Biodiversity Study on Segara Anakan Lagoon

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Abstract. Segara Anakan is the only estuary on the southern coast and the widest mangrove ecosystem in Java Island. However, it is currently not included in the list of government protected conservation area. This study aims to identify the biodiversity in Segara Anakan conservation area. The results of this identification show the types of flora, fauna and their conservation status in a biodiversity profile. The results of this study showed that Segara Anakan conservation area is 16,253.2 ha with mangrove ecosystem as its main ecosystem. The total area of mangrove is 3,980 ha. There are 60 species of mangrove plants, one of them has a "near threatened" status according to the IUCN Red List (i.e. Ceriops decandra). According to the IUCN Red List, two birds are on "vulnerable" and one mammal has a "near threatened" conservation status. From the Shannon-Wiener biodiversity index calculation, the biodiversity level of the Segara Anakan Lagoon is categorized as a medium with the value 1.76 – 2.80. The Segara Anakan community also uses mangroves for processed food and batik colouring which can generate group turnover of around 2 to 3 million rupiahs per month.

1. Introduction
Indonesia is an archipelagic country with its 81,000 km of coastline. 60% of the population lives shows the direct relationship between society and the sea. Mangrove forests are a distinguishing element of the Indonesian coastal regions [1].

Segara Anakan is one of the widest mangrove ecosystems in Java Island. Segara Anakan Lagoon is located at the southern coast of Central Java (S7° 39'- S7° 43', E108°50'- E109°00'). The lagoon is an estuarine ecosystem with freshwater entry from rivers located in the north and seawater entry during high tide at the eastern and western inlets of the lagoon. The island of Nusa Kambangan separates the lagoon from the Indian Ocean [2].

Segara Anakan mangrove ecosystem carries both economic and social values for the local residents [3]. The main source of local residents incomes are obtained from Segara Anakan ecosystem. Mangrove ecosystem runs as a breeding place for local residents’ caught fish. Moreover, locals also work on mangrove-based crafts and processed food. With all prosperity provided by the ecosystem, the conservation program continues.

Number of flora and fauna spreads on the area, yet, Segara Anakan has not been listed on national protected area by the government. Segara Anakan mangrove ecosystems biodiversity rapidly decreases as the area remains unprotected. This study aims to analyze possibility in the establishment of Segara Anakan area as a world biosphere reserve.
2. Materials and methods

2.1 Location of Study Area
The study area is located within Segara Anakan area which administratively covers 5 villages: (1) Ujung Alang Village, (2) Ujung Gagak Village, (3) Panikel Village, (4) Klaces Village, and (5) Desa Kutawaru. For biodiversity study, the study area is divided into 4 division and 19 unit analysis to facilitate in analyzing. The division and unit analysis of the study area are presented in Table 1. The study area and unit analysis map are presented in Figure 1.

Table 1. Division and Unit Analysis of Study Area

| No. | Division | Unit Analysis Number | Unit Analysis Name | Coordinate S˚ E’ | Transect |
|-----|----------|----------------------|--------------------|------------------|----------|
| 1   | S15      | S1                  | Tritih 1           | 07° 39.841’ 109° 01.699’ | S15A – S15B |
| 2   | S16      | S1                  | Tritih 2           | 07° 39.841’ 109° 01.699’ | S16A – S16B |
| 3   | S17      | 1                    | North Donan        | 07° 39.581’ 109° 00.672’ | S17A – S17B |
| 4   | S18      | S1                  | Lomanis Hill       | 07° 39.978’ 109° 00.506’ | S18A – S18B |
| 5   | S19      | S1                  | Front Frenca       | 07° 42.905’ 108° 59.500’ | S19A – S19B |
| 6   | S2       | 1                    | East Candi         | 07° 43.053’ 108° 57.439’ | S1       |
| 7   | S3       | 2                    | Candi              | 07° 43.154’ 108° 56.441’ | S2       |
| 8   | S4       | 2                    | South              | 07° 42.508’ 108° 55.547’ | S3B – S3C |
| 9   | S13      | S1                  | Cilora             | 07° 40.674’ 108° 55.743’ | S13A – S13B |
| 10  | S14      | S1                  | Dangal River       | 07° 41.697’ 108° 57.595’ | S14A – S14B |
| 11  | S5       | S1                  | North Pasuruan     | 07° 42.525’ 108° 53.680’ | S4A – S4B |
| 12  | S6       | S1                  | Ketapang           | 07° 42.513’ 108° 52.409’ | S5A – S5B |
| 13  | S3       | 3                    | West Bagja         | 07° 42.922’ 108° 52.755’ | S8A – S8B |
| 14  | S11      | 2                    | Blanakan           | 07° 42.293’ 108° 53.709’ | S11A – S11B |
| 15  | S12      | 2                    | Dusun Bondan       | 07° 41.465’ 108° 53.406’ | S12A – S12B |
| 16  | S6       | 4                    | Masigit Sela       | 07° 41.435’ 108° 50.836’ | S6A – S6B |
| 17  | S7       | 4                    | Front Klaces       | 07° 40.996’ 108° 49.532’ | S7       |
| 18  | S9       | 4                    | South Monggor      | 07° 40.901’ 108° 48.741’ | S9A – S9B |
| 19  | S10      | 4                    | West Bagian        | 07° 40.507’ 108° 49.940’ | S10A – S10B |

2.2 Method
This study is a literature review sourced from publications by PT. Pertamina RU IV Cilacap and on-site related studies concerning Segara Anakan lagoon. The portrayal of Segara Anakan is observed further to discern the merits which subsequently used as a basis for studying the various possibilities of its designation as a world biosphere reserve. Identification result and biodiversity analysis is presented in a form of spatial information. This study is divided into four divisions. Each division will be calculated its biodiversity index according to the Shannon-Wiener Index.

The Shannon-Wiener Diversity Index [4]:

\[ H' = - \sum p_i \ln p_i \]  (1)

where \( p_i \) is the proportion of individuals found in species i. For a well-sampled community, this proportion can be estimated as \( p_i = n_i/N \), where \( n_i \) is the number of individuals in species I and \( N \) is the total number of individuals in the community. Since by definition the \( p_i \) will all be between zero and one, the natural log makes all of the terms of the summation negative, which is why the inverse of the sum is taken. Standard value to determine the biodiversity level of a certain area is shown below:
• If $H' > 3$, the biodiversity level categorized as high
• If $H'$ between 1-3, the biodiversity level categorized as medium
• If $H'$ less than 1, the biodiversity level categorized as low

Locals also work on mangrove-based crafts and processed food. This study also briefly discusses the use of mangrove by the community. The data is sourced from direct interview and documentation.

Figure 1. Study Area and Unit Analysis Map

The total management area (1st - 4th Division) is about 16,253.2 ha with mangrove ecosystem as its main ecosystem with its total area is about 3,980 ha.

3. Findings and Analysis

3.1. Study Area Profile

The land surface of the study area is mostly covered by mangrove and grove of swamps. The detail information of the land surface will be provided in Table 2, Figure 2 and Figure 3 for the map.

Table 2. Land Use of Study Area

| Div. | Swamps  | Forest | Industry | Mangrove | Residential | Agriculture | Rice Field | Fishpond/Ex Fishpond | Water Body | Total (ha) |
|------|---------|--------|----------|----------|-------------|-------------|------------|----------------------|------------|-----------|
| 1    | 240.38  | 0.0    | 316.0    | 1,158.97 | 1,462.7     | 1,397.0     | 586.5      | 328.5                | 728.8      | 6,219.84  |
| 2    | 842.25  | 43.5   | -        | 1,672.40 | 44.3        | 112.0       | 92.0       | 225.0                | 521.4      | 3,555.05  |
| 3    | 1,100.25| 5.3    | -        | 629.45   | 17.0        | -           | 9.5        | 814.88               | 178.0      | 2,757.37  |
| 4    | 915.75  | 668.0  | -        | 519.18   | 38.0        | -           | 140.0      | 536.0                | 900.0      | 3,720.93  |
Table 2. Land Use of Study Area

| Div. | Land Use (ha) | Total (ha) |
|------|---------------|------------|
|      | Swamps        | 3,098.63   |
|      | Forest        | 716.8      |
|      | Industry      | 316.0      |
|      | Mangrove      | 3,980.0    |
|      | Residential   | 1,562.0    |
|      | Agriculture   | 1,509.0    |
|      | Rice Field    | 828        |
|      | Fishpond / Ex Fishpond | 1,904.38 |
|      | Water Body    | 2,328.4    |
| Total|               | 16,253.2   |

Figure 2. Study Area Condition

Figure 3. Land Use Map of Study Area
3.2. Mangrove Ecosystem Biodiversity

3.2.1. Variety of Flora. According to research conducted by Pertamina RU IV and BKSDA Cilacap in 2018, 43 varieties of flora are listed in the location of study. The list of the varieties can be found in Table 3, and the map of flora biodiversity as shown in Figure 4.

| No | Binomial Name | Unit Analysis (S) | IUCN Red List Status |
|----|---------------|------------------|----------------------|
| 1  | Acacia mangium | √ | - |
| 2  | Avicenia marina | √ √ | - |
| 3  | Avicenia alba | √ √ | - |
| 4  | Rhizophora mucronata | √ √ | Least Concern |
| 5  | Rhizophora apiculata | √ √ | - |
| 6  | Sonneratia castolaris | √ | - |
| 7  | Sonneratia alba | √ | Least Concern |
| 8  | Derris heterophylla | √ √ √ √ √ | - |
| 9  | Acanthus ilicifolius | √ √ √ √ | Least Concern |
| 10 | Heritiera littoralis | √ √ | Least Concern |
| 11 | Corypha utan | √ | Least Concern |
| 12 | Aegiceras corniculatum | √ √ √ | Least Concern |
| 13 | Clerodendron marae | √ | - |
| 14 | Sphianthes acmella Merr. | √ | - |
| 15 | Imperata sp. | √ | - |
| 16 | Dolichandrone spathacea | √ | Least Concern |
| 17 | Cordia dichotoma Forst.F. | √ | - |
| 18 | Clerodendron serratum | √ | - |
| 19 | Caesalpinia nuga Ait. | √ | - |
| 20 | Sandoricum ketjape | √ | - |
| 21 | Xanthophyllum villosum Merr. | √ | - |
| 22 | Xerosepermum noronhianum Blume | √ | - |
| 23 | Citrus medica Linn. | √ | - |
| 24 | Clerodendron | √ | - |
Sanjatmiko [5] have identified other mangrove vegetation which had not been mentioned by Pertamina RU IV and BKSDA. The vegetation list is presented in Table 4.

**Table 4. Mangrove Vegetation List**

| No. | Binomial Name               | Unit Analysis (S) | IUCN Red List Status |
|-----|------------------------------|-------------------|----------------------|
| 25  | *Finlaysonia interme*       | ✓     ✓     ✓     ✓ | -                    |
| 26  | *Berrya cordofolia* Roxb.   | ✓     |                     |
| 27  | *Flacourtia sp.*            |               |                      |
| 29  | *Leucaena leucocephala*     | ✓     ✓     ✓     ✓ |                     |
| 30  | *Ceriops decandra*          | ✓     ✓     | Near Threatened      |
| 31  | *Vitex pubescens*           | ✓     |                     |
| 32  | *Nypa fruticans*            | ✓     ✓     ✓     ✓ | Least Concern        |
| 33  | *Xylocarpus granatum*       | ✓     ✓     ✓     ✓ | Least Concern        |
| 34  | *Xylocarpus moluccensis*    | ✓     ✓     ✓     ✓ | Least Concern        |
| 35  | *Bruguiera gymnorrhiza*     | ✓     ✓     ✓     ✓ | Least Concern        |
| 36  | *Bruguiera cylindrica*      | ✓     ✓     ✓     | Least Concern        |
| 37  | *Ceriops tagal*             | ✓     ✓     ✓     ✓ | Least Concern        |
| 38  | *Oldenlandia sp.*           | ✓     ✓     | Least Concern        |
| 39  | *Acrostichum aureum*        | ✓     ✓     ✓     ✓ | Least Concern        |
| 40  | *Excoecaria agallocha*      | ✓     ✓     ✓     | Least Concern        |
| 41  | *Lumnitzera racemosa*       | ✓     ✓     ✓     ✓ | Least Concern        |
| 42  | *Merope angulata*           | ✓     ✓     ✓     ✓ | Least Concern        |
| 43  | *Intsia bijuga*             | ✓     ✓     ✓     ✓ | Least Concern        |

**Table 4. Mangrove Vegetation List**
Table 4. Mangrove Vegetation List

| No. | Binomial Name                  | IUCN Red List Status |
|-----|--------------------------------|----------------------|
| 9   | *Calophyllum inophyllum*       | Least Concern        |
| 10  | *Passiflora foetida*           | -                    |
| 11  | *Pandanus tectorius*           | -                    |
| 12  | *Ficus retuso*                 | -                    |
| 13  | *Stachydrpha jamaicensis*      | -                    |
| 14  | *Pandanus odoratissima*        | -                    |
| 15  | *Bruguiera sexangula*          | Least Concern        |
| 16  | *Acrostichum speciosum*        | Least Concern        |
| 17  | *Sambucus javanica*            | -                    |

Summing up from Table 3 and Table 4, there are 60 types of flora scattered around Segara Anakan. 18 of the listed flora hold IUCN status of least concern. Moreover, there is a flora holds the status of near threatened namely *Ceriops decandra*.

3.2.2. Variety of Fauna. Segara Anakan mangrove ecosystem is also rich in fauna types. Table 5 shows fauna variety which conservation status have been identified and acknowledged. The fauna types identified are birds, mammals, and reptiles.

- **CITES (The Convention on International Trade in Endangered Species of Wild Fauna and Flora)**
  The species covered by CITES are listed in three Appendices, according to the degree of protection they need. Appendix I includes species threatened with extinction. Trade in specimens of these species is permitted only in exceptional circumstances. Appendix II includes species not necessarily threatened with extinction, but in which trade must be controlled in order to avoid utilization incompatible with their survival. Appendix III contains species that are protected in at least one country, which has asked other CITES Parties for assistance in controlling the trade. Changes to Appendix III follow a distinct procedure from changes to Appendices I and II, as each Party’s is entitled to make unilateral amendments to it. [6]

- **Status of Protection by The Indonesian Government**
  Status of protection by the government of Indonesia which refers to government regulation no. 7 of 1999 (PP No.7) concerning preservation of plant and animal species. The species covered by PP No. 7 are listed in two statuses namely protected and not protected. [7]

- **The IUCN Red List of Threatened Species [8]**
  According to IUCN (2012), the species covered by IUCN are listed in five statuses.
  
  | Status       |
  |--------------|
  | LC = Least Concern | EN = Endangered |
  | NT = Near Threatened | CR = Critically Endangered |
  | VU = Vulnerable   |                      |

Table 5. List of Fauna

| No. | Family       | Binomial Name              | Conservation Status | IUCN Red List |
|-----|--------------|-----------------------------|---------------------|---------------|
| 1   | Pelecanidae  | *Pelecanus conspicillatus*  | Protected           | LC            |
| 2   | Phalacrocoracidae | *Phalacrocorax sulcirostris* |                     | LC            |
| 3   |               | *Phalacrocorax niger*       |                     | LC            |
| No. | Family        | Binomial Name              | Conservation Status | CITES | PP No. 7 | IUCN Red List |
|-----|---------------|-----------------------------|---------------------|-------|----------|---------------|
| 4   | Ardeidae      | Ardea sumatrana             | LC                  |       |          |               |
| 5   | Ardeidae      | Ardea cinera                | LC                  |       |          |               |
| 6   | Ardeidae      | Ardeola speciosa            | LC                  |       |          |               |
| 7   | Ardeidae      | Casmerodius albus           | LC                  |       |          |               |
| 8   | Ardeidae      | Eretta garzetta             | Protected           | LC    |          |               |
| 9   | Ardeidae      | Isobrychus cinnamomeus      | LC                  |       |          |               |
| 10  | Ardeidae      | Butorides striatus          | Not Protected       | LC    |          |               |
| 11  | Ciconidae     | Mycteris cinerea            | Appendix I          | Protected | VU      |               |
| 12  | Ciconidae     | Leptoptilos javanicus       | Appendix I          | Protected | VU      |               |
| 13  | Accipitridae  | Haliaetus lucogaster        | Appendix II         | Protected | LC      |               |
| 14  | Accipitridae  | Spilornis cheela            | Appendix II         | Protected | LC      |               |
| 15  | Accipitridae  | Microhierax fringillarius   | Appendix II         | Protected | LC      |               |
| 16  | Accipitridae  | Amaurornis phoenicurus      | Appendix II         | Protected | LC      |               |
| 17  | Accipitridae  | Porphyrio porphyrio         | Not Protected       | LC    |          |               |
| 18  | Accipitridae  | Limosa lapponica            | LC                  |       |          |               |
| 19  | Scolopacida   | Tringa totanus              | LC                  |       |          |               |
| 20  | Scolopacida   | Actitis hypoleucos          | LC                  |       |          |               |
| 21  | Scolopacida   | Gygis alba                  | LC                  |       |          |               |
| 22  | Scolopacida   | Treron vernans              | LC                  |       |          |               |
| 23  | Scolopacida   | Stigmatopelia chinensis     | LC                  |       |          |               |
| 24  | Scolopacida   | Cacomantis sonneratii       | LC                  |       |          |               |
| 25  | Scolopacida   | Cacomantis merulinus        | LC                  |       |          |               |
| 26  | Scolopacida   | Centropus bengalensis       | LC                  |       |          |               |
| 27  | Scolopacida   | Collocalia linchi          | LC                  |       |          |               |
| 28  | Scolopacida   | Alcedo meninting            | Protected           | LC    |          |               |
| 29  | Scolopacida   | Alcedo coerulescens         | Protected           | LC    |          |               |
| 30  | Scolopacida   | Pelargopsis capensis        | Protected           | LC    |          |               |
| 31  | Scolopacida   | Halcyon cyanoventris        | Protected           | LC    |          |               |
| 32  | Scolopacida   | Todirampus chloris          | Protected           | LC    |          |               |
| 33  | Scolopacida   | Todirampus sanctus          | Protected           | LC    |          |               |
| 34  | Scolopacida   | Megalaima australis         | LC                  |       |          |               |
| 35  | Scolopacida   | Dendrocopos moluccensis     | LC                  |       |          |               |
| 36  | Scolopacida   | Hirundo Tahitica            | LC                  |       |          |               |
| 37  | Scolopacida   | Hirundo striolata           | LC                  |       |          |               |
| 38  | Scolopacida   | Lalage nigra                | LC                  |       |          |               |
| 39  | Scolopacida   | Aegithina tephia            | LC                  |       |          |               |
| No. | Family          | Binomial Name          | Conservation Status | CITES | PP No. 7 | IUCN Red List |
|-----|----------------|------------------------|---------------------|-------|----------|---------------|
| 40  | Pycnonotidae   | *Pycnonotus goiavier*  | LC                  |       |          |               |
| 41  | Pycnonotidae   | *Pycnonotus plumosus*  | LC                  |       |          |               |
| 42  | Dicruridae     | *Dicrurus macrocercus* | LC                  |       |          |               |
| 43  | Acanthisiidae  | *Gerygone sulphurea*   | LC                  |       |          |               |
| 44  | Sylviidae      | *Orthotomus ruficeps*  | LC                  |       |          |               |
| 45  | Sylviidae      | *Orthotomus sepium*    | LC                  |       |          |               |
| 46  | Cisticolidae   | *Prinia inornata*      | LC                  |       |          |               |
| 47  | Cisticolidae   | *Prinia familiaris*    | LC                  |       |          |               |
| 48  | Rhipiduridae   | *Rhipidura javanica*   | LC                  |       |          |               |
| 49  | Pachycephalidae| *Pacycephala grisola*  | Protected           |       |          |               |
| 50  | Sturnidae      | *Acidotheeres javanicus| LC                  |       |          |               |
| 51  | Nectariniidae  | *Nectarinia calcostetha*| Protected         |       |          |               |
| 52  | Nectariniidae  | *Nectarinia jugularis* | Protected          |       |          |               |
| 53  | Nectariniidae  | *Arachnothera longirostra*| Protected       |       |          |               |
| 54  | Zosteropidae   | *Zosterops palpebrosus*| LC                |       |          |               |
| 55  | Estrildidae    | *Lonchura leucogastroides*| LC          |       |          |               |
| 56  | Estrildidae    | *Lonchura punctulata*  | LC                  |       |          |               |
| 57  | Pandionidae    | *Pandion haliaetus*    | Protected II       |       |          |               |
| 58  | Recurvirostrida| *Himantopus leucocephalus*| Not Protected    |       |          |               |
| 59  | Recurvirostrida| *Himantopus leucocephalus*| Not Protected    |       |          |               |
| 60  | Anatidae       | *Anas gibberifrons*    | LC                  |       |          |               |
| 61  | Suidae         | *Sus scrofa*           | Not Protected      |       |          | LC            |
| 62  | Herpestidae    | *Herpestes javanicus*  | Appendix II        |       |          |               |
| 63  | Mustelidae     | *Aonyx cinereus*       | Not Protected VU   |       |          |               |
| 64  | Megadermatidae | *Megaderma spasma*     | LC                  |       |          |               |
| 65  | Cercopithecidae| *Macaca fascicularis*  | LC                  |       |          |               |
| 66  | Cercopithecidae| *Trachypithecus auratus*| Protected   |       |          |               |
| 67  | Felidae        | *Prionailurus viverrinus*| Protected VU       |       |          |               |
| 68  | Varanidae      | *Varanus salvator*     | Appendix II        |       |          | LC            |
| 69  | Colubridae     | *Ptyas mucosus*        | Appendix II        |       |          | NE            |
| 70  | Scincidae      | *Eutropis multifasciata*| Not Protected NE  |       |          | NE            |
All of the identified fauna, there is one animal that bears the conservation status of endangered, Milky Stork (Mycteria cinerea). The two other animals holding reserve status of vulnerable are Lesser Adjutant (Leptoptilos javanicus) and Javan Myna (Acridotheres javanicus). On the other hand, most of the animals have LC status. Inferring from the obtained information, the animals around the area have the relatively low extinction risk. In spite of the low average extinction risk, there are some birds and mammals protected by the government. The international trade status pertained varies from Appendix II and Appendix I.

3.3. Vegetation Analysis

3.3.1. The 1st Division. The 1st Division area consists of Tritih, Donan, Bukit Lomanis, and Frenca. These areas are divided into 5 unit analysis (S15, S16, S17, S18, S19). The list of the varieties on the 1st Division can be found in Table 6.

| No. | Binomial Name          | Unit Analysis |
|-----|------------------------|---------------|
| 1   | Acacia mangium         | √             |
| 2   | Avicenia alba          | √             |
| 3   | Rhizophora mucronata   | √             |
| 4   | Rhizophora apiculata   | √             |
| 5   | Sonneratia alba        | √             |
| 6   | Derris heterophylla    |               |
| 7   | Acanthus ilicifolius   |               |
| 8   | Corypha utan           |               |
| 9   | Aegiceras corniculatum |               |
| 10  | Sphilanthes acmella Merr. |             |
| 11  | Imperata sp.           |               |
| 12  | Caesalpinia nuga Ait.  |               |
| 13  | Sandoricum ketjape     |               |
| 14  | Leucaena leucocephala  |               |
| 15  | Nypa fruticans         |               |
| 16  | Xylocarpus granatum    |               |
| 17  | Bruguiera gymnorrhiza  |               |

From the Table 6, there are 17 types of flora scattered around the 1st division of the study area. The calculation of biodiversity index in the 1st division is shown on Table 7.

| No | Binomial Name | Number of Species | P_i (N/N) | ln P_i | P_i * ln P_i |
|----|---------------|-------------------|----------|-------|--------------|
| 1  | Acacia mangium| 21                | 0.04     | -3.32 | -0.12        |
From the table 7, the Biodiversity Index (H') of the 1st division is 2.47. According to Shannon-Wiener diversity index, the biodiversity level of the 1st division is categorized as medium.

### 3.3.2. The 2nd Division

The 2nd Division area consists of Candi, Cilora, and Dangal. These areas are divided into 5 unit analysis (S1, S2, S3, S13, S14). The list of the varieties on the 2nd Division can be found in Table 8.

#### Table 8. 2nd Division List of Flora

| No. | Binomial Name          | Unit Analysis (S) | 1  | 2  | 3  | 13 | 14 |
|-----|------------------------|-------------------|----|----|----|----|----|
| 1   | Rhizophora apiculata   | ✓                 | ✓  | ✓  | ✓  |    |    |
| 2   | Derris heterophylla    | ✓                 | ✓  | ✓  |    |    |    |
| 3   | Acanthus ilicifolius   | ✓                 | ✓  | ✓  |    |    |    |
| 4   | Heritiera littoralis   | ✓                 | ✓  | ✓  |    |    |    |
| 5   | Corypha utan           |                  | ✓  |           |    |    |    |
| 6   | Aegiceras corniculatum | ✓                 | ✓  | ✓  | ✓  | ✓  | ✓  |
| 7   | Clerodendron marae     |                  | ✓  |           |    |    |    |
| 8   | Cordia dichotoma Forst.F. |              | ✓  |           |    |    |    |
| 9   | Xerospermum noronhianum Blume |           | ✓  |           |    |    |    |
| 10  | Finlaysonia maritima   |                  | ✓  |           |    |    |    |
| 11  | Ceriops decandra       |                  | ✓  |           |    |    |    |
| 12  | Vitex pubescens        |                  | ✓  |           |    |    |    |

Biodiversity Index: 2.47
From the Table 8, there are 21 types of flora scattered around the 2nd division of the study area. The calculation of biodiversity index in the 2nd division is shown on Table 9.

**Table 9. Biodiversity Index Calculation in the 2nd Division**

| No. | Binomial Name                  | Number of Species | $P_i (n/N)$ | $\ln P_i$ | $P_i \times \ln P_i$ |
|-----|--------------------------------|-------------------|-------------|----------|---------------------|
| 1   | *Rhizophora apiculata*         | 40                | 0.16        | -1.81    | -0.30               |
| 2   | *Derris heterophylla*          | 2                 | 0.01        | -4.81    | -0.04               |
| 3   | *Acanthus ilicifolius*         | 3                 | 0.01        | -4.40    | -0.05               |
| 4   | *Heritiera littoralis*         | 15                | 0.06        | -2.79    | -0.17               |
| 5   | *Corypha utan*                 | 7                 | 0.03        | -3.56    | -0.10               |
| 6   | *Aegiceras corniculatum*       | 76                | 0.31        | -1.17    | -0.36               |
| 7   | *Clerodendron marue*           | 33                | 0.13        | -2.00    | -0.27               |
| 8   | *Cordia dichotoma Forst.F.*    | 7                 | 0.03        | -3.56    | -0.10               |
| 9   | *Xerospermum noronhianum Blume*| 7                 | 0.03        | -3.56    | -0.10               |
| 10  | *Finlaysonia maritima*         | 2                 | 0.01        | -4.81    | -0.04               |
| 11  | *Ceriops decandra*             | 4                 | 0.02        | -4.11    | -0.07               |
| 12  | *Vitex pubescens*              | 7                 | 0.03        | -3.56    | -0.10               |
| 13  | *Nypa fruticans*               | 8                 | 0.03        | -3.42    | -0.11               |
| 14  | *Xylocarpus granatum*          | 12                | 0.05        | -3.02    | -0.15               |
| 15  | *Xylocarpus moluccensis*       | 1                 | 0.00        | -5.50    | -0.02               |
| 16  | *Ceriops tagal*                | 6                 | 0.02        | -3.71    | -0.09               |
| 17  | *Oldenlandia sp.*              | 1                 | 0.00        | -5.50    | -0.02               |
| 18  | *Excocaria agallocha*          | 1                 | 0.00        | -5.50    | -0.02               |
| 19  | *Lumnitzera racemosa*          | 9                 | 0.04        | -3.30    | -0.12               |
| 20  | *Merope angulata*              | 3                 | 0.01        | -4.40    | -0.05               |
| 21  | *Intsia bijuga*                | 1                 | 0.00        | -5.50    | -0.02               |
|     | **Total**                      | **245**           |             |          | **-1.76**           |

**Biodiversity Index** 1.76
From the table 9, the Biodiversity Index (H’) of the 2nd division is 1.76. According to Shannon-Wiener diversity index, the biodiversity level of the 2nd division is categorized as medium.

3.3.3. The 3rd Division. The 3rd division area consists of Pasuruan, Ketapang, Belanakan and Bondan Village. These areas are divided into 5 unit analysis (S4, S5, S8, S11, S12). The list of the varieties on the 3rd division can be found in Table 10.

| No. | Binomial Name              | Unit Analysis (S) |
|-----|----------------------------|-------------------|
| 1   | Avicenia marina            | √                 |
| 2   | Avicenia alba              |                   |
| 3   | Rhizophora mucronata       | √                 |
| 4   | Rhizopora apiculata        |                   |
| 5   | Sonneratia alba            |                   |
| 6   | Derris heterophylla        | √                 |
| 7   | Acanthus ilicifolius       | √                 |
| 8   | Heritiera littoralis       |                   |
| 9   | Aegiceras corniculatum     |                   |
| 10  | Clerodendron marae         |                   |
| 11  | Sphylanthes acmella Merr.  |                   |
| 12  | Dolichandrone spathacea    |                   |
| 13  | Clerodendron serratum      |                   |
| 14  | Xanthophyllum villosum Merr. |           |
| 15  | Citrus medica Linn.        |                   |
| 16  | Clerodendron inerme        |                   |
| 17  | Finlaysonia maritima       |                   |
| 18  | Berrya cordofolia Roxb.    |                   |
| 19  | Flacourtia sp.             |                   |
| 20  | Andropogon modestus        |                   |
| 21  | Ceriops decandra           |                   |
| 22  | Nypa fruticans             | √                 |
| 23  | Xylocarpus granatum        |                   |
| 24  | Xylocarpus moluccensis     |                   |
| 25  | Bruguiera cylindrica       |                   |
| 26  | Acrostichum aureum         |                   |
| 27  | Excoecaria agallocha       |                   |
| 28  | Lumnitzera racemosa        |                   |

From the Table 10, there are 28 types of flora scattered around the 3rd division of the study area. The calculation of biodiversity index in the 3rd division is shown on Table 11.
Table 11. Biodiversity Index Calculation in 3rd Division

| No. | Binomial Name               | Number of Species | $p_i (n/N)$ | $\ln p_i$ | $p_i \ast \ln p_i$ |
|-----|-----------------------------|-------------------|------------|-----------|--------------------|
| 1   | Avicenia marina             | 10                | 0.01       | -4.28     | -0.06              |
| 2   | Avicenia alba               | 45                | 0.06       | -2.78     | -0.17              |
| 3   | Rhizophora mucronata        | 184               | 0.25       | -1.37     | -0.35              |
| 4   | Rhizophora apiculata        | 52                | 0.07       | -2.63     | -0.19              |
| 5   | Sonneratia alba             | 32                | 0.04       | -3.12     | -0.14              |
| 6   | Derris heterophylla         | 25                | 0.03       | -3.37     | -0.12              |
| 7   | Acanthus ilicifolius        | 15                | 0.02       | -3.88     | -0.08              |
| 8   | Heritiera littoralis        | 8                 | 0.01       | -4.51     | -0.05              |
| 9   | Aegiceras corniculatum      | 30                | 0.04       | -3.18     | -0.13              |
| 10  | Clerodendron marae          | 53                | 0.07       | -2.61     | -0.19              |
| 11  | Sphilanthes acmella Merr.   | 7                 | 0.01       | -4.64     | -0.04              |
| 12  | Dolichandrone spathacea     | 46                | 0.06       | -2.76     | -0.18              |
| 13  | Clerodendron serratum       | 7                 | 0.01       | -4.64     | -0.04              |
| 14  | Xanthophyllum villosum Merr.| 13                | 0.02       | -4.02     | -0.07              |
| 15  | Citrus medica Linn.         | 46                | 0.06       | -2.76     | -0.18              |
| 16  | Clerodendron inerme         | 16                | 0.02       | -3.81     | -0.08              |
| 17  | Finlaysonia maritima        | 2                 | 0.00       | -5.89     | -0.02              |
| 18  | Berrya cordofolia Roxb.     | 7                 | 0.01       | -4.64     | -0.04              |
| 19  | Flacourtia sp.              | 3                 | 0.00       | -5.49     | -0.02              |
| 20  | Andropogon modestus         | 26                | 0.04       | -3.33     | -0.12              |
| 21  | Ceriops decandra            | 7                 | 0.01       | -4.64     | -0.04              |
| 22  | Nypa fruticans              | 11                | 0.02       | -4.19     | -0.06              |
| 23  | Xylocarpus granatum         | 7                 | 0.01       | -4.64     | -0.04              |
| 24  | Xylocarpus moluccensis      | 7                 | 0.01       | -4.64     | -0.04              |
| 25  | Bruguiera cylindrica        | 13                | 0.02       | -4.02     | -0.07              |
| 26  | Acrostichum aureum          | 13                | 0.02       | -4.02     | -0.07              |
| 27  | Excoecaria agallocha        | 33                | 0.05       | -3.09     | -0.14              |
| 28  | Lumnitzera racemosa         | 6                 | 0.01       | -4.79     | -0.04              |
|     | Total                       | 724               |            | -2.80     |                    |

From the table 11, the Biodiversity Index ($H'$) of the 3rd division is 2.80. According to Shannon-Wiener diversity index, the biodiversity level of the 3rd division is categorized as medium.

3.3.4. The 4th Division. The 4th division area consists of Masigit, Klaces, Mongggor and Pulu Bagian. These areas are divided into 4 unit analysis (S6, S7, S9, S10). The list of the varieties on the 4th division can be found in Table 12.
Table 12. 4th Division List of Flora

| No. | Binomial Name            | Unit Analysis (S) |
|-----|--------------------------|-------------------|
| 1   | Avicenia marina          | √                 |
| 2   | Avicenia alba            | √                 |
| 3   | Rhizophora mucronata     | √                 |
| 4   | Rhizophora apriculata    | √                 |
| 5   | Sonneratia casiorlaris   | √                 |
| 6   | Sonneratia alba          | √                 |
| 7   | Derris heterophylla      | √                 |
| 8   | Acanthus ilicifolius     | √                 |
| 9   | Heritiera littoralis     | √                 |
| 10  | Nypa fruticans           | √                 |
| 11  | Xylocarpus moluccensis   | √                 |
| 12  | Bruguiera cylindrica     | √                 |
| 13  | Lumnitzera racemosa      | √                 |

From the Table 12, there are 13 types of flora scattered around the 4th division of the study area. The calculation of biodiversity index in the 4th division is shown on Table 13.

Table 13. Biodiversity Index Calculation in 4th Division

| No. | Binomial Name            | Number of Species | P_i (n/N) | ln P_i | P_i * ln P_i |
|-----|--------------------------|-------------------|-----------|--------|--------------|
| 1   | Avicenia marina          | 4                 | 0.01      | -4.62  | -0.05        |
| 2   | Avicenia alba            | 42                | 0.10      | -2.27  | -0.23        |
| 3   | Rhizophora mucronata     | 50                | 0.12      | -2.10  | -0.26        |
| 4   | Rhizophora apriculata    | 70                | 0.17      | -1.76  | -0.30        |
| 5   | Sonneratia casiorlaris   | 22                | 0.05      | -2.92  | -0.16        |
| 6   | Sonneratia alba          | 37                | 0.09      | -2.40  | -0.22        |
| 7   | Derris heterophylla      | 12                | 0.03      | -3.52  | -0.10        |
| 8   | Acanthus ilicifolius     | 120               | 0.29      | -1.22  | -0.36        |
| 9   | Heritiera littoralis     | 2                 | 0.00      | -5.32  | -0.03        |
| 10  | Nypa fruticans           | 12                | 0.03      | -3.52  | -0.10        |
| 11  | Xylocarpus moluccensis   | 17                | 0.04      | -3.18  | -0.13        |
| 12  | Bruguiera cylindrica     | 18                | 0.04      | -3.12  | -0.14        |
| 13  | Lumnitzera racemosa      | 1                 | 0.00      | -6.01  | -0.01        |

Total 407 -2.10

Biodiversity Index 2.10

From the table 13, the Biodiversity Index (H’) of the 4th division is 2.10. According to Shannon-Wiener diversity index, the biodiversity level of the 4th division is categorized as medium.
Figure 4. Map of Flora Biodiversity in Segara Anakan Area
Figure 5. Map of Fauna Biodiversity in Segara Anakan Area.
3.4. The Utilization of Mangroves by the Community in The Segara Anakan Area

The people who live in the Segara Anakan area, especially the people of Ujung Alang Village and Klaces Village, are working with Pertamina RU IV to form two independent groups based on mangrove utilization. Each group has around 20 members. The first group is the Patra Bina Mandiri group. This group is based in the Ujung Alang Village. The activities they do are planting mangroves in the 4 ha arboretum and also making and marketing mangrove-based processed foods. They make mangrove-based processed foods from the fruit and leaves of Acanthus ilicifolius and Bruguiera gymnorrhiza. Mangrove products are marketed around the sub-district of Kampung Laut and Cilacap District. The turnover earned by this group is around 3 million rupiah per month.

Figure 6. Mangrove Arboretum located in Ujung Alang Village
The second group is the Patra Mekar Canting Group. This group is based in Klaces Village. The activities they carried out are utilizing mangrove as a natural colouring material in making batik cloth.
The type of mangrove used is leaf, fruit and stem waste of Rhizopora apiculata and Ceriops decandra. The turnover earned by this group is around 2 million rupiah per month.

**Figure 10.** Patra Mekar Canting Group Activities in Making Batik Clothes with mangrove-based Colouring

4. **Conclusion**

Segara Anakan conservation area is 16,253.2 ha with mangrove ecosystem as its main ecosystem. The total area of mangrove is 3,980 ha. There are 60 species of mangrove plants, one of them has a "near threatened" status according to the IUCN Red List (i.e. *Ceriops decandra*). There are also 60 species of birds, 7 species of mammals and 3 species of reptile. According to the IUCN Red List, there is one animal that bears the conservation status of endangered, Milky Stork (*Mycteria cinerea*), two birds are on "vulnerable" status and one mammal has a "near threatened" conservation status. There are 22 species of fauna protected by Indonesia Government. From the Shannon-Wiener biodiversity index calculation, the biodiversity level of the Segara Anakan Lagoon is categorized as a medium with the value 1.76 – 2.80. The Segara Anakan community uses mangroves for mangrove-based crafts and processed food which can generate group turnover of around 2 to 3 million rupiahs per month.

**References**

[1] Reichel C, Fromming U U and Glaser M 2009 Conflict between stakeholder groups affecting the ecology and economy of the Segara Anakan Region J. Reg Environ Change. JREC9(2009)335

[2] Hinrichs S, Nordhaus I and Geist S J 2008 Status, diversity and distribution patterns of mangrove vegetation in the Segara Anakan lagoon, Java, Indonesia J. Reg Environ Change. JREC9(2009)275

[3] Pollnac R B and Pomeroy R S 2005 Factors influencing the sustainability of integrated coastal management projects in the Philippines and Indonesia. J. Ocean & Coastal Management. JOCM48(2005)233

[4] Keylock C J 2005 Simpson diversity and the Shannon-Wiener index as special cases of a generalized entropy. Earth and Biosphere Institute and School of Geography, Univ. of Leeds, Woodhouse Lane, Leeds, UK.

[5] Sanjatmiko P, Wahyono, Rahmawati P, Bahtiar M R 2017 Segara Anakan Mangrove Potency (Depok: Antropology Department of University of Indonesia)

[6] CITES 2017 *The Convention on International Trade in Endangered Species of Wild Fauna and Flora.*
[7] Indonesian Government 1999 Government Regulation No 7 of 1999 Concerning Preservation Of Plant and Animal Species.
[8] IUCN Red List 2015 The IUCN Red List of Threatened Species (Switzerland: IUCN)

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