Hierarchical Synthesis of Coastal Ecosystem Health Indicators at Karimunjawa National Marine Park

by Frida P

Submission date: 26-Jul-2022 10:42PM (UTC+0700)
Submission ID: 1875470355
File name: system_Health_Indicators_at_Karimunjawa_National_Marine_Park.pdf (752.19K)
Word count: 2961
Character count: 17183

Hierarchical Synthesis of Coastal Ecosystem Health Indicators at Karimunjawa National Marine Park

Hierarchical Synthesis of Coastal Ecosystem Health Indicators at Karimunjawa National Marine Park

Johan Danu Prasetya [1,2], Ambariyanto [2,3], Supriharyono [2], Frida Purwanti [2]

[1]Environmental Engineering, the Universitas Pembangunan Nasional Veteran Yogyakarta. 55283, Indonesia.
[2]Faculty of Fisheries and Marine Sciences, Diponegoro University, Semarang 50275, Indonesia
[3]Coastal Disaster Rehabilitation and Mitigation Center, Diponegoro University, Semarang 50275, Indonesia.

Email: johan.danu@upnyk.ac.id.

Abstract. The coastal ecosystem of Karimunjawa National Marine Park (KNMP) is facing various pressures, including from human activity. Monitoring the health condition of coastal ecosystems periodically is needed as an evaluation of the ecosystem condition. Systematic and consistent indicators are needed in monitoring of coastal ecosystem health. This paper presents hierarchical synthesis of coastal ecosystem health indicators using Analytic Hierarchy Process (AHP) method. Hierarchical synthesis is obtained from process of weighting by paired comparison based on expert judgments. The variables of coastal ecosystem health indicators in this synthesis consist of 3 level of variable, i.e. main variable, sub-variable and operational variable. As a result of assessment, coastal ecosystem health indicators consist of 3 main variables, i.e. State of Ecosystem, Pressure and Management. Main variables State of Ecosystem and Management obtain the same value i.e. 0.400, while Pressure value was 0.200. Each main variable consist of several sub-variable, i.e. coral reef, reef fish, mangrove and seagrass for State of Ecosystem; fisheries and marine tourism activity for Pressure; planning and regulation, institutional and also infrastructure and financing for Management. The highest value of sub-variable of main variable State of Ecosystem, Pressure and Management were coral reef (0.186); marine tourism pressure (0.133) and institutional (0.171), respectively. The highest value of operational variable of main variable State of Ecosystem, Pressure and Management were percent of coral cover (0.058), marine tourism pressure (0.133) and presence of zonation plan, regulation also socialization of monitoring program (0.53), respectively. Potential pressure from marine tourism activity is the variable that most affect the health of the ecosystem. The results of this research suggest that there is a need to develop stronger conservation strategies to facing with pressures from marine tourism activities.

Keywords: Ecosystem, Conservation, Karimunjawa, Indicator, AHP

1. Introduction

Indonesia is the world's largest archipelagic state. All provinces and more than 80% of the districts and municipalities have coastal areas [1]. Indonesia is also known as the center of marine mega-biodiversity [2], [3]. In Indonesia, there are about 590 coral species consist of 82 genera [4]. Indonesia

has coral reef area with an estimated area of about 51,000 km², which is the largest coral reef area in Southeast Asia. Some 15 plant families, with 18 genera and 41 species, and 1 associated species are found in the mangrove ecosystems in Indonesia. Indonesian mangrove forest covers an area of 35.337 km², which is 76% of the total mangroves in the Southeast Asia. There are also 13 species of seagrass, covering an area 30.000 km² [1].

Increasing threats to the Indonesian coastal ecosystem was widely reported and contributes to the degradation of ecosystem and resources [5]. Threats are mainly occur on mangroves, seagrass and also coral reefs ecosystem. Mangrove facing various threats, large areas of mangrove have been converted for aquaculture [6]; timber extraction and the expansion of urban areas [7] and also oil palm plantations [8]. Seagrass in Indonesia also have been degraded, about 30–40% of the seagrass beds have been lost in the last 50 years, with as much as 60% being destroyed around Java [9]. Among Coral Triangle Countries, Indonesian coral reef was the most at risk. For about 50% of these reefs, the level of threat is high or very high. Only about 12% is low risk [1].

Healthy coastal ecosystem provides maximum benefits for biodiversity. Maintaining ecosystem in a healthy condition is crucial to maintain biodiversity [10]. Marine Protected Area (MPA) is one of the main strategy to maintain ecosystem in a healthy condition and conserve biodiversity. MPA play fundamental roles in the conservation of biodiversity [11]. Effectiveness conservation management based on MPA strategy need to be evaluated continuously, based on ecosystem condition. Ecosystem monitoring is one of the methods to providing information about effectiveness conservation management. Monitoring is a fundamental part of resource management [12]. Monitoring the condition of the ecosystems in MPA periodically to ensure ecosystem in a healthy condition [10]. A set of systematic and consistent indicators in monitoring program, need to be investigated to indicate the real condition of ecosystem. Present study investigates a set of indicators namely Coastal Ecosystem Health Indicators (CEHI) and perform indicators weighting using hierarchical synthesis. Selected indicator included consistent weighting use to evaluate coastal ecosystem health of Karimunjawa National Marine Park (KNMP).

2. Method

Coastal Ecosystem Health Indicators (CEHI) were identified and selected based on field observation and reviewing reference. The weights of importance of the variables on the health of coastal ecosystems were determined through the Analytic Hierarchy Process (AHP) developed by Thomas L. Saaty. The AHP is a basic approach to decision making [13]. The indicators list that consist of Main variables, Sub-variables and Operational variables arranged into a decision tree using the AHP. Four steps are conducted in using the AHP i.e. setting up the decision hierarchy; collecting input data by pairwise comparisons of decision elements; using the eigenvalue method to estimate the relative weights of decision elements and aggregating the relative weights of decision elements [14]. Expert judgments were organized to conduct pairwise comparisons of strength each variables compared other variables. The expert judgments were divided into representative groups namely, coastal manager, local government, academics and non-government organization.

Three main variables were identified namely, State of Ecosystem, Pressure and Management. Each Main variables consist of several Sub-variables, each Sub-variables divided into some Operational variables. The strength of preference is evaluated through a 9-point intensity scale (see table 1). The application of AHP considers consistency in judgment through consistency ratio (CR). Consistency indicates that: if a > b ; b > c then a > c [15]. The value of CR ranges from 0 to 1, a CR of 0.10 or less is considered acceptable [13].

Table 1. Intensity scale of importance [13]

Intensity of Importance	Definition	Explanation
1	Equal Importance	Two Activities contribute equally to the objective
3	Weak importance of one over another	Experience and judgment slightly favor one indicator over another
5	Essential or strong importance	Experience and judgment strongly favor one criterion/indicator over another A
7	Demonstrated importance Absolute importance	A indicator is strongly favored and its dominance is demonstrated in practice
9	Absolute importance	The evidence favoring one indicator over another is of the highest possible order of affirmation
2, 4, 6, 8	Intermediate values between the two adjacent judgments	When compromise is needed

3. Results and Discussion

3.1. Main and Sub-Variables of Coastal Health Ecosystem

The variables of coastal ecosystem health indicators in this synthesis consist of 3 level of variable, i.e. main variable, sub-variable and operational variable. As a result of assessment, coastal ecosystem health indicators consist of 3 main variable, i.e. State Of Ecosystem, Pressure and Management. Main variable State of Ecosystem and Management obtain the same value i.e. 0.400, while Pressure value was 0.200 (see **Figure 1**).

Main variable State of Ecosystem consist of 4 sub-variables i.e. Coral reef, Reef fish, Mangrove and Seagrass. Coral reef gain the best value (0,184), followed by Mangrove (0,090), Coral reef fish (0,069) and Seagrass (0,058), respectively (see **Figure 2**). In the other main variable, Pressure, the sub-variable Pressure of tourism activity (0,133) get the superior value because of their importance based on rating from expert judgment, while lower value obtain by Pressure of fishery activity (0,067) (see **Figure 3**). Main variable Management situated two sub-variables i.e. Planning & regulation and also Institutional (0,16) as the highest sub-variable, while the lowest was Infrastructure & Financing Facility (0,08) (see **Figure 4**). The figures of Operational variables and Sub-variables show original value from Expert Choice software, before adjusted by each Sub-variables values.

Figure 1. Main Variables Intensity Scale

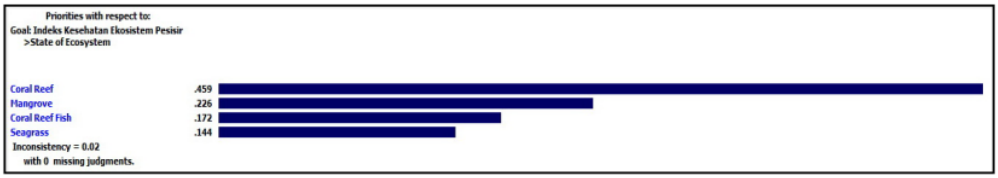

Figure 2. Sub-Variables State of Ecosystem Intensity Scale

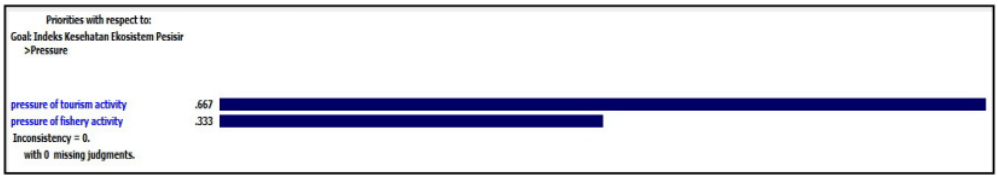

Figure 3. Sub-Variables Pressure Intensity Scale

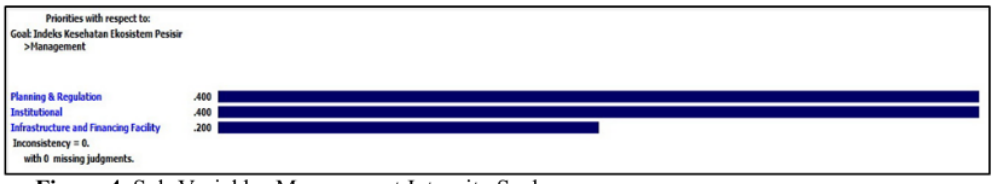

Figure 4. Sub-Variables Management Intensity Scale

3.2. Operational Variables of Coastal Health Ecosystem

Sub-variables were divided into several Operational variables. Sub-variables Coral reef and Coral reef fish consist of 5 Operational variable while sub-variables Mangrove and Seagrass consist of 6 Operational variable. Operational variables of Coral reef i.e. Coral reef percent cover; Coral reef biodiversity; Coral reef similarity; Coral reef dominance and Coral reef cover. The highest and the lowest importance value were Coral reef percent cover (0,058) and Coral reef dominance (0,017), respectively (see **Figure 5)**. Operational variables of Coral reef fish i.e. Species abundance per family, Number of species, Coral reef fish biodiversity, Coral reef fish similarity and Coral reef fish dominance. Coral reef fish biodiversity (0,025) was the highest variables, while Coral reef fish dominance and Coral reef fish similarity, obtain the same value (0,007) (see **Figure 6)**. Operational variables mangrove consist of 6 Operational variable, i.e. Mangrove percent cover; Mangrove density; Mangrove biodiversity; Mangrove similarity; Mangrove dominance and Mangrove cover. The highest and the lowest importance value were Mangrove percent cover (0,019) and Mangrove similarity (0,009), respectively (see **Figure 7)**. Operational variables of Seagrass i.e. Seagrass percent cover; Seagrass density; Seagrass biodiversity; Seagrass similarity; Seagrass dominance and Seagrass cover. Seagrass density (0,012) and Seagrass similarity (0,005) were the highest and the lowest variables (see **Figure 8)**.

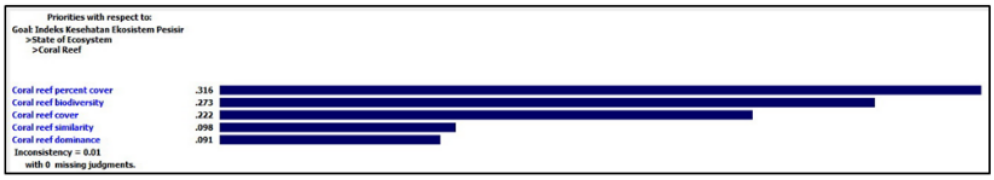

Figure 5. Operational Variables Coral Reef Intensity Scale

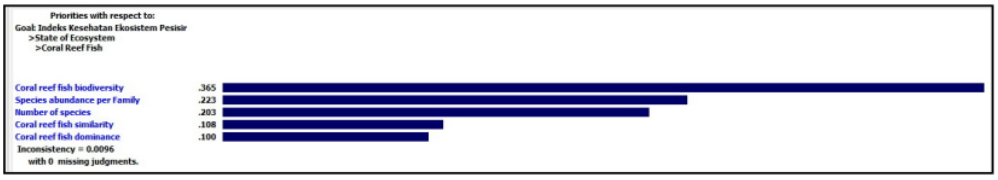

Figure 6. Operational Variables Coral Reef fish Intensity Scale

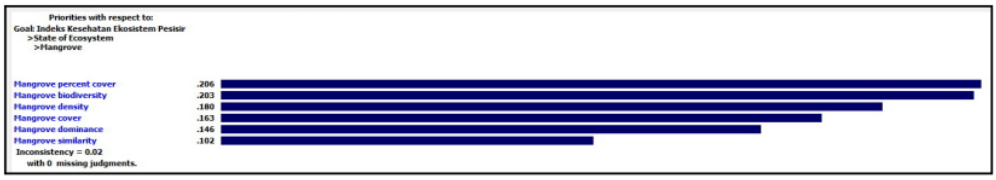

Figure 7. Operational Variables Mangrove Intensity Scale

Figure 8. Operational Variables Seagrass Intensity Scale

Sub-variables Planning & regulation consist of 3 Operational variable while sub-variables Institutional and Infrastructure & financing facility consist of 4. Sub-variables Planning & regulation and Infrastructure & financing facility have Operational variables which have same value that is 0,053 and 0,020 respectively. The highest and the lowest Operational variables in each Sub-variable Institutional were Coordination (0,048) and Number of employees (0,034) (see **Figure 9**).

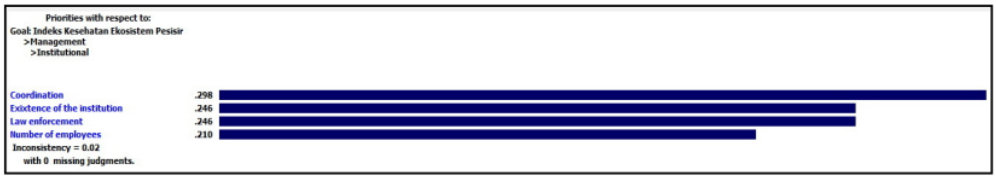

Figure 9. Operational Variables Institutional Intensity Scale

3.3. Overall Variables Analysis of Coastal Health Ecosystem

A set of variable that will be used as indicators of coastal ecosystem health have been determined and weighted. The variables consist of 3 level i.e. Main variables, Sub-variables and Operational variables. Afterward, operational variables will be used as indicators of coastal ecosystem health assessment. Based on integrated analysis of AHP to all of variables, 3 variables get the highest value i.e. Pressure of tourism activity (0,064); Coral reef percent cover (0,059) and Coral reef biodiversity (0,051) (see **Figure 10**).

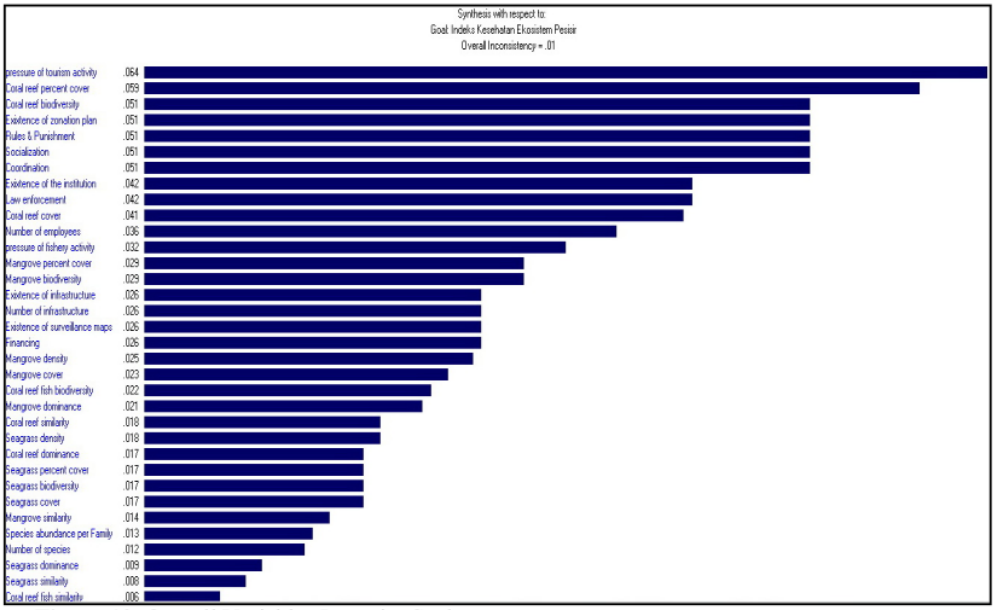

Figure 10. Overall Variables Intensity Scale

Most of the expert respondents agreed that there is an increasing number of potential pressures derived from tourism activities in Karimunjawa National Marine Park (KNMP). It is in line with the fact that there is an increase in the number of visitors. The number of visitors' karimunjawa in 2014 increased by nine times greater when compared in 2004 [16]. Increased intensity of tourist visit has the potential to threaten coral reef ecosystem in TNMP [17], [18].

The threat of degradation of ecosystem quality in KNMP arrives particularly from fishery activities and marine tourism activities that are not environmentally friendly [18]. Destructive fishing activities in the form of not environmentally friendly fishing gear and zoning transgressions have been monitored. Moreover, some transgressions in fishing activities have been punished. Contrary with monitoring fisheries activities which has been done, supervision of destructive marine tourism activity has not been optimally monitored. It is seen from the absence of reports of transgressions in marine tourism activity whereas there has been some ecosystem damage due to marine tourism activity. Broken branching corals and massive corals that die from being trampled by tourists found in locations with high marine tourism activity [18]. The high biodiversity of KNMP makes this area as a potential as a tourist destination. Destructive marine tourism activities will cause ecosystem damage and threaten biodiversity. There is a need to develop stronger conservation strategies to facing with pressures from marine tourism activities.

4. Conclusion

Pressure of tourism activity is the variable that most affect the health of the ecosystem in KNMP, based on expert respondents. Tourism activities that are not environmentally friendly have not been optimally monitored. There is a need to develop stronger conservation strategies to facing with pressures from marine tourism activities.

References

[1] Asian Development Bank 2014 State of The Coral Triangle: Indonesia. Asian Development

Bank, Mandaluyong City, Philippines:1-84.
[2] Ambariyanto 2010 Kebijakan pengelolaan organisme laut dilindungi: kasus kerang raksasa. Undip Press, Semarang.
[3] Barber P H, Ablan-Lagman M C A, Ambariyanto, Berlinck R G S, Cahyani D, Crandall E D, Ravago-Gotanco R, Juinio-Meñez M A, Mahardika I G N, Shanker K, Starger C J, Toha A H A, Anggoro A W and Willette D A 2014 Advancing biodiversity research in developing countries: the need for changing paradigms. *Bull. Mar. Sci.*, 90(1): 187–210.
[4] Veron J E N 1995 Corals in space and time. The biogeography and evolution of the scleractinia. UNSW Press, Sydney.
[5] Ambariyanto 2017 Conserving endangered marine organisms: causes, trends and challenges. *IOP Conf. Ser. Earth Environ. Sci.*, 55: 1-10.
[6] van Oudenhoven A P E, Siahainenia A J, Sualia I, Tonneijck F H, van der Ploeg S, de Groot R S, R. Alkemade and Leemans R 2015 Effects of different management regimes on mangrove ecosystem services in Java, Indonesia. *Ocean Coast. Manag.*, 116: 353–367.
[7] Giesen W, Wulffraat S, Zieren M and Scholten L 2007 Mangrove guidebook for Southeast Asia. Dharmasarn Co., Ltd: 1-781.
[8] Clough B 2013 Continuing the journey amongst mangroves. ISME Mangrove Educaitonal Book Series. International Society for Mangrove Ecosystem (ISME), Okinawa, Japan and International Tropical Timber Organization,Yokohama, Japan. 1: 1-86.
[9] Mimura N, Ed. 2008 Asia-Pasific Coasts and Their Management. Springer, 11: 1-365.
[10] Prasetya J D, Ambariyanto, Supriharyono and Purwanti F 2017 Mangrove health index as part of sustainable management in mangrove ecosystem at Karimunjawa National Marine Park Indonesia. *Adv. Sci. Lett.*, 23(4): 3277-3282.
[11] Juffe-Bignoli D, Burgess N, Bingham H, Belle E M S, De-Lima M G, Deguignet M, Bertzky B, Milam A N, Martinez-Lopez J, Lewis E, Eassom A, Wicander S, Geldmann J, van Soesbergen A, Arnell A P, O'Connor B, Park S, Shi Y N, Danks F S, MacSharry B, Kingston N 2014 Protected planet report 2014. Cambridge, UK: 1-68.
[12] Flower J, Ortiz J C, Chollett I, Abdullah S, Castro-Sanguino C, Hock K, Lam V and Mumby P J 2017 Interpreting coral reef monitoring data: A guide for improved management decisions. *Ecol. Indic.*, 72: 848-869.
[13] Saaty T L and Vargas L G 2012 Models, methods, concepts & applications of the Analytic Hierarchy Process. Springer Science+Business Media New York, 175: 1-341.
[14] Zahedi F 1986 The Analytic Hierarchy Process: A survey of the method and its applications, *Interfaces (Providence).* 16(4): 96–108.
[15] Soma K 2003 How to involve stakeholders in fisheries management a country case study in Trinidad and Tobago. *Mar. Policy*, 27: 47–58.
[16] DKP. Prov. Jateng 2014 Identifikasi potensi dan pemetaan pulau-pulau kecil di pulau Menjangan Kecil Karimunjawa. Dinas Kelautan dan Perikanan Provinsi Jawa Tengah.
[17] Kartawijaya T, Prasetia R, Ripanto and Jamaludin 2011 Pengembangan ekowisata berbasis masyarakat di Taman Nasional Karimunjawa. Wildlife Conservation Society-Indonesia Program.
[18] Pardede S, Tarigan S A R, Setiawan F, Muttaqin E, Muttaqin A and Muhidin 2016 Laporan Teknis Monitoring Ekosistem Terumbu Karang Taman Nasional Karimunjawa 2016. Wildlife Conservation Society-Indonesia Program.

Hierarchical Synthesis of Coastal Ecosystem Health Indicators at Karimunjawa National Marine Park

ORIGINALITY REPORT

12%	%	12%	%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	Şehnaz Şener, Erhan Sener, Remzi Karagüzel. "Solid waste disposal site selection with GIS and AHP methodology: a case study in Senirkent–Uluborlu (Isparta) Basin, Turkey", Environmental Monitoring and Assessment, 2010 Publication	3%
2	Merlina N. Andalecio. "Including coastal resource users in fisheries management evaluation of San Miguel Bay, Philippines", Ocean & Coastal Management, 2011 Publication	3%
3	PingSun Leung, Jill Muraoka, Stuart T Nakamoto, Sam Pooley. "Evaluating fisheries management options in Hawaii using analytic hierarchy process (AHP)", Fisheries Research, 1998 Publication	1%
4	"Asia-Pacific Coasts and Their Management", Springer Science and Business Media LLC,	1%

2008
Publication

5	Ma'ruf Kasim. "Chapter 8 Measuring Vulnerability of Coastal Ecosystem and Identifying Adaptation Options of Indonesia's Coastal Communities to Climate Change: Case Study of Southeast Sulawesi, Indonesia", Springer Science and Business Media LLC, 2021 Publication	1 %
6	Julie P. Hawkins. "The threatened status of restricted-range coral reef fish species", Animal Conservation, 2/2000 Publication	1 %
7	Alexander P.E. van Oudenhoven, Audrie J. Siahainenia, Ita Sualia, Femke H. Tonneijck et al. "Effects of different management regimes on mangrove ecosystem services in Java, Indonesia", Ocean & Coastal Management, 2015 Publication	<1 %
8	Henri Vallès, Hazel A. Oxenford, Alex Henderson. "Switching between standard coral reef benthic monitoring protocols is complicated: proof of concept", PeerJ, 2019 Publication	<1 %
9	MacKinnon, D., C. J. Lemieux, K. Beazley, S. Woodley, R. Helie, J. Perron, J. Elliott, C. Haas,	<1 %

J. Langlois, H. Lazaruk, T. Beechey, and P. Gray. "Canada and Aichi Biodiversity Target 11: understanding ‘other effective area-based conservation measures’ in the context of the broader target", Biodiversity and Conservation, 2015.
Publication

10	Indra Jaya, Fayakun Satria, Wudianto, Duto Nugroho et al. ""Are the working principles of fisheries management at work in Indonesia?"", Marine Policy, 2022 Publication	<1 %
11	"Threats to Mangrove Forests", Springer Science and Business Media LLC, 2018 Publication	<1 %
12	Mangrove Ecosystems of Asia, 2014. Publication	<1 %

Exclude quotes	On	Exclude matches	Off
Exclude bibliography	On		