and misuse of coastal vegetation bioshields for managing natural disasters. *Conservation Letters, 3*(1), 1-11. http://dx.doi.org/10.1111/j.1755-263X.2009.00087.x

Firdaus, M., Hatanaka, K., & Saville, R. (2021). Mangrove forest restoration by fisheries communities in Lampung Bay: A study based on perceptions, Willingness to Pay, and Management Strategy. *Forest and Society, 5*(2), 224-244. http://dx.doi.org/10.24259/fs.v5i2.12008

Fistiningrum, W., & Harini, R. (2021). The impacts of mangrove ecotourism management on the socio-economic conditions of people in Kulonprogo Regency. *IOP Conference Series: Earth and Environmental Science, 683*, 012116. http://dx.doi.org/10.1088/1755-1315/683/1/012116

Frampton, G. K., Livoreil, B., & Petrokofsky, G. (2017). Eligibility screening in evidence synthesis of environmental management topics. *Environmental Evidence, 6*(1), 1-13. http://dx.doi.org/10.1186/s13750-017-0102-2

Gilal, F. G., Zhang, J., Paul, J., & Gilal, N. G. (2019). The role of self-determination theory in marketing science: An integrative review and agenda for research. *European Management Journal, 37*(1), 29-44. https://doi.org/10.1016/j.emj.2018.10.004

Hamzah, A., Pratama, H., Anggoro, S., & Puryono, S. (2020). Co-management in mangrove rehabilitation at Langkat Regency. *E3S Web of Conferences, 202*, 02001. http://dx.doi.org/10.1051/e3sconf/202020202001

Handayani, S. (2021). *Strategi pengelolaan ekosistem mangrove berkelanjutan berbasis sistem sosial-ekologi di pesisir kabupaten demak*. IPB University.

Hasnanda, Syahputra, O. K., Nugroho, B., Kartodihardjo, H., & Santoso, N. (2018). Stakeholder analysis in community based mangrove management: Case of forest management unit in Region 3 of Aceh Province. *Jurnal Manajemen Hutan Tropika, 24*(3), 152-161. https://doi.org/10.7226/jtfm.24.3.152

Hassan, L. M., Shiu, E., & Parry, S. (2016). Addressing the cross-country applicability of the Theory of Planned Behaviour (TPB): A structured review of multi-country TPB studies. *Journal of Consumer Behaviour, 15*, 72-86. https://doi.org/10.1002/cb

Heumann, B. W. (2011). Satellite remote sensing of mangrove forests: Recent advances and future opportunities. *Progress in Physical Geography, 35*(1), 87-108. https://doi.org/10.1177/0309133310385371

Idajati, H., & Widiyahwati, M. (2018). The sustainable management priority of ecotourism mangrove Wonorejo, Surabaya-Indonesia. *IOP Conference Series: Earth and Environmental Science, 202*, 012048. https://doi.org/10.1088/1755-1315/202/1/012048

Idajati, H., Pamungkas, A., & Kukinul, S. V. (2016). The level of participation in mangrove

ecotourism development, Wonorejo Surabaya. *Procedia - Social and Behavioral Sciences, 227*(11), 515-520. https://doi.org/10.1016/j.sbspro.2016.06.109

Indah, P. N., Radianto, I., Abidin, Z., Amir, I. T., & Pribadi, D. U. (2018). Management mangrove experiences form coastal people. *Journal of Physics: Conference Series, 953*, 012241. https://doi.org/10.1088/1742-6596/953/1/012241

Jamili, D. S., Qayim, I., & Guhardja, E. (2021). *Mangrove: Karakteristik ekosistemnya pada pulau-pulau kecil*. Penerbit NEM.

Jati, I. W., & Pribadi, R. (2018). Economic valuation as an instrument to determine the management strategy of baros mangrove forest, Bantul, Yogyakarta, Indonesia. *E3S Web of Conferences, 31*, 08024. https://doi.org/10.1051/e3sconf/20183108024

Kahiya, E. T. (2018). Five decades of research on export barriers: Review and future directions. *International Business Review, 27*(6), 1172-1188. https://doi.org/10.1016/j.ibusrev.2018.04.008

Kehutanan, K. L. H. (2022). *Sebaran Mangrove Indonesia*. DKI Jakarta.

Koutsos, T. M., Menexes, G. C., & Dordas, C. A. (2019). An efficient framework for conducting systematic literature reviews in agricultural sciences. *Science of the Total Environment, 682*, 106-117. https://doi.org/10.1016/j.scitotenv.2019.04.354

Kovacs, J. M. (2000). Perceptions of environmental change in a tropical coastal Wetland. *Land Degradation and Development, 11*(3), 209-220. https://doi.org/10.1002/1099-145X(200005/06)11:3<209::AID-LDR378>3.0.CO;2-Y

Kuenzer, C., Bluemel, A., Gebhardt, S., Quoc, T. V., & Dech, S. (2011). Remote sensing of mangrove ecosystems: A review. *Remote Sensing, 3*(5), 878-928. https://doi.org/10.3390/rs3050878

Kumar, A., Paul, J., & Unnithan, A. B. (2020). 'Masstige' Marketing: A review, synthesis and research agenda. *Journal of Business Research, 113*(7), 384-398. https://doi.org/10.1016/j.jbusres.2019.09.030

Kurniawan, M. A., Yusran, Y., & Sabar, A. (2020). Analysis of actors in the management of lantebung mangrove ecotourism, Bira Village, Tamalanrea District, Makassar City. *IOP Conference Series: Earth and Environmental Science, 575*, 012216. https://doi.org/10.1088/1755-1315/575/1/012216

Kurniawansyah, A., Pin, T. G., & Rahatiningtyas, N. (2021). Carrying capacity of mangrove tourism in the district of Cilamaya Wetan, Karawang Regency, West Java province. *Journal of Physics: Conference Series, 1943*(1), 012001. https://doi.org/10.1088/1742-6596/1943/1/012001

Kurniawansyah, A., Pin, T. G., & Rahatiningtyas, N. (2022). The suitability of mangrove tourism in the district of Cilamaya Wetan, Karawang Regency, West Java province. *Earth and Environmental Science, 1089*(1). 012054. https://doi.org/10.1088/1755-1315/1089/1/012054

Liberati, A., Altman, D. G., Tetzlaff, J., Mulrow, C., Gøtzsche, P. C., Ioannidis, J. P. A., Clarke, M., Devereaux, P. J., Kleijnen, J., & Moher, D. (2009). The PRISMA statement for reporting systematic reviews and meta-analyses of studies that evaluate healthcare interventions: Explanation and elaboration. *BMJ, 339*, b2700. https://doi.org/10.1136/bmj.b2700

Liu, X., Yang, C., Yu, X., Yu, H., Zhuang, W., Gu, H., Xu, K., Zheng, X., Wang, C., Xiao, F., Wu, B., He, Z., & Yan, Q. (2020). Revealing structure and assembly for rhizophyte-endophyte diazotrophic community in mangrove ecosystem after introduced Sonneratia Apetala and Laguncularia Racemosa. *Science of the Total Environment, 721*(132), 1-11. https://doi.org/10.1016/j.scitotenv.2020.137807

Lyu, J. D., Krasonikolakis, I., & Vrontis, D. (2022). A systematic literature review of store atmosphere in alternative retail commerce channels. *Journal of Business Research, 153*, 412-427. https://doi.org/10.1016/j.jbusres.2022.08.050

Majesty, K. I., & Fadmastuti, M. (2018). Degree of community participation in mangrove resources management as livelihood support in West Java, Indonesia. *E3S Web of Conferences, 74*, 10005. http://dx.doi.org/10.1051/e3sconf/20187410005

Manesh, F. M., Pellegrini, M. M., Marzi, G., & Dabic, M. (2021). Knowledge management in the fourth industrial revolution: Mapping the literature and scoping future avenues. *IEEE Transactions on Engineering Management, 68*(1), 289-300. https://doi.org/10.1109/TEM.2019.2963489

Marlianingrum, P. R., Kusumastanto, T., Adrianto, L., & Fahrudin, A. (2019). Economic analysis of management option for sustainable mangrove ecosystem in Tangerang district, Banten Province, Indonesia. *IOP Conference Series: Earth and Environmental Science, 241*, 012026. https://doi.org/10.1088/1755-1315/241/1/012026

Martuti, N. K. T., Setyowati, D. L., Nugraha, S. B., & Masyarakat. (2019). *Ekosistem Mangrove: Perannya Di Pesisir*. Lembaga Penelitian dan Pengabdian kepada Masyarakat, Universitas Negeri Semarang.

Massiseng, A. N. A., Tuwo, A., Fachry, M. E., & Bahar, A. (2020). A dynamic simulation of mangrove ecotourism management at the Lantebung of Makassar City. *IOP Conference Series: Earth and Environmental Science, 584*, 012039. https://doi.org/10.1088/1755-1315/584/1/012039

Melo, R. H., Kusmana, C., Eriyatno, & Nurrochmat, D. R. (2019). A stakeholder analysis of sustainable mangrove management in Kwandang, sub-district of North, Gorontalo district. *IOP Conference Series: Earth and Environmental Science, 399*, 012071. https://doi.org/10.1088/1755-1315/399/1/012071

Melo, R. H., Kusmana, C., Eriyatno, & Nurrochmat, D. R. (2020). Short communication: Mangrove forest management based on multi dimension scalling (Rap-Mforest) in Kwandang sub-district, North Gorontalo district, Indonesia. *Biodiversitas, 21*(4), 1352-1357. https://doi.org/10.13057/biodiv/d210411

Moher, D., Liberati, A., Tetzlaff, J., & Altman, D. G. (2009). Preferred reporting items for systematic reviews and meta-analyses: The PRISMA statement. *BMJ, 339*(7716), 332-336. https://doi.org/10.1136/bmj.b2535

Mortensen, M. L., Adam, G. P., Trikalinos, T. A., Kraska, T., & Wallace, B. C. (2017). An exploration of crowdsourcing citation screening for systematic reviews. *Research Synthesis Methods, 8*(3), 366-386. https://doi.org/10.1002/jrsm.1252

Mugi, L. M., Kiss, D., Kairo, J. G., & Huxham, M. R. (2022). Stocks and productivity of dead wood in mangrove forests: A systematic literature review. *Frontiers in Forests and Global Change, 5*(5), 1-12. https://doi.org/10.3389/ffgc.2022.767337

Nanlohy, H., & Ruban, A. (2021). Development strategy of the community perception, behavior, and participation for the management of mangrove ecosystem in Kotania Bay, Maluku. *IOP Conference Series: Earth and Environmental Science, 805*, 012019. https://doi.org/10.1088/1755-1315/805/1/012019

Nanlohy, H., Talakua, W., Soukotta, L. M., & Talakua, E. G. (2019). Factors affecting implementation of sasi in the management of mangrove ecosystem at Rutong and Leahari Village, South Leitimur sub-district, Ambon City, Indonesia. *IOP Conference Series: Earth and Environmental Science, 339*, 012010. https://doi.org/10.1088/1755-1315/339/1/012010

Nawari, A. S., & Siregar, Y. I. (2021). Community-based mangrove forest management as ecosystem services provider for reducing CO_2 emissions with carbon credit system in Bengkalis district, Riau, Indonesia. *Journal of Physics: Conference Series, 2049*, 012074. https://doi.org/10.1088/1742-6596/2049/1/012074

Nurdin, N., Akbar, M., & Patittingi, F. (2015). Dynamic of mangrove cover change with anthropogenic factors on small Island, Spermonde Archipelago. *Proceedings, 9638*, 96380T. https://doi.org/10.1117/12.2194645

Pae, C. U. (2015). Why systematic review rather than narrative review? *Psychiatry Investigation, 12*(3), 417-419. https://doi.org/10.4306/pi.2015.12.3.417

Paembonan, S. A., Bachtiar, B., & Ridwan, M. (2020). Sustainable forest management through natural mangrove regeneration on Pannikiang Island, South Sulawesi. *IOP Conference Series: Earth and Environmental Science, 468*, 012082. https://doi.org/10.1088/1755-1315/486/1/012082

Page, M. J., McKenzie, J. E., Bossuyt, P. M., Boutron, I., Hoffmann, T. C., Mulrow, C. D., Shamseer, L., Tetzlaff, J. M., Akl, E. A., Brennan, S. E., Chou, R., Glanville, J., Grimshaw, J. M., Hróbjartsson, A., Lalu, M. M., Li, T., Loder, E. W., Mayo-Wilson, E., McDonald, S., McGuinness, L. A., Stewart, L. A., Thomas, J., Tricco, A. C., Welch, V. A., Whiting, P., & Moher, D. (2021). The PRISMA 2020 statement: An updated guideline for reporting systematic reviews. *BMJ, 372*, n71. https://doi.org/10.1136/bmj.n71

Paul, J., Parthasarathy, S., & Gupta, P. (2017). Exporting challenges of SMEs: A review and future research agenda. *Journal of World Business, 52*(3), 327-342. https://doi.org/10.1016/j.jwb.2017.01.003

Prasetya, J. D., Ambariyanto, Supriharyono, & Purwanti, F. (2018). Hierarchical synthesis of coastal ecosystem health indicators at Karimunjawa National Marine Park. *IOP Conference Series: Earth and Environmental Science, 116*, 012094. https://doi.org/10.1088/1755-1315/116/1/012094

Prasetya, J. D., Maharani, Y. N., & Rahatmawati, I. (2018). Mangrove ecotourism management at local community in Jangkaran, Kulonprogo, using hierarchy analysis. *IOP Conference Series: Earth and Environmental Science, 212*, 012006. https://doi.org/10.1088/1755-1315/212/1/012006

Prihadi, D. J., Riyantini, I. R., & Ismail, M. R. (2018). Pengelolaan kondisi ekosistem mangrove dan daya dukung lingkungan kawasan wisata bahari mangrove di karangsong Indramayu. *Jurnal Kelautan Nasional, 1*(1), 53-64. https://doi.org/10.15578/jkn.v1i1.6748

Primavera, J. H. (2000). Development and conservation of Philippine mangroves: Institutional issues. *Ecological Economics, 35*(1), 91-106. https://doi.org/10.1016/S0921-8009(00)00170-1

Puryono, S., & Suryanti, S. (2019). Degradation of mangrove ecosystem in Karimunjawa Island based on public perception and management. *IOP Conference Series: Earth and Environmental Science, 246*, 012080. https://doi.org/10.1088/1755-1315/246/1/012080

Rahadian, A., Leilan, F., Arafat, I. N., & Lestari, T. A. (2019). Ecosystem mangrove management in Urban Area: Case study mangrove Kali Adem Jakarta Indonesia. *IOP Conference Series: Earth and Environmental Science, 399*, 012008. https://doi.org/10.1088/1755-1315/399/1/012008

Rana, J., & Paul, J. (2020). Health motive and the purchase of organic food: A meta-analytic review. *International Journal of Consumer Studies, 44*(2), 162-171. https://doi.org/10.1111/ijcs.12556

Rihulay, T. D., & Papilaya, F. S. (2022). Analisis perubahan luas tutupan lahan mangrove di teluk ambon dalam menggunakan OBIA. *Information System, Graphics, Hospitality and Technology, 4*, 7-12.

Romanach, S. S., DeAngelis, D. L., Koh, H. L., Li, Y., Teh, S. Y., Barizan, R. S. R., & Zhai, L. (2018). Conservation and restoration of mangroves: Global status, perspectives, and prognosis. *Ocean and Coastal Management, 154*(2), 72-82. https://doi.org/10.1016/j.ocecoaman.2018.01.009

Rosck, H., Loureiro, S. M. C., & Breitsohl, J. (2017). Calibrating 30 years of experimental research: A meta-analysis of the atmospheric effects of music, scent, and color. *Journal of Retailing, 2*, 228-240. https://doi.org/10.1016/j.jretai.2016.10.001

Roziqin, A. (2018). Environmental policy of mangroves management in Rembang Regency. *E3S*

Web of Conferences, 31, 09002. https://doi.org/10.1051/e3sconf/20183109002

Sahputra, E., Harahap, R. H., Wahyuningsih, H., & Utomo, B. (2022). Assessing the sustainability status of mangrove forest ecosystem management by coastal community in Jaring Halus Village, North Sumatra, Indonesia. *Biodiversitas, 23*(1), 1-9. https://doi.org/10.13057/biodiv/d230101

Salminah, M., Alviya, I., Ekawati, S., Salaka, F., Kartikasari, G., Subarudi, & Bachri, A. (2020). Challenges of mangrove management in supporting climate change mitigation Policy in East Kalimantan. *IOP Conference Series: Earth and Environmental Science, 487*, 012009. https://doi.org/10.1088/1755-1315/487/1/012009

Santos, L. C. M., & Bitencourt, M. D. (2016). Remote sensing in the study of Brazilian mangroves: Review, gaps in the knowledge, new perspectives and contributions for management. *Journal of Integrated Coastal Zone Management, 16*(3), 245-261. https://doi.org/10.5894/rgci662

Santoso, M, P. T., Putra, A, S., Hendriyani, R. M., & Nopiana, M. (2021). Implementation strategy of mangrove area conservation based on social capital development: A case study in the East Coastal Area of Karawang Regency, Indonesia. *AACL Bioflux, 14*(3), 1295-1307.

Santoso, N., Sutopo, & Nugraha, R. P. (2019). Analysis of sustainability ecosystem mangrove management in Pangkah Wetan and Pangkah Kulon Villages Area, Ujungpangkah district, Gresik Regency, East Java province. *IOP Conference Series: Earth and Environmental Science,* 012007. https://doi.org/10.1088/1755-1315/399/1/012007

Saparinto, C. (2007). *Pendayagunaan ekosistem mangrove*. Semarang: Dahara Prize.

Sarkis-Onofre, R., Catalá-López, F., Aromataris, E., & Lockwood, C. (2021). How to properly use the PRISMA statement. *Systematic Reviews, 10*(1), 13-15. https://doi.org/10.1186/s13643-021-01671-z

Satyanarayana, B., Mulder, S., Jayatissa, L. P., & Dahdouh-Guebas, F. (2013). Are the mangroves in the Galle-Unawatuna Area (Sri Lanka) at risk? A social-ecological approach involving local stakeholders for a better conservation policy. *Ocean and Coastal Management, 71*, 225-237. https://doi.org/10.1016/j.ocecoaman.2012.10.008

Selcuk, A. A. (2019). A guide for systematic reviews: PRISMA. *Turkish Archives of Otorhinolaryngology, 57*(1), 57-58. https://doi.org/10.5152/tao.2019.4058

Setiawati, R. T. R. I. (2019). *Strategi pengelolaan mangrove di ekowisata mangrove wonorejo*. Institut Teknologi Sepuluh Nopember.

Shamsollahi, A., Chmielewski-Raimondo, D. A., Bell, S. J., & Kachouie, R. (2021). Buyer-supplier relationship dynamics: A systematic review. *Journal of the Academy of Marketing Science, 49*(2), 418-436. https://doi.org/10.1007/s11747-020-00743-1

Siswanto. (2010). Systematic review as a research method to synthesize research results (An introduction). *Buletin Penelitian Sistem Kesehatan, 13*(4), 326-333.

Tricco, A. C., Lillie, E., Zarin, W., O'Brien, K., Colquhoun, H., Kastner, M., Levac, D., Ng, C., Sharpe, J. P., Wilson, K., Kenny, M., Warren, R., Wilson, C., Stelfox, H. T., & Straus, S. E. (2016). A scoping review on the conduct and reporting of scoping reviews. *BMC Medical Research Methodology, 16*(1), 1-10. https://doi.org/10.1186/s12874-016-0116-4

Tufliha, A. R., Putra, D. M., Amara, D. M., Santika, R. M., Oktavian, S. M., & Kelana, P. P. (2019). Kondisi ekosistem mangrove di kawasan ekowisata karangsong kabupaten indramayu. *Akuatika Indonesia, 4*(1), 11. https://doi.org/10.24198/jaki.v4i1.23494

Utina, R., Nusantari, E., Katili, A. S., & Tamu, Y. (2017). *Ekosistem dan sumber daya alam pesisir*. Cetakan Pe. Yogyakarta: Deepublish.

Valiela, I., Bowen, J. L., & York, J. K. (2001). Mangrove forests: One of the World's threatened major tropical environments. *BioScience, 51*(10), 807-815. https://doi.org/10.1641/0006-3568(2001)051[0807:MFOOTW]2.0.CO;2

Wahyurini, E. T., Darsono, Kusnandar, & Harisudin, M. (2021). Analysis of mangrove

management to increase the economy of coastal communities in Madura Island. *IOP Conference Series: Earth and Environmental Science, 637*(1), 012048. https://doi.org/10.1088/1755-1315/637/1/012048

Yilmaz, O., & Yazılar, D. (2006). Sağlık bilimlerinde süreli yayıncılık 4. *Bilgi Dünyası, 8*(1), 181-182.

Yonvitner, P., Agus, S. B., Rusrita, G., Ramadhani, R. A., & Akmal, S. G. (2020). Mangrove governance: Establish a new paradigm of mangrove management from village to the World. *IOP Conference Series: Earth and Environmental Science, 550*, 012012. https://doi.org/10.1088/1755-1315/550/1/012012

Yu, X., Yang, X., Wu, Y., Peng, Y., Yang, T., Xiao, F., Zhong, Q., Xu, K., Shu, L., He, Q., Tian, Y., Yan, Q., Wang, C., Wu, B., & He, Z. (2020). Sonneratia apetala introduction alters methane cycling microbial communities and increases methane emissions in mangrove ecosystems. *Soil Biology and Biochemistry, 144*(132), 107775. https://doi.org/10.1016/j.soilbio.2020.107775

Yulianda, F. (2007). Ekowisata bahari sebagai alternatif pemanfaatan sumberdaya pesisir berbasis konservasi. *Makalah Seminar Sains, 21*, 119-129.

Yusran, & Sabar, A. (2020). Mangrove management collaboration in the marusu coastal region of Maros Regency. *IOP Conference Series: Earth and Environmental Science, 486*, 012036. https://doi.org/10.1088/1755-1315/486/1/012036

Zhu, J. J., & Yan, B. (2022). Blue carbon sink function and carbon neutrality potential of mangroves. *Science of the Total Environment, 822*, 153438. https://doi.org/10.1016/j.scitotenv.2022.153438