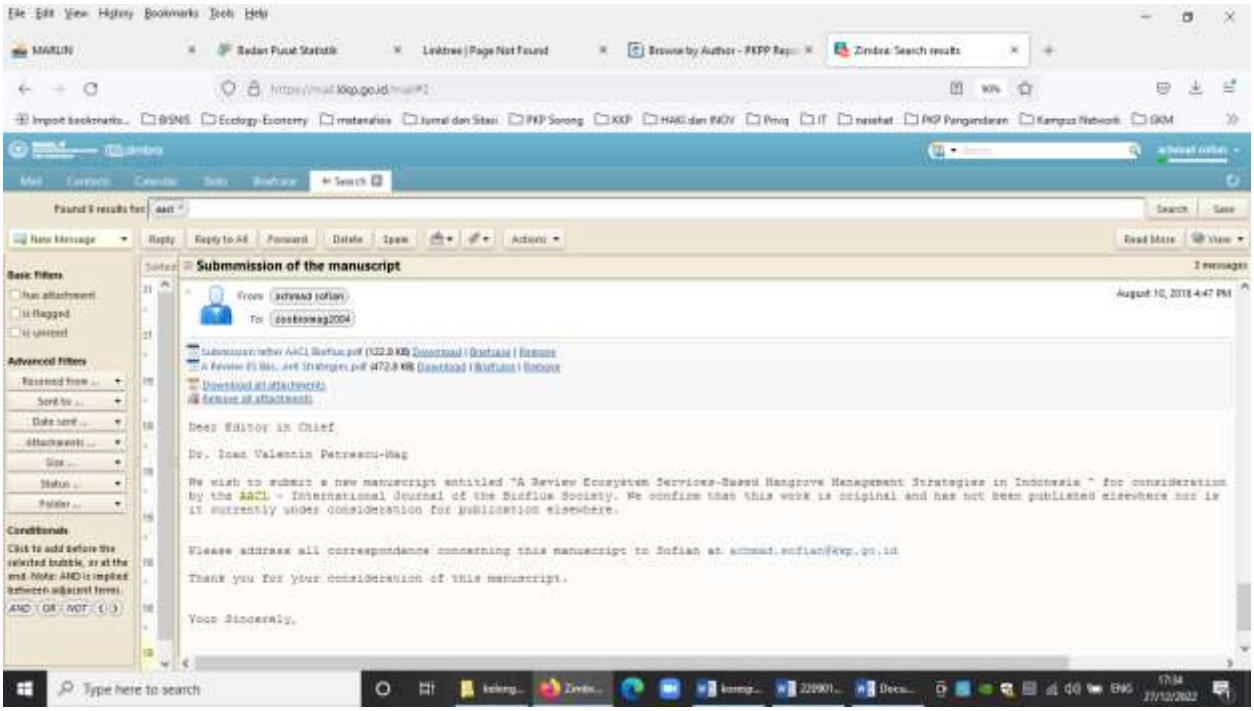
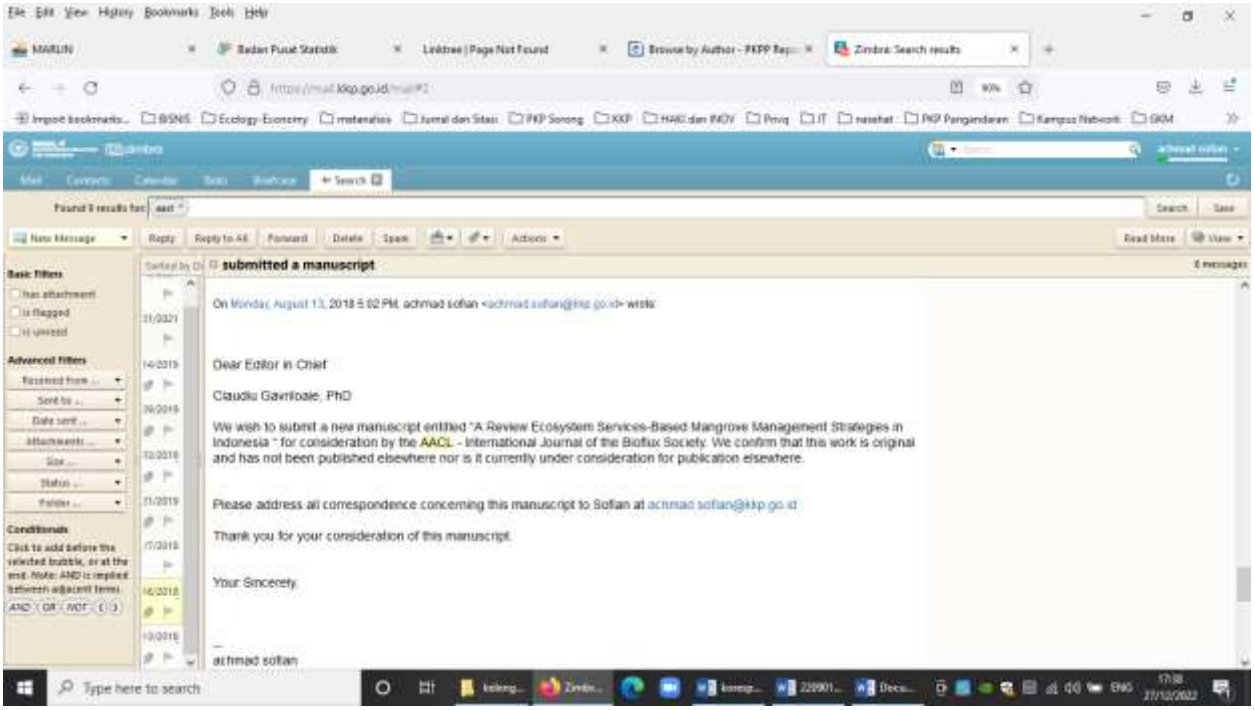
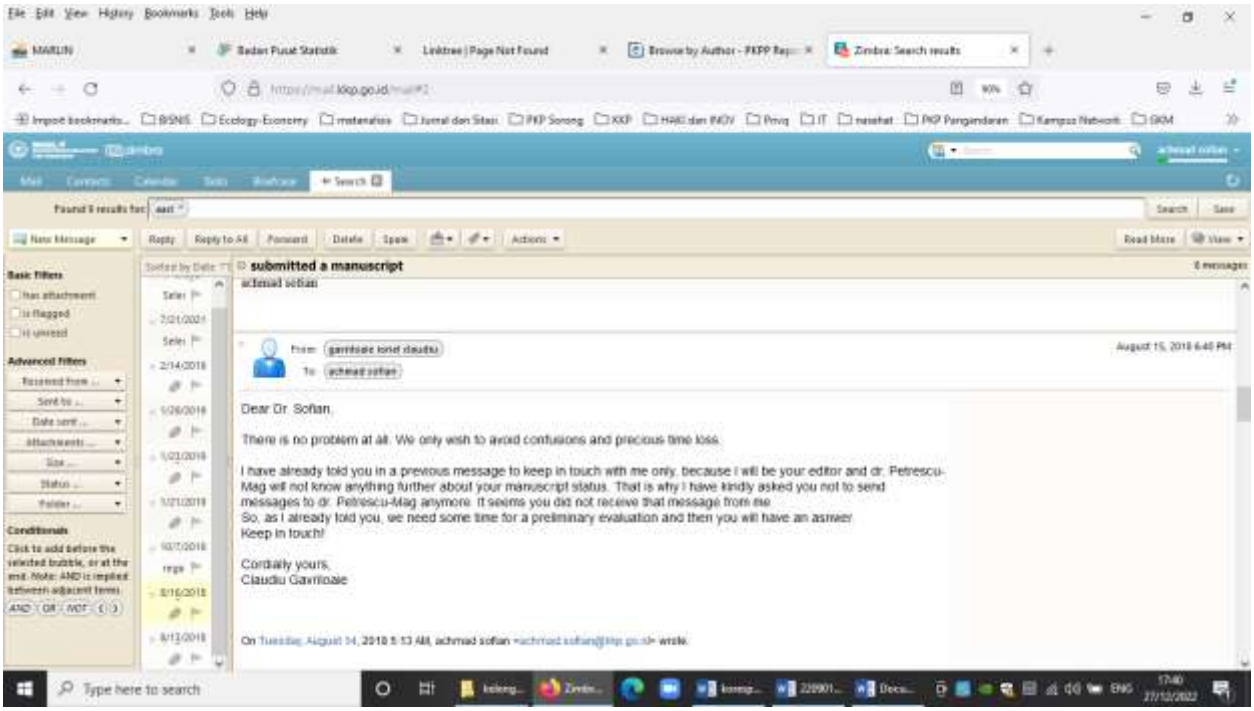
Ecosystem services-based mangrove management strategies in Indonesia: a review

Submission






submitted a manuscript
achmad sofian
From: gavriloaie ionel claudiu
To: achmad sofian
August 15, 2018 6:40 PM
Dear Dr. Sofian,
There is no problem at all. We only wish to avoid confusions and precious time loss.
I have already told you in a previous message to keep in touch with me only, because I will be your editor and dr. Petrescu-Mag will not know anything further about your manuscript status. That is why I have kindly asked you not to send messages to dr. Petrescu-Mag anymore. It seems you did not receive that message from me.
So, as I already told you, we need some time for a preliminary evaluation and then you will have an answer.
Keep in touch!
Cordially yours,
Claudiu Gavriloaie
On Tuesday, August 14, 2018 5:13 AM, achmad sofian wrote:
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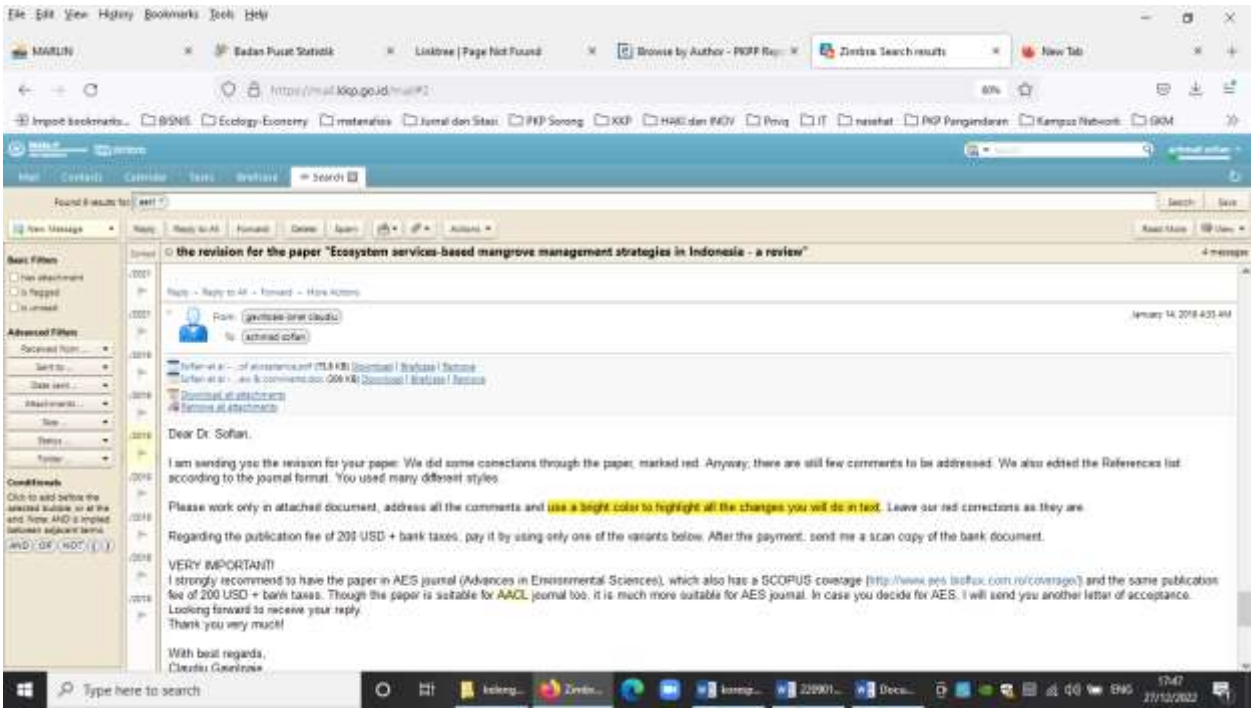
Review 1


the revision for the paper "Ecosystem services-based mangrove management strategies in Indonesia - a review"
From: gavriloaie ionel claudiu
To: achmad sofian
January 14, 2019 4:33 AM
Dear Dr. Sofian,
I am sending you the revision for your paper. We did some corrections through the paper, marked red. Anyway, there are still few comments to be addressed. We also edited the References list according to the journal format. You used many different styles.
Please work only in attached document, address all the comments and use a bright color to highlight all the changes you will do in text. Leave our red corrections as they are.
Regarding the publication fee of 200 USD + bank taxes, pay it by using only one of the variants below. After the payment, send me a scan copy of the bank document.
VERY IMPORTANT!
I strongly recommend to have the paper in AES journal (Advances in Environmental Sciences), which also has a SCOPUS coverage (http://www.aes.bioflux.com.ro/coverage/) and the same publication fee of 200 USD + bank taxes. Though the paper is suitable for AACL journal too, it is much more suitable for AES journal. In case you decide for AES, I will send you another letter of acceptance.
Looking forward to receive your reply.
Thank you very much!
With best regards,
Claudiu Gavriloaie
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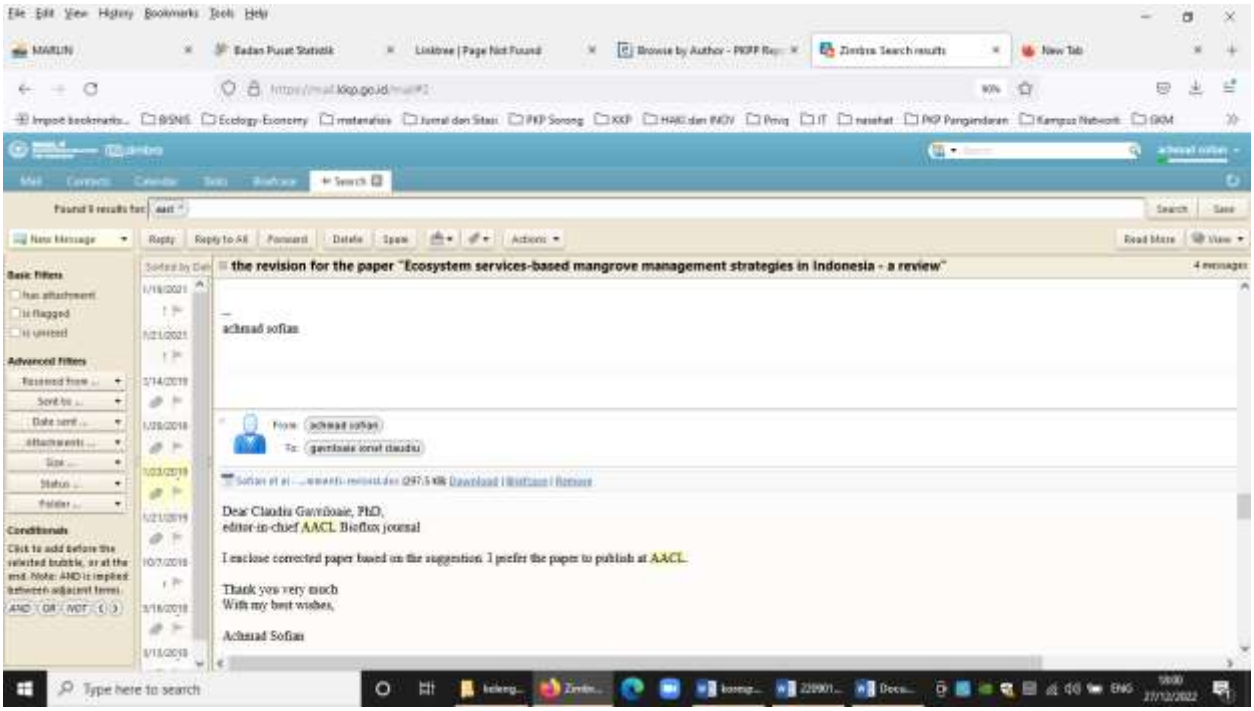
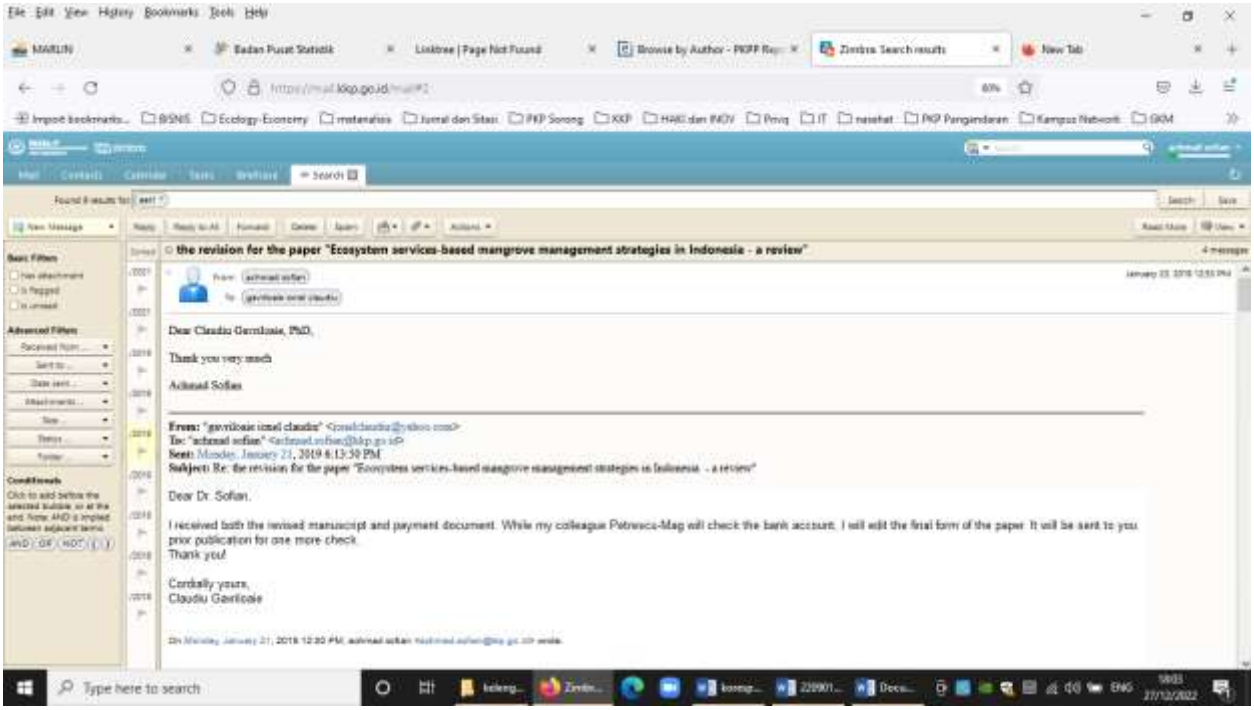
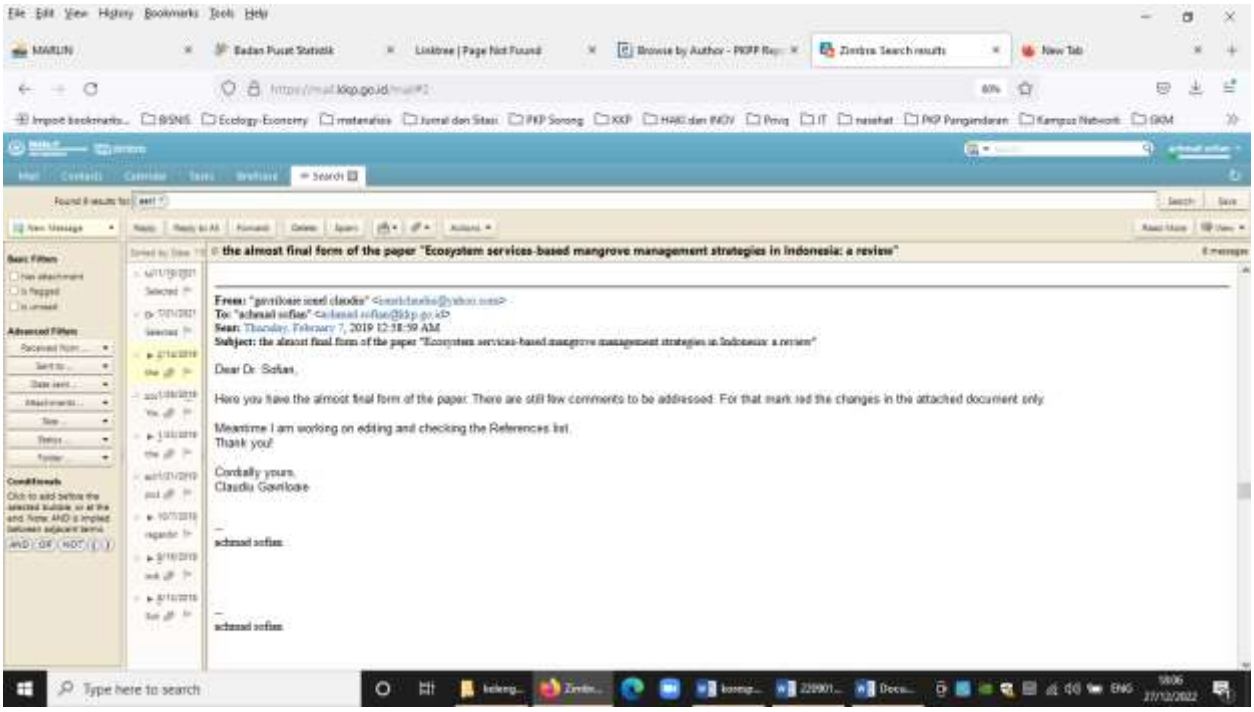
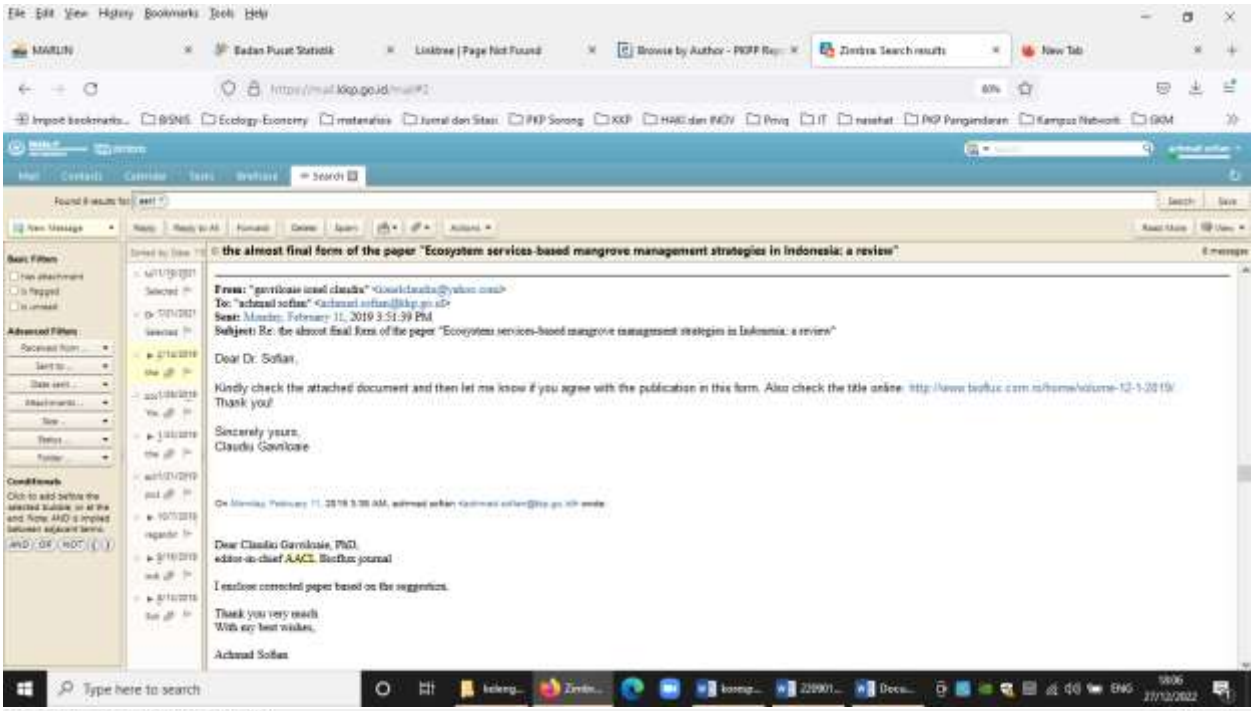

the revision for the paper "Ecosystem services-based mangrove management strategies in Indonesia - a review"
achmad sofian
Dear Claudia Gavriloaie, PhD,
editor-in-chief AACL Bioflux journal
I enclose corrected paper based on the suggestion. I prefer the paper to publish at AACL.
Thank you very much
With my best wishes,
Achmad Sofian


the revision for the paper "Ecosystem services-based mangrove management strategies in Indonesia - a review"
Dear Claudia Gavriloaie, PhD,
Thank you very much
Achmad Sofian
From: "gavriloaie ionel claudiu"
To: "achmad sofian"
Sent: Monday, January 21, 2019 6:13:30 PM
Subject: Re: the revision for the paper "Ecosystem services-based mangrove management strategies in Indonesia - a review"
Dear Dr. Sofian,
I received both the revised manuscript and payment document. While my colleague Petrescu-Mag will check the bank account, I will edit the final form of the paper. It will be sent to you prior publication for one more check.
Thank you!
Cordially yours,
Claudiu Gavriloaie

Review 2


the almost final form of the paper "Ecosystem services-based mangrove management strategies in Indonesia: a review"
From: "gavriloaie sorel claudiu"
To: "achmad sofian"
Sent: Thursday, February 7, 2019 12:38:59 AM
Subject: the almost final form of the paper "Ecosystem services-based mangrove management strategies in Indonesia: a review"
Dear Dr. Sofian,
Here you have the almost final form of the paper. There are still few comments to be addressed. For that mark red the changes in the attached document only.
Meantime I am working on editing and checking the References list.
Thank you!
Cordially yours,
Claudiu Gavriloaie
achmad sofian
achmad sofian
Type here to search



the almost final form of the paper "Ecosystem services-based mangrove management strategies in Indonesia: a review"

From: "gavriloaie ionel claudiu"
To: "achmad sofian"
Sent: Monday, February 11, 2019 3:51:39 PM
Subject: Re: the almost final form of the paper "Ecosystem services-based mangrove management strategies in Indonesia: a review"

Dear Dr. Sofian,

Kindly check the attached document and then let me know if you agree with the publication in this form. Also check the title online: http://www.bioflux.com.ro/home/volume-12-1-2019/
Thank you!

Sincerely yours,
Claudiu Gavriloaie

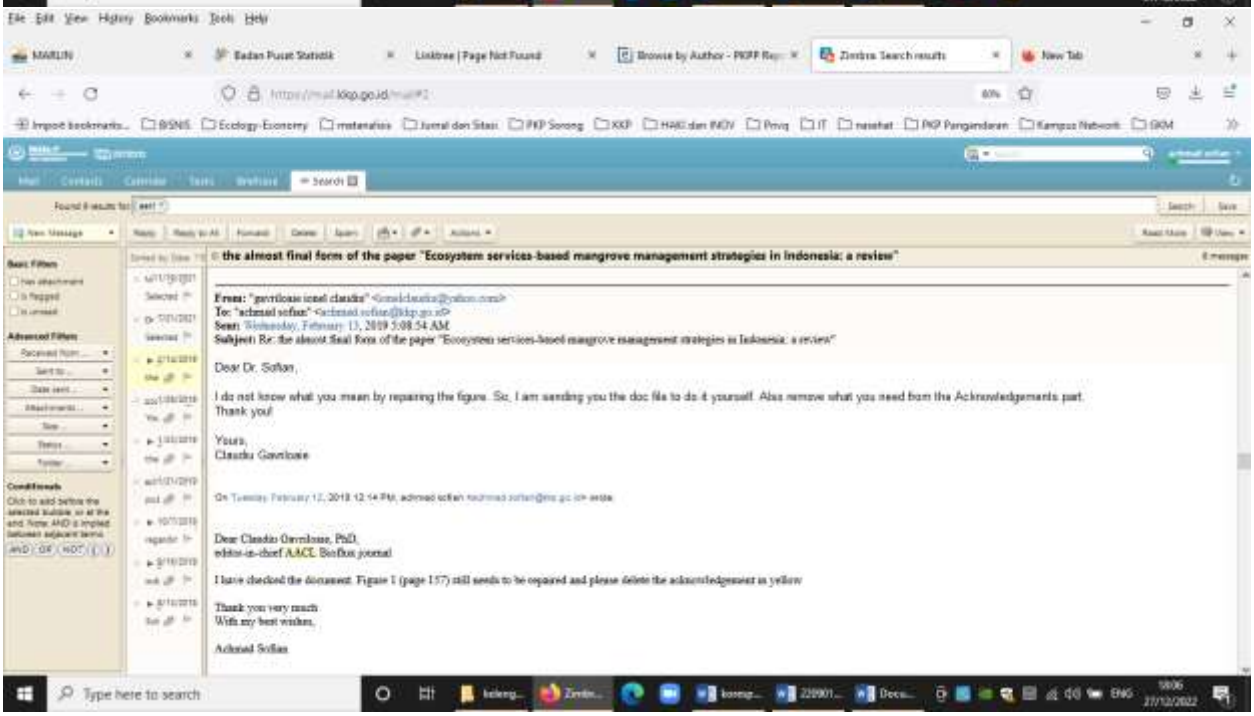
On Monday, February 11, 2019 3:36 AM, achmad sofian wrote:

Dear Claudiu Gavriloaie, PhD,
editor-in-chief AACL Bioflux journal

I enclose corrected paper based on the suggestion.

Thank you very much
With my best wishes,

Achmad Sofian



the almost final form of the paper "Ecosystem services-based mangrove management strategies in Indonesia: a review"

From: "gavriloaie ionel claudiu"
To: "achmad sofian"
Sent: Wednesday, February 13, 2019 5:08:54 AM
Subject: Re: the almost final form of the paper "Ecosystem services-based mangrove management strategies in Indonesia: a review"

Dear Dr. Sofian,

I do not know what you mean by repairing the figure. So, I am sending you the doc file to do it yourself. Also remove what you need from the Acknowledgements part.
Thank you!

Yours,
Claudiu Gavriloaie

On Tuesday, February 12, 2019 12:14 PM, achmad sofian wrote:

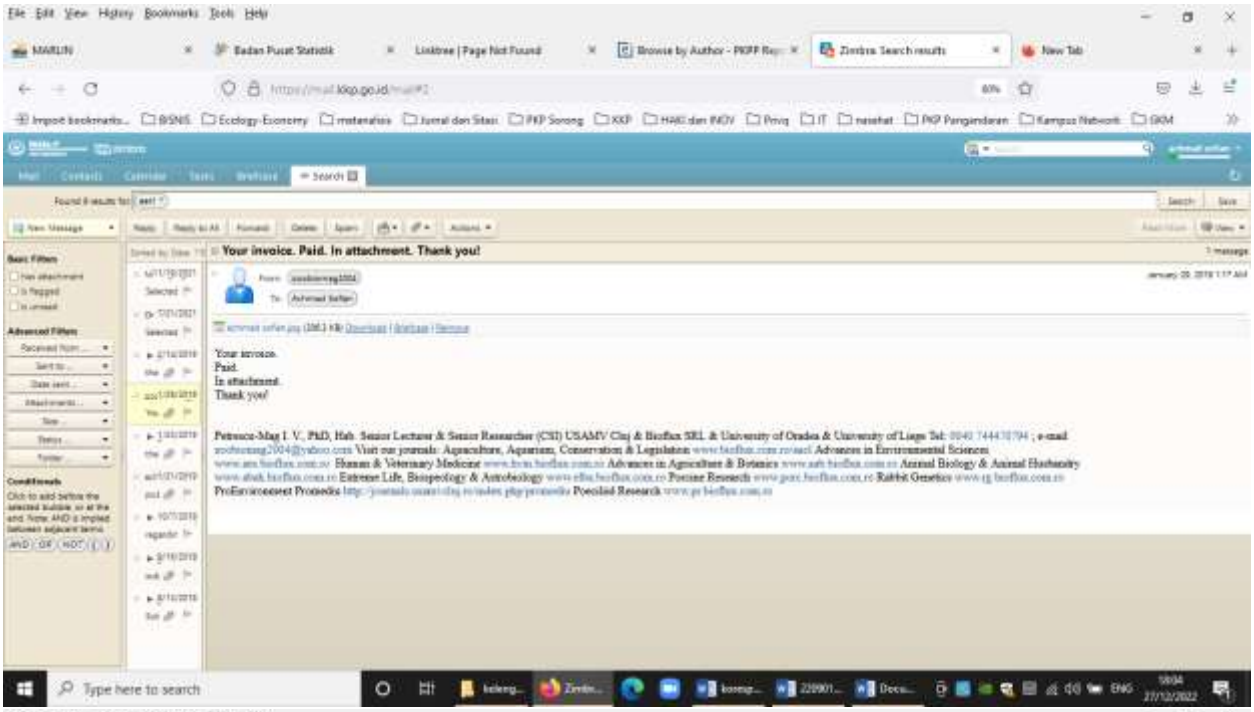
Dear Claudiu Gavriloaie, PhD,
editor-in-chief AACL Bioflux journal

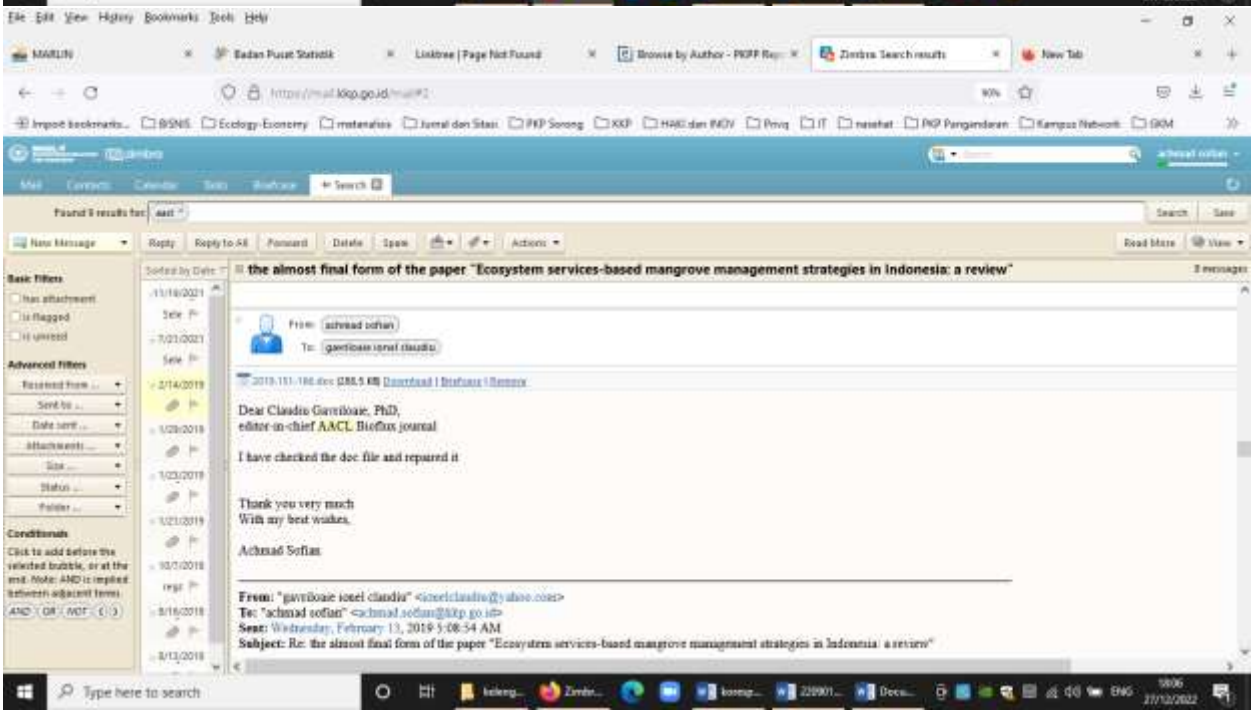
I have checked the document. Figure 1 (page 157) still needs to be repaired and please delete the acknowledgement in yellow

Thank you very much
With my best wishes,

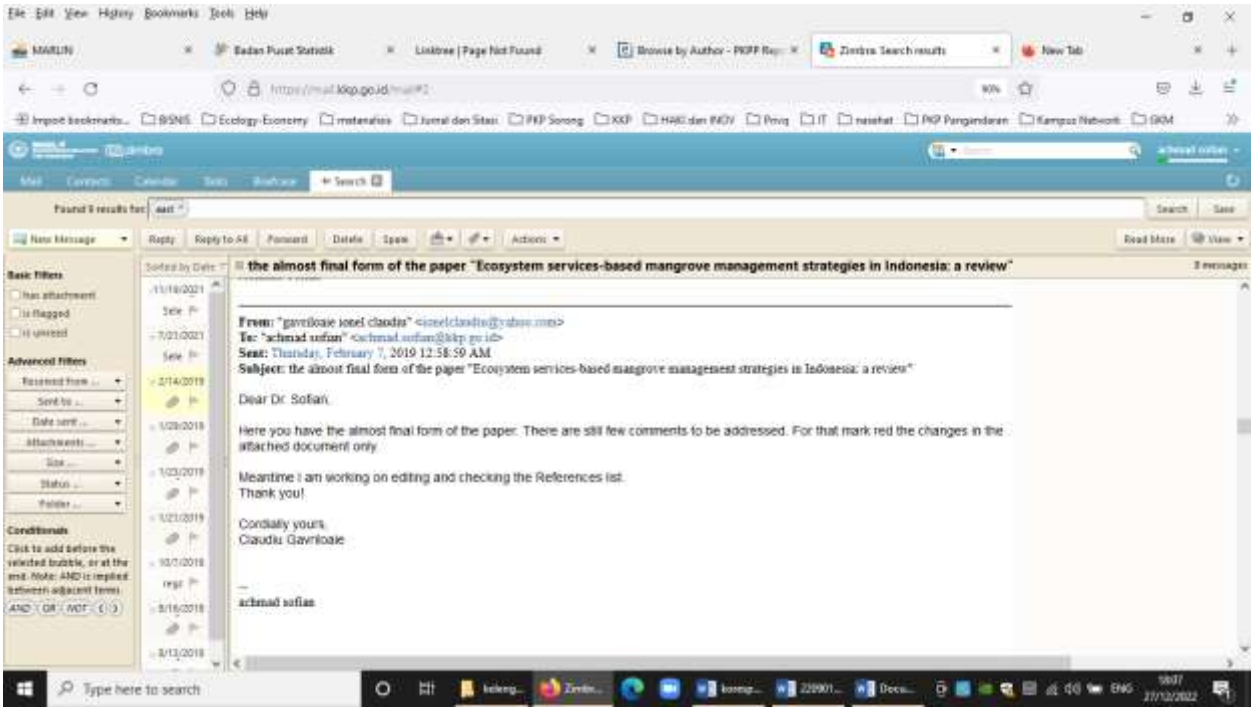
Achmad Sofian

Pembayaran

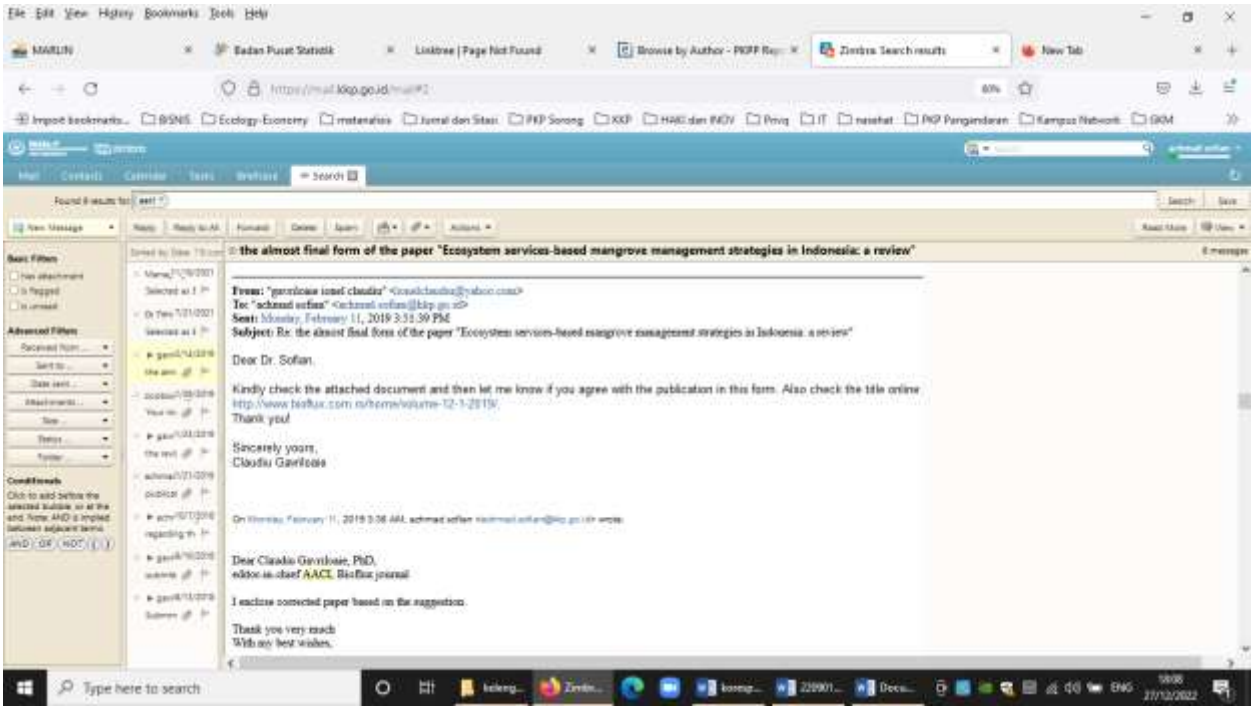

Your invoice. Paid. In attachment. Thank you!
Your invoice.
Paid.
In attachment.
Thank you!


the almost final form of the paper "Ecosystem services-based mangrove management strategies in Indonesia: a review"
Dear Claudio Gavriloaie, PhD,
editor-in-chief AACL Bioflux journal
I have checked the doc file and repaired it
Thank you very much
With my best wishes,
Achmad Sofian
From: "gavriloaie ionel claudiu"
To: "achmad sofian"
Sent: Wednesday, February 13, 2019 5:08:54 AM
Subject: Re: the almost final form of the paper "Ecosystem services-based mangrove management strategies in Indonesia: a review"

Accepted



Publish



Submission letter

Article title: A Review
Ecosystem Services-Based Mangrove Management Strategies in Indonesia

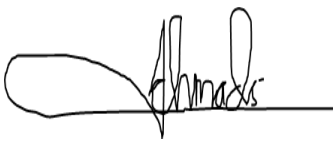
Name of the authors: Achmad Sofian, Cecep Kusmana, Akhmad Fauzi, Omo Rusdiana

Hereby I would like to submit the manuscript entitled "**A Review Ecosystem Services-Based Mangrove Management Strategies in Indonesia**" to Aquaculture, Aquarium, Conservation & Legislation - International Journal of the Bioflux Society.

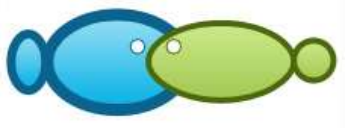
This manuscript was not submitted or published to any other journal. The authors declare that the manuscript is an original paper and contain no plagiarised text. All authors declare that they are not currently affiliated or sponsored by any organization with a direct economic interest in subject of the article. My co-authors have all contributed to this manuscript and approve of this submission.

Corresponding author

Achmad Sofian



August 10, 2018



A Review

Ecosystem services-based mangrove management strategies in Indonesia

[1,2]Achmad Sofian, [1,4]Cecep Kusmana, [3]Akhmad Fauzi, [4]Omo Rusdiana

[1] Study Program of Natural Resources and Environmental Management, Graduate School of Bogor Agricultural University (IPB), Bogor, Indonesia; [2] KKD-BP Sosial Ekonomi Perikanan, Marine and Fisheries Polytechnic of Sorong, Sorong, West Papua, Indonesia; [3] Department of Resources and Environmental Economics, Faculty of Economics and Management, Bogor Agricultural University (IPB), Bogor, Indonesia; [4] Department of Silviculture, Faculty of Forestry, Bogor Agricultural University (IPB), Bogor, Indonesia. Corresponding author: A. Sofian, achmad.sofian@kkp.go.id

Abstract. Mangrove ecosystems have strategic benefits and complex management. Management of mangrove ecosystems also faces pressures and challenges to maintain them in sustainable condition. This study was aimed to review various literatures on mangrove management, particularly related to ecosystem services, and to find contribution opportunities in this field of research. Ecosystem service approach is more developed in natural resource management and becomes an instrument connecting ecosystem functions with human wellbeing. Analysis results showed that ecosystem services are an important part of mangrove management. Mangrove provides many ecosystem services and has an important role in both the number and the type of ecosystem services. There are several research opportunities which can be conducted namely ecosystem service condition analysis, socio-economic analysis and valuation, system structure, and future prospective strategies. These aspects are certainly a challenge in developing a dynamic and complex mangrove ecosystem management strategy in Indonesia as an effort to achieve sustainable management objectives.

Key Words: ecosystem services, management, valuation, mangrove, socio-economic.

Introduction. Ecosystem service is one of the great interest topics for many scientists and has been on the rise over the past decade (Mcdonough et al 2017). Ecosystem services are the benefits that humans derive directly or indirectly from ecosystem functions (Costanza et al 1997; Häyhä & Franzese 2014). Ecosystem service is defined as benefits of ecosystems for human wellbeing (Millennium Ecosystem Assessment 2005a; TEEB 2010; Elliff & Kikuchi 2015). The concept of ecosystem services is very interesting and challenge caused by: (1) it may assist describing the connection and dependence of humans on nature; and (2) describes how human impacts on ecosystems alter the capacity in providing services, so appropriate policies can be developed (Haines-Young & Potschin 2013). Ecosystem is a functional unit of the biological community of animals, plants, microorganisms and non-biological environments that are complex and highly dynamic, and interact with each other (Millennium Ecosystem Assessment 2003). The mangrove ecosystem is one of the ecosystems that have various benefits of service for the society welfare but faces the pressures.

Indonesia is an archipelago country with more than 17,504 islands and about 95,181 km coastline (Kusmana & Sukristijiono 2016). Indonesia has a 3.1-3.7 million hectares mangrove forest area or more than 20% of world's mangrove forests with high species diversity (Giri et al 2011; Kusmana 2015b; Ilman et al 2016). Beside that, Potential area to be planted with mangrove species is around 7.8 million hectares (Kusmana 2015b). Indonesia's mangrove has a specific function because it lies between the terrestrial and marine ecosystems, and support various types of human needs, especially for local communities in mangrove forests and surrounding areas (Kusmana

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2015b; Kusmana & Sukristijiono 2016). This facts show that the potential of mangrove ecosystem in Indonesia is quite large at this time.

Mangrove forests contribute in providing ecosystem services and supporting the livelihoods of coastal communities around the world (Polidoro et al 2010). Mangrove ecosystems have an important role in the socio-economic of communities, even for millions of people in the tropics and subtropics (Atkinson et al 2016). The important role of mangrove ecosystems are providing ecological and biophysical services, and providing a variety of important ecosystem products and services that are critical to the livelihoods of nearby communities (Barbier et al 2011; Malik et al 2015a; Orchard et al 2016). In addition, mangrove ecosystems also serve ecological functions in providing ecosystem services, nutrient cycles, soil formation, timber production, fish spawning, ecotourism and carbon storage (C) (Murdiyarso et al 2015) including economic activities such as providing timber and leaves as raw medicine materials (Sonjaya 2007).

The mangrove ecosystem is one of the most endangered ecosystems in the world. It experiences encroachment pressure and land degradation continuously, mainly driven by human activities (Ghosh et al 2015). Ilman et al (2016) studied about the drivers of the loss of Indonesia's mangrove forests through historical image analysis and estimated the decline of mangrove forest area in all regions of Indonesia by 22 percent. The largest percentage was occurred in Java Island by 75 percent. Pressures on mangrove ecosystems and more widespreading of degraded land have potential in affecting ecosystem services as well. Ecosystem services are also attached to the mangrove ecosystem so that it will also affect the management policy. Therefore, the mangrove ecosystem need to be managed to provide benefits for current and future generations.

Mangrove and conservation management policies are emerging worldwide in line with the increasing appreciation of the benefit of mangrove (Carter et al 2015). Mangrove ecosystem as described by Kusmana (2015a) requires a management because mangroves have the benefit of providing ecosystem goods and services, but also experiences the destruction. The management needs to be integrated and sustained. Management of sustainable mangrove ecosystems is an integration of all efforts to realize the sustainability of mangrove ecosystem functions for the community wellbeing (Presidential Regulation of the Republic of Indonesia No. 73 of 2012). Sustainable management in accordance with the development orientation that attention to social, ecological and economic sustainability (Turner et al 2016). Indicators used in the management of mangrove ecosystems were ecology, economy, social and institutional (Iftekhar & Islam 2004; KKMTN 2013; Schmitt & Duke 2015; Kusmana 2015a; Orchard et al 2016).

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Ecosystem services are important aspect in ecological and socio-economic studies of mangrove management. The linkage of ecosystem services and mangrove management is very closely related to the function of mangrove ecosystem to human wellbeing. Therefore, mangrove ecosystem services must be an important aspect in the management. This study was aimed to review various literatures on mangrove management, particularly related to ecosystem services and to find contribution opportunities in this field of research.

This review used a literature study concerning "mangrove management" and "ecosystem services" in the title, abstract, keywords, and content. A review of the literature to better understand current conditions in the development of research fields, both theme, methods and other combinations are associated with ecosystem services and mangrove management. The study was conducted through defining stages and topics, searching and selecting studies, analyzing and synthesizing. The defining stage is done by explaining the ecosystem services and mangrove management, while the topics were focused on six studies after introduction, those are: (1) the concept of ecosystem services, (2) mangrove ecosystem services, (3) the value of mangrove ecosystem services, (4) mangrove ecosystem management in Indonesia, (5) study, analysis, and strategy of mangrove services management, and (6) research prospect of ecosystem service management. Scientific publications which become reference are derived from the scopus data base (https://www.scopus.com), google scholar

(https://scholar.google.com/), garuda portal (http://id.portalgaruda.org/) as well as various other literatures such as reports, and supporting books.

Concept of ecosystem services. Ecosystem provides many services to the human as part of the ecosystem itself. Changes that occur in the ecosystem will certainly affect the existence of ecosystem services and ultimately on human wellbeing (Millennium Ecosystem Assessment 2003). According to the literature reviews, ecosystem service approach is connecting between environmental and socio-economic interests (De Groot et al 2010a; Haines-Young & Potschin 2010). The concept of ecosystem services has undergone many developments and has been used in natural resource assessments since the late 1970s and then continued in the 1990s with the main focus on ecosystem services in the literature (Gómez-Baggethun et al 2010). A study of ecosystem services was conducted among others by Costanza et al (1997) who first valued ecosystem services and natural resource capital globally, and the study was further expanded, particularly since the publication of the concept of ecosystem services carried out by Millennium Ecosystem Assessment in 2003.

The concept of ecosystem services is very important in connecting ecosystem functions with human welfare (Fauzi & Anna 2005). The classification of ecosystem services used should refer to the importance characteristics of the ecosystem and in the context of decisions for how ecosystem services will be used (Fisher et al 2009). Understanding the rules of ecosystem services and functions (provision) to human well-being is also essential in obtaining identification and targets of seeking the natural capital of a system and complementing the requirements of sustainable development (De Jonge et al 2012). The classification of ecosystem services used by the Common International Classification of Ecosystem Services (CICES) has three types of ecosystem services (Haines-Young & Potschin 2013) comprises provisioning categories such as biomass and water, regulating and maintenance such as pest and disease control, and cultural such as physical interactions, intellectual and spiritual with the ecosystem.

Classification of ecosystem services is useful to clarify the understanding in identification of services according to the studied ecosystem. Classification of ecosystem services of Millennium Ecosystem Assessment is widely used (Fisher et al 2009). The classification of CICES specifically focuses on ecosystem outputs that directly contribute to public wellbeing and aims for economic assessment (Haines-Young & Potschin 2013). The use of classification needs to be adapted according to the objectives of the study, particularly if it is related to economic valuations to avoid recurring calculations (Elliff & Kikuchi 2015). A good understanding of ecosystem services will assist in gaining a picture of ecosystem connection with community wellbeing.

Various appropriate efforts in mangrove ecosystem management strategies should be continued. According to Walters et al (2008), improper anticipatory efforts in resource management and land use against the pressures faced may threaten the existence of ecosystems and humans who depend on it. Complexity of the mangrove ecosystem also requires cooperation and participation of all government levels, in addition to policies and programs which still become a key to sustainability of mangrove management and coastal ecosystems (Carter et al 2015). Knowledge and attention to the mangrove ecosystems including changes in ecosystem management is an important basis in further management. Ecosystem service becomes one of the tools to increase the knowledge (Luque et al 2017) and use it in mangrove ecosystem management strategy.

Mangrove ecosystem services. Mangrove has many important ecosystem services and values (Salem & Mercer 2012; Schmitt & Duke 2015). The role of mangrove ecosystem is very important at least on two things (Kusmana & Purwanegara 2015):

1. approximately 75 to 90% of all marine fish species, a whole or a part of its life cycle depends on estuarine habitat, and its productivity depends largely on the production of organic materials from mangrove and seagrass plants;

2. mangrove is one of the main ecosystem types in maintaining coastal environmental quality where approximately 50% of the population in the world and 2/3 of the world's major cities are living in coastal areas.

Indicators of mangrove ecosystem services based on literature reviews vary considerably from provisional, regulatory and maintenance, and cultural. Indonesian people have been traditionally since long time ago utilize mangrove ecosystem services (provisioning) such as for firewood, charcoal, medicines, dye and other uses such as the use of aquatic fauna to support daily life (Kusmana & Sukristijiono 2016). Ecosystem services provided by the mangrove ecosystem are summarized in Table 1.

Table 1

Indicators of mangrove ecosystem services

No	*Category*	*Indicator*	*Description*	*Source*
1	Provisioning	Fishery (food)	Providing fisheries as a source of food	Harahab (2009); Macintosh et al (2010); Kuenzer et al (2011); Sofian et al (2012); Uddin et al (2013); Mukherjee et al (2014); Malik et al (2015b); Vo et al (2015)
		Aquaculture	Cultivation of brackish fisheries such as shrimp and milkfish ponds	Macintosh et al (2010); Kuenzer et al (2011); Mukherjee et al (2014); Malik et al (2015b); Sina et al (2017)
		Honey	A sweet fluid collected by insect	Macintosh et al (2010); Kuenzer et al (2011); Uddin et al (2013); Mukherjee et al (2014)
		Medicines	Traditional medicines	Macintosh et al (2010); Kuenzer et al (2011); Mukherjee et al (2014)
		Feedstock	Mangrove as raw material	Mukherjee et al (2014)
		Energy source	Wood fuel is used for daily activities such as making charcoal, cooking food, burning bricks	Macintosh et al (2010); Kuenzer et al (2011); Uddin et al (2013); Mukherjee et al (2014); Malik et al (2015b)
		Timber	Wood for building and carpentry	Macintosh et al (2010); Uddin et al (2013); Mukherjee et al (2014); Vo et al (2015); Sina et al (2017)
		Tannin	Phenolic substances derived from plants used for tannery	Kuenzer et al (2011)
2	Regulation and maintenance	Water bioremediation	Maintaining water quality	Walters et al (2008); Barbier et al (2011); Mukherjee et al (2014)
		Reducing emission	The presence of mangrove reduces emissions	Mukherjee et al (2014)
		Environmental risk indicator	Mangrove as risk indicator	Mukherjee et al (2014)
		Protecting from sedimentation	Stabilization of land by restraining sediment	Macintosh et al (2010); Mukherjee et al (2014)
		Protecting from sea water intrusion	Mangrove can protect from intrusion	Mukherjee et al (2014); Malik et al (2015b)
		Coastal protector (seawall)	Protecting the coastal from the onslaught of waves, winds and floods	Macintosh et al (2010); Barbier et al (2011); Kuenzer et al (2011); Mukherjee et al (2014); Malik et al (2015b); Barbier (2016)
		Fish nursery	Mangrove as nursery ground for fish	Mukherjee et al (2014); Malik et al (2015b)
		Carbon sink	Absorbing carbon dioxide	Walters et al (2008); Macintosh et al (2010); Mukherjee et al (2014); Malik et al (2015b); Vo et al (2015)
		Reducing coast and soil erosion	Reduction of coast and soil erosion	Macintosh et al (2010); Barbier et al (2011); Vo et al (2015)
		Climate regulator	an important role on climate change	Macintosh et al (2010)
3	Cultural	Ecotourism and recreation	Providing unique and aesthetic values, and as a suitable habitat for flora and fauna	Macintosh et al (2010); Barbier et al (2011); Kuenzer et al (2011); Uddin et al (2013); Mukherjee et al (2014)
		Aesthetic value	The value of appreciation of the beauty of nature	Uddin et al (2013); Mukherjee et al (2014)
		Spiritual appreciation	Appreciation related to belief	Macintosh et al (2010); Kuenzer et al (2011); Uddin et al (2013)

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Ecosystem services are identified in accordance with the presence of mangrove ecosystems in an area and need to be valued in monetary terms (money) so that they can be clearly calculated for their economic contribution and compared to the market of goods and services (Häyhä & Franzese 2014). The value of ecosystem services can not be ignored, for example the cultural are essential in understanding how humans use and assess nature, but are often ignored in forest assessments due to limitations in measurement and mapping (Luque et al 2017). The values can clarify and strengthen the position of ecosystem services into consideration in the formulation of management strategies.

Value of mangrove ecosystem services. Value of mangrove ecosystem service describes the relative price, usefulness, and importance of a thing (Moore et al 2017). Although assessment of the ecosystem and its services is still a debate (Häyhä & Franzese 2014), economic valuation plays an important role in the assessment of natural resources to assist in decision-making and sustainable management processes (Zhang & Lu 2010; Fauzi 2014; Vo et al 2015). A study conducted by Moore et al (2017) using the ecosystem services natural resource approach (Ecosystem Services-Natural Resources Management) stated that valuation will assist decision makers in evaluating and communicating overall benefits and trade-offs to stakeholders. In assessing forest ecosystem services, the capacity of ecosystem services are determined by the long-term temporal dynamic (Luque et al 2017).

Assessment of goods and services of mangrove ecosystems is needed because mangrove provides many benefits and plays important roles for better conservation (Muraleedharan et al 2009). Economic valuation approach of mangrove resources will help policy makers and decision makers to know the value of mangrove ecosystem comprehensively (Ilman & Suryadiputra 2011). The economic valuation of goods and services of mangrove ecosystems is able to show the benefits of a good mangrove ecosystem for the community and this is an important reason to manage and protect the mangroves (Schmitt & Duke 2015). Understanding of the value and services of mangrove ecosystems is becoming increasingly important for local, national, and global policies and decisions (Kairo et al 2001; Vo et al 2015).

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Mangrove provides real ecosystem services, but is not fully supported by optimal conservation and protection. Conservation as a biodiversity protection often faces inadequate economic resources and thus requires the support of integrative instruments and incorporates economic goals and conservation impacts (Luque et al 2017). Although not all the benefits of ecosystems can be expressed monetarily, some analyzes can still contribute to the various decision options (De Jonge et al 2012).

Studies of mangrove ecosystem valuation in Indonesia have been carried out such as Malik et al (2015b) which estimates that annual mangrove total economic value (TEV) in Takalar District, South Sulawesi ranges from 4,000 to 8,000 USD per hectare, compared to commercial aquaculture that provides net benefits of 3,000 USD per hectare. Indrayanti et al (2015) studied the value of mangrove ecosystem services in Blanakan Subang Bay, West Java obtained the TEV at Rp. 3,815,790,110.97 per year for 782.34 ha mangrove area. Other study by Suharti et al (2016) found the total value of mangroves in East Sinjai with a total area of 758 ha was Rp. 37,535,809,496 per year.

Mangrove ecosystem management in Indonesia. Management of mangrove ecosystems faces a complexity of problems. Mangrove ecosystems as renewable resources provide various types of life support products (Kusmana 2015a), but the ecosystem is subjected to continuous pressure due to natural factors and human activities. Based on the literature reviews, mangrove ecosystem received considerable attention in the theme of ecosystem management in Indonesia. The aspects of the study and coverage area of the studies are diverse, including the conceptual (Effendy 2009; Kusmana 2015a), biophysical analysis (Fahrian et al 2015; Zurba et al 2017), social analysis (Ritohardoyo & Ardi 2011; Harahab 2011; Kustanti et al 2015; Febryano et al 2015), economic valuation (Ruitenbeek 1992; Saprudin & Halidah 2012), institutional (Suharti et al 2016; Kuvaini et al 2017), and regulation (Sunyowati et al 2016). Other

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studies were done on sustainability status (Mukhlisi et al 2014; Theresia et al 2015; Karlina et al 2017), system model (Datunsolang 2016) and management strategies (Wijayanto et al 2013; Yenny et al 2017; Lugina et al 2017). The studies generally focused on the sustainability and socio-economic aspect. The management of mangrove ecosystems that comprehensively focuses analyze ecosystem services and institutional structure is still relatively limited.

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Management of mangrove ecosystems requires an approach that can connect the interests of environmental sustainability and benefits for human wellbeing in a balanced way. One of the efforts can be done is by comprehensive reviewing of ecosystem services. It is supported by several aspects that have been widely discussed in various studies, including:

1. Ecology - mangrove ecosystem has been recognized to have the function and benefits for the environment and the preservation of biodiversity. Based on Kusmana (2014), mangrove resources in Indonesia have been supporting many kinds of human needs ;

2. Socio-economic - mangrove ecosystem plays an important role for the community wellbeing such as food and livelihood sources ;

3. Institutional - mangrove ecosystem is a means of managing both protection, rehabilitation, and even utilization that involves the attention and participation of many parties such as government, private, NGO, and society. Since 2013, the Indonesian government has initiated the formation of a National Mangrove Working Group (KKMN) that consists of cross-sector/institutional/NGO ;

4. Regulations and laws - mangrove ecosystem in Indonesia already has a regulatory instrument that specifically focuses on the national management strategy, namely Presidential Regulation no. 73 of 2012. In addition, it is supported by Government Regulation no. 26 of 2008 concerning about national spatial plan, Government Regulation no. 73 of 2013 concerning about swamps, Presidential Regulation No. 51 of 2016 concerning about coastline boundaries.

The concept of ecosystem services is also used by academics, researchers and decision makers to support and explain environmental management and biodiversity conservation strategies (Martín-López et al 2012). Ecosystem services still need to be studied as a basis for the development strategy for mangrove ecosystem management because it is an important part in the management of mangrove ecosystems (Macintosh et al 2008; Schmitt & Duke 2015; Karlina et al 2017). According to Brander et al (2012) potential research on mangrove ecosystems in the future is research that combines ecology and economy to make a model of supply and service of mangrove ecosystem. Policies and programs are becoming more complex with the bureaucracy and authority involved in mangrove conservation, but it is still a key for the sustainability of mangrove and coastal ecosystem management (Carter et al 2015). Therefore, a new and more integrative approach is needed to assess sustainable development (Turner et al 2016), including the management of mangrove ecosystems.

Ecosystem service approaches can be applied in the context of mangrove ecosystem management as shown in Figure 1. Mangrove ecosystems face various pressures and dynamic changes that will also impact on ecosystem services and human life, thus it is necessary to develop sustainable ecosystem service-based management strategies.

One of the challenges of managing mangrove ecosystems is linking dynamic mangrove ecosystems with complex socio-economic life of communities such as mangrove positions near settlements and in urban areas. Management of mangrove ecosystems in the future also need to be oriented broadly to be able to measure the importance of mangrove ecosystem services for the community itself. Well managed mangrove ecosystems have the potential to have good ecosystem services and will support the sustainability of mangrove development. The role of mangrove ecosystems also requires sustainable mangrove ecosystem management. It is supported by three important pillars, namely ecology, social and economy which are covered by appropriate institutional and regulation (Kusmana 2015a). Mangroves can not be ignored because

their ecosystem services have distinctive characteristics that indicate that ecosystems provide services and have value for human wellbeing.

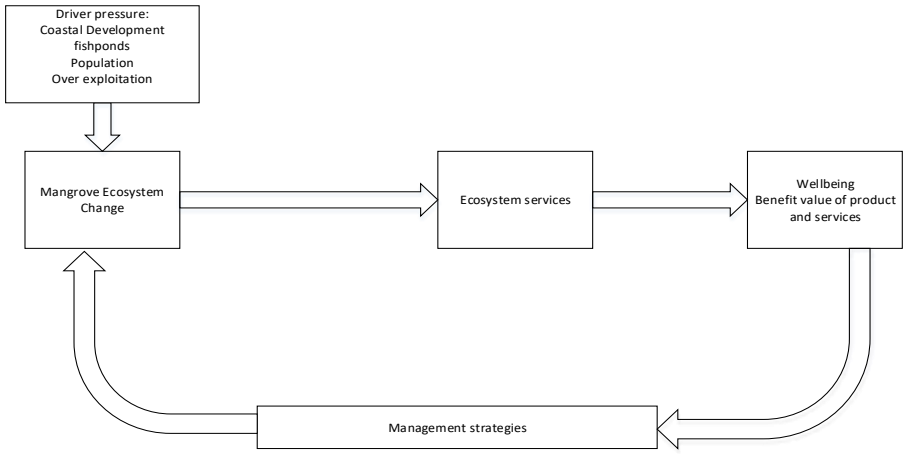

Figure 1. The application of ecosystem services approach on mangrove management (adopted from De Groot et al 2010a; Haines-Young & Potschin 2010).

Study, analysis, and strategy of mangrove ecosystem services. A review of mangrove ecosystem service management is conducted as a strategy to develop management policy to be more able to guarantee ecosystem services both in the present and in the future. Several studies that have been conducted previously provided an illustration of the importance of ecosystem service management (Mukherjee et al 2014; Kusmana 2015a; Carter et al 2015; Kustanti et al 2015; Vo et al 2015; Malik et al 2015a; Ilman et al 2016; Orchard et al 2016; Suharti et al 2016). Studies on ecosystem service approaches are also widely conducted (De Groot et al 2010a; De Groot et al 2010b; Haines-Young & Potschin 2010; Martín-López et al 2012; Elliff & Kikuchi 2015; Moore et al 2017). Researches on mangroves management related to ecosystem services have been developed, those are:

a. Analysis of ecosystem service conditions. Assessment of ecosystem services can be assessed by analyzing conditions and indicators of the ecosystem service. This aspect is crucial because directly related to the processes occurring in the ecosystem and will have an impact on the availability of ecosystem services. Similarly with mangrove ecosystems, intensive mangrove forest use has had an impact on biodiversity and mangrove ecosystem services (Malik et al 2015a). Therefore, knowledge of the status of mangrove forests is essential for better planning and management (Schmitt & Duke 2015). A study conducted by Malik et al (2015a) has assessed the ecological impact of mangrove utilization and the level of exploitation of ecosystem services in mangrove forests of South Sulawesi. Analysis of the mangrove ecosystem condition and its services is identified either directly or indirectly and analyzed according to the characteristics, coverage areas and categories specified. Geographic information systems (GIS) and remote sensing are used in various areas including in the management of mangrove ecosystems. Spatial analysis through GIS and remote sensing can assist spatially in mapping ecosystem services conditions. Ecosystem service mapping is crucial to understand the contribution of ecosystems to human wellbeing and supporting policies that impact natural resources (Burkhard & Maes 2017). Conservation and management of effective mangrove habitats need to consider remote sensing and GIS based on a comprehensive data approach (Ghosh et al 2015). Several studies related to mangrove ecosystem services using GIS approach and remote sensing have been conducted, such as Omo-Irabor et al (2011), reviewed comprehensively the use of socio-economic and environmental criteria with the opinion of expert, GIS, and SMCA (Spatial Multi Criteria

Analysis) for vulnerability assessment of mangroves. Atkinson et al (2016) has assessed the value and priority of mangrove ecosystem services using spatial GIS and cost benefit of ecosystem services in decision making. Studies with GIS and remote sensing approaches can provide spatial advantages, one of which can generate significant ecological and economic benefits by obtaining real time data from unreachable area (Ghosh et al 2015). However, there are several things that need to be considered, including ecosystem services that must be assessed in the right spatial context and economic valuations that can support decisions so that policies are more useful (Vo et al 2015).

b. Social economics and valuation. Socioeconomic studies of mangrove ecosystem management related to ecosystem services have also received much attention in line with the dynamic changes and complexity that occur in mangrove ecosystem. Study of Orchard et al (2016) has reviewed the dynamics of mangrove systems in Southeast Asia by linking livelihoods with the services of mangrove ecosystems. Other socio-economic studies are economic valuations as conducted by Uddin et al (2013) that implement economic valuation of ecosystem services for protected areas of mangrove ecosystem in Sundarbarns, Bangladesh. Economic valuation of the mangrove ecosystem is quite widely studied, although not many of the result were used as one of the foundations in policy making. Valuation of ecosystem services highly depends on services from the nature, such as ecosystem functions that produce goods and services that can be sold with various alternative methods (Salem & Mercer 2012). Various types of monetary valuation measurements are used according to the type of ecosystem services, although it does not allow to explain the scope of the monetary value of all ecosystem services (De Jonge et al 2012). Several methods of economic valuation are used in the valuation of mangrove ecosystem services as shown in Table 2.

Table 2

Economic valuation method of mangrove ecosystem services

Method	*Description*	*Example application*
TCM	The revealed assessment method to assess the non-use benefit based on the observed behavior of individual expenditures for travel	Indrayanti et al (2015); Fitriana et al (2017)
MM	An assessment obtained directly from the amount a person must pay for goods and services such as timber products	Sofian et al (2012); Uddin et al (2013); Malik et al (2015b); Vo et al (2015); Ye et al (2016); Suharti et al (2016)
HPM	Describes an assessment of a thing (goods or service) that is perceived because of pleasure characteristic, such as beautiful scenery, convenience or other characteristics	Syukri (2016)
PA	The value of services assessed by the impact of these services on economic outcomes (e.g. increased shrimp yields from wetland increases)	Malik et al (2015b)
CVM	Non-market valuation which is a direct method for economic assessment through willingness to pay (WTP)	Suharti et al (2016)
CA	A person is asked to evaluate different service scenarios/ecological condition in combining the conditions (wetland scenarios by differentiating protection levels from floods and fishery products)	McDonough et al (2014)
RC	Calculates the loss of natural system services at the cost incurred to replace the service	Malik et al (2015b); Vo et al (2015); Suharti et al (2016)
AC	Calculating services based on avoidable expenses such as clean water reduces the cost of diarrhea treatment	-
REA/ HEA	The damage assessment method based on calculating the scale of the restoration project to restore the resource service to the initial conditions	Winarno et al (2016)
BoE	Methods economic valuation on marketed components such as the calculation of economic losses due to pollution to health	-
BT	Transfers from the alleged value of non-market benefits from other sites to the research sites	Brander et al (2012); Malik et al (2015b); Vo et al (2015); Ye et al (2016); Suharti et al (2016)

TCM : Travel Cost Method; MM: Market Method; HPM: Hedonic Price Method; PA: Production Approach, CVM: Contingent Valuation Method; CA: Conjoint Analysis; RC: Replacement Cost; AC: Avoidance Cost; REA/HEA: Resource Equivalency Analysis/Habitat Equivalency Analysis; BoE: Back of the envelope; BT: Benefit Transfer.

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c. System structure. System is a unity of efforts, consisting of interrelated parts regularly, and trying to achieve goals in a complex environment (Marimin & Maghfiroh 2010). Structure describes the arrangement of the elements and relationships between elements in forming a system. Every system approach always prioritizes the study of the system structure both explanatory and as policy support (Eriyatno 2012). Management of mangrove ecosystem services can be analyzed by a system approach because mangrove ecosystem is a complex system. Understanding of the system structure is one way to achieve the effective management objectives of the complex system.

Structural analysis is a good and powerful design tool for sharing knowledge and experience (Omran et al 2014). The core of this method is the measurement of the relationship between variables and the simplification of the system by selecting the most influential external variables and the most sensitive internal variables (key variables) (Fierro 2015). The most popular structuring tool for indirect relationship is MICMAC, whereas for direct relationship is used Interpretative Structural Modeling (ISM) technique (Eriyatno 2012).

MICMAC (Matrice d'Impacts Croisés Multiplication Appliquée à un Classement Cross-Impact Matrix) is a structural analysis (Suprun et al 2016) that uses Boolean matrix to classify variables based on strength and dependence (Ambrosio-Albala & Delgado 2008). Structural analysis provides simulated reflection with expert skill and can be easily applied to problem formulation in a matrix design and supports qualitative studies (Omran et al 2014). MICMAC is one of the standard tools of scenario analysis built by Michel Godet, which presents a structured process in identifying variables for scenarios that may occur in the future based on expert opinions on system interactions (Veltmeyer & Sahin 2014). MICMAC method is performed by defining the problem and proceeding with 3 following stages (Benjumea-Arias et al 2016; Nazarko et al 2017):

- identification of internal and external variables;
- analysis of relationship between variables in the system;
- identification of key variable qualifies: direct and indirect classification.

Furthermore, the influence and dependence analysis is obtained through the position of the variable indicator in the quadrant. Variables can be in the variable power, autonomous, conflict or the output variables depending on the level of influence and dependence it has.

d. Future prospective strategies. The characteristic of strategies decisions is long term, dynamic environment and influences factors with very low certainty (Marimin & Maghfiroh 2010). Godet (2000) has described scenario analysis, the concept of prospective strategy, and the stages of scenario analysis process along with its usable tools and case study examples. A prospective method is as a tool for generalize of strategic knowledge to design future sustainability and allowing for designing different future scenarios by planning the transformation of the current situation into the expected future (Fierro 2015). Aryanto & Yuniarty (2010) mentioned that prospective analysis is appropriately used for policy strategy design and has two main uses, namely: preparing strategic actions that need to be done and to see if the changes are needed in the future. The objectives of identifying future conditions are to identify their characteristics and impacts, and to calculate the relative probability of occurrence (Bishop et al 2007).

Strategy is needed to overcome the mangrove ecosystem pressure. Management strategies should also be developed to achieve the sustainability objectives of the mangrove ecosystem to ensure the sustainability of ecological and socio-economic functions and not harm the lives of present and future generations (KKMTN 2013). Iftekhar & Islam (2004) mention the key strategies of mangrove management such as holistic management adoption, conservation and biodiversity improvement, impact zone management, government and non-government collaboration in management, community participation, non-exploitative utilization promotion, and sustainability planting on deltaber.

Several studies of mangrove ecosystem management strategies have been conducted including Iftekhar & Islam (2004) assessed the management of mangrove ecosystem using strategy analysis, and Atkinson et al (2016) assessed the management

of mangrove ecosystems using cost-effectiveness analysis with the cost benefit of ecosystem services for several scenarios to obtain effective management. Other studies such as Faperi et al (2015), reviewed mangrove degradation management strategies using vegetation analysis, structural equation modeling (SEM), AHP and SWOT. Another prospective method that has been used in other fields is SMIC-Prob-Expert. SMIC-Prob-Expert is a cross-impact analysis built by Michael Godet to combine beneficial aspects, both quality and quantity (Lakner & Baker 2014). SMIC (Cross Impact Systems and Matrices) has several advantages among cross impact methods, including easy to use with the help of questionnaires, quick, and inexpensive. These characteristics make it easy to explain the results. However, this method requires a lot of thought in giving information treatment to choose an important hypothesis. The strategy hypothesis formulation also requires structural analysis and understanding of key variables. The results of the SMIC method are scenario hierarchy and sensitivity analysis.

Research prospect of mangrove ecosystem services. Ecosystem services as previously reviewed have an important position in the management of mangrove ecosystems and may assist describe the ecosystem relationship with human life. There are several assessment opportunities related to the management of mangrove ecosystem services that can be further examined, including:

1. mangrove ecosystem condition that focuses on ecosystem service in accordance with the region;
2. economic valuation of mangrove ecosystem services is important in determining the value and can be a consideration in the management strategy;
3. system structure of the mangrove ecosystem management variables associated with the ecosystem services and main variable analysis;
4. pressures and complexity that exist in the mangrove ecosystem and its survival strategies in facing future changes (prospective) based on current conditions in the management of ecosystem services.

Aspects of the study as previously described certainly integrate mangrove ecosystem services into challenges in the development of management strategies. Although ecosystem services from a number of existing studies may connecting ecosystem and community wellbeing, yet the existing literature is limited, particularly in linking ecosystem services to future management strategies. This is particularly important considering the dynamic nature of ecosystems and external pressures such as continuous population increases. Existing mangrove ecosystem management strategies have not fully reviewed ecosystem services comprehensively in order to anticipate changes in the ecosystem and ensure services to be provided. In addition, the review can be an answer in the context of a sustainable development assessment requiring a new and more integrative approach (Turner et al 2016), included in the management of mangrove ecosystem services in Indonesia.

Conclusions. Mangroves have ecosystem services that are beneficial for human life and other biota, but continue to experience destruction and decline due to excessive exploitation. Increasingly large and complex pressures on mangrove ecosystems will greatly increase the pressure on sustainability of ecosystem services. This should be considered by policy makers in mangrove ecosystem management strategies. Ecosystem services will also be closely linked to the characteristics of each region and the value that requires in-depth analysis. The study of mangrove ecosystem management variables will also be very useful in decision making for development of management strategies in the future. This article contributes to provide a road map for research opportunities in mangrove ecosystem management especially in the context of ecosystem services. This study will become an input in answering the challenges of managing complex and dynamic mangrove ecosystems in Indonesia. Therefore, the development of ecosystem management strategies is still likely to be studied as an effort to achieve sustainable management objectives.

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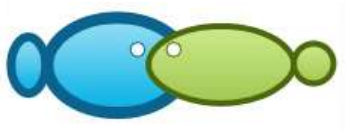

Ecosystem services-based mangrove management strategies in Indonesia : a review

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Abstract. Mangrove ecosystems have strategic benefits and complex management. Management of mangrove ecosystems also faces pressures and challenges to maintain them in sustainable condition. This study was aimed to review various literatures on mangrove management, particularly related to ecosystem services, and to find contribution opportunities in this field of research. Ecosystem service approach is more developed in natural resource management and becomes an instrument connecting ecosystem functions with human wellbeing. Analysis results showed that ecosystem services are an important part of mangrove management. Mangrove provides many ecosystem services and has an important role in both the number and the type of ecosystem services. There are several research opportunities which can be conducted namely ecosystem service condition analysis, socio-economic analysis and valuation, system structure, and future prospective strategies. These aspects are certainly a challenge in developing a dynamic and complex mangrove ecosystem management strategy in Indonesia as an effort to achieve sustainable management objectives.
Key Words: ecosystem services, management, valuation, mangrove, socio-economic.

Introduction. Ecosystem service is one of the great interest topics for many scientists and has been on the rise over the past decade (Mcdonough et al 2017). Ecosystem services are the benefits that humans derive directly or indirectly from ecosystem functions (Costanza et al 1997; Häyhä & Franzese 2014). Ecosystem service is defined as benefits of ecosystems for human wellbeing (Millennium Ecosystem Assessment 2005a; TEEB 2010; Elliff & Kikuchi 2015). The concept of ecosystem services is very interesting to study for some reason: (1) it may assist describing the connection and dependence of humans on nature; and (2) describes how human impacts on ecosystems alter the capacity in providing services, so appropriate policies can be developed (Haines-Young & Potschin 2013). Ecosystem is a functional unit of the biological community of animals, plants, microorganisms and non-biological environments that are complex and highly dynamic, and interact with each other (Millennium Ecosystem Assessment 2003). The mangrove ecosystem is one of the ecosystems that have various benefits of service for the society welfare but faces the pressures.

Indonesia is an archipelago country with more than 17,504 islands and about 95,181 km coastline (Kusmana & Sukristijiono 2016). Indonesia has a 3.1-3.7 million hectares mangrove forest area or more than 20% of world's mangrove forests with high species diversity (Giri et al 2011; Kusmana 2015b; Ilman et al 2016). Beside that, Potential area to be planted with mangrove species is around 7.8 million hectares (Kusmana 2015b). Indonesia's mangrove has a specific function because it lies between the terrestrial and marine ecosystems, and support various types of human needs, especially for local communities in mangrove forests and surrounding areas (Kusmana

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2015b; Kusmana & Sukristijiono 2016). This facts show that the potential of mangrove ecosystem in Indonesia is quite large at this time.

Mangrove forests contribute in providing ecosystem services and supporting the livelihoods of coastal communities around the world (Polidoro et al 2010). Mangrove ecosystems have an important role in the socio-economic of communities, even for millions of people in the tropics and subtropics (Atkinson et al 2016). The important role of mangrove ecosystems are providing ecological and biophysical services, and providing a variety of important ecosystem products and services that are critical to the livelihoods of nearby communities (Barbier et al 2011; Malik et al 2015a; Orchard et al 2016). In addition, mangrove ecosystems also serve ecological functions in providing ecosystem services, nutrient cycles, soil formation, timber production, fish spawning, ecotourism and carbon storage (C) (Murdiyarso et al 2015) including economic activities such as providing timber and leaves as raw medicine materials (Sonjaya 2007).

The mangrove ecosystem is one of the most endangered ecosystems in the world. It experiences encroachment pressure and land degradation continuously, mainly driven by human activities (Ghosh et al 2015). Ilman et al (2016) studied about the drivers of the loss of Indonesia's mangrove forests through historical image analysis and estimated the decline of mangrove forest area in all regions of Indonesia by 22 percent. The largest percentage was occurred in Java Island by 75 percent. Pressures on mangrove ecosystems and more widespreading of degraded land have potential in affecting ecosystem services as well. Ecosystem services are also attached to the mangrove ecosystem so that it will also affect the management policy. Therefore, the mangrove ecosystem need to be managed to provide benefits for current and future generations.

Mangrove and conservation management policies are emerging worldwide in line with the increasing appreciation of the benefit of mangrove (Carter et al 2015). Mangrove ecosystem as described by Kusmana (2015a) requires a management because mangroves have the benefit of providing ecosystem goods and services, but also experiences the destruction. The management needs to be integrated and sustained. Management of sustainable mangrove ecosystems is an integration of all efforts to realize the sustainability of mangrove ecosystem functions for the community wellbeing (Presidential Regulation of the Republic of Indonesia No. 73 of 2012). Sustainable management is in accordance with the development orientation that attention to social, ecological and economic sustainability (Turner et al 2016). Indicators used in the management of mangrove ecosystems were ecology, economy, social and institutional (Iftekhar & Islam 2004; KKMTN 2013; Schmitt & Duke 2015; Kusmana 2015a; Orchard et al 2016).

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Ecosystem services are important aspect in ecological and socio-economic studies of mangrove management. The linkage of ecosystem services and mangrove management is very closely related to the function of mangrove ecosystem to human wellbeing. Therefore, mangrove ecosystem services must be an important aspect in the management. This study was aimed to review various literatures on mangrove management, particularly related to ecosystem services and to find contribution opportunities in this field of research.

This review used a literature study concerning "mangrove management" and "ecosystem services" in the title, abstract, keywords, and content. A review of the literature to better understand current conditions in the development of research fields, both theme, methods and other combinations are associated with ecosystem services and mangrove management. The study was conducted through defining stages and topics, searching and selecting studies, analyzing and synthesizing. The defining stage is done by explaining the ecosystem services and mangrove management, while the topics were focused on six studies after introduction, those are: (1) the concept of ecosystem services, (2) mangrove ecosystem services, (3) the value of mangrove ecosystem services, (4) mangrove ecosystem management in Indonesia, (5) study, analysis, and strategy of mangrove services management, and (6) research prospect of ecosystem service management. Scientific publications which become reference are derived from the scopus data base (https://www.scopus.com), google scholar

(https://scholar.google.com/), garuda portal (http://id.portalgaruda.org/) as well as various other literatures such as reports, and supporting books.

Concept of ecosystem services. Ecosystem provides many services to the human as part of the ecosystem itself. Changes that occur in the ecosystem will certainly affect the existence of ecosystem services and ultimately on human wellbeing (Millennium Ecosystem Assessment 2003). According to the literature reviews, ecosystem service approach is connecting between environmental and socio-economic interests (De Groot et al 2010a; Haines-Young & Potschin 2010). The concept of ecosystem services has undergone many developments and has been used in natural resource assessments since the late 1970s and then continued in the 1990s with the main focus on ecosystem services in the literature (Gómez-Baggethun et al 2010). A study of ecosystem services was conducted among others by Costanza et al (1997) who first valued ecosystem services and natural resource capital globally, and the study was further expanded, particularly since the publication of the concept of ecosystem services carried out by Millennium Ecosystem Assessment in 2003.

The concept of ecosystem services is very important in connecting ecosystem functions with human welfare (Fauzi & Anna 2005). The classification of ecosystem services used should refer to the importance characteristics of the ecosystem and in the context of decisions for how ecosystem services will be used (Fisher et al 2009). Understanding the rules of ecosystem services and functions (provision) to human well-being is also essential in obtaining identification and targets of seeking the natural capital of a system and complementing the requirements of sustainable development (De Jonge et al 2012). The classification of ecosystem services used by the Common International Classification of Ecosystem Services (CICES) has three types of ecosystem services (Haines-Young & Potschin 2013) comprises provisioning categories such as biomass and water, regulating and maintenance such as pest and disease control, and cultural such as physical interactions, intellectual and spiritual with the ecosystem.

Classification of ecosystem services is useful to clarify the understanding in identification of services according to the studied ecosystem. Classification of ecosystem services of Millennium Ecosystem Assessment is widely used (Fisher et al 2009). The classification of CICES specifically focuses on ecosystem outputs that directly contribute to public wellbeing and aims for economic assessment (Haines-Young & Potschin 2013). The use of classification needs to be adapted according to the objectives of the study, particularly if it is related to economic valuations to avoid recurring calculations (Elliff & Kikuchi 2015). A good understanding of ecosystem services will assist in gaining a picture of ecosystem connection with community wellbeing.

Various appropriate efforts in mangrove ecosystem management strategies should be continued. According to Walters et al (2008), improper anticipatory efforts in resource management and land use against the pressures faced may threaten the existence of ecosystems and humans who depend on it. Complexity of the mangrove ecosystem also requires cooperation and participation of all government levels, in addition to policies and programs which still become a key to sustainability of mangrove management and coastal ecosystems (Carter et al 2015). Knowledge and attention to the mangrove ecosystems including changes in ecosystem management is an important basis in further management. Ecosystem service becomes one of the tools to increase the knowledge (Luque et al 2017) and use it in mangrove ecosystem management strategy.

Mangrove ecosystem services. Mangrove has many important ecosystem services and values (Salem & Mercer 2012; Schmitt & Duke 2015). The role of mangrove ecosystem is very important at least on two things (Kusmana & Purwanegara 2015):

1. approximately 75 to 90% of all marine fish species, a whole or a part of its life cycle depends on estuarine habitat, and its productivity depends largely on the production of organic materials from mangrove and seagrass plants;

2. mangrove is one of the main ecosystem types in maintaining coastal environmental quality where approximately 50% of the population in the world and 2/3 of the world's major cities are living in coastal areas.

Indicators of mangrove ecosystem services based on literature reviews vary considerably from provisional, regulatory and maintenance, and cultural. Indonesian people have been traditionally since long time ago utilize mangrove ecosystem services (provisioning) such as for firewood, charcoal, medicines, dye and other uses such as the use of aquatic fauna to support daily life (Kusmana & Sukristijiono 2016). Ecosystem services provided by the mangrove ecosystem are summarized in Table 1.

Table 1

Indicators of mangrove ecosystem services

No	*Category*	*Indicator*	*Description*	*Source*
1	Provisioning	Fishery (food)	Providing fisheries as a source of food	Harahab (2009); Macintosh et al (2010); Kuenzer et al (2011); Sofian et al (2012); Uddin et al (2013); Mukherjee et al (2014); Malik et al (2015b); Vo et al (2015)
		Aquaculture	Cultivation of brackish fisheries such as shrimp and milkfish ponds	Macintosh et al (2010); Kuenzer et al (2011); Mukherjee et al (2014); Malik et al (2015b); Sina et al (2017)
		Honey	A sweet fluid collected by insect	Macintosh et al (2010); Kuenzer et al (2011); Uddin et al (2013); Mukherjee et al (2014)
		Medicines	Traditional medicines	Macintosh et al (2010); Kuenzer et al (2011); Mukherjee et al (2014)
		Feedstock	Mangrove as raw material	Mukherjee et al (2014)
		Energy source	Wood fuel is used for daily activities such as making charcoal, cooking food, burning bricks	Macintosh et al (2010); Kuenzer et al (2011); Uddin et al (2013); Mukherjee et al (2014); Malik et al (2015b)
		Timber	Wood for building and carpentry	Macintosh et al (2010); Uddin et al (2013); Mukherjee et al (2014); Vo et al (2015); Sina et al (2017)
		Tannin	Phenolic substances derived from plants used for tannery	Kuenzer et al (2011)
2	Regulation and maintenance	Water bioremediation	Maintaining water quality	Walters et al (2008); Barbier et al (2011); Mukherjee et al (2014)
		Reducing emission	The presence of mangrove reduces emissions	Mukherjee et al (2014)
		Environmental risk indicator	Mangrove as risk indicator	Mukherjee et al (2014)
		Protecting from sedimentation	Stabilization of land by restraining sediment	Macintosh et al (2010); Mukherjee et al (2014)
		Protecting from sea water intrusion	Mangrove can protect from intrusion	Mukherjee et al (2014); Malik et al (2015b)
		Coastal protection	Protecting the coastal from the onslaught of waves, winds and floods	Macintosh et al (2010); Barbier et al (2011); Kuenzer et al (2011); Mukherjee et al (2014); Malik et al (2015b); Barbier (2016)
		Fish nursery	Mangrove as nursery ground for fish	Mukherjee et al (2014); Malik et al (2015b)
		Carbon sink	Absorbing carbon dioxide	Walters et al (2008); Macintosh et al (2010); Mukherjee et al (2014); Malik et al (2015b); Vo et al (2015)
		Reducing coast and soil erosion	Reduction of coast and soil erosion	Macintosh et al (2010); Barbier et al (2011); Vo et al (2015)
		Climate regulator	an important role on climate change	Macintosh et al (2010)
3	Cultural	Ecotourism and recreation	Providing unique and aesthetic values, and as a suitable habitat for flora and fauna	Macintosh et al (2010); Barbier et al (2011); Kuenzer et al (2011); Uddin et al (2013); Mukherjee et al (2014)
		Aesthetic value	The value of appreciation of the beauty of nature	Uddin et al (2013); Mukherjee et al (2014)
		Spiritual appreciation	Appreciation related to belief	Macintosh et al (2010); Kuenzer et al (2011); Uddin et al (2013)

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Ecosystem services are identified in accordance with the presence of mangrove ecosystems in an area and need to be valued in monetary terms (money) so that they can be clearly calculated for their economic contribution and compared to the market of goods and services (Häyhä & Franzese 2014). The value of ecosystem services can not be ignored, for example the cultural are essential in understanding how humans use and assess nature, but are often ignored in forest assessments due to limitations in measurement and mapping (Luque et al 2017). The values can clarify and strengthen the position of ecosystem services into consideration in the formulation of management strategies.

Value of mangrove ecosystem services. Value of mangrove ecosystem service describes the relative price, usefulness, and importance of a thing (Moore et al 2017). Although assessment of the ecosystem and its services is still a debate (Häyhä & Franzese 2014), economic valuation plays an important role in the assessment of natural resources to assist in decision-making and sustainable management processes (Zhang & Lu 2010; Fauzi 2014; Vo et al 2015). A study conducted by Moore et al (2017) using the ecosystem services natural resource approach (Ecosystem Services-Natural Resources Management) stated that valuation will assist decision makers in evaluating and communicating overall benefits and trade-offs to stakeholders. In assessing forest ecosystem services, the capacity of ecosystem services are determined by the long-term temporal dynamic (Luque et al 2017).

Assessment of goods and services of mangrove ecosystems is needed because mangrove provides many benefits and plays important roles for better conservation (Muraleedharan et al 2009). Economic valuation approach of mangrove resources will help policy makers and decision makers to know the value of mangrove ecosystem comprehensively (Ilman & Suryadiputra 2011). The economic valuation of goods and services of mangrove ecosystems is able to show the benefits of a good mangrove ecosystem for the community and this is an important reason to manage and protect the mangroves (Schmitt & Duke 2015). Understanding of the value and services of mangrove ecosystems is becoming increasingly important for local, national, and global policies and decisions (Kairo et al 2001; Vo et al 2015).

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Mangrove provides real ecosystem services, but is not fully supported by optimal conservation and protection. Conservation as a biodiversity protection often faces inadequate economic resources and thus requires the support of integrative instruments and incorporates economic goals and conservation impacts (Luque et al 2017). Although not all the benefits of ecosystems can be expressed monetarily, some analyzes can still contribute to the various decision options (De Jonge et al 2012).

Studies of mangrove ecosystem valuation in Indonesia have been carried out such as Malik et al (2015b) which estimates that annual mangrove total economic value (TEV) in Takalar District, South Sulawesi ranges from 4,000 to 8,000 USD per hectare, compared to commercial aquaculture that provides net benefits of 3,000 USD per hectare. Indrayanti et al (2015) studied the value of mangrove ecosystem services in Blanakan Subang Bay, West Java obtained the TEV at Rp. 3,815,790,110.97 per year for 782.34 ha mangrove area. Other study by Suharti et al (2016) found the total value of mangroves in East Sinjai with a total area of 758 ha was Rp. 37,535,809,496 per year.

Mangrove ecosystem management in Indonesia. Management of mangrove ecosystems faces a complexity of problems. Mangrove ecosystems as renewable resources provide various types of life support products (Kusmana 2015a), but the ecosystem is subjected to continuous pressure due to natural factors and human activities. Based on the literature reviews, mangrove ecosystem received considerable attention in the theme of ecosystem management in Indonesia. The aspects of the study and coverage area of the studies are diverse, including the conceptual (Effendy 2009; Kusmana 2015a), biophysical analysis (Fahrian et al 2015; Zurba et al 2017), social analysis (Ritohardoyo & Ardi 2011; Harahab 2011; Kustanti et al 2015; Febryano et al 2015), economic valuation (Ruitenbeek 1994; Saprudin & Halidah 2012), institutional (Suharti et al 2016; Kuvaini et al 2017), and regulation (Sunyowati et al 2016). Other

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studies were done on sustainability status (Mukhlisi et al 2014; Theresia et al 2015; Karlina et al 2017), system model (Datunsolang 2016) and management strategies (Wijayanto et al 2013; Yenny et al 2017; Lugina et al 2017). The studies generally focused on the sustainability and socio-economic aspect. The study of mangrove ecosystems management that comprehensively focuses analyze ecosystem services and institutional structure is still relatively limited.

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Management of mangrove ecosystems requires an approach that can connect the interests of environmental sustainability and benefits for human wellbeing in a balanced way. One of the efforts can be done is by comprehensive reviewing of ecosystem services. It is supported by several aspects that have been widely discussed in various studies, including:

1. Ecology - mangrove ecosystem has been recognized to have the function and benefits for the environment and the preservation of biodiversity. Based on Kusmana (2014), mangrove resources in Indonesia have been supporting many kinds of human needs ;
2. Socio-economic - mangrove ecosystem plays an important role for the community wellbeing such as food and livelihood sources ;
3. Institutional - mangrove ecosystem is a means of managing both protection, rehabilitation, and even utilization that involves the attention and participation of many parties such as government, private, NGO, and society. Since 2013, the Indonesian government has initiated the formation of a National Mangrove Working Group (KKMN) that consists of cross-sector/institutional/NGO;
4. Regulations and laws - mangrove ecosystem in Indonesia already has a regulatory instrument that specifically focuses on the national management strategy, namely Presidential Regulation no. 73 of 2012. In addition, it is supported by Government Regulation no. 26 of 2008 concerning about national spatial plan, Government Regulation no. 73 of 2013 concerning about swamps, Presidential Regulation No. 51 of 2016 concerning about coastline boundaries.

The concept of ecosystem services is also used by academics, researchers and decision makers to support and explain environmental management and biodiversity conservation strategies (Martín-López et al 2012). Ecosystem services still need to be studied as a basis for the development strategy for mangrove ecosystem management because it is an important part in the management of mangrove ecosystems (Schmitt & Duke 2015; Karlina et al 2017). According to Brander et al (2012) potential research on mangrove ecosystems in the future is research that combines ecology and economy to make a model of supply and service of mangrove ecosystem. Policies and programs are becoming more complex with the bureaucracy and authority involved in mangrove conservation, but it is still a key for the sustainability of mangrove and coastal ecosystem management (Carter et al 2015). Therefore, a new and more integrative approach is needed to assess sustainable development (Turner et al 2016), including the management of mangrove ecosystems.

Ecosystem service approaches can be applied in the context of mangrove ecosystem management as shown in Figure 1. Mangrove ecosystems face various pressures and dynamic changes that will also impact on ecosystem services and human life, thus it is necessary to develop sustainable ecosystem service-based management strategies.

One of the challenges of managing mangrove ecosystems is linking dynamic mangrove ecosystems with complex socio-economic life of communities such as mangrove positions near settlements and in urban areas. Management of mangrove ecosystems in the future also need to be oriented broadly to be able to measure the importance of mangrove ecosystem services for the community itself. Well managed mangrove ecosystems have the potential to have good ecosystem services and will support the sustainability of mangrove development. The role of mangrove ecosystems also requires sustainable mangrove ecosystem management. It is supported by three important pillars, namely ecology, social and economy which are covered by appropriate institutional and regulation (Kusmana 2015a). Mangroves can not be ignored because

their ecosystem services have distinctive characteristics that indicate that ecosystems provide services and have value for human wellbeing.

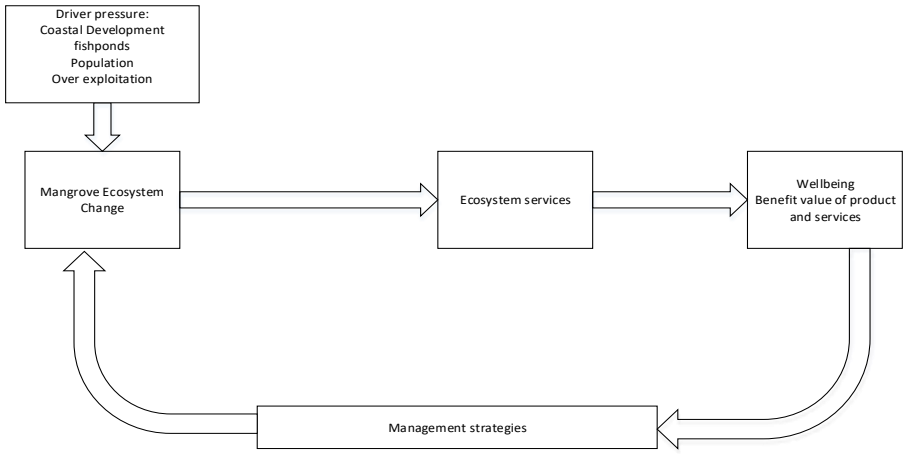

Figure 1. The application of ecosystem services approach on mangrove management (adopted from De Groot et al 2010a; Haines-Young & Potschin 2010).

Study, analysis, and strategy of mangrove ecosystem services. A review of mangrove ecosystem service management is conducted as a strategy to develop management policy to be more able to guarantee ecosystem services both in the present and in the future. Several studies that have been conducted previously provided an illustration of the importance of ecosystem service management (Mukherjee et al 2014; Kusmana 2015a; Carter et al 2015; Kustanti et al 2015; Vo et al 2015; Malik et al 2015a; Ilman et al 2016; Orchard et al 2016; Suharti et al 2016). Studies on ecosystem service approaches are also widely conducted (De Groot et al 2010a; De Groot et al 2010b; Haines-Young & Potschin 2010; Martín-López et al 2012; Elliff & Kikuchi 2015; Moore et al 2017). Researches on mangroves management related to ecosystem services have been developed, those are:

a. Analysis of ecosystem service conditions. Assessment of ecosystem services can be assessed by analyzing conditions and indicators of the ecosystem service. This aspect is crucial because directly related to the processes occurring in the ecosystem and will have an impact on the availability of ecosystem services. Similarly with mangrove ecosystems, intensive mangrove forest use has had an impact on biodiversity and mangrove ecosystem services (Malik et al 2015a). Therefore, knowledge of the status of mangrove forests is essential for better planning and management (Schmitt & Duke 2015). A study conducted by Malik et al (2015a) has assessed the ecological impact of mangrove utilization and the level of exploitation of ecosystem services in mangrove forests of South Sulawesi. Analysis of the mangrove ecosystem condition and its services is identified either directly or indirectly and analyzed according to the characteristics, coverage areas and categories specified. Geographic information systems (GIS) and remote sensing are used in various areas including in the management of mangrove ecosystems. Spatial analysis through GIS and remote sensing can assist spatially in mapping ecosystem services conditions. Ecosystem service mapping is crucial to understand the contribution of ecosystems to human wellbeing and supporting policies that impact natural resources (Burkhard & Maes 2017). Conservation and management of effective mangrove habitats need to consider remote sensing and GIS based on a comprehensive data approach (Ghosh et al 2015). Several studies related to mangrove ecosystem services using GIS approach and remote sensing have been conducted, such as Omo-Irabor et al (2011), reviewed comprehensively the use of socio-economic and environmental criteria with the opinion of expert, GIS, and SMCA (Spatial Multi Criteria

Analysis) for vulnerability assessment of mangroves. Atkinson et al (2016) has assessed the value and priority of mangrove ecosystem services using spatial GIS and cost benefit of ecosystem services in decision making. Studies with GIS and remote sensing rapproaches can provide spatial advantages, one of which can generate significant ecological and economic benefits by obtaining real time data from unreachable area (Ghosh et al 2015). However, there are several things that need to be considered, including ecosystem services that must be assessed in the right spatial context and economic valuations that can support decisions so that policies are more useful (Vo et al 2015).

b. Social economics and valuation. Socioeconomic studies of mangrove ecosystem management related to ecosystem services have also received much attention in line with the dynamic changes and complexity that occur in mangrove ecosystem. Study of Orchard et al (2016) has reviewed the dynamics of mangrove systems in Southeast Asia by linking livelihoods with the services of mangrove ecosystems. Other socio-economic studies are economic valuations as conducted by Uddin et al (2013) that implement economic valuation of ecosystem services for protected areas of mangrove ecosystem in Sundarbarns, Bangladesh. Economic valuation of the mangrove ecosystem is quite widely studied, although not many of the result were used as one of the foundations in policy making. Valuation of ecosystem services highly depends on services from the nature, such as ecosystem functions that produce goods and services that can be sold with various alternative methods (Salem & Mercer 2012). Various types of monetary valuation measurements are used according to the type of ecosystem services, although it does not allow to explain the scope of the monetary value of all ecosystem services (De Jonge et al 2012). Several methods of economic valuation are used in the valuation of mangrove ecosystem services as shown in Table 2.

Table 2

Economic valuation method of mangrove ecosystem services

Method	*Description*	*Example application*
TCM	The revealed assessment method to assess the non-use benefit based on the observed behavior of individual expenditures for travel	Indrayanti et al (2015); Fitriana et al (2017)
MM	An assessment obtained directly from the amount a person must pay for goods and services such as timber products	Uddin et al (2013); Malik et al (2015b); Vo et al (2015); Ye et al (2016); Suharti et al (2016)
HPM	Describes an assessment of a thing (goods or service) that is perceived because of pleasure characteristic, such as beautiful scenery, convenience or other characteristics	Syukri (2016)
PA	The value of services assessed by the impact of these services on economic outcomes (e.g. increased shrimp yields from wetland increases)	Malik et al (2015b)
CVM	Non-market valuation which is a direct method for economic assessment through willingness to pay (WTP)	Suharti et al (2016)
CE	Choice experiment is a choice technique. it allows reveal the role of an attribute that causes an individual to choose an object from several alternative object choices	McDonough et al (2014)
RC	Calculates the loss of natural system services at the cost incurred to replace the service	Malik et al (2015b); Vo et al (2015); Suharti et al (2016)
AC	Calculating services based on avoidable expenses such as clean water reduces the cost of diarrhea treatment	-
REA/ HEA	The damage assessment method based on calculating the scale of the restoration project to restore the resource service to the initial conditions	Winarno et al (2016)
BoE	Methods economic valuation on marketed components such as the calculation of economic losses due to pollution to health	-
BT	Transfers from the alleged value of non-market benefits from other sites to the research sites	Brander et al (2012); Malik et al (2015b); Vo et al (2015); Ye et al (2016); Suharti et al (2016)

The description according to Fauzi (2014); Turner et al (2016).

TCM : Travel Cost Method; MM: Market Method; HPM: Hedonic Price Method; PA: Production Approach, CVM: Contingent Valuation Method; CE: Choice Experiment; RC: Replacement Cost; AC: Avoidance Cost; REA/HEA: Resource Equivalency Analysis/Habitat Equivalency Analysis; BoE: Back of the envelope; BT: Benefit Transfer.

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c. System structure. System is a unity of efforts, consisting of interrelated parts regularly, and trying to achieve goals in a complex environment (Marimin & Maghfiroh 2010). Structure describes the arrangement of the elements and relationships between elements in forming a system. Every system approach always prioritizes the study of the system structure both explanatory and as policy support (Eriyatno 2012). Management of mangrove ecosystem services can be analyzed by a system approach because mangrove ecosystem is a complex system. Understanding of the system structure is one way to achieve the effective management objectives of the complex system.

Structural analysis is a good and powerful design tool for sharing knowledge and experience (Omran et al 2014). The core of this method is the measurement of the relationship between variables and the simplification of the system by selecting the most influential external variables and the most sensitive internal variables (key variables) (Fierro 2015). The most popular structuring tool for indirect relationship is MICMAC, whereas for direct relationship is used Interpretative Structural Modeling (ISM) technique (Eriyatno 2012).

MICMAC (cross-impact matrix multiplication applied to classification) is a structural analysis (Suprun et al 2016) that uses Boolean matrix to classify variables based on strength and dependence (Ambrosio-Albala & Delgado 2008). Structural analysis provides simulated reflection with expert skill and can be easily applied to problem formulation in a matrix design and supports qualitative studies (Omran et al 2014). MICMAC is one of the standard tools of scenario analysis built by Michel Godet, which presents a structured process in identifying variables for scenarios that may occur in the future based on expert opinions on system interactions (Veltmeyer & Sahin 2014). MICMAC method is performed by defining the problem and proceeding with 3 following stages (Benjumea-Arias et al 2016; Nazarko et al 2017):

- identification of internal and external variables;
- analysis of relationship between variables in the system;
- identification of key variable qualifies: direct and indirect classification.

Furthermore, the influence and dependence analysis is obtained through the position of the variable indicator in the quadrant. Variables can be in the variable power, autonomous, conflict or the output variables depending on the level of influence and dependence it has.

d. Future prospective strategies. The characteristic of strategies decisions is long term, dynamic environment and influences factors with very low certainty (Marimin & Maghfiroh 2010). Godet (2000) has described scenario analysis, the concept of prospective strategy, and the stages of scenario analysis process along with its usable tools and case study examples. A prospective method is as a tool for generalize of strategic knowledge to design future sustainability and allowing for designing different future scenarios by planning the transformation of the current situation into the expected future (Fierro 2015). The objectives of identifying future conditions are to identify their characteristics and impacts, and to calculate the relative probability of occurrence (Bishop et al 2007).

Strategy is needed to overcome the mangrove ecosystem pressure. Management strategies should also be developed to achieve the sustainability objectives of the mangrove ecosystem to ensure the sustainability of ecological and socio-economic functions and not harm the lives of present and future generations (KKMTN 2013). Iftekhar & Islam (2004) mention the key strategies of mangrove management such as holistic management adoption, conservation and biodiversity improvement, impact zone management, government and non-government collaboration in management, community participation, non-exploitative utilization promotion, and sustainability planting on deltaber.

Several studies of mangrove ecosystem management strategies have been conducted including Iftekhar & Islam (2004) assessed the management of mangrove ecosystem using strategy analysis, and Atkinson et al (2016) assessed the management of mangrove ecosystems using cost-effectiveness analysis with the cost benefit of ecosystem services for several scenarios to obtain effective management. Other studies

such as Faperi et al (2015), reviewed mangrove degradation management strategies using vegetation analysis, structural equation modeling (SEM), AHP and SWOT. Another prospective method that has been used in other fields is SMIC-Prob-Expert. SMIC-Prob-Expert is a cross-impact analysis built by Michael Godet to combine beneficial aspects, both quality and quantity (Lakner & Baker 2014). SMIC (Cross Impact Systems and Matrices) has several advantages among cross impact methods, including easy to use with the help of questionnaires, quick, and inexpensive. These characteristics make it easy to explain the results. However, this method requires a lot of thought in giving information treatment to choose an important hypothesis. The strategy hypothesis formulation also requires structural analysis and understanding of key variables. The results of the SMIC method are scenario hierarchy and sensitivity analysis.

Research prospect of mangrove ecosystem services. Ecosystem services as previously reviewed have an important position in the management of mangrove ecosystems and may assist describe the ecosystem relationship with human life. There are several assessment opportunities related to the management of mangrove ecosystem services that can be further examined, including:

1. mangrove ecosystem condition that focuses on ecosystem service in accordance with the region;
2. economic valuation of mangrove ecosystem services is important in determining the value and can be a consideration in the management strategy;
3. system structure of the mangrove ecosystem management variables associated with the ecosystem services and main variable analysis;
4. pressures and complexity that exist in the mangrove ecosystem and its survival strategies in facing future changes (prospective) based on current conditions in the management of ecosystem services.

Aspects of the study as previously described certainly integrate mangrove ecosystem services into challenges in the development of management strategies. Although ecosystem services from a number of existing studies may connecting ecosystem and community wellbeing, yet the existing literature is limited, particularly in linking ecosystem services to future management strategies. This is particularly important considering the dynamic nature of ecosystems and external pressures such as continuous population increases. Existing mangrove ecosystem management strategies have not fully reviewed ecosystem services comprehensively in order to anticipate changes in the ecosystem and ensure services to be provided. In addition, the review can be an answer in the context of a sustainable development assessment requiring a new and more integrative approach (Turner et al 2016), included in the management of mangrove ecosystem services in Indonesia.

Conclusions. Mangroves have ecosystem services that are beneficial for human life and other biota, but continue to experience destruction and decline due to excessive exploitation. Increasingly large and complex pressures on mangrove ecosystems will greatly increase the pressure on sustainability of ecosystem services. This should be considered by policy makers in mangrove ecosystem management strategies. Ecosystem services will also be closely linked to the characteristics of each region and the value that requires in-depth analysis. The study of mangrove ecosystem management variables will also be very useful in decision making for development of management strategies in the future. This article contributes to provide a road map for research opportunities in mangrove ecosystem management especially in the context of ecosystem services. This study will become an input in answering the challenges of managing complex and dynamic mangrove ecosystems in Indonesia. Therefore, the development of ecosystem management strategies is still likely to be studied as an effort to achieve sustainable management objectives.

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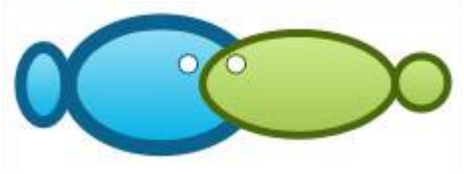

Ecosystem services-based mangrove management strategies in Indonesia - a review[indra1][a2]

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Abstract. Mangrove ecosystems have strategic benefits and complex management. Management of mangrove ecosystems also faces pressures and challenges to maintain them in sustainable condition. This study was aimed to review various literatures on mangrove management, particularly related to ecosystem services, and to find contribution opportunities in this field of research. Ecosystem service approach is more developed in natural resource management and becomes an instrument connecting ecosystem functions with human wellbeing. Analysis results showed that ecosystem services are an important part of mangrove management. Mangrove provides many ecosystem services and has an important role in both the number and the type of ecosystem services. There are several research opportunities which can be conducted namely ecosystem service condition analysis, socio-economic analysis and valuation, system structure, and future prospective strategies. These aspects are certainly a challenge in developing a dynamic and complex mangrove ecosystem management strategy in Indonesia as an effort to achieve sustainable management objectives.
Key Words: ecosystem services, management, valuation, mangrove, socio-economic.

Introduction. Ecosystem service is one of the great interest topics for many scientists and has been on the rise over the past decade (Mcdonough et al 2017). Ecosystem services are the benefits that humans derive directly or indirectly from ecosystem functions (Costanza et al 1997; Häyhä & Franzese 2014). Ecosystem service is defined as benefits of ecosystems for human wellbeing (Millennium Ecosystem Assessment 2005a; TEEB 2010; Elliff & Kikuchi 2015). The concept of ecosystem services is very interesting to study for some reason[indra5][a6]: (1) it may assist describing the connection and dependence of humans on nature; and (2) describes how human impacts on ecosystems alter the capacity in providing services, so appropriate policies can be developed (Haines-Young & Potschin 2013). Ecosystem is a functional unit of the biological community of animals, plants, microorganisms and non-biological environments that are complex and highly dynamic, and interact with each other (Millennium Ecosystem Assessment 2003). The mangrove ecosystem is one of the ecosystems that have various benefits of service for the society welfare but faces the pressures.

Indonesia is an archipelago country with more than 17,504 islands and about 95,181 km coastline (Kusmana & Sukristijiono 2016). Indonesia has a 3.1-3.7 million hectares mangrove forest area or more than 20% of world's mangrove forests with high species diversity (Giri et al 2011; Kusmana 2015b; Ilman et al 2016). Beside that, Potential area to be planted with mangrove species is around 7.8 million hectares (Kusmana 2015b). Indonesia's mangrove has a specific function because it lies between the terrestrial and marine ecosystems, and support various types of human needs,

especially for local communities in mangrove forests and surrounding areas (Kusmana 2015b; Kusmana & Sukristijiono 2016). This facts show that the potential of mangrove ecosystem in Indonesia is quite large at this time.

Mangrove forests contribute in providing ecosystem services and supporting the livelihoods of coastal communities around the world (Polidoro et al 2010). Mangrove ecosystems have an important role in the socio-economic of communities, even for millions of people in the tropics and subtropics (Atkinson et al 2016). The important role of mangrove ecosystems are providing ecological and biophysical services, and providing a variety of important ecosystem products and services that are critical to the livelihoods of nearby communities (Barbier et al 2011; Malik et al 2015a; Orchard et al 2016). In addition, mangrove ecosystems also serve ecological functions in providing ecosystem services, nutrient cycles, soil formation, timber production, fish spawning, ecotourism and carbon storage (C) (Murdiyarso et al 2015) including economic activities such as providing timber and leaves as raw medicine materials (Sonjaya 2007).

The mangrove ecosystem is one of the most endangered ecosystems in the world. It experiences encroachment pressure and land degradation continuously, mainly driven by human activities (Ghosh et al 2015). Ilman et al (2016) studied about the drivers of the loss of Indonesia's mangrove forests through historical image analysis and estimated the decline of mangrove forest area in all regions of Indonesia by 22 percent. The largest percentage was occurred in Java Island by 75 percent. Pressures on mangrove ecosystems and more widespreading of degraded land have potential in affecting ecosystem services as well. Ecosystem services are also attached to the mangrove ecosystem so that it will also affect the management policy. Therefore, the mangrove ecosystem need to be managed to provide benefits for current and future generations.

Mangrove and conservation management policies are emerging worldwide in line with the increasing appreciation of the benefit of mangrove (Carter et al 2015). Mangrove ecosystem as described by Kusmana (2015a) requires a management because mangroves have the benefit of providing ecosystem goods and services, but also experiences the destruction. The management needs to be integrated and sustained. Management of sustainable mangrove ecosystems is an integration of all efforts to realize the sustainability of mangrove ecosystem functions for the community wellbeing (Presidential Regulation of the Republic of Indonesia No. 73 of 2012). Sustainable management is in accordance with the development orientation that attention to social, ecological and economic sustainability[indra7][a8] (Turner et al 2016). Indicators used in the management of mangrove ecosystems were ecology, economy, social and institutional (Iftekhar & Islam 2004; KKMTN 2013; Schmitt & Duke 2015; Kusmana 2015a; Orchard et al 2016).

Ecosystem services are important aspect in ecological and socio-economic studies of mangrove management. The linkage of ecosystem services and mangrove management is very closely related to the function of mangrove ecosystem to human wellbeing. Therefore, mangrove ecosystem services must be an important aspect in the management. This study was aimed to review various literatures on mangrove management, particularly related to ecosystem services and to find contribution opportunities in this field of research.

This review used a literature study concerning "mangrove management" and "ecosystem services" in the title, abstract, keywords, and content. A review of the literature to better understand current conditions in the development of research fields, both theme, methods and other combinations are associated with ecosystem services and mangrove management. The study was conducted through defining stages and topics, searching and selecting studies, analyzing and synthesizing. The defining stage is done by explaining the ecosystem services and mangrove management, while the topics were focused on six studies after introduction, those are: (1) the concept of ecosystem services, (2) mangrove ecosystem services, (3) the value of mangrove ecosystem services, (4) mangrove ecosystem management in Indonesia, (5) study, analysis, and strategy of mangrove services management, and (6) research prospect of ecosystem service management. Scientific publications which become reference are derived from the

scopus data base (https://www.scopus.com), google scholar (https://scholar.google.com/), garuda portal (http://id.portalgaruda.org/) as well as various other literatures such as reports, and supporting books.

Concept of ecosystem services. Ecosystem provides many services to the human as part of the ecosystem itself. Changes that occur in the ecosystem will certainly affect the existence of ecosystem services and ultimately on human wellbeing (Millennium Ecosystem Assessment 2003). According to the literature reviews, ecosystem service approach is connecting between environmental and socio-economic interests (De Groot et al 2010a; Haines-Young & Potschin 2010). The concept of ecosystem services has undergone many developments and has been used in natural resource assessments since the late 1970s and then continued in the 1990s with the main focus on ecosystem services in the literature (Gómez-Baggethun et al 2010). A study of ecosystem services was conducted among others by Costanza et al (1997) who first valued ecosystem services and natural resource capital globally, and the study was further expanded, particularly since the publication of the concept of ecosystem services carried out by Millennium Ecosystem Assessment in 2003.

The concept of ecosystem services is very important in connecting ecosystem functions with human welfare (Fauzi & Anna 2005). The classification of ecosystem services used should refer to the importance characteristics of the ecosystem and in the context of decisions for how ecosystem services will be used (Fisher et al 2009). Understanding the rules of ecosystem services and functions (provision) to human well-being is also essential in obtaining identification and targets of seeking the natural capital of a system and complementing the requirements of sustainable development (De Jonge et al 2012). The classification of ecosystem services used by the Common International Classification of Ecosystem Services (CICES) has three types of ecosystem services (Haines-Young & Potschin 2013) comprises provisioning categories such as biomass and water, regulating and maintenance such as pest and disease control, and cultural such as physical interactions, intellectual and spiritual with the ecosystem.

Classification of ecosystem services is useful to clarify the understanding in identification of services according to the studied ecosystem. Classification of ecosystem services of Millennium Ecosystem Assessment is widely used (Fisher et al 2009). The classification of CICES specifically focuses on ecosystem outputs that directly contribute to public wellbeing and aims for economic assessment (Haines-Young & Potschin 2013). The use of classification needs to be adapted according to the objectives of the study, particularly if it is related to economic valuations to avoid recurring calculations (Elliff & Kikuchi 2015). A good understanding of ecosystem services will assist in gaining a picture of ecosystem connection with community wellbeing.

Various appropriate efforts in mangrove ecosystem management strategies should be continued. According to Walters et al (2008), improper anticipatory efforts in resource management and land use against the pressures faced may threaten the existence of ecosystems and humans who depend on it. Complexity of the mangrove ecosystem also requires cooperation and participation of all government levels, in addition to policies and programs which still become a key to sustainability of mangrove management and coastal ecosystems (Carter et al 2015). Knowledge and attention to the mangrove ecosystems including changes in ecosystem management is an important basis in further management. Ecosystem service becomes one of the tools to increase the knowledge (Luque et al 2017) and use it in mangrove ecosystem management strategy.

Mangrove ecosystem services. Mangrove has many important ecosystem services and values (Salem & Mercer 2012; Schmitt & Duke 2015). The role of mangrove ecosystem is very important at least on two things (Kusmana & Purwanegara 2015):

1. approximately 75 to 90% of all marine fish species, a whole or a part of its life cycle depends on estuarine habitat, and its productivity depends largely on the production of organic materials from mangrove and seagrass plants;

2. mangrove is one of the main ecosystem types in maintaining coastal environmental quality where approximately 50% of the population in the world and 2/3 of the world's major cities are living in coastal areas.

Indicators of mangrove ecosystem services based on literature reviews vary considerably from provisional, regulatory and maintenance, and cultural. Indonesian people have been traditionally since long time ago utilize mangrove ecosystem services (provisioning) such as for firewood, charcoal, medicines, dye and other uses such as the use of aquatic fauna to support daily life (Kusmana & Sukristijiono 2016). Ecosystem services provided by the mangrove ecosystem are summarized in Table 1.

Table 1

Indicators of mangrove ecosystem services

No	*Category*	*Indicator*	*Description*	*Source*
1	Provisioning	Fishery (food)	Providing fisheries as a source of food	Harahab (2009); Macintosh et al (2010); Kuenzer et al (2011); Sofian et al (2012); Uddin et al (2013); Mukherjee et al (2014); Malik et al (2015b); Vo et al (2015)
		Aquaculture	Cultivation of brackish fisheries such as shrimp and milkfish ponds	Macintosh et al (2010); Kuenzer et al (2011); Mukherjee et al (2014); Malik et al (2015b); Sina et al (2017)[indra9][a10]
		Honey	A sweet fluid collected by insect	Macintosh et al (2010); Kuenzer et al (2011); Uddin et al (2013); Mukherjee et al (2014)
		Medicines	Traditional medicines	Macintosh et al (2010); Kuenzer et al (2011); Mukherjee et al (2014)
		Feedstock	Mangrove as raw material	Mukherjee et al (2014)
		Energy source	Wood fuel is used for daily activities such as making charcoal, cooking food, burning bricks	Macintosh et al (2010); Kuenzer et al (2011); Uddin et al (2013); Mukherjee et al (2014); Malik et al (2015b)
		Timber	Wood for building and carpentry	Macintosh et al (2010); Uddin et al (2013); Mukherjee et al (2014); Vo et al (2015); Sina et al (2017)
		Tannin	Phenolic substances derived from plants used for tannery	Kuenzer et al (2011)
2	Regulation and maintenance	Water bioremediation	Maintaining water quality	Walters et al (2008); Barbier et al (2011); Mukherjee et al (2014)
		Reducing emission	The presence of mangrove reduces emissions	Mukherjee et al (2014)
		Environmental risk indicator	Mangrove as risk indicator	Mukherjee et al (2014)
		Protecting from sedimentation	Stabilization of land by restraining sediment	Macintosh et al (2010); Mukherjee et al (2014)
		Protecting from sea water intrusion	Mangrove can protect from intrusion	Mukherjee et al (2014); Malik et al (2015b)
		Coastal protector (seawall)	Protecting the coastal from the onslaught of waves, winds and floods	Macintosh et al (2010); Barbier et al (2011); Kuenzer et al (2011); Mukherjee et al (2014); Malik et al (2015b); Barbier (2016)
		Fish nursery	Mangrove as nursery ground for fish	Mukherjee et al (2014); Malik et al (2015b)
		Carbon sink	Absorbing carbon dioxide	Walters et al (2008); Macintosh et al (2010); Mukherjee et al (2014); Malik et al (2015b); Vo et al (2015)
		Reducing coast and soil erosion	Reduction of coast and soil erosion	Macintosh et al (2010); Barbier et al (2011); Vo et al (2015)
		Climate regulator	an important role on climate change	Macintosh et al (2010)
3	Cultural	Ecotourism and recreation	Providing unique and aesthetic values, and as a suitable habitat for flora and fauna	Macintosh et al (2010); Barbier et al (2011); Kuenzer et al (2011); Uddin et al (2013); Mukherjee et al (2014)

	Aesthetic value	The value of appreciation of the beauty of nature	Uddin et al (2013); Mukherjee et al (2014)
	Spiritual appreciation	Appreciation related to belief	Macintosh et al (2010); Kuenzer et al (2011); Uddin et al (2013)

Ecosystem services are identified in accordance with the presence of mangrove ecosystems in an area and need to be valued in monetary terms (money) so that they can be clearly calculated for their economic contribution and compared to the market of goods and services (Häyhä & Franzese 2014). The value of ecosystem services can not be ignored, for example the cultural are essential in understanding how humans use and assess nature, but are often ignored in forest assessments due to limitations in measurement and mapping (Luque et al 2017). The values can clarify and strengthen the position of ecosystem services into consideration in the formulation of management strategies.

Value of mangrove ecosystem services. Value of mangrove ecosystem service describes the relative price, usefulness, and importance of a thing (Moore et al 2017). Although assessment of the ecosystem and its services is still a debate (Häyhä & Franzese 2014), economic valuation plays an important role in the assessment of natural resources to assist in decision-making and sustainable management processes (Zhang & Lu 2010; Fauzi 2014; Vo et al 2015). A study conducted by Moore et al (2017) using the ecosystem services natural resource approach (Ecosystem Services-Natural Resources Management) stated that valuation will assist decision makers in evaluating and communicating overall benefits and trade-offs to stakeholders. In assessing forest ecosystem services, the capacity of ecosystem services are determined by the long-term temporal dynamic (Luque et al 2017).

Assessment of goods and services of mangrove ecosystems is needed because mangrove provides many benefits and plays important roles for better conservation (Muraleedharan et al 2009). Economic valuation approach of mangrove resources will help policy makers and decision makers to know the value of mangrove ecosystem comprehensively (Ilman & Suryadiputra 2011[indra11][a12]). The economic valuation of goods and services of mangrove ecosystems is able to show the benefits of a good mangrove ecosystem for the community and this is an important reason to manage and protect the mangroves (Schmitt & Duke 2015). Understanding of the value and services of mangrove ecosystems is becoming increasingly important for local, national, and global policies and decisions (Kairo et al 2001; Vo et al 2015).

Mangrove provides real ecosystem services, but is not fully supported by optimal conservation and protection. Conservation as a biodiversity protection often faces inadequate economic resources and thus requires the support of integrative instruments and incorporates economic goals and conservation impacts (Luque et al 2017). Although not all the benefits of ecosystems can be expressed monetarily, some analyzes can still contribute to the various decision options (De Jonge et al 2012).

Studies of mangrove ecosystem valuation in Indonesia have been carried out such as Malik et al (2015b) which estimates that annual mangrove total economic value (TEV) in Takalar District, South Sulawesi ranges from 4,000 to 8,000 USD per hectare, compared to commercial aquaculture that provides net benefits of 3,000 USD per hectare. Indrayanti et al (2015) studied the value of mangrove ecosystem services in Blanakan Subang Bay, West Java obtained the TEV at Rp. 3,815,790,110.97 per year for 782.34 ha mangrove area. Other study by Suharti et al (2016) found the total value of mangroves in East Sinjai with a total area of 758 ha was Rp. 37,535,809,496 per year.

Mangrove ecosystem management in Indonesia. Management of mangrove ecosystems faces a complexity of problems. Mangrove ecosystems as renewable resources provide various types of life support products (Kusmana 2015a), but the ecosystem is subjected to continuous pressure due to natural factors and human activities. Based on the literature reviews, mangrove ecosystem received considerable attention in the theme of ecosystem management in Indonesia. The aspects of the study and coverage area of the studies are diverse, including the conceptual (Effendy 2009; Kusmana 2015a), biophysical analysis (Fahrian et al 2015; Zurba et al 2017), social

analysis (Ritohardoyo & Ardi 2011; Harahab 2011; Kustanti et al 2015; Febryano et al 2015), economic valuation (Ruitenbeek 1994[indra13][a14]; Saprudin & Halidah 2012), (Suharti et al 2016; Kuvaini et al 2017), and regulation (Sunyowati et al 2016). Other studies were done on sustainability status (Mukhlisi et al 2014; Theresia et al 2015; Karlina et al 2017), system model (Datunsolang 2016) and management strategies (Wijayanto et al 2013; Yenny et al 2017; Lugina et al 2017). The studies generally focused on the sustainability and socio-economic aspect. The study of mangrove ecosystems management that comprehensively focuses analyze ecosystem services and institutional structure is still relatively limited.[indra15][a16]

Management of mangrove ecosystems requires an approach that can connect the interests of environmental sustainability and benefits for human wellbeing in a balanced way. One of the efforts can be done is by comprehensive reviewing of ecosystem services. It is supported by several aspects that have been widely discussed in various studies, including:

1. Ecology - mangrove ecosystem has been recognized to have the function and benefits for the environment and the preservation of biodiversity. Based on Kusmana (2014), mangrove resources in Indonesia have been supporting many kinds of human needs ;

2. Socio-economic - mangrove ecosystem plays an important role for the community wellbeing such as food and livelihood sources ;

3. Institutional - mangrove ecosystem is a means of managing both protection, rehabilitation, and even utilization that involves the attention and participation of many parties such as government, private, NGO, and society. Since 2013, the Indonesian government has initiated the formation of a National Mangrove Working Group (KKMN) that consists of cross-sector/institutional/NGO;

4. Regulations and laws - mangrove ecosystem in Indonesia already has a regulatory instrument that specifically focuses on the national management strategy, namely Presidential Regulation no. 73 of 2012. In addition, it is supported by Government Regulation no. 26 of 2008 concerning about national spatial plan, Government Regulation no. 73 of 2013 concerning about swamps, Presidential Regulation No. 51 of 2016 concerning about coastline boundaries.

The concept of ecosystem services is also used by academics, researchers and decision makers to support and explain environmental management and biodiversity conservation strategies (Martín-López et al 2012). Ecosystem services still need to be studied as a basis for the development strategy for mangrove ecosystem management because it is an important part in the management of mangrove ecosystems (Schmitt & Duke 2015; Karlina et al 2017). According to Brander et al (2012) potential research on mangrove ecosystems in the future is research that combines ecology and economy to make a model of supply and service of mangrove ecosystem. Policies and programs are becoming more complex with the bureaucracy and authority involved in mangrove conservation, but it is still a key for the sustainability of mangrove and coastal ecosystem management (Carter et al 2015). Therefore, a new and more integrative approach is needed to assess sustainable development (Turner et al 2016), including the management of mangrove ecosystems.

Ecosystem service approaches can be applied in the context of mangrove ecosystem management as shown in Figure 1. Mangrove ecosystems face various pressures and dynamic changes that will also impact on ecosystem services and human life, thus it is necessary to develop sustainable ecosystem service-based management strategies.

One of the challenges of managing mangrove ecosystems is linking dynamic mangrove ecosystems with complex socio-economic life of communities such as mangrove positions near settlements and in urban areas. Management of mangrove ecosystems in the future also need to be oriented broadly to be able to measure the importance of mangrove ecosystem services for the community itself. Well managed mangrove ecosystems have the potential to have good ecosystem services and will support the sustainability of mangrove development. The role of mangrove ecosystems also requires sustainable mangrove ecosystem management. It is supported by three

important pillars, namely ecology, social and economy which are covered by appropriate institutional and regulation (Kusmana 2015a). Mangroves can not be ignored because their ecosystem services have distinctive characteristics that indicate that ecosystems provide services and have value for human wellbeing.

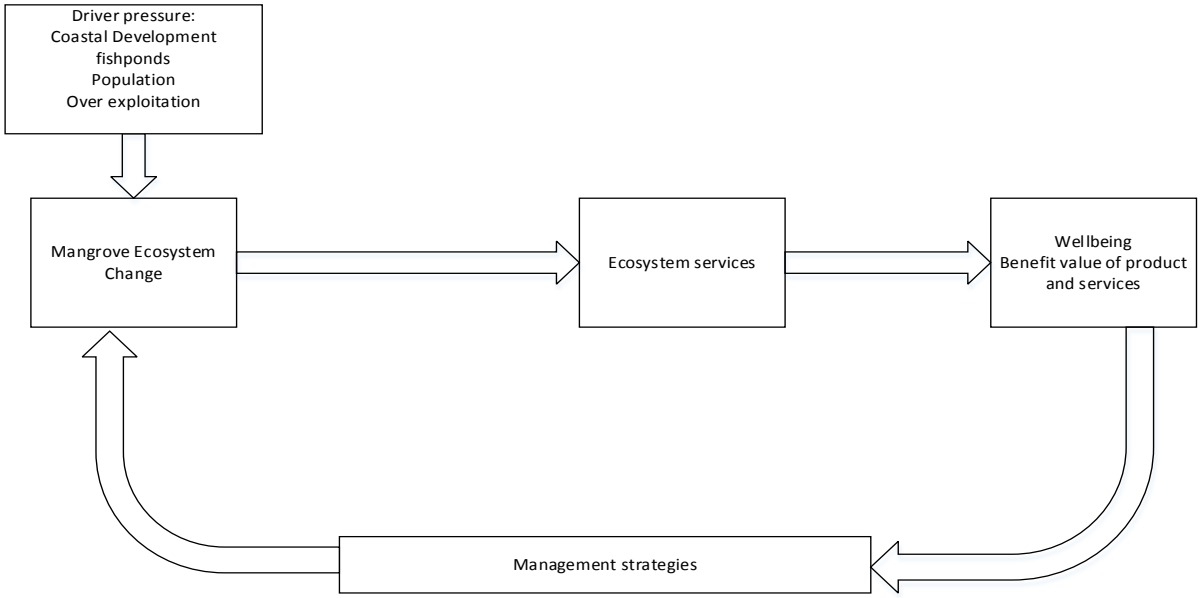

Figure 1. The application of ecosystem services approach on mangrove management (adopted from De Groot et al 2010a; Haines-Young & Potschin 2010).

Study, analysis, and strategy of mangrove ecosystem services. A review of mangrove ecosystem service management is conducted as a strategy to develop management policy to be more able to guarantee ecosystem services both in the present and in the future. Several studies that have been conducted previously provided an illustration of the importance of ecosystem service management (Mukherjee et al 2014; Kusmana 2015a; Carter et al 2015; Kustanti et al 2015; Vo et al 2015; Malik et al 2015a; Ilman et al 2016; Orchard et al 2016; Suharti et al 2016). Studies on ecosystem service approaches are also widely conducted (De Groot et al 2010a; De Groot et al 2010b; Haines-Young & Potschin 2010; Martín-López et al 2012; Elliff & Kikuchi 2015; Moore et al 2017). Researches on mangroves management related to ecosystem services have been developed, those are:

a. Analysis of ecosystem service conditions. Assessment of ecosystem services can be assessed by analyzing conditions and indicators of the ecosystem service. This aspect is crucial because directly related to the processes occurring in the ecosystem and will have an impact on the availability of ecosystem services. Similarly with mangrove ecosystems, intensive mangrove forest use has had an impact on biodiversity and mangrove ecosystem services (Malik et al 2015a). Therefore, knowledge of the status of mangrove forests is essential for better planning and management (Schmitt & Duke 2015). A study conducted by Malik et al (2015a) has assessed the ecological impact of mangrove utilization and the level of exploitation of ecosystem services in mangrove forests of South Sulawesi. Analysis of the mangrove ecosystem condition and its services is identified either directly or indirectly and analyzed according to the characteristics, coverage areas and categories specified. Geographic information systems (GIS) and remote sensing are used in various areas including in the management of mangrove ecosystems. Spatial analysis through GIS and remote sensing can assist spatially in mapping ecosystem services conditions. Ecosystem service mapping is crucial to understand the contribution of ecosystems to human wellbeing and supporting policies that impact natural resources (Burkhard & Maes 2017). Conservation and management of effective mangrove habitats need to consider remote sensing and GIS based on a comprehensive data approach (Ghosh et al 2015). Several studies related to mangrove ecosystem services using GIS approach and remote sensing have been conducted, such

as Omo-Irabor et al (2011), reviewed comprehensively the use of socio-economic and environmental criteria with the opinion of expert, GIS, and SMCA (Spatial Multi Criteria Analysis) for vulnerability assessment of mangroves. Atkinson et al (2016) has assessed the value and priority of mangrove ecosystem services using spatial GIS and cost benefit of ecosystem services in decision making. Studies with GIS and remote sensing rapproaches can provide spatial advantages, one of which can generate significant ecological and economic benefits by obtaining real time data from unreachable area (Ghosh et al 2015). However, there are several things that need to be considered, including ecosystem services that must be assessed in the right spatial context and economic valuations that can support decisions so that policies are more useful (Vo et al 2015).

b. Social economics and valuation. Socioeconomic studies of mangrove ecosystem management related to ecosystem services have also received much attention in line with the dynamic changes and complexity that occur in mangrove ecosystem. Study of Orchard et al (2016) has reviewed the dynamics of mangrove systems in Southeast Asia by linking livelihoods with the services of mangrove ecosystems. Other socio-economic studies are economic valuations as conducted by Uddin et al (2013) that implement economic valuation of ecosystem services for protected areas of mangrove ecosystem in Sundarbarns, Bangladesh. Economic valuation of the mangrove ecosystem is quite widely studied, although not many of the result were used as one of the foundations in policy making. Valuation of ecosystem services highly depends on services from the nature, such as ecosystem functions that produce goods and services that can be sold with various alternative methods (Salem & Mercer 2012). Various types of monetary valuation measurements are used according to the type of ecosystem services, although it does not allow to explain the scope of the monetary value of all ecosystem services (De Jonge et al 2012). Several methods of economic valuation are used in the valuation of mangrove ecosystem services as shown in Table 2.

Table 2

Economic valuation method of mangrove ecosystem services

Method	*Description*	*Example application*
TCM	The revealed assessment method to assess the non-use benefit based on the observed behavior of individual expenditures for travel	Indrayanti et al (2015); Fitriana et al (2017)[indra17][a18]
MM	An assessment obtained directly from the amount a person must pay for goods and services such as timber products	Uddin et al (2013); Malik et al (2015b); Vo et al (2015); Ye et al (2016)[indra19][a20]; Suharti et al (2016)
HPM	Describes an assessment of a thing (goods or service) that is perceived because of pleasure characteristic, such as beautiful scenery, convenience or other characteristics	Syukri (2016)
PA	The value of services assessed by the impact of these services on economic outcomes (e.g. increased shrimp yields from wetland increases)	Malik et al (2015b)
CVM	Non-market valuation which is a direct method for economic assessment through willingness to pay (WTP)	Suharti et al (2016)
CE	Choice experiment is a choice technique. it allows reveal the role of an attribute that causes an individual to choose an object from several alternative object choices	McDonough et al (2014[indra21][a22])
RC	Calculates the loss of natural system services at the cost incurred to replace the service	Malik et al (2015b); Vo et al (2015); Suharti et al (2016)
AC	Calculating services based on avoidable expenses such as clean water reduces the cost of diarrhea treatment	-
REA/ HEA	The damage assessment method based on calculating the scale of the restoration project to restore the resource service to the initial conditions	Winarno et al (2016)
BoE	Methods economic valuation on marketed components such as the calculation of economic losses due to pollution to health	-
BT	Transfers from the alleged value of non-market benefits from other sites to the research sites	Brander et al (2012); Malik et al (2015b); Vo et al (2015); Ye et al (2016); Suharti et al (2016)

The description according to Fauzi (2014); Turner et al (2016).

TCM : Travel Cost Method; MM: Market Method; HPM: Hedonic Price Method; PA: Production Approach, CVM: Contingent Valuation Method; CE: Choice Experiment; RC: Replacement Cost; AC: Avoidance Cost; REA/HEA: Resource Equivalency Analysis/Habitat Equivalency Analysis; BoE: Back of the envelope; BT: Benefit Transfer.

c. System structure. System is a unity of efforts, consisting of interrelated parts regularly, and trying to achieve goals in a complex environment (Marimin & Maghfiroh 2010). Structure describes the arrangement of the elements and relationships between elements in forming a system. Every system approach always prioritizes the study of the system structure both explanatory and as policy support (Eriyatno 2012). Management of mangrove ecosystem services can be analyzed by a system approach because mangrove ecosystem is a complex system. Understanding of the system structure is one way to achieve the effective management objectives of the complex system.

Structural analysis is a good and powerful design tool for sharing knowledge and experience (Omran et al 2014). The core of this method is the measurement of the relationship between variables and the simplification of the system by selecting the most influential external variables and the most sensitive internal variables (key variables) (Fierro 2015). The most popular structuring tool for indirect relationship is MICMAC, whereas for direct relationship is used Interpretative Structural Modeling (ISM) technique (Eriyatno 2012).

MICMAC (cross-impact matrix multiplication applied to classification) is a structural analysis (Suprun et al 2016) that uses Boolean matrix to classify variables based on strength and dependence (Ambrosio-Albala & Delgado 2008). Structural analysis provides simulated reflection with expert skill and can be easily applied to problem formulation in a matrix design and supports qualitative studies (Omran et al 2014). MICMAC is one of the standard tools of scenario analysis built by Michel Godet, which presents a structured process in identifying variables for scenarios that may occur in the future based on expert opinions on system interactions (Veltmeyer & Sahin 2014). MICMAC method is performed by defining the problem and proceeding with 3 following stages (Benjumea-Arias et al 2016; Nazarko et al 2017):

- identification of internal and external variables;
- analysis of relationship between variables in the system;
- identification of key variable qualifies: direct and indirect classification.

Furthermore, the influence and dependence analysis is obtained through the position of the variable indicator in the quadrant. Variables can be in the variable power, autonomous, conflict or the output variables depending on the level of influence and dependence it has.

d. Future prospective strategies. The characteristic of strategies decisions is long term, dynamic environment and influences factors with very low certainty (Marimin & Maghfiroh 2010). Godet (2000) has described scenario analysis, the concept of prospective strategy, and the stages of scenario analysis process along with its usable tools and case study examples. A prospective method is as a tool for generalize of strategic knowledge to design future sustainability and allowing for designing different future scenarios by planning the transformation of the current situation into the expected future (Fierro 2015). Aryanto & Yuniarty (2010) mentioned that prospective analysis is appropriately used for policy strategy design and has two main uses, namely: preparing strategic actions that need to be done and to see if the changes are needed in the future. The objectives of identifying future conditions are to identify their characteristics and impacts, and to calculate the relative probability of occurrence (Bishop et al 2007).

Strategy is needed to overcome the mangrove ecosystem pressure. Management strategies should also be developed to achieve the sustainability objectives of the mangrove ecosystem to ensure the sustainability of ecological and socio-economic functions and not harm the lives of present and future generations (KKMTN 2013). Iftekhar & Islam (2004) mention the key strategies of mangrove management such as holistic management adoption, conservation and biodiversity improvement, impact zone management, government and non-government collaboration in management, community participation, non-exploitative utilization promotion, and sustainability planting on deltaber.

Several studies of mangrove ecosystem management strategies have been conducted including Iftekhar & Islam (2004) assessed the management of mangrove ecosystem using strategy analysis, and Atkinson et al (2016) assessed the management of mangrove ecosystems using cost-effectiveness analysis with the cost benefit of ecosystem services for several scenarios to obtain effective management. Other studies such as Faperi et al (2015), reviewed mangrove degradation management strategies using vegetation analysis, structural equation modeling (SEM), AHP and SWOT. Another prospective method that has been used in other fields is SMIC-Prob-Expert. SMIC-Prob-Expert is a cross-impact analysis built by Michael Godet to combine beneficial aspects, both quality and quantity (Lakner & Baker 2014). SMIC (Cross Impact Systems and Matrices) has several advantages among cross impact methods, including easy to use with the help of questionnaires, quick, and inexpensive. These characteristics make it easy to explain the results. However, this method requires a lot of thought in giving information treatment to choose an important hypothesis. The strategy hypothesis formulation also requires structural analysis and understanding of key variables. The results of the SMIC method are scenario hierarchy and sensitivity analysis.

Research prospect of mangrove ecosystem services. Ecosystem services as previously reviewed have an important position in the management of mangrove ecosystems and may assist describe the ecosystem relationship with human life. There are several assessment opportunities related to the management of mangrove ecosystem services that can be further examined, including:

1. mangrove ecosystem condition that focuses on ecosystem service in accordance with the region;
2. economic valuation of mangrove ecosystem services is important in determining the value and can be a consideration in the management strategy;
3. system structure of the mangrove ecosystem management variables associated with the ecosystem services and main variable analysis;
4. pressures and complexity that exist in the mangrove ecosystem and its survival strategies in facing future changes (prospective) based on current conditions in the management of ecosystem services.

Aspects of the study as previously described certainly integrate mangrove ecosystem services into challenges in the development of management strategies. Although ecosystem services from a number of existing studies may connecting ecosystem and community wellbeing, yet the existing literature is limited, particularly in linking ecosystem services to future management strategies. This is particularly important considering the dynamic nature of ecosystems and external pressures such as continuous population increases. Existing mangrove ecosystem management strategies have not fully reviewed ecosystem services comprehensively in order to anticipate changes in the ecosystem and ensure services to be provided. In addition, the review can be an answer in the context of a sustainable development assessment requiring a new and more integrative approach (Turner et al 2016), included in the management of mangrove ecosystem services in Indonesia.

Conclusions. Mangroves have ecosystem services that are beneficial for human life and other biota, but continue to experience destruction and decline due to excessive exploitation. Increasingly large and complex pressures on mangrove ecosystems will greatly increase the pressure on sustainability of ecosystem services. This should be considered by policy makers in mangrove ecosystem management strategies. Ecosystem services will also be closely linked to the characteristics of each region and the value that requires in-depth analysis. The study of mangrove ecosystem management variables will also be very useful in decision making for development of management strategies in the future. This article contributes to provide a road map for research opportunities in mangrove ecosystem management especially in the context of ecosystem services. This study will become an input in answering the challenges of managing complex and dynamic mangrove ecosystems in Indonesia. Therefore, the development of ecosystem

management strategies is still likely to be studied as an effort to achieve sustainable management objectives.

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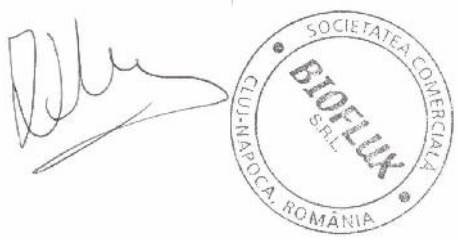

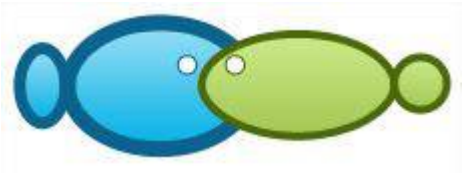

Ecosystem services-based mangrove management strategies in Indonesia: a review

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Abstract. Mangrove ecosystems have strategic benefits and complex management. Management of mangrove ecosystems also faces pressures and challenges to maintain them in sustainable condition. This study was aimed to review various literatures on mangrove management, particularly related to ecosystem services, and to find contribution opportunities in this field of research. Ecosystem service approach is more developed in natural resource management and becomes an instrument connecting ecosystem functions with human wellbeing. Analysis results showed that ecosystem services are an important part of mangrove management. Mangrove provides many ecosystem services and has an important role in both the number and the type of ecosystem services. There are several research opportunities which can be conducted namely ecosystem service condition analysis, socio-economic analysis and valuation, system structure, and future prospective strategies. These aspects are certainly a challenge in developing a dynamic and complex mangrove ecosystem management strategy in Indonesia as an effort to achieve sustainable management objectives.
Key Words: ecosystem services, management, valuation, mangrove, socio-economic.

Introduction. Ecosystem service is one of the great interest topics for many scientists and has been on the rise over the past decade (Mcdonough et al 2017). Ecosystem services are the benefits that humans derive directly or indirectly from ecosystem functions (Costanza et al 1997; Häyhä & Franzese 2014). Ecosystem service is defined as benefits of ecosystems for human wellbeing (Millennium Ecosystem Assessment 2005; TEEB 2010; Elliff & Kikuchi 2015). The concept of ecosystem services is very interesting to study for some reasons: (1) it may assist describing the connection and dependence of humans on nature; and (2) describes how human impacts on ecosystems alter the capacity in providing services, so appropriate policies can be developed (Haines-Young & Potschin 2013). Ecosystem is a functional unit of the biological community of animals, plants, microorganisms and non-biological environments that are complex and highly dynamic, and interact with each other (Millennium Ecosystem Assessment 2003). The mangrove ecosystem is one of the ecosystems that have various benefits of service for the society welfare but faces the pressures.

Indonesia is an archipelago country with more than 17,504 islands and about 95,181 km coastline (Kusmana & Sukristijiono 2016). Indonesia has a 3.1-3.7 million hectares mangrove forest area or more than 20% of world's mangrove forests with high species diversity (Giri et al 2011; Kusmana 2015b; Ilman et al 2016). Beside that, Potential area to be planted with mangrove species is around 7.8 million hectares (Kusmana 2015b). Indonesia's mangrove has a specific function because it lies between the terrestrial and marine ecosystems, and support various types of human needs, especially for local communities in mangrove forests and surrounding areas (Kusmana 2015b; Kusmana & Sukristijiono 2016). This facts show that the potential of mangrove ecosystem in Indonesia is quite large at this time.

Mangrove forests contribute in providing ecosystem services and supporting the livelihoods of coastal communities around the world (Polidoro et al 2010). Mangrove ecosystems have an important role in the socio-economic of communities, even for millions of people in the tropics and subtropics (Atkinson et al 2016). The important role of mangrove ecosystems are providing ecological and biophysical services, and providing a variety of important ecosystem products and services that are critical to the livelihoods of nearby communities (Barbier et al 2011; Malik et al 2015a; Orchard et al 2016). In addition, mangrove ecosystems also serve ecological functions in providing ecosystem services, nutrient cycles, soil formation, timber production, fish spawning, ecotourism and carbon storage (C) (Murdiyarso et al 2015) including economic activities such as providing timber and leaves as raw medicine materials (Sonjaya 2007).

The mangrove ecosystem is one of the most endangered ecosystems in the world. It experiences encroachment pressure and land degradation continuously, mainly driven by human activities (Ghosh et al 2015). Ilman et al (2016) studied about the drivers of the loss of Indonesia's mangrove forests through historical image analysis and estimated the decline of mangrove forest area in all regions of Indonesia by 22 percent. The largest percentage was occurred in Java Island by 75 percent. Pressures on mangrove ecosystems and more widespreading of degraded land have potential in affecting ecosystem services as well. Ecosystem services are also attached to the mangrove ecosystem so that it will also affect the management policy. Therefore, the mangrove ecosystem need to be managed to provide benefits for current and future generations.

Mangrove and conservation management policies are emerging worldwide in line with the increasing appreciation of the benefit of mangrove (Carter et al 2015). Mangrove ecosystem as described by Kusmana (2015a) requires a management because mangroves have the benefit of providing ecosystem goods and services, but also experiences the destruction. The management needs to be integrated and sustained. Management of sustainable mangrove ecosystems is an integration of all efforts to realize the sustainability of mangrove ecosystem functions for the community wellbeing (Presidential Regulation of the Republic of Indonesia No. 73 of 2012). Sustainable management is in accordance with the development orientation that pays attention to social, ecological and economic sustainability (Turner et al 2016). Indicators used in the management of mangrove ecosystems were ecology, economy, social and institutional (Iftekhar & Islam 2004; KKMTN 2013; Schmitt & Duke 2015; Kusmana 2015a; Orchard et al 2016).

Ecosystem services are important aspect in ecological and socio-economic studies of mangrove management. The linkage of ecosystem services and mangrove management is very closely related to the function of mangrove ecosystem to human wellbeing. Therefore, mangrove ecosystem services must be an important aspect in the management. This study was aimed to review various literatures on mangrove management, particularly related to ecosystem services and to find contribution opportunities in this field of research.

This review used a literature study concerning "mangrove management" and "ecosystem services" in the title, abstract, keywords, and content. A review of the literature to better understand current conditions in the development of research fields, both theme, methods and other combinations are associated with ecosystem services and mangrove management. The study was conducted through defining stages and topics, searching and selecting studies, analyzing and synthesizing. The defining stage is done by explaining the ecosystem services and mangrove management, while the topics were focused on six studies after introduction, those are: (1) the concept of ecosystem services, (2) mangrove ecosystem services, (3) the value of mangrove ecosystem services, (4) mangrove ecosystem management in Indonesia, (5) study, analysis, and strategy of mangrove services management, and (6) research prospect of ecosystem service management. Scientific publications which become reference are derived from the scopus data base (https://www.scopus.com), google scholar (https://scholar.google.com/), garuda portal (http://id.portalgaruda.org/) as well as various other literatures such as reports, and supporting books.

Concept of ecosystem services. Ecosystem provides many services to the human as part of the ecosystem itself. Changes that occur in the ecosystem will certainly affect the existence of ecosystem services and ultimately on human wellbeing (Millennium Ecosystem Assessment 2003). According to the literature reviews, ecosystem service approach is connecting between environmental and socio-economic interests (De Groot et al 2010a; Haines-Young & Potschin 2010). The concept of ecosystem services has undergone many developments and has been used in natural resource assessments since the late 1970s and then continued in the 1990s with the main focus on ecosystem services in the literature (Gómez-Baggethun et al 2010). A study of ecosystem services was conducted among others by Costanza et al (1997) who first valued ecosystem services and natural resource capital globally, and the study was further expanded, particularly since the publication of the concept of ecosystem services carried out by Millennium Ecosystem Assessment in 2003.

The concept of ecosystem services is very important in connecting ecosystem functions with human welfare (Fauzi & Anna 2005). The classification of ecosystem services used should refer to the importance characteristics of the ecosystem and in the context of decisions for how ecosystem services will be used (Fisher et al 2009). Understanding the rules of ecosystem services and functions (provision) to human well-being is also essential in obtaining identification and targets of seeking the natural capital of a system and complementing the requirements of sustainable development (De Jonge et al 2012). The classification of ecosystem services used by the Common International Classification of Ecosystem Services (CICES) has three types of ecosystem services (Haines-Young & Potschin 2013) comprises provisioning categories such as biomass and water, regulating and maintenance such as pest and disease control, and cultural such as physical interactions, intellectual and spiritual with the ecosystem.

Classification of ecosystem services is useful to clarify the understanding in identification of services according to the studied ecosystem. Classification of ecosystem services of Millennium Ecosystem Assessment is widely used (Fisher et al 2009). The classification of CICES specifically focuses on ecosystem outputs that directly contribute to public wellbeing and aims for economic assessment (Haines-Young & Potschin 2013). The use of classification needs to be adapted according to the objectives of the study, particularly if it is related to economic valuations to avoid recurring calculations (Elliff & Kikuchi 2015). A good understanding of ecosystem services will assist in gaining a picture of ecosystem connection with community wellbeing.

Various appropriate efforts in mangrove ecosystem management strategies should be continued. According to Walters et al (2008), improper anticipatory efforts in resource management and land use against the pressures faced may threaten the existence of ecosystems and humans who depend on it. Complexity of the mangrove ecosystem also requires cooperation and participation of all government levels, in addition to policies and programs which still become a key to sustainability of mangrove management and coastal ecosystems (Carter et al 2015). Knowledge and attention to the mangrove ecosystems including changes in ecosystem management is an important basis in further management. Ecosystem service becomes one of the tools to increase the knowledge (Luque et al 2017) and use it in mangrove ecosystem management strategy.

Mangrove ecosystem services. Mangrove has many important ecosystem services and values (Salem & Mercer 2012; Schmitt & Duke 2015). The role of mangrove ecosystem is very important at least on two things (Kusmana & Purwanegara 2015):

1. approximately 75 to 90% of all marine fish species, a whole or a part of its life cycle depends on estuarine habitat, and its productivity depends largely on the production of organic materials from mangrove and seagrass plants;

2. mangrove is one of the main ecosystem types in maintaining coastal environmental quality where approximately 50% of the population in the world and 2/3 of the world's major cities are living in coastal areas.

Indicators of mangrove ecosystem services based on literature reviews vary considerably from provisional, regulatory and maintenance, and cultural. Indonesian people have been traditionally since long time ago utilize mangrove ecosystem services

(provisioning) such as for firewood, charcoal, medicines, dye and other uses such as the use of aquatic fauna to support daily life (Kusmana & Sukristijiono 2016). Ecosystem services provided by the mangrove ecosystem are summarized in Table 1.

Table 1

Indicators of mangrove ecosystem services

No	*Category*	*Indicator*	*Description*	*Source*
1	Provisioning	Fishery (food)	Providing fisheries as a source of food	Harahab (2009); Macintosh et al (2010); Kuenzer et al (2011); Uddin et al (2013); Mukherjee et al (2014); Malik et al (2015b); Vo et al (2015).
		Aquaculture	Cultivation of brackish fisheries such as shrimp and milkfish ponds	Macintosh et al (2010); Kuenzer et al (2011); Mukherjee et al (2014); Malik et al (2015b); Sina et al (2017).
		Honey	A sweet fluid collected by insect	Macintosh et al (2010); Kuenzer et al (2011); Uddin et al (2013); Mukherjee et al (2014).
		Medicines	Traditional medicines	Macintosh et al (2010); Kuenzer et al (2011); Mukherjee et al (2014).
		Feedstock	Mangrove as raw material	Mukherjee et al (2014).
		Energy source	Wood fuel is used for daily activities such as making charcoal, cooking food, burning bricks	Macintosh et al (2010); Kuenzer et al (2011); Uddin et al (2013); Mukherjee et al (2014); Malik et al (2015b).
		Timber	Wood for building and carpentry	Macintosh et al (2010); Uddin et al (2013); Mukherjee et al (2014); Vo et al (2015); Sina et al (2017).
		Tannin	Phenolic substances derived from plants used for tannery	Kuenzer et al (2011).
2	Regulation and maintenance	Water bioremediation	Maintaining water quality	Walters et al (2008); Barbier et al (2011); Mukherjee et al (2014).
		Reducing emission	The presence of mangrove reduces emissions	Mukherjee et al (2014).
		Environmental risk indicator	Mangrove as risk indicator	Mukherjee et al (2014).
		Protecting from sedimentation	Stabilization of land by restraining sediment	Macintosh et al (2010); Mukherjee et al (2014).
		Protecting from sea water intrusion	Mangrove can protect from intrusion	Mukherjee et al (2014); Malik et al (2015b).
		Coastal protection	Protecting the coastal from the onslaught of waves, winds and floods	Macintosh et al (2010); Barbier et al (2011); Kuenzer et al (2011); Mukherjee et al (2014); Malik et al (2015b); Barbier (2016).
		Fish nursery	Mangrove as nursery ground for fish	Mukherjee et al (2014); Malik et al (2015b).
		Carbon sink	Absorbing carbon dioxide	Walters et al (2008); Macintosh et al (2010); Mukherjee et al (2014); Malik et al (2015b); Vo et al (2015) .
		Reducing coast and soil erosion	Reduction of coast and soil erosion	Macintosh et al (2010); Barbier et al (2011); Vo et al (2015).
		Climate regulator	an important role on climate change	Macintosh et al (2010).
3	Cultural	Ecotourism and recreation	Providing unique and aesthetic values, and as a suitable habitat for flora and fauna	Macintosh et al (2010); Barbier et al (2011); Kuenzer et al (2011); Uddin et al (2013); Mukherjee et al (2014).
		Aesthetic value	The value of appreciation of the beauty of nature	Uddin et al (2013); Mukherjee et al (2014).
		Spiritual appreciation	Appreciation related to belief	Macintosh et al (2010); Kuenzer et al (2011); Uddin et al (2013).

Ecosystem services are identified in accordance with the presence of mangrove ecosystems in an area and need to be valued in monetary terms (money) so that they can be clearly calculated for their economic contribution and compared to the market of goods and services (Häyhä & Franzese 2014). The value of ecosystem services can not be ignored, for example the cultural are essential in understanding how humans use and assess nature, but are often ignored in forest assessments due to limitations in measurement and mapping (Luque et al 2017). The values can clarify and strengthen the position of ecosystem services into consideration in the formulation of management strategies.

Value of mangrove ecosystem services. Value of mangrove ecosystem service describes the relative price, usefulness, and importance of a thing (Moore et al 2017). Although assessment of the ecosystem and its services is still a debate (Häyhä & Franzese 2014), economic valuation plays an important role in the assessment of natural resources to assist in decision-making and sustainable management processes (Zhang & Lu 2010; Fauzi 2014; Vo et al 2015). A study conducted by Moore et al (2017) using the ecosystem services natural resource approach (Ecosystem Services-Natural Resources Management) stated that valuation will assist decision makers in evaluating and communicating overall benefits and trade-offs to stakeholders. In assessing forest ecosystem services, the capacity of ecosystem services are determined by the long-term temporal dynamic (Luque et al 2017).

Assessment of goods and services of mangrove ecosystems is needed because mangrove provides many benefits and plays important roles for better conservation (Muraleedharan et al 2009). Economic valuation approach of mangrove resources will help policy makers and decision makers to know the value of mangrove ecosystem comprehensively (Ilman et al 2011). The economic valuation of goods and services of mangrove ecosystems is able to show the benefits of a good mangrove ecosystem for the community and this is an important reason to manage and protect the mangroves (Schmitt & Duke 2015). Understanding of the value and services of mangrove ecosystems is becoming increasingly important for local, national, and global policies and decisions (Kairo et al 2001; Vo et al 2015).

Mangrove provides real ecosystem services, but is not fully supported by optimal conservation and protection. Conservation as a biodiversity protection often faces inadequate economic resources and thus requires the support of integrative instruments and incorporates economic goals and conservation impacts (Luque et al 2017). Although not all the benefits of ecosystems can be expressed monetarily, some analyzes can still contribute to the various decision options (De Jonge et al 2012).

Studies of mangrove ecosystem valuation in Indonesia have been carried out such as Malik et al (2015b) which estimates that annual mangrove total economic value (TEV) in Takalar District, South Sulawesi ranges from 4,000 to 8,000 USD per hectare, compared to commercial aquaculture that provides net benefits of 3,000 USD per hectare. Indrayanti et al (2015) studied the value of mangrove ecosystem services in Blanakan Subang Bay, West Java obtained the TEV at Rp. 3,815,790,110.97 per year for 782.34 ha mangrove area. Other study by Suharti et al (2016) found the total value of mangroves in East Sinjai with a total area of 758 ha was Rp. 37,535,809,496 per year.

Mangrove ecosystem management in Indonesia. Management of mangrove ecosystems faces a complexity of problems. Mangrove ecosystems as renewable resources provide various types of life support products (Kusmana 2015a), but the ecosystem is subjected to continuous pressure due to natural factors and human activities. Based on the literature reviews, mangrove ecosystem received considerable attention in the theme of ecosystem management in Indonesia. The aspects of the study and coverage area of the studies are diverse, including the conceptual (Effendy 2009; Kusmana 2015a), biophysical analysis (Fahrian et al 2015; Zurba et al 2017), social analysis (Ritohardoyo & Ardi 2011; Harahab 2011; Kustanti et al 2015; Febryano et al 2015), economic valuation (Ruitenbeek 1994; Saprudin & Halidah 2012), institutional (Suharti et al 2016; Kuvaini et al 2017), and regulation (Sunyowati et al 2016). Other

studies were done on sustainability status (Mukhlisi et al 2014; Theresia et al 2015; Karlina et al 2016), system model (Datunsolang 2016) and management strategies (Wijayanto et al 2013; Yenny et al 2017; Lugina et al 2017). Those studies are generally focused on sustainability and socio-economic aspect, while the study on analysis ecosystem services and institutional structure are still limited.

Management of mangrove ecosystems requires an approach that can connect the interests of environmental sustainability and benefits for human wellbeing in a balanced way. One of the efforts can be done is by comprehensive reviewing of ecosystem services. It is supported by several aspects that have been widely discussed in various studies, including:

1. Ecology - mangrove ecosystem has been recognized to have the function and benefits for the environment and the preservation of biodiversity. Based on Kusmana (2014), mangrove resources in Indonesia have been supporting many kinds of human needs ;

2. Socio-economic - mangrove ecosystem plays an important role for the community wellbeing such as food and livelihood sources ;

3. Institutional - mangrove ecosystem is a means of managing both protection, rehabilitation, and even utilization that involves the attention and participation of many parties such as government, private, NGO, and society. Since 2013, the Indonesian government has initiated the formation of a National Mangrove Working Group (KKMN) that consists of cross-sector/institutional/NGO ;

4. Regulations and laws - mangrove ecosystem in Indonesia already has a regulatory instrument that specifically focuses on the national management strategy, namely Presidential Regulation no. 73 of 2012. In addition, it is supported by Government Regulation no. 26 of 2008 concerning about national spatial plan, Government Regulation no. 73 of 2013 concerning about swamps, Presidential Regulation No. 51 of 2016 concerning about coastline boundaries.

The concept of ecosystem services is also used by academics, researchers and decision makers to support and explain environmental management and biodiversity conservation strategies (Martín-López et al 2012). Ecosystem services still need to be studied as a basis for the development strategy for mangrove ecosystem management because it is an important part in the management of mangrove ecosystems (Schmitt & Duke 2015; Karlina et al 2016). According to Brander et al (2012) potential research on mangrove ecosystems in the future is research that combines ecology and economy to make a model of supply and service of mangrove ecosystem. Policies and programs are becoming more complex with the bureaucracy and authority involved in mangrove conservation, but it is still a key for the sustainability of mangrove and coastal ecosystem management (Carter et al 2015). Therefore, a new and more integrative approach is needed to assess sustainable development (Turner et al 2016), including the management of mangrove ecosystems.

Ecosystem service approaches can be applied in the context of mangrove ecosystem management as shown in Figure 1. Mangrove ecosystems face various pressures and dynamic changes that will also impact on ecosystem services and human life, thus it is necessary to develop sustainable ecosystem service-based management strategies.

One of the challenges of managing mangrove ecosystems is linking dynamic mangrove ecosystems with complex socio-economic life of communities such as mangrove positions near settlements and in urban areas. Management of mangrove ecosystems in the future also need to be oriented broadly to be able to measure the importance of mangrove ecosystem services for the community itself. Well managed mangrove ecosystems have the potential to have good ecosystem services and will support the sustainability of mangrove development. The role of mangrove ecosystems also requires sustainable mangrove ecosystem management. It is supported by three important pillars, namely ecology, social and economy which are covered by appropriate institutional and regulation (Kusmana 2015a). Mangroves can not be ignored because their ecosystem services have distinctive characteristics that indicate that ecosystems provide services and have value for human wellbeing.

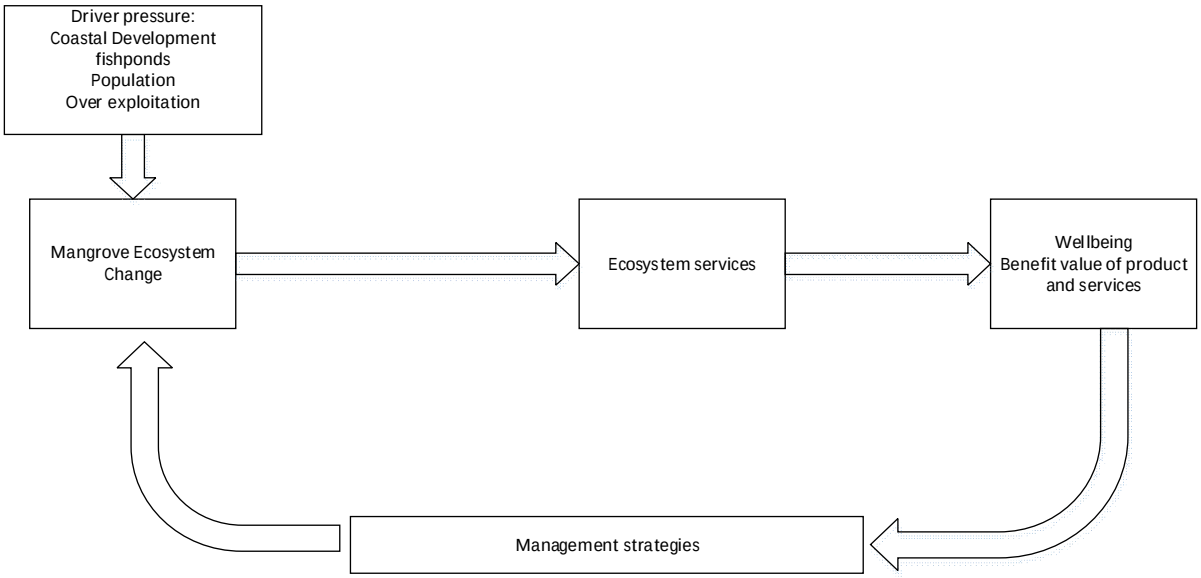

Figure 1. The application of ecosystem services approach on mangrove management (adopted from De Groot et al 2010a; Haines-Young & Potschin 2010).

Study, analysis, and strategy of mangrove ecosystem services. A review of mangrove ecosystem service management is conducted as a strategy to develop management policy to be more able to guarantee ecosystem services both in the present and in the future. Several studies that have been conducted previously provided an illustration of the importance of ecosystem service management (Mukherjee et al 2014; Kusmana 2015a; Carter et al 2015; Kustanti et al 2015; Vo et al 2015; Malik et al 2015a; Ilman et al 2016; Orchard et al 2016; Suharti et al 2016). Studies on ecosystem service approaches are also widely conducted (De Groot et al 2010a; De Groot et al 2010b; Haines-Young & Potschin 2010; Martín-López et al 2012; Elliff & Kikuchi 2015; Moore et al 2017). Researches on mangroves management related to ecosystem services have been developed, those are:

a. Analysis of ecosystem service conditions. Assessment of ecosystem services can be assessed by analyzing conditions and indicators of the ecosystem service. This aspect is crucial because directly related to the processes occurring in the ecosystem and will have an impact on the availability of ecosystem services. Similarly with mangrove ecosystems, intensive mangrove forest use has had an impact on biodiversity and mangrove ecosystem services (Malik et al 2015a). Therefore, knowledge of the status of mangrove forests is essential for better planning and management (Schmitt & Duke 2015). A study conducted by Malik et al (2015a) has assessed the ecological impact of mangrove utilization and the level of exploitation of ecosystem services in mangrove forests of South Sulawesi. Analysis of the mangrove ecosystem condition and its services is identified either directly or indirectly and analyzed according to the characteristics, coverage areas and categories specified. Geographic information systems (GIS) and remote sensing are used in various areas including in the management of mangrove ecosystems. Spatial analysis through GIS and remote sensing can assist spatially in mapping ecosystem services conditions. Ecosystem service mapping is crucial to understand the contribution of ecosystems to human wellbeing and supporting policies that impact natural resources (Burkhard & Maes 2017). Conservation and management of effective mangrove habitats need to consider remote sensing and GIS based on a comprehensive data approach (Ghosh et al 2015). Several studies related to mangrove ecosystem services using GIS approach and remote sensing have been conducted, such as Omo-Irabor et al (2011), reviewed comprehensively the use of socio-economic and environmental criteria with the opinion of expert, GIS, and SMCA (Spatial Multi Criteria Analysis) for vulnerability assessment of mangroves. Atkinson et al (2016) has assessed the value and priority of mangrove ecosystem services using spatial GIS and cost benefit

of ecosystem services in decision making. Studies with GIS and remote sensing approaches can provide spatial advantages, one of which can generate significant ecological and economic benefits by obtaining real time data from unreachable area (Ghosh et al 2015). However, there are several things that need to be considered, including ecosystem services that must be assessed in the right spatial context and economic valuations that can support decisions so that policies are more useful (Vo et al 2015).

b. Social economics and valuation. Socioeconomic studies of mangrove ecosystem management related to ecosystem services have also received much attention in line with the dynamic changes and complexity that occur in mangrove ecosystem. Study of Orchard et al (2016) has reviewed the dynamics of mangrove systems in Southeast Asia by linking livelihoods with the services of mangrove ecosystems. Other socio-economic studies are economic valuations as conducted by Uddin et al (2013) that implement economic valuation of ecosystem services for protected areas of mangrove ecosystem in Sundarbarns, Bangladesh. Economic valuation of the mangrove ecosystem is quite widely studied, although not many of the result were used as one of the foundations in policy making. Valuation of ecosystem services highly depends on services from the nature, such as ecosystem functions that produce goods and services that can be sold with various alternative methods (Salem & Mercer 2012). Various types of monetary valuation measurements are used according to the type of ecosystem services, although it does not allow to explain the scope of the monetary value of all ecosystem services (De Jonge et al 2012). Several methods of economic valuation are used in the valuation of mangrove ecosystem services as shown in Table 2.

Table 2

Economic valuation method of mangrove ecosystem services

Method	*Description*	*Example application*
TCM	The revealed assessment method to assess the non-use benefit based on the observed behavior of individual expenditures for travel	Indrayanti et al (2015); Fitriana et al (2017).
MM	An assessment obtained directly from the amount a person must pay for goods and services such as timber products	Uddin et al (2013); Malik et al (2015b); Vo et al (2015); Ye et al (2016); Suharti et al (2016).
HPM	Describes an assessment of a thing (goods or service) that is perceived because of pleasure characteristic, such as beautiful scenery, convenience or other characteristics	Syukri (2016).
PA	The value of services assessed by the impact of these services on economic outcomes (e.g. increased shrimp yields from wetland increases)	Malik et al (2015b).
CVM	Non-market valuation which is a direct method for economic assessment through willingness to pay (WTP)	Suharti et al (2016).
CE	Choice experiment is a choice technique. It allows reveal to the role of an attribute that causes an individual to choose an object from several alternative object choices	McDonough et al (2014).
RC	Calculates the loss of natural system services at the cost incurred to replace the service	Malik et al (2015b); Vo et al (2015); Suharti et al (2016).
AC	Calculating services based on avoidable expenses such as clean water reduces the cost of diarrhea treatment	-
REA/ HEA	The damage assessment method based on calculating the scale of the restoration project to restore the resource service to the initial conditions	Winarno et al (2016).
BoE	Methods economic valuation on marketed components such as the calculation of economic losses due to pollution to health	-
BT	Transfers from the alleged value of non-market benefits from other sites to the research sites	Brander et al (2012); Malik et al (2015b); Vo et al (2015); Ye et al (2016); Suharti et al (2016).

The description according to Fauzi (2014); Turner et al (2016). TCM : Travel Cost Method; MM: Market Method; HPM: Hedonic Price Method; PA: Production Approach, CVM: Contingent Valuation Method; CA: Conjoint Analysis; RC: Replacement Cost; AC: Avoidance Cost; REA/HEA: Resource Equivalency Analysis/Habitat Equivalency Analysis; BoE: Back of the envelope; BT: Benefit Transfer.

c. System structure. System is a unity of efforts, consisting of interrelated parts regularly, and trying to achieve goals in a complex environment (Marimin & Maghfiroh 2010). Structure describes the arrangement of the elements and relationships between elements in forming a system. Every system approach always prioritizes the study of the system structure both explanatory and as policy support (Eriyatno 2012). Management of mangrove ecosystem services can be analyzed by a system approach because mangrove ecosystem is a complex system. Understanding of the system structure is one way to achieve the effective management objectives of the complex system.

Structural analysis is a good and powerful design tool for sharing knowledge and experience (Omran et al 2014). The core of this method is the measurement of the relationship between variables and the simplification of the system by selecting the most influential external variables and the most sensitive internal variables (key variables) (Fierro 2015). The most popular structuring tool for indirect relationship is MICMAC, whereas for direct relationship is used Interpretative Structural Modeling (ISM) technique (Eriyatno 2012).

MICMAC MICMAC (cross-impact matrix multiplication applied to classification) is a structural analysis (Suprun et al 2016) that uses Boolean matrix to classify variables based on strength and dependence (Ambrosio-Albala & Delgado 2008). Structural analysis provides simulated reflection with expert skill and can be easily applied to problem formulation in a matrix design and supports qualitative studies (Omran et al 2014). MICMAC is one of the standard tools of scenario analysis built by Michel Godet, which presents a structured process in identifying variables for scenarios that may occur in the future based on expert opinions on system interactions (Veltmeyer & Sahin 2014). MICMAC method is performed by defining the problem and proceeding with 3 following stages (Benjumea-Arias et al 2016; Nazarko et al 2017):

- identification of internal and external variables;
- analysis of relationship between variables in the system;
- identification of key variable qualifies: direct and indirect classification.

Furthermore, the influence and dependence analysis is obtained through the position of the variable indicator in the quadrant. Variables can be in the variable power, autonomous, conflict or the output variables depending on the level of influence and dependence it has.

d. Future prospective strategies. The characteristic of strategies decisions is long term, dynamic environment and influences factors with very low certainty (Marimin & Maghfiroh 2010). Godet (2000) has described scenario analysis, the concept of prospective strategy, and the stages of scenario analysis process along with its usable tools and case study examples. A prospective method is as a tool for generalize of strategic knowledge to design future sustainability and allowing for designing different future scenarios by planning the transformation of the current situation into the expected future (Fierro 2015). Aryanto & Yuniarty (2010) mentioned that prospective analysis is appropriately used for policy strategy design and has two main uses, namely: preparing strategic actions that need to be done and to see if the changes are needed in the future. The objectives of identifying future conditions are to identify their characteristics and impacts, and to calculate the relative probability of occurrence (Bishop et al 2007).

Strategy is needed to overcome the mangrove ecosystem pressure. Management strategies should also be developed to achieve the sustainability objectives of the mangrove ecosystem to ensure the sustainability of ecological and socio-economic functions and not harm the lives of present and future generations (KKMTN 2013). Iftekhar & Islam (2004) mention the key strategies of mangrove management such as holistic management adoption, conservation and biodiversity improvement, impact zone management, government and non-government collaboration in management, community participation, non-exploitative utilization promotion, and sustainability planting on deltaber.

Several studies of mangrove ecosystem management strategies have been conducted including Iftekhar & Islam (2004) assessed the management of mangrove ecosystem using strategy analysis, and Atkinson et al (2016) assessed the management

of mangrove ecosystems using cost-effectiveness analysis with the cost benefit of ecosystem services for several scenarios to obtain effective management. Other studies such as Faperi et al (2015), reviewed mangrove degradation management strategies using vegetation analysis, structural equation modeling (SEM), AHP and SWOT. Another prospective method that has been used in other fields is SMIC-Prob-Expert. SMIC-Prob-Expert is a cross-impact analysis built by Michael Godet to combine beneficial aspects, both quality and quantity (Lakner & Baker 2014). SMIC (Cross Impact Systems and Matrices) has several advantages among cross impact methods, including easy to use with the help of questionnaires, quick, and inexpensive. These characteristics make it easy to explain the results. However, this method requires a lot of thought in giving information treatment to choose an important hypothesis. The strategy hypothesis formulation also requires structural analysis and understanding of key variables. The results of the SMIC method are scenario hierarchy and sensitivity analysis.

Research prospect of mangrove ecosystem services. Ecosystem services as previously reviewed have an important position in the management of mangrove ecosystems and may assist describe the ecosystem relationship with human life. There are several assessment opportunities related to the management of mangrove ecosystem services that can be further examined, including:

1. mangrove ecosystem condition that focuses on ecosystem service in accordance with the region;
2. economic valuation of mangrove ecosystem services is important in determining the value and can be a consideration in the management strategy;
3. system structure of the mangrove ecosystem management variables associated with the ecosystem services and main variable analysis;
4. pressures and complexity that exist in the mangrove ecosystem and its survival strategies in facing future changes (prospective) based on current conditions in the management of ecosystem services.

Aspects of the study as previously described certainly integrate mangrove ecosystem services into challenges in the development of management strategies. Although ecosystem services from a number of existing studies may connecting ecosystem and community wellbeing, yet the existing literature is limited, particularly in linking ecosystem services to future management strategies. This is particularly important considering the dynamic nature of ecosystems and external pressures such as continuous population increases. Existing mangrove ecosystem management strategies have not fully reviewed ecosystem services comprehensively in order to anticipate changes in the ecosystem and ensure services to be provided. In addition, the review can be an answer in the context of a sustainable development assessment requiring a new and more integrative approach (Turner et al 2016), included in the management of mangrove ecosystem services in Indonesia.

Conclusions. Mangroves have ecosystem services that are beneficial for human life and other biota, but continue to experience destruction and decline due to excessive exploitation. Increasingly large and complex pressures on mangrove ecosystems will greatly increase the pressure on sustainability of ecosystem services. This should be considered by policy makers in mangrove ecosystem management strategies. Ecosystem services will also be closely linked to the characteristics of each region and the value that requires in-depth analysis. The study of mangrove ecosystem management variables will also be very useful in decision making for development of management strategies in the future. This article contributes to provide a road map for research opportunities in mangrove ecosystem management especially in the context of ecosystem services. This study will become an input in answering the challenges of managing complex and dynamic mangrove ecosystems in Indonesia. Therefore, the development of ecosystem management strategies is still likely to be studied as an effort to achieve sustainable management objectives.

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