Socio-Ecological System perspective of seagrass ecosystem in Wakatobi

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Abstract. The Socio-Ecological System (SES) perspective is widely used to identify and explain the relationship between seagrass ecosystem and their dependent community. These relationships can be recognized when humans utilize the seagrass ecosystem that benefits as a dependent community. Further, these utilization patterns can be used as a basis for managing the seagrass ecosystems themselves. This study was conducted to identify and map the relationship between seagrass ecosystem and their communities in Wangi-wangi Island, Kaledupa Island and Tomia Island. The data were collected in June–July 2019 through observation, focused group discussions and interviews with 59 respondents. The relationship between the seagrass ecosystem and its community was analyzed descriptively. The results show that the SES built a simple pattern. Seagrass ecosystems were used as the main source of daily food for island people. Seagrass products were traded limited inside the island. Resource users, infrastructure providers, as well as public infrastructure formed a short chain. It is important to preserve the condition of seagrass ecosystems by ensuring existing legal rules and local wisdom to enhance the SES.

Keywords: seagrass ecosystem; Socio-Ecological System; daily food source; Wakatobi

1. Introduction

An ecosystem is the reciprocal relationship processes between living things and their environment. Inside the ecosystem, every living organism has a role in forming an interaction among them. Interactions that occur may be mutualism or parasitism. The social system is one important aspect that has a significant influence on the ecosystem. Ecosystems will change due to unbalanced interactions between the social systems related to the ecosystem itself. Excessive social systems will trigger exploitation into ecosystems. Therefore controlling the interaction that occurs between the two systems becomes essential. Integrating ecosystem-based management by considering the social systems’ dynamicity has been known as the Socio-Ecological System (SES) approach [1–2]. The discussion in SES includes ecosystem units associated with social structures and their processes. The two systems interact dynamically and co-evolve, which means that if one system changes, the other system will also change.

Seagrass ecosystems are related to the surrounding ecosystems (mangrove and coral reef ecosystems) and also provide ecosystem services to the surrounding community [3-11]. An example of the linkage
of seagrass with surrounding ecosystems has shown in emperor fish/ *Lethrinus harak*, which utilizing both habitats [12], as nursery ground areas [13] and nutrient contributors [14]. Seagrass ecosystem services, usually shown as provisioning services, means there is a relationship between those ecosystems and human. This relationship has been reported by several researchers from a different point of view. Torre and Ronnback [4]; Norlund *et al.* [6]; Unsworth *et al.* [9] reported the link between the seagrass ecosystem and humans in Africa. Unsworth *et al.* [15] said that seagrass meadows in a small tropical island community to be of a high subsistence and financial value to local fishers. Hereinafter, Unsworth *et al.* [9] found that the seagrass ecosystem protects biodiversity and food security. Moreover, Quiros *et al.* [11] found that seagrass small-scale fisheries can reduce social vulnerability. However, the relationship between seagrass ecosystems and humans from an SES perspective is still limited. Therefore, this study aims to map the Socio-Ecological System components of the seagrass ecosystem in the Wakatobi Regency. The results of this study were expected to be able to use as basic information for managing the seagrass ecosystem in the islands.

2. Methodology

2.1. Study site
The study was located on Wakatobi Islands is a district as well as a national park. The islands are situated at the junction of the Banda Sea and the Flores Sea. Wakatobi is an abbreviation of four large islands in the region, namely Wangi-wangi Island, Kaledupa Island, Tomia Island, and Binongko Island. The Wakatobi archipelago was designated as National Park in 1996 with 1,390,000 hectares, consisting of 39 islands, three patch reefs and five atolls (Minister of Forestry Decree No. 393 / Kpts-VI / 1996). Geographically, the Wakatobi Islands are located between 123°15'00''–124°45'00'' East Longitude and 05°15'00''–06°10'00'' South Latitude. Initially, the Wakatobi islands were administratively included in Buton Regency, Southeast Sulawesi Province, and then based on Law No. 29 of 2003 established as Wakatobi Regency [16].

![Study location](image1.jpg)
2.2. Location and time
The data collection was carried out in June–July 2019. The research was conducted at Liyamawi Village (Wangi-wangi Island), Sama Bahari Village (Kaledupa Island) and Onemay Village (Tomia Island). Site selection has been determined based on the utilization level of seagrass ecosystems by local communities. Seagrass ecosystems are stretched almost along with the islands, with an area estimated at approximately 1,000 hectares [9].

2.3. Data collection and analysis
Ecological conditions of seagrass ecosystems and their social data related are the main target of this study. Ecological condition data has been used to provide an overview of seagrass ecosystem changes and their affected factors. In contrast, social data related has been used to provide an overview of seagrass ecosystem utilization by local communities. Most of the ecological condition data on this study has been obtained through secondary data, and social data has been collected through real measurement and other primary data. Other primary data have been collected through Focused Group Discussion (FGD), group interviews and field observation. On the FGD and interviews, respondents were selected for those who had directly utilizing seagrass ecosystems. The total respondents were 59 people, with details as follows: Liya Mawi village 19 respondents, Sama Bahari village 20 respondents, and Onemay village 20 respondents. Global Positioning System (GPS) tracking has been done in each area using local peoples and their boats to get the real area size extended to the utilization level in each community. Further, the obtained data then be analyzed descriptively supported by spatial data analysis, diagrams and tables.

3. Result

3.1. Seagrass ecosystem condition
In Wakatobi Islands, especially in the three main islands subjected to this study, seagrass ecosystems have been found in large quantities. It extends outward from 1–5 m of shoreline into the reef slope along with the islands. However, the number of seagrass species and those percentages of cover had varied between locations (table 1).

3.2. Socio-economic condition
The location of this study is three villages, which are included in three sub-districts; all three villages are on different islands (table 2). The size of each village varied as well as the population density and distribution (table 2). Liya Mawi Village has the largest area, while Sama Bahari village has a smaller size but the largest population compared among threes. This condition was because the residents of Sama Bahari Village consist of Bajo people in general, and the majority live above the water and use all sea resources as their livelihood compliance [21], so they generally live in dense communities.

The highest number of fishers were found at Sama Bahari Village, which was 24.65% of the total population, and it was recognized as fishing fishers and marine culture fishers. Meanwhile, the percentage of fishers was counted for 6.66% in Liya Mawi Village, and this number was higher than in Onemay Village, which was only 5.44%. Further, all fishers in Onemay village are identified as fishing fishers, while in Liya Mawi Village, about half of them are identified as seaweed culturists.

3.3. Human and seagrass ecosystem interaction
Fishers in three villages have the main occupation as fishing fishers. Their main catching targets are small pelagic fish, reef fish, and demersal fish. All catches are sold in the market, while their household daily needs were fulfilled from the seagrass ecosystem. They are usually using seagrass ecosystems in their backyard or on small islands surrounding their village to set their daily food; indeed, they sell the captured valuable biota into the local market inside their community. Observation in the local market found that almost all eatable biota originated from seagrass ecosystems, such as mollusks, fish, crabs, shrimp, cuttlefish, sea urchins, and octopus (figure 2).
Local fishers are using simple fishing gear and small boats to capture biota inside seagrass ecosystems. The type of boats is rowing boats or outboard engines. Simultaneously, the fishing gears used are nets, spears, crowbars, traps, arrows, fishing rods, *kulu-kulu* (fish trap), *puria*, bamboo rods, *sifu* (net), *soron soro*, machetes, *sero, deu* and *nabu* (gleaning) (table 3 and figure 3).

**Table 1.** Seagrass percentage cover and number of species in Wakatobi Regency.

| Location/village | Island  | % Cover | Number of species | Reference |
|------------------|---------|---------|-------------------|-----------|
| Waha             | Tomia   | 9       | 9 species         | [17]      |
|                  |         |         | *Halodule pinifolia, Halophila ovalis,*<br>*Thalassodendron ciliatum,*<br>*Halodule universis,*<br>*Thalassia hemprichii, Enhalus acoroides,*<br>*Cymodocea serrulata, Cymodocea rotundata,*<br>*Syringodium isoetifolium.* |           |
| Mandati          | Wangi-wangi | 72.4    | 7 species         | [18]      |
| Numana           | Kaledupa | 47.5    | *Enhalus acoroides, Thalassia hemprichii,*<br>*Cymodocea serrulata,*<br>*Cymodocea rotundata, Halodule uninervis,*<br>*Halophila ovalis,*<br>*Syringodium isoetifolium.* |           |
| Sama Bahari      | Kaledupa | 78.2    | 4 species         |           |
| Mantigola        |         | 69.4    |                   |           |
| Hurou            |         | 81.1    |                   |           |
| South of Karang Kapota | Wangi-wangi | 37.22   | 2 species         | [19]      |
| Karang Kapota    |         | 46.16   | 4 species         |           |
| Kabitatogo       |         | 40.63   | 4 species         |           |
| Sousu            |         | 57.77   | 5 species         |           |
| Darawa           | Kaledupa | 51.42   | 4 species         |           |
| Tanomeha         |         | 41.86   | 6 species         |           |
| Hoga Island      |         | 50.28   | 4 species         |           |
| Sombano          |         | 42.80   | 4 species         |           |
| Sombano Timur    |         | 53.98   | 3 species         |           |
| Kolosoha         | Tomia   | 38.41   | 6 species         | [19]      |
| Onemay           |         | 70.17   | 7 species         |           |
| Wakatobi Regency |         | 48.24   | 8 species         |           |

**Table 2.** Population number, density, and fishers number in the study site.

| Villages   | Sub District | Island name   | Area (km²) | Population (person) | Density (person/km²) | Fishers number |
|------------|--------------|---------------|------------|---------------------|----------------------|----------------|
| Liya Mawi  | South Wangi-wangi | Wangi-wangi | 6.94       | 1,652               | 238                  | 60             |
| Sama Bahari| Kaledupa      | Kaledupa      | 1.5        | 1,870               | 1,246                | 261            |
| Onemay     | Tomia         | Tomia         | 6          | 1,746               | 291                  | 95             |

Source: [21–23]
Table 3. Fishing gear and species target in the study area.

| Fishing Gear    | Liya Mawi | Sama Bahari | Onemay | Species target                  |
|----------------|-----------|-------------|--------|---------------------------------|
| Net*           | 0         | 80          | 7      | Fish                            |
| Fishing rod*   | 30        | 30          | 15     | Fish                            |
| Trap*          | 0         | 15          | 5      | Swimming crab, fish             |
| Others**       |           |             |        |                                 |
| Tombak/spears  | √         | -           | √      | fish                            |
| Panah/speargun | √         | √           | √      | fish                            |
| Sero/fish trap | √         | -           | -      | fish, squid, swimming crab      |
| Pengko         | -         | √           | -      | crustacea                       |
| Nabu/gleaning  | √         | √           | √      | Seaweed, sea urchin, mollusk    |
| Kulu-kulu/fish trap | -   | -          | √      | fish                            |
| Puria          | -         | -           | √      | octopus                         |
| Joran bambu/bamboo rod | -   | -          | √      | fish                            |
| Sifu/net       | -         | -           | √      | Juvenile fish                   |
| Soran soro     | -         | -           | √      | fish                            |
| Deu            | -         | -           | √      | octopus                         |
| Parang/machetes | -      | -          | √      | fish                            |
| Buanililala    | -         | -           | √      | fish                            |
| Pontu/Linggis/crowbar | -   | -          | √      | octopus                         |
| Bubu/fish trap | √         |            |        | fish                            |
| Bubu rajungan/swimming crab trap | -   |            | √      | Swimming crab                   |

Source: *[21–23]; **this study.

The FGDs activity revealed that fish captured in seagrass ecosystems had different prices depending on the fishing gear used. This difference is because certain fishing gear has a product characteristic, like better size, valuable kind species, better visual appearances and any other characteristic. The result also shows that fishing nets, pengko and sero have the highest effectivity on capturing the fish; those fishing gears can obtain the highest yield with the value of about Rp. 200,000,-/setting or US$ 14.29 (figure 4).

People utilizing the seagrass ecosystems in three villages are relatively in the same pattern: fishers, local community and peddlers. They give a role for seagrass ecosystems as a source of daily household food consumption. As fishers, they catch fish in seagrass ecosystems, and a small part of their captured fish will be brought home as daily food while the other part will be sold to the community, peddlers, or even in the local market. Peddlers and village traders will be bringing their purchased biota from fishers to the bigger scale of the consumer either at the external market or to the middleman or even to the wholesaler. In the opposite ways, the local people (other than fishers) take the seagrass ecosystem biota directly at the low tides (gleaning) to fulfill their daily needs [18]; sometimes, they also buy from fishers, peddlers or local market. The interactions between users and resources of the seagrass ecosystem in Wakatobi, starting from fishing, selling, and consumption, all concentrated and occurred within the island (figure 5), therefore it can be said that the pattern that was built is a simple pattern.
Figure 2. Several edible biotas found in the seagrass ecosystem at the study site.

Figure 3. Several traditional fishing gear in study area.
Figure 4. The results of the acquisition of each fishing gear every day.

Figure 5. Utilization pattern of seagrass ecosystem in the study site.
Note: thick line = many; medium line = medium; thin line = few
4. Discussion

4.1. Socio-ecological pattern in seagrass ecosystem

Utilization of seagrass ecosystem resources cannot be separated from the four components of exertions: the resources themselves, resource users, resource providers and those public infrastructures [1]. The status of those fourth components mentioned was identified, and the results were summarized in table 4. The simple utilization pattern of seagrass ecosystems is shown in the related table by considering the correlation among those fourth SES components. The simple pattern occurred because seagrass ecosystem resources in the Wakatobi area are mostly used only to fulfill the daily food consumption of the local community, and it also happens limited within those islands. Unlike the utilization pattern that happened in Wakatobi, the SES component of seagrass ecosystems in the Bintan Regency was forming a more complex pattern compared to Wakatobi’s [24]; this was because the utilization in Bintan mostly tends to gain the commercial purposes than to fulfill the daily needs. Further, Unsworth et al. [15]; Unsworth et al. [9] and Torre-Castro et al. [8] have been reported that the seagrass ecosystems are playing the role of food security in small islands.

4.2. The necessity of seagrass ecosystem management

The Wakatobi Regency was occupied by a population of 95,737 people in 2018, with a density of 116 residents per km² [16]. Those populations dominantly stayed in the coastal area and exploited a seagrass ecosystem for their daily activity. This condition is considered pressure for marine resources, especially in the seagrass ecosystem, although it has long been practiced to fulfill the daily needs. Since the seagrass ecosystem has significantly contributed to the Wakatobi islands community, it has become urgent for local governments to pay attention to the sustainability of these ecosystems.

On behalf of seagrass ecosystem management and utilization with the existed simple SES pattern, several aspects of being considered are the resources units (seagrass ecosystem itself), resources governance (regulations related to seagrass ecosystem management), and resources user (islands community) [2]. The percentage of seagrass cover in the Wakatobi Islands has been reported in 48-69% [19, 18], which means the condition was categorized as unhealthy ecosystem based on Ministry of Environment Decree Number 200 the year 2004. However, further analysis was shown that the water quality in the related area had been found in between the range for standard water quality for biota based on the Ministry of Environment Decree Number 51 the years 2014. This finding has also emphasized a report by Suherlan et al. [17], which has measured several water quality parameters in Waha Villages - Tomia Island. They reported that the water temperature ranged between 26.5–31.2 °C, while water transparency was 100% into the bottom floor of the coastal area. Further, seagrass ecosystem was found in-depth ranged from 13–159 cm, with water current was 0.04–0.049 m/sec, salinity ranged from 29.7–32, 5 ‰, tidal ranged from 13–159 cm, nitrate content in water bodies ranged from 0.0160 to 0.0180 mg/L, and phosphate content ranged from 0.0074 to 0.0091 mg/L. In contrast, all water quality parameters were considered as suitable conditions for the growth of seagrasses.

There are several rules related to the protection of seagrass ecosystems in the Wakatobi Regency. First, Minister of Forestry Decree Number 393 / Kpts-VI / 1995 declared the establishment of the Wakatobi Islands as a National Park area. The regulation also includes zoning management that consists of a core zone, buffer zone, and the utilization zone.

Second, the local wisdom, such as ‘tuba dikatutuang’. Tuba dikatutuang is the local wisdom rule of the Bajo community applied on Hoga Island. The aim to preserve biodiversity, especially fish resources that are still abundant in certain places. The specific contents of Tuba Dikatutuang regulation include: 1) limitation/regulation of catch production in conservation areas; 2) fishing is not allowed for fish laying their eggs in any location; 3) prohibition of all forms of fishing activities in certain areas; 4) prohibition for anchor disposal because it will damage the reef at the Tuba location; 5) prohibition on catching the protected species of fish [25].

Third, community agreement. There is a Tomia fishing organization known as Komunto (Tomia Fishermen Community) in Tomia Island. This organization was formed in response to community
concerns about foreign commercial fishing, the use of destructive fishing methods, and the vacuum of local government leadership in the sustainable management of Wakatobi Islands natural resources [26]. Based on this situation, the organization has established several roles for ecological utilization with the reward and punishment at the local level. This method is proven to be useful, especially to bind the local people because the roles established are containing a social punishment followed by other forms of punishment.

According to the above discussions, based on the SES perspective, it could be concluded that proper arrangements of utilization can maintain the sustainability of seagrass ecosystems in the Wakatobi Islands. It is also demanding awareness and participation from related communities and their local government.

Table 4. Comparison SES component between 2 location.

| Component                              | Wakatobi Regency | Bintan Regency* |
|----------------------------------------|------------------|-----------------|
| Used seagrass ecosystem for Resources  | Mostly used for the consumption of the island community | Used as a household income |
|                                        | Fish, swimming crabs, mollusk, sea cucumber, octopus, seaweed, squid, sea urchin, sipunculus | Fish, swimming crab, mollusk, sea horse, squid. |
| Resources user                         | Fishermen, island community, peddler | Fishermen, the village community, peddler, local trader, district trader, domestic tourist |
| Resource provider                      | Fishers, island community, peddler | Fishers, the village community, peddler, local trader, district trader, |
| Public infrastructure                  | Village market, jetty | Village market, district market, pier |
| Formal regulations and traditional wisdom related to ecosystem protection | Yes—Minister of Forestry Decree, Bajo traditional wisdom | Yes—Bupati of Bintan Regency Decree No. 267/V1/2010 about Seagrass Conservation Area. |
| Society engaged in Conservation        | Yes—in Tomia, namely Tomia Fishermen Community | Yes—Fishers society |
| Anthropogenic threat                   | Resort development | Resort development, *tarball*, domestic waste |
| Natural threat                         | Not known         | Not known       |

*[24]

5. Conclusion

The SES pattern formed in the seagrass ecosystem at Wakatobi Regency has been identified as a simple pattern. The main use of biota from seagrass ecosystems was to fulfill the daily food needs of the community within the island. The distribution of captured biota among the islands happened by trading from fishers to peddlers or traditional markets available above the islands. This pattern has been proven that seagrass ecosystems generally play a role as a food security agent for communities. The sustainability of seagrass ecosystems needs to be ensured by implementing the existing legal rules and local wisdom to maintain the SES in Wakatobi Regency.

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Reference

[1] Anderies J M, Janssen M A and Ostrom E 2004 A framework to analyze the robustness of social-ecological systems from an institutional perspective *Ecology and Society* 9(1): 18 http://www.ecologyandsociety.org/vol9/iss1/art18

[2] Ostrom E 2009 A general framework for analysing sustainability of social-ecological systems Science 325: 419–422

[3] Costanza R, d’Arge R, de Groot R, Farberk S, Grasso M, Hannon B, Limburg K, Naeem S, O’Neill R V, Paruelo J, Raskin R G, Sutton P and van den Belt M 1997 The value of the world’s ecosystem services and natural capital *Nature* 387: 253–260

[4] de la Torre-Castro M and Ronnback P 2004 Link between humans-seagrasses – an example from Tropical East Africa *Ocean & Coastal Management* 47: 361–387

[5] Millenium Ecosystem Assessment 2005 *Ecosystems and Well-Human Being Synthesis* Island Press. Washington DC 137 p

[6] Nordlund L, Erlandsson J, de la Torre-Castro M and Jiddawi N 2010 Changes in an East African social-ecological seagrass system: invertebrate harvesting affecting species composition and local livelihood *Aquat. Living Resour* 23: 399–416 DOI: 10.1051/alr/2011006

[7] Cullen-Unsworth L C, Nordlund L M, Paddock J, Baker S, McKenzie L J and Unsworth R K F 2014 Seagrass meadows globally as a coupled social-ecological system: Implication for human wellbeing *Marine Pollution Bulletin* 83: 387–397

[8] de la Torre-Castro M, Di Carlo G and Jiddawi N S 2014 Seagrass importance for small-scale fishery in the tropics: The need for seascapes management *Marine Pollution Bulletin* 83: 398–407 http://dx.doi.org/10.1016/j.marpolbul.2014.03.034

[9] Unsworth R K F, Hinder S L, Bodger O G and Cullen-Unsworth L C 2014 Food supply depends on seagrass meadows in the coral triangle *Environ. Res. Lett.* 9: 094005 9pp.

[10] Tebaiy S 2016 Connectivity pattern of Socio-Ecology System of Youtefa Bay community in utilizing seagrass ecosystem *KnE Social Sciences* 2016 11 pages DOI 10.18502/kss.v1i1.433

[11] Quiros T E A L, Beck M W, Araw A, Croll D A and Tershy B 2018 Small-scale seagrass fisheries can reduce social vulnerability: a comparative case study *Ocean and Coastal Management* 157: 56–67 https://doi.org/10.1016/j.ocecoaman.2018.02.003

[12] Unsworth R K F, De León P S, Garrard S L, Smith D J and Bell J J 2009 Habitat usage of the Thumbprint Emperor *Lethrinus harak* (Forsskal, 1775) in Indo-Pasific Coastal Seascape *The Open Marine Biology Journal* 3: 16–20

[13] Jaxion-Ham J, Saunders J and Speight M R 2012 Distribution of fish in seagrass, mangrove and coral reef: life-stage independent habitat use in Honduras *Rev. Biol. Trop.* 60(2): 683–698

[14] Shih-Han C, Yen-Hsun H and Hsing-Juh L 2013 Carbon budget of leaves of the tropical intertidal seagrass *Thalassia hemprichii* *Estuarine, Coastal and Self Science* 125: 27–35

[15] Unsworth R K F, Cullen L C, Pretty J N, Smith D J and Bell J J 2010 Economic and subsistence values of the standing stocks of seagrass fisheries: Potential benefits of no-fishing marine protected area management *Ocean and Coastal Management* 53(5-6): 218–224 https://doi.org/10.1016/j.ocecoaman.2010.04.002

[16] BPS Kabupaten Wakatobi 2019 *Kabupaten Wakatobi dalam Angka 2019* Badan Pusat Statistik Kabupaten Wakatobi 395 hal

[17] Suherlan D O and Arami H 2016 Keragaman jenis Lamun di Perairan Pantai Waha Kecamatan Tomia, Kabupaten Wakatobi *Jurnal Manajemen Sumber Daya Perairan* 1(3): 311–321

[18] Furkon, Nessa N, Ambo-Rappe R, Cullen-Unsworth L C and Unsworth R F K 2018 Social-ecological drivers and dynamics of seagrass gleaning fisheries *AMBIO A Journal of the Human Environment* 49(7) https://doi.org/10.1007/s13280-019-01267-x

[19] Utama R S, Cappenberg H A W, Angraeni D, Edrus I N, Makatipu P, Irawan A, Dharmawan I W E, Budiyanto A, Dzumalex A R and Salatalohi A 2019 Kondisi Kesehatan Terumbu Karang dan Ekosistem Terkait Di Kabupaten Wakatobi, Sulawesi Tenggara 2019 Jakarta Pusat Penelitian Oceanografi Lembaga Ilmu Pengetahuan Indonesia 102 hal
[20] Suryanegara E, Suprajaka and Nahib I 2015 Perubahan sosial pada kehidupan Suku Bajo: Studi kasus di Kepulauan Wakatobi, Sulawesi Tenggara *Majalah Globe* 17(1): 067–078

[21] BPS Kabupaten Wakatobi 2018a *Kecamatan Wangi-wangi Selatan dalam Angka 2018* Badan Pusat Statistik Kabupaten Wakatobi 146 hal

[22] BPS Kabupaten Wakatobi 2018b *Kecamatan Kaledupa dalam Angka 2018* Badan Pusat Statistik Kabupaten Wakatobi 146 hal

[23] BPS Kabupaten Wakatobi 2018c *Kecamatan Tomia dalam Angka 2018* Badan Pusat Statistik Kabupaten Wakatobi 146 hal

[24] Sjafrie N D M 2018 Identifikasi Sistem Sosial-Ekologi (SES) ekosistem lamun di Kabupaten Bintan *Oceanologi dan Limnologi di Indonesia* 3 (2): 123–136

[25] Haraswaty E, Anas P and Wisudo S H 2017 Peran kearifan lokal Suku Bajo dalam mendukung pengelolaan kawasan konservasi Kabupaten Wakatobi *Jurnal Penyuluhan Perikanan dan Kelautan* 11(1): 25–34

[26] United Nations Development Programme 2012 *Fishing Community of Tomia (KOMUNTO), Indonesia Equator Initiative Case Study Series* New York (NY) 9 pp

**Other References**

Keputusan Menteri Kehutanan Nomor 393/Kpts-VI/1996 tentang Penetapan Kawasan Taman Nasional Wakatobi

Keputusan Menteri Lingkungan Hidup Nomor 200 Tahun 2004 Tentang Kriteria Baku Kerusakan dan Pedoman Penentuan Status Padang Lamun

Keputusan Menteri Lingkungan Hidup Nomor 51 tahun 2004 tentang Baku Mutu Air Laut