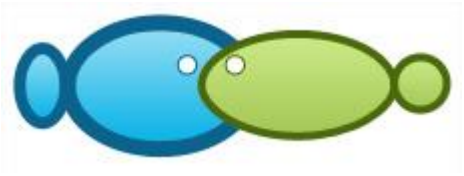


Sustainability analysis of artisanal fisheries in the coastal area of Karawang Regency

[1]Robet Perangin-angin, [1]Dian Sutono, [2]Kim V. Van, [1]Beta I. Sulistyowati, [1]Apih Suparlin, [1]Suharyanto

[1] Karawang Marine and Fisheries Polytechnic, Jalan Lingkar Tanjungpura, Karangpawitan, Karawang, Indonesia; [2] Fisheries Faculty, Vietnam National University of Agriculture, Trau Quy-Gia Lam-Hanoi, Vietnam. Corresponding author: R. Perangin-angin, robert.peranginangin@yahoo.com

Abstract. The coastal area of Karawang Regency is dominated by artisanal fishing activities, with the majority of fishing households conducting fishing activities using outboard motorboats. This study aimed to determine the sustainability conditions of small-scale fisheries with an ecological index analysis approach and sustainability window analysis on the coast of Karawang Regency. The diversity index (H') of fish resources in the Karawang coastal waters was 2.69, and the evenness index (J') of fish resources was 0.76. The level of thickness of sustainability window analysis (SuWi) tended to have a value below 1, with a thickness level between 0-0.48 for the period 2015-2019. Thus, the level of sustainability of artisanal fisheries is still "quite good", but it needs to be regulated by restrictions on fishing efforts.
Key Words: ecological index, diversity index, small-scale fisheries, resources, *Portunus pelagicus*.

Introduction. Karawang Regency has 30 districts, of which 8 districts have fishing households dominated by Cilamaya Wetan with 458 households, Cilamaya Kulon with 248 households, and Tempuran with 224 households (BPS 2019). The majority of fishing households do fishing activities using outboard motorboats, so it can be said that the coast of Karawang Regency is dominated by artisanal fishing activities.

Artisanal fisheries are identical to the use of a small tonnage fleet and relatively small operational capital. Management of small-scale fisheries is crucial. These artisanal fisheries can guarantee food security, income and community welfare. Besides, maintaining the health artisanal fisheries and the resilience of the marine ecosystems makes small-scale fisheries assessment a critical issue. The trend towards the fishing gear diversification is also a challenge for the sustainability of ecosystems and fish resources (Mozumder et al 2018).

Two main components must be considered in the utilization of fish resources, in particular by the small scale (artisanal) fisheries: they are an important source of community economic survival and they must cover the daily nutritional needs of many people depending on fishing. Issues often arise with over-fishing activities caused by population growth and by an increased market demand for fish resources. As a consequence, the environmental pressures increase, following the intensive exploitation of fish resources, which can lead to the depletion of the fish resources in these waters (Satria 2006).

The sustainability of the utilization of fish resources can be measured through the ecological index of the waters. The sustainability window analysis method can also be applied to the demersal fisheries in the South China Sea (Perangin-angin et al 2018).

The sustainable development is relying on three pillars: environmental, economic and social (WCED 1987). With the Sustainability Window method, providing optimal economic development information in order to support social and ecological sustainability, comparative analyses can be easily made with different indicators and for different periods. This method provides a new perspective for analyzing the trends of

sustainability and the impacts of underlying policies (Luukkanen et al 2015). The purpose of this study was to assess the sustainability conditions of the artisanal fisheries situated on the coast of Karawang Regency, with both the ecological index approach and the sustainability window analysis.

Material and Method. This research was conducted on the coastal of the Karawang Regency in August to December 2019, with the study area, as presented in Figure 1. Data collection was carried out by inventorying the catches and economic conditions of fishers on the Karawang coast located in 8 districts, namely Cilamaya Wetan, Cilamaya Kulon, Tempuran, Pedes, Cilebar, Cibuaya, Tirtajaya, and Pakisjaya.

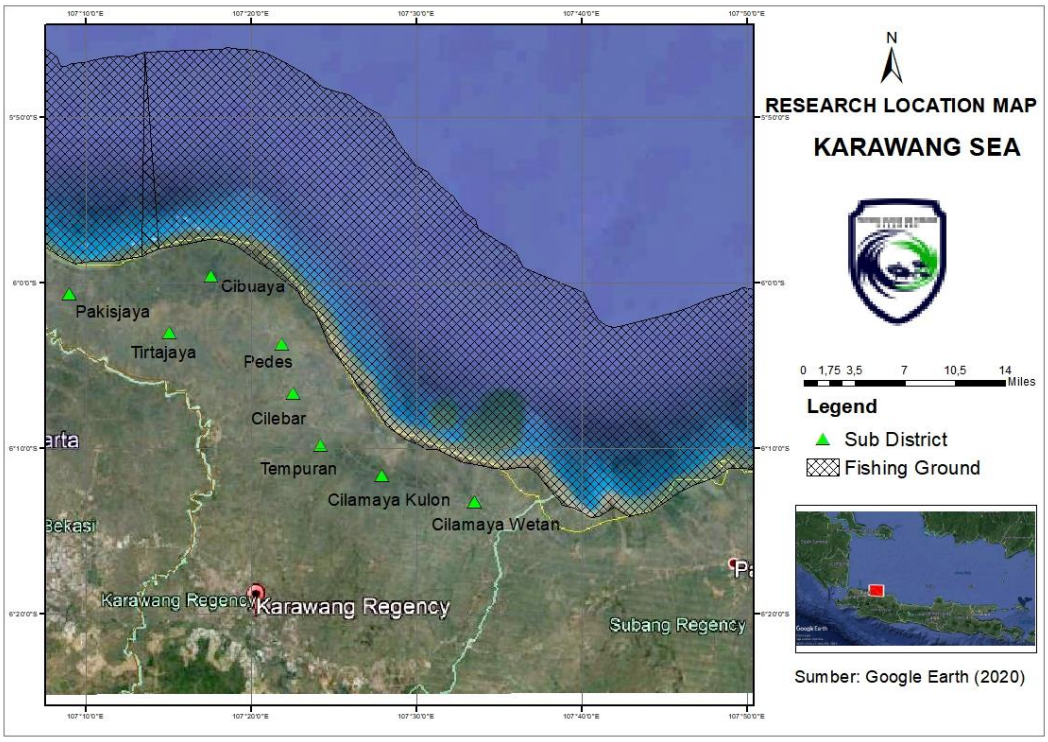


Figure 1. Map of Karawang Regency Coastal, Indonesia.

The ecological index analysis was performed using the Shannon-Wiener diversity index (Shannon & Weaver 1949), and the Pielou evenness index (Pielou 1975), as seen in Equation 1 and Equation 2.
Shannon-Weaver Index:

$$H' = - \sum(p_i . \ln(p_i)) \quad (1)$$

Where:
H'- species diversity index;
p_i - the fraction of the number of individuals of species i in the total population (ni/N);
ln - the natural logarithm of a number.
Pielou Index:

$$J' = H' / \ln (S) \qquad (2)$$

Where:
J '- Pielou's evenness index;
H'- species diversity index;
ln - the natural logarithm of a number;
S - number of species.

A simultaneous analysis of the three dimensions of sustainability can be done using the Sustainability Window analysis (Luukanen et al 2015; Perangin-angin et al 2018). The SuWi analysis rates lower and upper limits of economic development, so that social and environmental development remains within the limits of sustainability.

Results

General conditions. The list of species with the highest amount of production in the coastal waters of Karawang Regency, include the following: *Sardinella lemuru* (2,056.39 tons year^{-1}), *Leiognathus splendens* (1,053.44 tons year^{-1}), *Portunus pelagicus* (874.01 tons year^{-1}) and *Johnius trachycephalus* (780.22 tons year^{-1}). Based on the value of production, the list extends to six main species, namely: *P. pelagicus*, *Fenneropenaeus merguiensis*, *J. trachycephalus*, *Rastrelliger* sp., *Loligo* sp. and *S. lemuru*. The value of *P. pelagicus* is higher than for other species, with a production value of 2,015.570.19 USD year^{-1} (Figure 2).

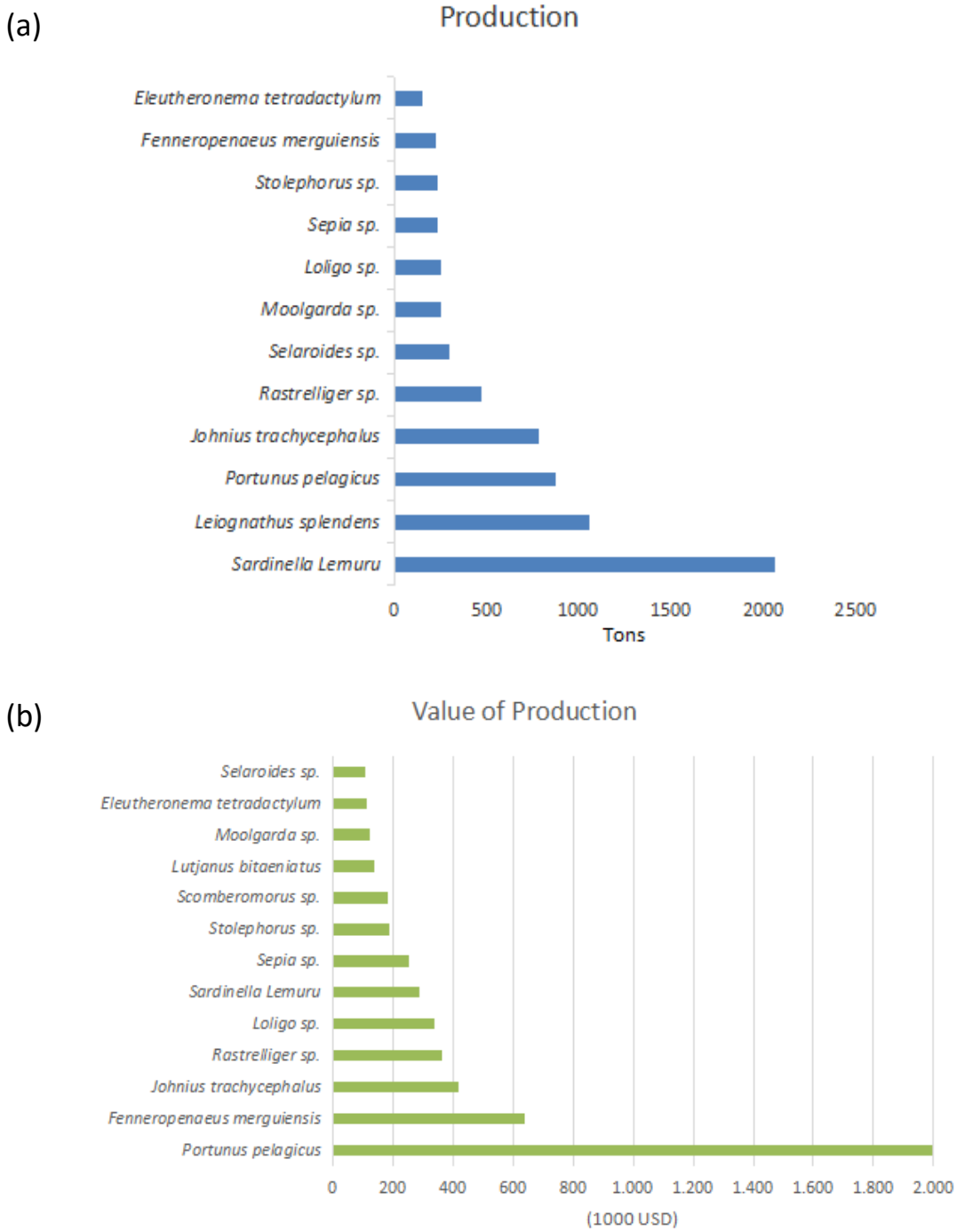


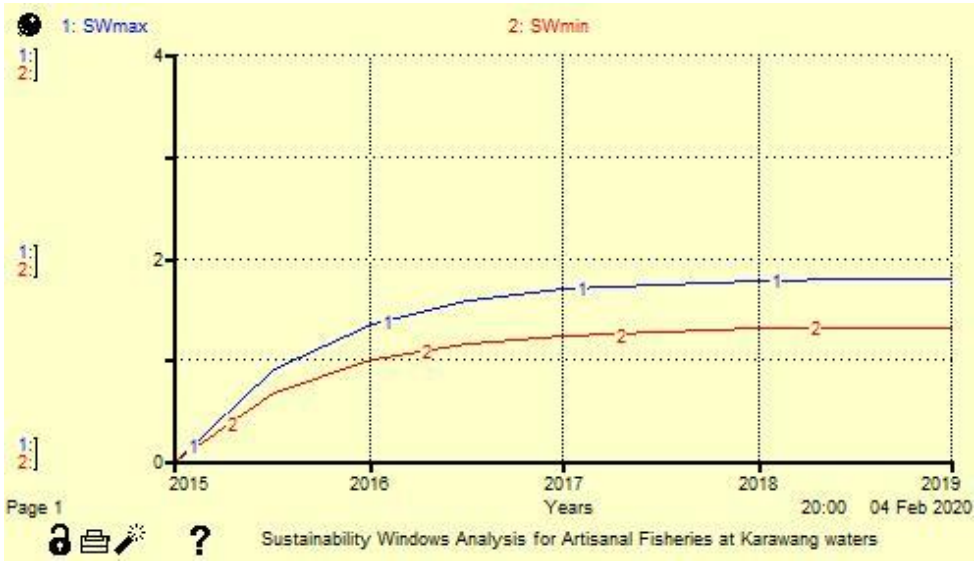
Figure 2. The catch of fish resources landed in Karawang Regency in 2014-2019, according to: (a). Production; (b). Value of production.

Ecology index. The diversity index (H') of fish resources in the Karawang coastal waters is 2.69, and the evenness index (J') of fish resources was 0.76. The results of the analysis of the level of waters diversity in the Karawang coast indicated that there may be a disturbance in the environment of the coastal ecosystem of Karawang Regency. The disruption can be caused by overfishing in these waters, so it is necessary to regulate the amount of capture effort to stabilize the ecosystem of the coastal water.

Sustainability window analysis (SuWi Analysis). Value of Sustainability Window (SuWi) from artisanal fisheries was obtained by comparing the value of fish resource production with the amount of production. Since 2015, the value of SuWi thickness increased significantly until 2017, then in the 2017-2019 time frame, SuWi thickness tended to be flat.

The level of thickness of SuWi analysis tended to have a value below 1, with a thickness level of 0-0.48, between 2015-2019. SuWi's value, which tended to increase, indicated that the activity of exploiting fish resources in the coastal waters of Karawang Regency which was still intensive, with a thickness level below 1, that fishing efforts and captures should be limited (Figure 3).

a



b

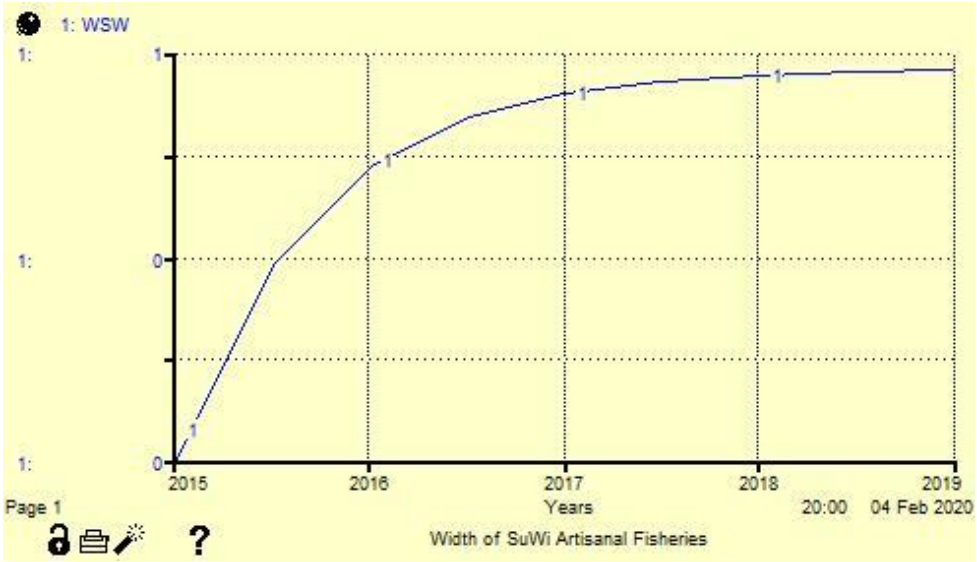


Figure 3. (a) Sustainability maximal and sustainability minimum; (b) Width of SuWi from artisanal fisheries.

Discussion. The production of artisanal fishers on the coast of Karawang Regency is dominated by four main species, namely *S. lemuru*, *L. splendens*, *P. pelagicus*, *J. trachycephalus.* According to Akbar et al (2019), the majority of fish caught in the Karawang was small pelagic fish, in proportion of 68%, compared to demersal with 22%, large pelagic with 6% and squids with 4%. Based on the economic values, the production was dominated by *P. pelagicus*, *F. merguiensis*, *J. trachycephalus*, *Rastrelliger* sp., *Loligo* sp. and *S. lemuru*. *L. splendens* was predominantly found along the coast on the west coast of Kalimantan (Perangin-angin et al 2016a; Perangin-angin et al 2016b), and the west coast of Sumatra (Wedjatmiko 2007). Although in terms of production it was less dominant, *P. pelagicus* dominates in terms of production value, due to the relatively high selling price. The average price of *P. pelagicus* in Karawang Regency is around 2.30 USD kg^{-1}; while the buying price of collectors in Demak Regency ranges from 3.09 USD kg^{-1} up to 4.19 USD kg^{-1} (Agustina et al 2014).

The diversity index (H') of fish resources in the Karawang coastal waters is 2.69, and the evenness index (J') of fish resources is 0.76. Previous studies in the waters of the South China Sea (WPP NRI-711) on demersal fish resources, obtained Shannon-Weaver (H') diversity index values ranging from 1.30-2.87 and Pielou flatness index values (J') ranged between 0.33-0.77. The values of the diversity index and the flatness index categorize the demersal fish resources in these waters as "in poor conditions" (Perangin-angin et al 2017). According to Mason (1996), the diversity index interval value is below or equal to 2.30 in the "low" category, and under the amount of 3.45 in the "medium" category. Evenness index measures the distribution of the population abundance in a multi-species community (assemblage), the maximum value of evenness index is one, indicating that the abundance of each species is balanced in the community (Ricotta 2003; Gosselin 2006). The higher the evenness index values in water, the better the environment in these waters. A good environment will increase diversity in the community (Loiseau et al 2016). The Shannon-Weaver (H') diversity index value of 2.69 and Pielou's evenness index (J') of 0.76 indicate that the coastal waters of Karawang Regency are in "good enough" condition, but need to limit catching efforts. According to Chang et al (2012), biological indices including the Shannon diversity index (H') and Pielou even index (J') show a tendency to increase when approaching the offshore.

Luukanen et al (2015) conducted a research related to sustainable development in China, with the SuWi method, and obtained a thickness level of the sustainability window ranging between 0 and 1.2. Research related to the sustainability of demersal fisheries in the South China Sea (WPP-NRI 711) using the SuWi method, obtained a thickness of the sustainability window between 0 and 0.84 (Perangin-angin et al 2018). Based on the existing graph with the base year of 2015, it can be seen that the level of thickness of the sustainability window of artisanal fisheries on the coast of Karawang Regency is situated between 0 and 0.48. The level of thickness of SuWi which tends to have a value below 1, which calls for caution in managing artisanal fisheries in the coastal waters of Karawang Regency. The narrow sustainability window can be due to the high effort to utilize fisheries resources in the Karawang Regency coast. Therefore, it is necessary to support the transformation of artisanal sea fishing fleets, in proximity of the exclusive economic zone of Indonesia (IEEZ).

The result for the SuWi index can fluctuate due to the economic development and to the resources management (Rumagia et al 2020). The capacity of regional economic sustainability must include all existing and potential financial capabilities. The environmental sustainability capacity is related to the ecological elements of the sustainable development capacity, which is not only focused on the ability to develop environmental protection regionally but must also include the ability to coordinate and develop the regional environment and its resources. The capacity of socially sustainable development is related to the social factors of local, consisting in effects on the community social-life and include the influence of societal development, level of education, and daily life-style of the community (Dempsey et al 2011).

Conclusions. The distribution of diversity and evenness index showed that there was a slight disturbance in the level of stability of the Karawang coastal waters ecosystem, and

the thickness value of SuWi analysis ranged from 0 to 0.48. This condition showed that the level of sustainability of artisanal fisheries on the Karawang Regency coast was still "quite good", but needs to be regulated by restrictions on fishing efforts.

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Authors:
Robet Perangin-angin, Karawang Marine and Fisheries Polytechnic, Fishing Technology Study Program, Jalan Lingkar Tanjungpura, Karangpawitan, 41315 Karawang, West Java, Indonesia, e-mail: robert.peranginangin@yahoo.com
Dian Sutono, Karawang Marine and Fisheries Polytechnic, Fishing Technology Study Program, Jalan Lingkar Tanjungpura, Karangpawitan, 41315 Karawang, West Java, Indonesia, e-mail: sutono_dian@yahoo.com
Kim Van Van, Vietnam National University of Agriculture, Fisheries Faculty, Trau Quy-Gia Lam-Hanoi, Vietnam, e-mail: kvvan@vnua.edu.vn
Beta Indy Sulistyowati, Karawang Marine and Fisheries Polytechnic, Fishing Technology Study Program, Jalan Lingkar Tanjungpura, Karangpawitan, 41315 Karawang, West Java, Indonesia, e-mail: betaindisulistyowati@gmail.com
Apih Suparlin, Karawang Marine and Fisheries Polytechnic, Fishing Technology Study Program, Jalan Lingkar Tanjungpura, Karangpawitan, 41315 Karawang, West Java, Indonesia, e-mail: apih_suparlin@yahoo.com
Suharyanto, Karawang Marine and Fisheries Polytechnic, Fishing Technology Study Program, Jalan Lingkar Tanjungpura, Karangpawitan, 41315 Karawang, West Java, Indonesia, e-mail: shy_pusdik@yahoo.co.id
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