The sustainability of seagrass traditional fisheries on the east cost of Bintan Regency

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Abstract. The traditional fishermen who life in the eastern coast of Bintan Regency is highly dependent on the seagrass ecosystem. This situation will give pressure especially on the resources that used by fishermen. The aims of this study is to measure the sustainability of the relationship between traditional fishermen and the utilized resources. The source of data is derived from data which was taken in 2014-2015 in Pengudang, Berakit, Malang Rapat and Teluk Bakau villages. The parameters of the seagrass ecosystem include: seagrass, phytoplankton, zooplankton, fish, crab, squid, mollusc, nitrate, phosphate and silicate. Social parameters include: fishermen, fuel and fishing gear. Emergy analysis is used to measure the sustainability of the relationship. The results shows that the Emergy Yield Ratio (EYR) is 9.93E-06 seJ / east season and 6.52E-06 seJ / north season; Emergy Investment Ratio (EIR) of 8.98E-01 seJ / east season and 9.87E-01 SE / North season; Emergy Loading Ratio (ELR) is 2.56E + 00 seJ / east season and 2.42 + 00 seJ / north season; Emergy Sustainability Index (ESI) of 3.88-06 seJ / east season and 2.70E-06 / north season. The seagrass traditional fisheries in the east coast of Bintan Regency is not sustainable.

1. Introduction
The sustainability of system will be an important thing for the future. This was based on the human population growth that grows higher while the natural resources to fulfilling human needs are decreasing each and every day. Looking forward to maintain the sustainability for a system, integration from various aspects is needed. Chua [1] stated that the integration from ecological, social, and economical aspect that linked to each other is the key to make a sustainable development happened. In case of seagrass ecosystem management, taking consideration on the social dynamic system was essential because both of them have a connection that affecting each other [2].

The existence of socio-ecological system in the seagrass ecosystem can actually be measured. Emergy Analysis Approach is one of method that can be used to visualize the comparison between highest and lowest environmental burden faced. Furthermore, Emergy Analysis can shows picture about the resources that can be restored, the resources that can not be restored, and the usage of energy outside the system [3]. Main components of Emergy Analysis are the input and output. So, the system should be treated as a chain of energy and the value of Emergy for every single chain in the system will be determined. All of the system will be build in form of a diagram so that every flow of energy from both the resources and social system (input-output) can be evaluated.
Emergy Analysis was already used in various cases. For the fish cultivation, emergy analysis used by some researchers such as Odum and Arding (1991) to evaluate the sustainability of shrimp cultivation in Ecuador; Lima et al. [4] to compare between organic and conventional shrimp cultivation at Guaraira Lagoon, Brazil; Vassalo et al. [5] to analyze fish cultivation at La Spezia Bay, Italy; and Garcia et al. [6] to analyze the parrot fish cultivation using floating net cages at Parana River, Brazil.

Emergy Analysis can also be applied on the villages’ scope. Listiyawati et al. [7] use it to evaluating the efficiency and sustainability of sewage processing into biogas at Independent Village (Desa Mandiri) of Tegalwaru. Desa Mandiri is one of the Indonesian Government program, one of the criteria to get into that program is the village’s ability to fill at least 60% of the energy needed from renewable resources. Furthermore, Siracusa et al. [3] use it to evaluating the sustainability of nature-friendly village in the south east of Sicily.

The east coast of Bintan Island Kepulauan Riau Province has about 2500 ha of seagrass meadow and has manage thru Seagrass Conservation Area [8]. This area covered a seagrass meadow about 2500 ha in area. Total number of species were 9 species of 12 species of seagrass in Indonesia. *Thalassia hempricii* and *Enhalus acroides*were dominant species [8]. Seagrass ecosystem services at this location have long been used, since 1970 by traditional fishermen. Provisioning services seem strongly related to the daily life of a traditional fisherman2. They catch fishes, swimming crabs, squids and molluscs from these ecosystems, most are then sold to the local fish trader and a small proportion used for their household consumption2. This situation will give pressure especially on the resources that used by fishermen. Hitherto, there has been no detailed information about the sustainability between the seagrass ecosystem and the fishermen.

2. Material and Methods
The boundary of seagrass ecosystem in the study site is the reef flat area which is 3018.22 ha2. The width of reef flat of each villages was 429.17 ha (Teluk Bakau), 789.53 ha (Malang Rapat), 1248.51 ha (Berakit) and 551.01 ha (Pengudang). Total number of fishermen in four villages is about 945, of whom 20% (189) are traditional fishermen. From 189 fishermen who work in the reef flat area, 128 caught fish and squid, 110 caught swimming crabs and 62 searching for mollusk. They use simple gear, such as traps (fish traps, swimming crab traps, fixed bamboo traps, moveable traps) and net (fishing nets, swimming crab nets). Fishermen who searching for mollusks do not use any tools, they just walk on seagrass ecosystem. Generally, the ages of fishermen older than 40 years old and became as fishermen more than 20 years. Sometimes, they fish without a boat (by walking), using a small boat (rowboat) that still depends on oar, or even machined boat with (2-5 Gross Ton).

2.1. Data source
The data used for the calculation of the emergy analysis was the biomass data of seagrass ecosystem in the research location. Hereinafter, biomass data was converted into calories by multiplying biomass with its calorific value. Calorie values were obtained from previous publications (Table 1.). To obtain energy in Joules, the calorific value was multiplied by 4.184. Data requirements are summarized in Table 1.

2.2. Data analysis
The following step to calculate emergy analysis follow:

2.2.1. Creating Emergy system diagram
The creation of emergy system’s diagram is similar with inventorying all things related to the system in seagrass ecosystem. The purpose of making this diagram is to get a whole picture by combining both the input and output information that would be analyzed. Dimension of this research is the East and North seasons.

Emergy System Diagram of seagrass ecosystem at the research location showed in the Fig. 1. Emergy that come inside system of seagrass ecosystem came from various sources. Sun, is the main source for
the life of biota that doing photosynthesis process to survive, in this specific research it is seagrass and phytoplankton. With the help of chlorophylls, sun will turns into carbohydrate. Wind, gave its contribution for the oxygen circulation that will be used by the biota in the metabolism process. Tides of the ocean also help oxygen circulation and take part for the nutrition transports such as Nitrate, Phosphate, and Silicate.

Table 1. Data source to calculate emergy analysis.

| No  | Type of data | Source of data                | Caloric value | Emergy transformity |
|-----|--------------|-------------------------------|---------------|---------------------|
| 1   | Seagrass     | Sjafrie et al. [2]            |               |                     |
|     |              | Setyati et al. [9]; El Din and El Sharif [10] |               |                     |
| 2   | Phytoplankton| Sjafrie et al. [2]            |               |                     |
|     |              | Cushing [11]; Platt and Irwin [12] |               |                     |
| 3   | Zooplankton  | Sjafrie et al. [2]            |               |                     |
|     |              | Yun et al. [26]               |               |                     |
| 4   | Fish         | Sjafrie et al. [2]            |               |                     |
|     |              | Palani et al. [13]            |               |                     |
| 5   | Swimming Crab| Sjafrie et al. [2]            |               |                     |
|     |              | Gokodlu and Yerlikaya [14]    |               |                     |
| 6   | Squid        | Sjafrie et al. [2]            |               |                     |
|     |              | Nurjanah [15]                |               |                     |
| 7   | Mollusks     | Sjafrie et al. [2]            |               |                     |
|     |              | Nurjanah [16]                |               |                     |
| 8   | Nitrate      | Sjafrie et al. [2]            |               | Ulgiati et al. [18] |
| 9   | Phosphate    | Sjafrie et al. [2]            |               | Ulgiati et al. [18] |
| 10  | Silicate     | Sjafrie et al. [2]            |               | Ulgiati et al. [18] |
| 11  | Fisherman    | Primary data                 | Indonesian National Standar [17] | Brown and Bardi [19] |
| 12  | Fishing gear | Villages Monograph           |               | Rahmadi [20]        |
| 13  | Fuel         | Primary data                 |               | Brown and Bardi [19] |
| 14  | Sun          | Odum and Arding [1]          |               |                     |
| 15  | Wind         | Odum and Arding [1]          |               |                     |
| 16  | Tidal        | Odum and Arding [1]          |               |                     |

Nutrients in the ocean’s water that usually became the main focus in the oceanic environment are phosphor and nitrogen [21]. Both of that substance has a vital part for the growth of phytoplankton or algae that usually used as an indicator of water quality and the fertility level of the waters²³. Nitrate and Phosphate contains in the sea water commonly came from the process of weathering and decomposing of biota. Aside from that two substances, Silicate is also one of the nutrients that used by Diatomae for their growth⁴.

Another emergy that get into the system came from human’s activity such as fisherman’s power, fuel oil, and variety of fishing gears. Indonesian National Standard [17] published calorie needs from the types of works. This research shows that fisherman categorized as the medium works that needs calorie around 275 cal/hour. On average, they do the fishing activity 8 hours/day. Every week, they did the fishing activity for 6 days with Friday as their day off. When the research happen, it shows that fishing activity on the East season are 77 days and 76 days on the North season. Even though traditional fishers who utilize seagrass ecosystem using rowboats for their activity, they use the machined boat for delivering their hauled fishes to the tauke (local trader). Data collecting shows that the average fuel oil used per day for boats and transportation are 2.5 litre/person/day. The data collection on fishing tools shows that there are 4920 units of bubu (trap made by bamboo), 136 units of fishing net, 27 units of kelong karang (fixed trap), and 4 units of empang (moveable trap).

Emergy inside the system came from lots of different biota such as seagrass, plankton, and several of sea catches (fish, crab, squid, and mollusc) that make a food chain between them. Seagrass and phytoplankton is the producer that utilizing sun for producing carbohydrate. Both of them being used either direct or indirect by other biota like the herbivore fishes from Siganidae family. Zooplankton is

³ Fachrul et al. (2005).
⁴ Nontji (2008).
the consumer of phytoplankton that also being utilized either directly or indirectly by fish, crab, squid, and mollusc.

![Image](image_url)

**Figure 1.** Seagrass ecosystem emergy system’s diagram at the research location.

2.2.2. Aggregation of Emergy System’s Diagram

The aggregation of emergy system’s diagram contains 4 components called Renewable Resources (R), Non-Renewable Resources (NR), Purchase (F), and Yield (Y). Up on Implementation, the four components can be specified by data’s availability and researcher point of view. Within this research’s context, the four components get differentiated by 2 dimensions of time, East and North season. All the components’ value of energy involved in the system will be measured (called by raw data) with this following method:

a) Renewable Resources are emergy that gathered by free from the nature such as sun, tides of ocean, and winds. Liu et al. [22], classifying emergy that gathered from the nature as free renewable resources. Energy from each item R measured by this following method:

- **Sun**’s energy measured by multiplying (the width of seagrass ecosystem area)* Insulation* (1-Albedo)* (exposure time).
  - The width of area are 3018.22 hectare
  - Insulation 4.5 KWh/m2/day (ZTE-Indosat, 2010) or 16,3 MJ/m2/day
  - The average of Albedo in Equator sea is 2.5% (http://www.climatedata.info/)
  - The exposure day is 1 season (90 days).

- **Winds’** energy measured by multiplying (the width of seagrass ecosystem area)* (wind density)* (drag coefficient)* (wind speed)* (3.14E+7 s/year) (season days).
  - The width of area are 3018.22 hectare
  - Wind density 1.2kg/m3
  - Drag coefficient 0.001
  - Average wind speed on East season are 1.54 m/sec and 2.42 m/sec on the North season [23]
  - Number days in each season are 90 days.

- **Tides of the ocean** measured by multiplying (the width of seagrass ecosystem area)* (0.5)* (tides/season)* (tidal average)* (density)* (gravity) (season days/year).
  - The width of area are 3018.22 hectare
  - The average tidal is 1.4 m [24, 25]
  - Tides per season are 126, predicted from 1.4 tidal
  - The gravity is 9.8
  - Number days in each season are 90 days.

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5 Odum (2000)
b) Non-renewable resources (N) is the emergy that can not be gathered freely from the nature such as Nitrate, Phosphate, Silicate, seagrass and plankton. The Energy from each N item measured by this following method:

- Nitrate is measured by multiplying (area)* (average depth)* (average Nitrate concentration).
  - The width of area are 3018.22 ha,
  - The average depth 1.4 meter [24, 25]
  - Average Nitrate concentration on the East season is 0.0065 mg/litre and 0.5mg/litre on the North season.

- Phosphate and Silicate are measured by the same way as Nitrate mass. Phosphate average concentration on the East season is 0.0181 mg/litre and 0.03mg/litre on the North season. Meanwhile, the average of Silicate concentration is 0.05mg/litre on the East season and 0.48mg/litre on the North.

- Seagrass energy were measured by multiplying (area)* (seagrass biomass class 1...n)* (seagrass calorie class 1...n) (4.18 J/cal).
  - The width of area are 3018.22 ha.
  - The biomass class measured from 9 variety of seagrass at the research location.
  - Value of seagrass calorie class measured according to Setyati et al. [9] and El din and El Sharif [10].

- Phytoplankton energy is measured by multiplying (area)* (average depth of water)* (phytoplankton biomass)* (phytoplankton calorie)* (4.18J/cal).
  - The width of area are 3018.22 ha.
  - The average depth of water is 1.4 meters [24, 25].
  - Phytoplankton biomass is measured according to Strickland and Parson [1868]

- Zooplankton energy measured by multiplying (area)* (depth average)* (zooplankton biomass)* (zooplankton calorie)* (4.18J/cal). Value of zooplankton calorie measured according to Yun et al. [26].


c) Purchase (F) that contains fuel oil, fisherman power, and fishing tools. Energy of each F item measured as follows:

- Fisherman power energy measured by multiplying (number of fisherman)* (work time)* (work day)* (calorie)* (joule).
  - The number of traditional fisherman are 189 person,
  - Work time 8 hour/day
  - Work day are 77 days on East season and 76 days on North season. Working days counted by normal calendar with Friday as the day off.
  - The calorie spent by fisherman is 275 kcal/hour/person (SNI, 2009).

- Fuel energy is measured by multiplying (numbers of fishermen)* (work days)* (average fuel needed)* (fuel density)* (fuel calorie)* (4184 J).
  - The average needs for fuel every day is 2.5 litre/person.
  - Fuel density is 0.87
  - Fuel caloric is 9,063 kcal/kg.

- Fishing gears are energy measured by multiplying (number of gear types)* (price per unit)* (unit’s lifetime).
  - The price for each unit of bubu are Rp. 50,000
  - The price for each unit of net are Rp. 135,000
  - The price for each unit of kelong karang and empang are Rp. 5,000,000
  - The lifetime of bubu is 5 years,
  - The lifetime of net is 3 years,
  - The lifetime of kelong karang is 1 year.
  - The lifetime of empang is 6 months.

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6 Strickland and Parson (1968).
- Emergy counting for fishing gears use the Em$/y$ approach so the result will be converted into $. In 2011, $ exchange rate to Rupiah was Rp. 8779 in average (http://www.bi.go.id/id/moneter/informasi-kurs/transaksi-bi/Default.aspx).

d) Yield (Y) is the traditional fisherman catches such as fish, crab, squid, and mollusk. The energy of each item of Y measured as follows:
- Fish energy measured by multiplying n (area)* (fish biomass class 1…n)* (fish calorie class 1…n)* (4.18 J/cal).
  - The width of area are 3018.22 ha.
  - Fish energy were counted from 20 variety of seagrass fishes caught by the fisherman. Calorie class of fishes listed according to Palami et al. [13].
  - Crab, squid, and mollusk energy counted by the same way to measuring fish energy. Value of calorie from crabs came from Gokudlu and Yerlikaya [14], squid by Nurjanah et al. [15] and mollusc according to Nurjanah et al. [16].

2.2.3. Creating energy analysis tabel
The purpose for creating Emergy analysis table is to facilitating measurement and aggregation results of four components that take part in seagrass ecosystem. Raw data will be tabulated. Emergy value of each components gathered by multiplying raw data with transformity of emergy. The Emergy transformity gathered from various sources except for seagrass, phytoplankton, and zooplankton. The way to measure emergy transformity of that 3 aspect will be done by this following method:
- Seagrass emergy transformity = R (without Silicate) divided by seagrass energy
- Phytoplankton emergy transformity = R divided by phytoplankton energy
- Zooplankton emergy transformity = R (without Silicate) + phytoplankton emergy divided by zooplankton energy

Table 2. Emergy Index.

| No | Name of Index                      | Expression          | Criteria* |
|----|-----------------------------------|---------------------|-----------|
| 1  | Rasio of energy output and input  | EYR = Y/F           | High      |
| 2  | Rasio of energy input and energy inside system | EIR = F/(R+N)   | Low       |
| 3  | Rasio of environment loading      | ELR = (F+N)/R       | Low       |
| 4  | Emergy Sustainability Index       | ESI = EYR/ELR       | High      |

*Odum [27]; Tao et al. 7
Note: R = Renewable energy; N =Non Renewable energy; F= Input emergy to the system; Y = Emergy Yield; U = total emergy inside system (U = R+N+F); %R = Rasio between renewable energy and total emergy inside system (R/U).

2.2.4. Counting the Emergy Index
The main indicator used in energy analysis is:
1. EYR (Emergy Yield Ratio) is a ratio between energy outputs (Y) with energy input (F). The ratio result from each output produced is a measurement for how much process that will give contribution for the economy;
2. EIR (Emergy Investment Ratio) is a ratio between energy input outside system with the energy input inside the system;
3. ELR (Emergy Loading Ratio) is a ratio between non-renewable energy (N) and imported energy (F) with renewable energy (R). It will become the indicator of pressure amounts from production process towards local environment;
4. ESI (Emergy Sustainability Index) is a measurement of sustainable results which assume that to get the highest result on the lowest burden to the environment (Table 2).
3. Results

3.1. Emergy input density

Result of emery measurements for seagrass ecosystem at Bintan area was summarized in Table 3 and 4.

| No | Item                   | Data/Unit (J,g/season) | Transformity (sej/unit) | Solar Emergy (sej/season) | References                   |
|----|------------------------|------------------------|-------------------------|---------------------------|------------------------------|
|    | **Renewable Resources-R** |                        |                         |                           |                              |
| 1  | Sun                    | 4.32E+16               | J                       | 4.32E+16                  | Odum et al. 5                |
| 2  | Wind                   | 4.32E+11               | J                       | 2.74E+03                  | 1.18E+15 Odum et al. 5       |
| 3  | Tidal                  | 9.28E+12               | J                       | 1.68E+04                  | 1.56E+17 Odum et al. 5       |
|    | **Non Renewable Resources-N** |                      |                         |                           |                              |
| 4  | Water nutrition        |                        |                         |                           |                              |
| 4a | Nitrate                | 2.75E+00               | g                       | 4.62E+09                  | 1.27E+10 Ulgiati et al. [18] |
| 4b | Phosphate              | 7.65E+00               | g                       | 2.96E+09                  | 2.26E+10 Ulgiati et al. [18] |
| 4c | Silicate               | 6.34E+03               | g                       | 1.00E+09                  | 6.34E+12 Ulgiati et al. [18] |
| 5  | Seagrass               | 1.21E+13               | J                       | 1.66E+04                  | 4.94E+16 **This study**      |
| 6  | Phytoplankton          | 1.50E+10               | J                       | 1.34E+07                  | 4.94E+16 **This study**      |
| 7  | Zooplankton            | 7.89E+07               | J                       | 3.94E+09                  | 7.68E+16 **This study**      |
| 8  | Fishermen power        | 1.34E+11               | J                       | 1.24E+06                  | 1.66E+17 Brown and Bardi [19]|
| 9  | Fuel                   | 1.20E+09               | J                       | 5.30E+04                  | 6.36E+13 Brown and Bardi [19]|
| 10 | Fishing gear           |                        |                         |                           |                              |
| 10a| Traps                  | 3.45E+04               | $                       | 4.40E+12                  | 1.52E+17 Rahmadi [20]        |
| 10b| Nets                   | 1.89E+03               | $                       | 4.40E+12                  | 8.32E+15 Rahmadi [20]        |
| 10c| Fix traps              | 3.79E+03               | $                       | 4.40E+12                  | 1.67E+16 Rahmadi [20]        |
| 10d| Moveable traps         | 1.13E+03               | $                       | 4.40E+12                  | 4.96E+15 Rahmadi [20]        |
|    | **Seasonal Yield**     |                        |                         |                           |                              |
| 11 | Fish                   | 3.14E+12               | J                       |                           |                              |
| 12 | Swimming crab          | 7.23E+10               | J                       |                           |                              |
| 13 | Squid                  | 1.16E+11               | J                       |                           |                              |
| 14 | Mollusc                | 1.73E+10               | J                       |                           |                              |
|    | Energy Yield           | 3.35E+12               | J                       | 7.24E+17                  |                              |

| No | Item                   | Data/Unit (J,g/season) | Transformity (sej/unit) | Solar Emergy (sej/season) | References                   |
|----|------------------------|------------------------|-------------------------|---------------------------|------------------------------|
|    | **Renewable Resources-R** |                        |                         |                           |                              |
| 1  | Sun                    | 4.32E+16               | J                       | 4.32E+16                  | Odum et al. 5                |
| 2  | Wind                   | 6.79E+11               | J                       | 2.74E+03                  | 1.86E+15 Odum et al. 5       |
| 3  | Tidal                  | 9.28E+12               | J                       | 1.68E+04                  | 1.56E+17 Odum et al. 5       |
|    | **Non Renewable Resources-N** |                      |                         |                           |                              |
| 4  | Seawater nutrition     |                        |                         |                           |                              |

Table 4. Emergy in the North monsoon.
| No | Item         | Data/Unit (J,g/season) | Transformity (seJ/unit) | Solar Emergy (seJ/season) | References                        |
|----|--------------|------------------------|-------------------------|---------------------------|-----------------------------------|
| 4a | Nitrate      | 5.21E+00               | g                       | 4.62E+09                  | 2.41E+10 Ulgiati et al. [18]     |
| 4b | Phosphate    | 3.13E+00               | g                       | 2.96E+09                  | 9.25E+09 Ulgiati et al. [18]     |
| 4c | Silicate     | 1.50E+04               | g                       | 1.00E+09                  | 1.50E+13 Ulgiati et al. [18]     |
| 5  | Segrass      | 1.21E+13               | J                       | 1.31E+04                  | 3.89E+16 This study               |
| 6  | Phytoplankton| 1.16E+10               | J                       | 1.36E+07                  | 3.89E+16 This study               |
| 7  | Zooplankton  | 6.11E+07               | J                       | 4.43E+09                  | 6.67E+16 This study               |

**Transformity - references**
- [18] Ulgiati et al.
- [19] Brown and Bardi
- [20] Rahmadi

**Energy Yield**

- 4.1. Emergy Yield Ratio (EYR)  
  EYR = Y/F
  Where Y is the emergy result and F is the emergy that has been used for the fishing activity. The higher the EYR is, the lower the emergy that used for fishing activity to get that certain result. Otherwise, if the EYR is low, the means to exploit the resources is bigger.

- 4.2. Discussion

  *Odum et. al.*

  **Table 5. Emergy index.**

| No | Indexes                      | Expression                  | Total number (seJ/season) | Criteria* |
|----|------------------------------|-----------------------------|---------------------------|-----------|
| 1  | Rasio emergy output and input| EYR = Y/F                   | East: 9.93E-6 North: 6.52E-6 | High      |
| 2  | Rasio emergy input and emergy inside system | EIR = F/(R+N)  | East: 0.898 North: 0.987 | Low       |
| 3  | Rasio environment loading   | ELR = (F+N)/R               | East: 2.56 North: 2.42    | Low       |
| 4  | Emergy Sustainability Index | ESI = EYR/ELR               | East: 3.88E-6 North: 2.70E-6 | High      |

3.2. Emergy index

Measurement emergy index result for seagrass ecosystem at Bintan Area summarized in Table 5.

**Table 5. Emergy index.**

4. Discussion

_Energy Yield Ratio_ (EYR) is a ratio between emergy results with emergy that been used for the fishing activity. The higher the EYR is, the lower the emergy that used for fishing activity to get that certain result. Otherwise, if the EYR is low, the means to exploit the resources is bigger. The result of emergy measurement summarized in Table 3 and 4. Energy Yield Ratio that measured on the East and North season was very low, only 9.93E-06 seJ/season for East and 6.52E-06 seJ/season for North. It means that the efforts spent by traditional fishermen are very big but did not get the maximum result. This was indicating that there were over exploitation on seagrass ecosystem resources. That certain condition can also be seen by the ratio between fishing activity emergy (F) with total emergy in system (U), amounts 46.6% on the East season and 49.68% on North season. That ratio can shows that fisherman power and fishing tools (particularly bubu) was the main factor for high EYR value (Fig. 2).
Emergy Investment Ratio (EIR) is a ratio between emergy inputs outside the system (fishing activity) with emergy input inside the system. The measurement shows that EIR on East season is 0.898 seJ/season and 0.987 seJ/season on North season. This amount was relatively high compared with EYR which means that economy investment needed from outside the system to exploit resources was relatively big. Liu [22] stated that low EIR value shows the least economy investment in exploiting resources and vice versa.

Emergy Loading Ratio (ELR) is a ratio between emergy inputs outside the system and emergy from non-renewable resources with emergy from renewable resources. This research shows that the ELR value from both East and North season was relatively high. It reaches 2.56 seJ/season for East season and 2.42 seJ/season for North season. That number shows that the environmental burden caused by fishing process in the seagrass ecosystem was relatively big. This was supported by Brown and Ulgiati (1977 in Liu [22]) which shows that ELR was the indicator for environmental burden from the process of production.

![Figure 2. Percentage of item F.](image)

Emergy Sustainability Index (ESI) is an indicator for sustainment of a system. High ESI value shows that the results from system gave an economic value for traditional fishermen while not giving any burden for seagrass ecosystem. The ESI value gathered from this research is really small which only 3.88-E6 seJ/season on the East season and 2.07E-6 seJ/season on North season. The numbers indicates that the connection between seagrass ecosystem and traditional fishermen was not sustained.

The emergy analysis approach was already being used by researcher for various concerns. High ELR value on cultivation process [6, 4, 5] shows that the process gave a quite high pressure to the environment, so it has to be evaluated. Evaluation was also needed to low scale fishery activities at Cilacap [28] and also for this research. Some of value of emergy indicator comparison from different sources was summarized in Table 6.

| Lokasi                  | Topik                          | EYR  | ELR  | EIR  | ESI   | Reference           |
|------------------------|--------------------------------|------|------|------|-------|---------------------|
| Ilha Solteira Reservoir, Brazil | Tilapia cage                   | 1.01 | 90.51| -    | 90.51 | Garcia et al. [6]   |
| Guaraira Lagoon, Brazil | Shrimp culture                 | 2.13 | 58.58| 0.88 | -     | Lima et al. [4]     |
|                        | Traditional shrimp culture     |      |      |      |       |                     |
|                        | Organic shrimp culture         | 4.31 | 51.64| 0.33 | -     |                     |

Table 6. Emergy Indicator Value from Several Sources.
| Lokasi                        | Topik                          | EYR | ELR  | EIR  | ESI   | Reference            |
|------------------------------|--------------------------------|-----|------|------|-------|----------------------|
| Sicily, Italia               | Eco village                    | 3.21| 0.48 | -    | 6.68  | Siracusa et al. [3]   |
| Cilacap, Indonesia           | Small scale fisheries          | 1   | 269.52| -    | 0.0037 | Patria et al. [28]    |
| MPA Olele, Indonesia         | Fisheries production           | 3.28| 0.44 | -    | 7.48  | Djau [29]            |
| Shiyang River Basin, Southwest China | Agro-ecosystem, Liang Zhou oasis | 9.85 | 1.07 | -    | 9.18  | Liu et al. [22]      |
|                             | Agro-ecosystem, Mingin oasis   | 8.51| 1.84 | -    | 4.63  |                      |
| Tegalwaru village, Indonesia | Autonomous village Current condition | 4.52E-11 | 7.31E-07 | 7.31E-07 | 6.18E-05 | Listyawati et al. [7] |
|                             | Village with biogas reactor    | 3.54E-09 | 1.98E-05 | 1.98E-05 | 1.79E-04 | Vassallo et al. [5]   |
| Gulf of La Spezia, Italy     | Fish culture Sparus aurata     | 1.2 | 5    | -    | -     |                      |
| East coast of Bintan Regency, Indonesia | SES seagrass ecosystem, east season | 9.93E-06 | 2.56E+00 | 8.98E-01 | 3.88E-06 | This study |
|                             | SES seagrass ecosystem, north season | 6.52E-06 | 2.42E+00 | 9.87E-01 | 2.70E-06 |                  |

5. Conclusion
The results of this research show couples of conclusions such as:
- The efforts spent by traditional fisherman was really high but not getting maximum result (EYR<)
- Traditional fishermen are in need of big economy investment to exploits resources in the seagrass ecosystem (EIR>)
- The environmental burden caused by fishing process in seagrass ecosystem was relatively big (ELR>)
- The connection between seagrass ecosystem with the fishermen was not sustained (ESI<)

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