Egyptian Journal of Aquatic Biology & Fisheries
Zoology Department, Faculty of Science,
Ain Shams University, Cairo, Egypt.
ISSN 1110 – 6131
Vol. 28(3): 335 – 353 (2024)
www.ejabf.journals.ekb.eg

Multidisciplinary Assessment of the Blue Swimming Crab (*Portunus pelagicus*) in the Bone Bay, South Sulawesi, Indonesia, Using Rapid Appraisal of Fisheries

Fitri Hardianti Wijaya[1] , Nadiarti Nurdin Kadir [2, 3, 4]*, Joeharnani Tresnati[2]

[1]Master's Program in Fisheries Science, Department of Fisheries, Faculty of Marine Science and Fisheries, Hasanuddin University, Makassar 90245, Indonesia
[2]Study Program of Aquatic Resources Management, Department of Fisheries, Faculty of Marine Science and Fisheries, Hasanuddin University Makassar 90245, Indonesia, 3LC-EAFM
[3]Center of Excellence for Marine Resilience and Sustainable Development, Universitas Hasanuddin, Makassar 90245, Indonesia
[4]Learning Center for Ecosystems Approach to Fisheries, Universitas Hasanuddin, Makassar 90245, Indonesia

[*]**Corresponding Author: nadiarti@unhas.co.id**

ARTICLE INFO

Article History:
Received: Feb. 16, 2024
Accepted: June 7, 2024
Online: July 20, 2024

Keywords:
Blue swimming crab
Sustainability,
Bone Bay,
Rapfish,
Fisheries management

ABSTRACT

This study aimed to assess the sustainability status of the blue swimming crab fisheries resources in Bone Bay through a rapid assessment approach to the dimensions of sustainable fisheries development. A multidimensional scaling (MDS) approach through the rapfish process was used to assess the sustainability status of the blue swimming crab fisheries. The sustainability analysis was expressed in the sustainability index of fisheries management. The results showed that the sustainability status of the blue swimming crab fishery in Bone Bay was categorized as less sustainable with an average value of 38.43%. The ecological, economic, social, technological and institutional dimensions were categorized as less sustainable. 24 attributes contributed to the sustainability index value (leverage analysis) of the blue swimming crab fisheries management in Bone Bay, which requires an important attention in the sustainability of the blue swimming crab fisheries management.

INTRODUCTION

The blue swimming crab, a member of the Portunidae family, is characterized by its distinctive features, including modified last legs adapted for flattened swimming paddles. Males typically showcase mottled blue coloration, while females exhibit variable mottled brown patterns with a varying intensity. The mature male and female crabs can be easily differentiated by the shape of the abdominal flap, which is narrow and triangular in males and broad and rounded in females **(Lai *et al*., 2010)**. Regarding their habitat, the blue swimming crabs inhabit a diverse range of environments, from inshore to continental shelf areas, encompassing sandy, muddy, algal, or seagrass habitats, and can be found from the intertidal zone to depths of 50 meters **(Webley *et al*., 2009)**.

The blue swimming crab is a crucial coastal and marine resource, playing a pivotal role for some countries such as Indonesia. Indonesia's fisheries export sector holds the 4th rank among significant export commodities such as shrimp, tuna, squid-octopus-cuttlefish, and seaweed. From 2017 to 2021, the blue swimming crab exports showed an average value of approximately USD 451 million, demonstrating a noteworthy average annual increase of 14.72% **(MMAF, 2022a)**. Typically, the blue swimming crab exports involve the dissemination of canned blue swimming crab meat **(Nugraheni *et al*., 2015)**. The blue swimming crab fisheries sector significantly contributes to the livelihoods of 65,000 fishermen and 130,000 blue swimming crab processors **(MMAF, 2015)**, establishing a direct dependency on blue swimming crab-related economic activities.

Over the past five years, Indonesia exports the blue swimming crabs to 50 countries, with Japan, China, and Hong Kong leading in export value **(MMAF, 2022b)**. However, excessive crab utilization has been reported in several countries, including Indonesia, particularly in Central and Eastern Java, as well as in Thailand and Pakistan. This has resulted in an over-exploitation **(Ihsan, 2014; Khongkhon, 2015; Afzaal *et al.*, 2016; Nabila, 2022)**, and in some cases, heavy overexploitation **(Ernawati *et al.* 2015)**. Overharvesting crabs endangers their population, disrupts the marine ecosystem, upsets the food chain balance, and may lead to further consequences.

Bone regency, a region in South Sulawesi, Indonesia, is a notable producer of the blue swimming crabs, with an average production reaching about 658 tons from 2018 to 2022, peaking at 940.50 tons in 2022 (Provincial Marine and Fisheries Service 2023). This emphasizes Bone Regency's significant role in the fisheries sector, particularly in the blue crab production.. The high volume of exports is increasing, the number of crab fishers is increasing, and the number of fishing gears is also increasing. However, information on the sustainability status and management of these crabs is not yet available.

The rapfish (Rapid Appraisal of Fisheries) is a multidisciplinary method that assesses the sustainability of fisheries through transparent and semi-quantitative scoring of ecological, economic, social, technological, and ethical attributes **(Pitcher, 2001; Tesfamichael & Pitchard., 2006)**. Rapfish, extensively elucidated with its statistical foundation detailed by **Alder (2000a, 2000b); Kavanagh and Pitcher (2004a, 2004b)**, employs non-parametric ordination techniques, specifically multidimensional scaling (MDS), to yield values indicating the relative sustainability of fisheries in comparison to predetermined benchmarks. Various studies have applied the rapfish method as an effective tool in evaluating the management status of certain fisheries, such as those of **Suresha (2015)** and **Yasir and Fujii (2020)**.

MATERIALS AND METHODS

1. Study site

This study centered on the Bone Regency, South Sulawesi Province, Indonesia. Observations and interviews were conducted in three districts, Tanete Riattang Timur, Tellu Siattinge and Tonra (Fig. 1).

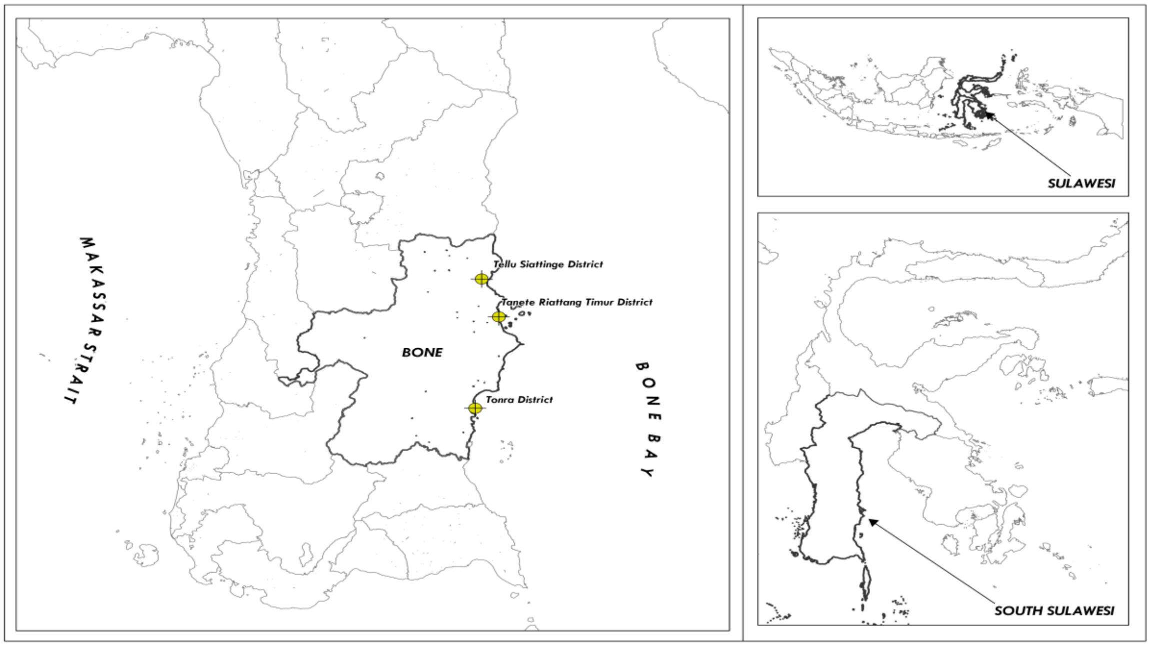

Fig. 1. Map of study sites, within Bone Regency, South Sulawesi, Indonesia

2. Data collecting method

This study collected data from 24 attributes that have been considered and grouped into five dimensions: ecological dimension, economic dimension, technological dimension, social dimension and institutional dimension. Most of the attributes and assessment scores refer to **Adrianto *et al.* (2014)**, **Tahmid (2016)** and **Annisa (2017)**, which have been modified. Primary and secondary data are the quantitative and qualitative data collected. Survey results, direct observations in the field, and structured interviews with the help of questionnaires are the primary data sources. Secondary data was collected through literature study by collecting all information relevant to the research or research objectives from various related sources both from agencies from the village level to the provincial level.

The selection of this method was based on the specific objective of the research study, which was to assess the sustainability status of crab resources. The criteria for respondents selected were local fishers with an access to and information on crab resource utilization who have been crab fishers for more than five years, community leaders, government institutions (provincial, district, and village), fisheries supervisors, and crab collectors. The number of respondents for interview purposes was around 5 to 7 people.

3. Rapid appraisal for fisheries

Rapfishwas developed at the University of British Columbia, Canada, and is used to evaluate the sustainability of fisheries by application of a novel multidisciplinary rapid assessment technique. Rapfish relies on the ordination of scored attributes clustered in multiple areas of evaluation using multidimensional scaling (MDS). These areas, or dimensions, are ecological, economic, technological, social, and ethical/ legal and institutional, as stated in the studies of **Alder (2000a, 2000b)** and **Pitcher and Preikshot (2001a, 2001b)**. The attributes, or indicators, associated with fisheries sustainability, such as those used in the studies of **Tahmid (2016)** and **Annisa (2017)**, were elaborated by referring to the work of **Pitcher and Preikshot (2001a, 2001b)**.

4. Identification and determination of attributes

Based on a thorough review and compilation of all available data, 24 attributes were defined in five dimensions: ecological (7), economic (5), social (3), technological (5), and institutional (4) (Table 1). These attributes represent sustainable blue swimming crab resource management in Bone Bay.

5. Definition and scoring of attributes

The second step of the analysis was to define and score the attributes in accordance with the rapfish **(Alder, 2000a, b)** in which a “bad” score designates the worst condition for the blue swimming crab, and a “good” score signifies the most favorable condition. Each of attribute’s score depends on its position within the range of bad to good.

6. Multidimensional scaling

MDS (Multidimensional Scaling) involves placing similar points or objects close and dissimilar ones far apart. Using a rotation axis, object positions are projected onto a horizontal line, where 0 indicates high threat and 100 indicates low threat. The ordination process includes identifying two main reference points (vertical for "good"/low threat and horizontal for "bad"/high threat), establishing an additional reference point ("anchor") for scoring stabilization, standardizing scores for each rapfish attribute to ensure accurate weighting, and calculating distances between rapfish points and reference points using MDS.

Table 1. Attributes of threats to the blue swimming crab in the Bone Bay, South Sulawesi, Indonesia and rapfish scoring criteria. Scores range from bad (unsustainable; 0) to good (very sustainable; highest scores vary among attributes)

No	Atribute	Good	Bad	Assessment criteria	Data source
	Ecological dimension				
1	Presentation of seagrass ecosystem cover	2	0	Low cover, 30% (0); ,medium cover 30 – 60% (1); high cover 60 – 100% (2)	Secondary data Journal (syarifuddin.,2022)
2	Presentation of mangrove cover	2	0	Low cover, 50% (0); medium cover 50 – 75% (1); cover above 75 % (2)	Secondary data journal (Irwan et al.,2018)
3	Coral reef cover presentation	2	0	Low cover, 30% (0) medium cover 30 – 60% (1); high cover 60 – 100% (2)	Secondary data Journal (Ayyub et al., 2018)
4	Crab catch size	2	0	The smaller (0); relatively the same (1); getting bigger (2)	Interview and observation
5	Location of capture area	2	0	The further away (0); relatively the same (1); Getting closer (2)	Interview
6	Environmental quality	2	0	Bad (0); medium (1); good (2)	Secondary data (Hanum.,2022)
7	Crabs caught before they mature	2	0	(>30- 60%) 2 ; >60-80%)(1); 80-100% (0)	Interview and observation
	Economi dimension				
8	Selling price of king crab	2	0	decreased (0); relatively stable (1); increased (2)	Interview
9	Crab production	2	0	decreased (0); relatively stable (1); increased (2)	Secondary data (DKP BONE,2023)
10	Average income of crab fishermen	2	0	Below minimum wage (0); same minimum wage (1); above minimum wage (2)	Interview
11	Subsidy dependency	3	0	Absolutely (0); necessary to help (1) not so necessary (2); not necessary (3).	Interview
12	Source of livelihood	2	0	Main (0); main with other sources (1); additional (2)	Interview
	Technology dimension				
13	Crab catching technique	1	0	Active (hunting/digging holes) 0 and Passive (fixed bubu/gillnet) 1	Interview and observation
14	Tool selectivity	2	0	Low (0); medium (1); high (2).	Interview and observation

15	Means of transportation used	2	0	Road (0); Rowboat (1); Motorboat (2)	Interview and observation
16	Crab landing site	2	0	Many and scattered (2); centralized (1); inadequate (0).	Interview
17	Growth of the capture fleet	2	0	Decrease (0) ; remain (1) ; increase (2)	Secondary data (DKP BONE, 2023)
	Social dimension				
18	Education level	2	0	Not / graduated from elementary school (0); graduated from junior high school (1); high school graduate (2)	Interview
19	Influence of local figures	2	0	no local leaders (0); not influential (1); moderately influential (2)	Interview
20	Conflict between fishermen	1	0	Present (0) and absent (1)	Interview
	Institutional dimension				
21	Level of community compliance with crab management rules	2	0	non-compliant ; more than 5 violations moderate (1); 2 -4 violations (2) compliant; less than 2 violations. (3)	Interview
22	Monitoring and supervision	2	0	low (0); medium (1); high (2)	Interview
23	The existence of community institutions in crab management	2	0	none (0); present , not active (1); implemented(2)	Interview
24	Existence of crab management rules	2	0	none (0); present , not active (1); implemented(2)	Interview

Table 2. Index scale of sustainability index scale of the crab fishery in the study area refers to **Susuilo (2003)** which ranges from 0 to 100 and is divided into four categories

Index	**Category**
0 - 25	Bad
26 – 50	Less
51 – 75	Simply
76 – 100	Good

7. Sensitivity analysis

Sensitivity analysis was conducted to determine which attributes contributed most to the sustainability of the blue swimming crab with the highest sensitivity. The influence of each attribute on the sustainability index was evaluated through the leverage analysis of the rapfish scores to determine the level of ordination alteration when specific attributes were omitted from the data. The impact of each attribute was determined by observing the alteration of the root mean square (R^2) of ordination, particularly on the x-axis or the accountability scale. A higher-level transformation of the R^2 value resulting from the omission of a particular attribute has a greater effect on the sustainability index; in other words, the attribute demonstrates greater sensitivity to the management of blue swimming crab. Such high sensitivity levels are subsequently utilized to formulate recommendations for the sustainability of the blue swimming crab.

8. Monte carlo analysis

Uncertainties in rapfish analysis usually occur in the estimated score of each attribute and the contribution to the evaluation results. For this reason, monte carlo techniques of rapfish are used to assess the uncertainty factor during the analysis. Monte carlo analysis was used in the current study to examine assessment errors caused by several factors, such as 1) inconsistency of assessment, 2) difference in assessment, 3) level of iterative stability, 4) data error, and 5) high S-values **(Kavanagh & Pitcher, 2004a, b)**.

RESULTS AND DISCUSSION

1. Sustainability index value

There are five dimensions of the mangrove crab sustainability, namely ecological (45.37%), economic (42.44%), technological (48.46%), social (27.75%), and institutional (28.14%), which are categorized as less sustainable. The results of the multidimensional analysis of the sustainability of the blue swimming crab fisheries in Bone Regency obtained a combined value of 38.43% (Fig. 3) with a less sustainable category. This is because fishermen are still catching immature crabs, the education level of fishermen is still low, transportation facilities are still simple, there is no community institution in the blue swimming crab management, and supervision of the blue swimming crab management regulations has not been running effectively. Therefore, it is necessary to make efforts to improve the less sustainable dimensions of rapfish in order to help improve the sustainability status of blue swimming crab resources, so that it can meet the living needs of current and future generations.

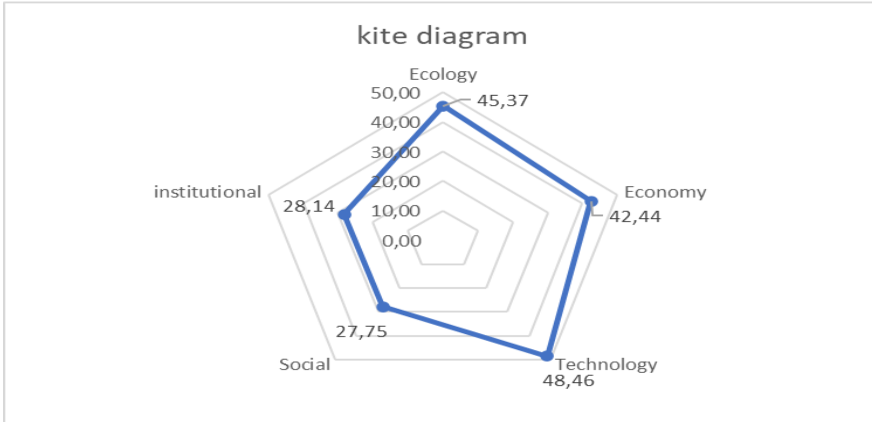

Fig. 2. Kite diagram blue swimming crab sustainability index in Bone Regency

2. Stress value and coefficient of determination

To see the effect of errors or disturbances from the results of the ordination of the sustainability status of the blue swimming crab fishery, the monte carlo analysis was conducted, which is a statistical simulation method to evaluate the effect of errors or disturbances on the statistical process. The results of the monte carlo analysis show that the points on the scatter plot are in a collecting position, this means that the results of the ordination points used in determining the sustainability status of the blue swimming crab fisheries in Bone Regency are quite stable, so that errors or disturbances can be overcome. According to **Kavanagh and Pitcher (2004a, 2004b)**, errors or disturbances in ordination results are indicated by points that are spread out or separated from other sets of points in the scatter plot caused by: (1) the influence of attribute scoring errors caused by lack of information, lack of understanding of the attributes or how to score the attributes; (2) the influence of scoring variations due to different opinions or assessments by different researchers; (3) the stability of the MDS analysis process carried out repeatedly (ancor position is not stable); (4) data entry errors or missing data and (5) the high value of "stress" analysis results. In detail, the results of the monte carlo ordination of the five dimensions of sustainability of blue swimming crab fisheries are presented in the form of a scatter plot in Table (3).

Table 3. Stress value and coefficient of determination of five dimensions of the blue swimming crab in Bone Regency

Dimension	Stress	R^2
Ecology	0,1439	0,9433
Economy	0.1619	0.9338
Technology	0,1723	0,9307
Social	0,1670	0,9292
Institutional	0,1593	0,9287

The stress values of the five dimensions are less than 0.25 (Table 4), while the coefficient of determination (R^2) is above 0.87. This indicates that the analysis results are adequate, as the stress value is below 0.25 and the coefficient of determination (R^2) is close to 1.0. Thus, these two parameters indicate that all indicators used are relatively good in explaining the five dimensions analyzed.

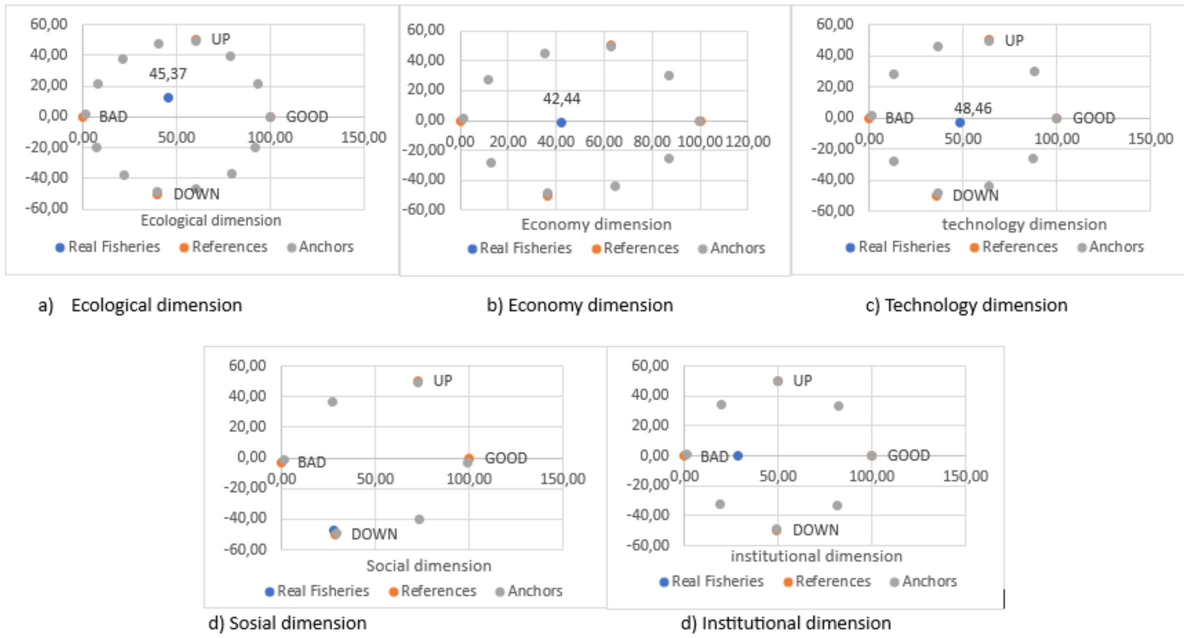

Fig. 3. a) Sustainability index value of ecology dimension, b)economy dimension, c) social dimension, d) technology dimension and e)institutional dimension.

3. Ecologycal dimenssion

Attributes used in analyzing the sustainability of crab include ecological dimension, which assesses the presentation of the mangrove cover, size of crabs caught and location of fishing grounds. Mangrove ecosystems are habitats for various types of juvenile fish, shrimp, crabs, and mollusks. The juvenile crabs are found in mangrove areas and mudflats for 8 to 12 months until they reach a carapace width of 80- 100mm. Based on the results of research by **Aswar (2017)**, mangrove cover in the Bone Bay area is classified as high (>75%), so that it is given a score of 2. Mangroves are very important for the sustainability of crabs since mangrove ecosystems are important habitats for crabs and various other marine biota. Mangroves provide feeding, breeding, and protection for crabs and other species, hence maintaining mangrove ecosystems also means maintaining the crab habitat **(Agus, 2016**; **Santoso & Raksun, 2016)**. Crabs are highly dependent on the existence of mangroves as their habitat, loss of mangroves can cause a decline in the crab population due to loss of nursery ground, food sources, and protection **(Kurnia & Boer, 2014)**. Therefore, mangrove conservation is necessary to support the sustainability of crab populations and aquatic ecosystems.

Based on the results of interviews with local fishermen regarding the size of the caught crab, they stated that in the last five years there has been a decrease in the size of the crab and the sampling results show that many of the sizes of crabs caught were classified as immature, namely the size of the carapace width below 10cm, not in accordance with the regulation of the Indonesian Minister of Marine Affairs and Fisheries No.17/PERMEN-KP/2021 which regulates the size of the crab catch, therefore given a score of 1. Catching crabs that are not in accordance with standards, such as catching crabs under 10m in size and ovigerous crabs, can cause disruption of the crab population structure. This can result in a decrease in the size and catch of crabs, as well as reducing opportunities for young crabs to grow into adults and for female crabs, caught in conditions that are incubating eggs, to hatch their eggs **(Mughni *et al.*, 2022)**.

Based on the results of interviews conducted with fishermen, it is stated that in the last five years the crab fishing location area has become deeper and farther from the coastline to get a bigger catch. In accordance with the research of **Agus *et al.* (2016)** in the waters of Pati Regency, crabs caught in coastal waters have a smaller carapace width size compared to crabs caught in offshore waters; the characteristics of crab fishing areas in Pati and the surrounding waters show that, the more heading toward the offshore, the more the depth of these waters increase . Research by **Zairion *et al.* (2014)** stated that, the size of the crab carapace width and the weight of the crab catch increased in each stratification toward the offshore, which increased according to the bathymetry stratification of 5, 10, and 15m. Similar distribution patterns were also shown in the Pati and surrounding waters. A similar distribution pattern was also recorded in a previous study **(Anam *et al.*, 2019)** in Demak waters, where zone 1 (100mm) was found in deeper waters.

Table 4. The value of laverage analysis to the five dimensions of crab in Bone Regency

Ecological		Economic		Social		Technology		Institutional	
Attribute	**Leverage**	**Attribute**	**Leverage**	**Attribute**	**Laverage**	**Attribute**	**Laverage**	**Attribute**	**Laverage**
Presentation of seagrass ecosystem cover	3,73	Selling price of king crab	3,13	Education level	22,91	Crab catching technique	1,39	Level of community compliance with crab management rules	5,91
Presentation of mangrove cover	6,01	Crab production	5,28*	Influence of local figures	21,93	Tool selectivity	1,98	Monitoring and supervision	9,21*
Coral reef cover presentation	4,72	Average income of crab fishermen	0,22	Conflict between fishermen	27,17*	Means of transportation used	3,01*	The existence of community institutions in crab management	9,12
Crab catch size	7,66*	Subsidy dependency	0,37			Fish landing site	1,21	Existence of crab management rules	5,91
Location of the capture area	6,52	Source of livelihood	0,41			Growth of the capture fleet	1,35		
Environmental Quality	1,16								
Crabs caught before they mature	2,14								

4. Economy dimension

The sustainability status of the economic dimension is less sustainable with an index of 42.44%. Attributes for analyzing the sustainability status of the economic dimension are: 1) selling price of crab; 2) crab production; 3) average income of crab fishermen; 4) source of livelihood, and 5) subsidy dependency (Fig. 3).

The economic dimension attributes that have the most influence on the crab sustainability are crab production and crab selling price. From the results of interviews and secondary data obtained in this study there was an increase in production in the last 5 years so that it was given a score of 2. Increased production can contribute to overfishing, which can disrupt the sustainability of the stock. Overfishing can cause population decline, thus threatening the sustainability of the resource **(Susilo, 2010)**. Catching small-sized crabs, uneven fishing areas and fisheries activities that are not environmentally friendly will cause overfishing **(Hamid *et al*., 2017)**.

From the results of interviews with fishermen and crab collectors, it was found that the selling price of the blue swimming crab in the last 5 years has decreased, which used to be 80,000 - Rp.100,000/ kg now only able to sell Rp.50,000/ kg, so it is given a score of 0. One of the causes of the decline in the selling price of the blue swimming crab is the decline in demand in the export market, the price of crab is also influenced by demand in the export market. As long as the economy in a number of destination countries has not recovered due to the COVID-19 pandemic. The declining selling price of crab is certainly a serious problem for fishermen since it directly affects their income. When the selling price drops, fishers tend to put more effort into catching crabs in order to keep making ends meet. This could mean increasing fishing intensity, using more time and resources to catch larger quantities **(Maduwu, 2023)**. However, the impact of this increased fishing effort can be mixed. On the one hand, fishers may get more catches, but on the other hand, this increase in fishing could also cause an excessive pressure on the crab populations and potentially damage marine ecosystems.

5. Technology dimension

The sustainability status of the technology dimension is less sustainable (index 48.46%). The attributes used were: 1) crab fishing techniques; 2) selectivity of fishing gear; 3) means of transportation; 4) fish landing sites, and 5) growth of the fishing fleet (Table 1).

Crab fishers utilize various forms of transportation, encompassing both sea and land options. Among these, small boats play a crucial role in activities such as scouting fishing locations, transporting equipment, and ferrying catches. Based on interviews with fishermen, motorboats were identified as the predominant means of transportation, earning a score of 2.

Transportation plays an important role in catching crab because it can affect efficiency, travel time, and catch quality **(Cendrakasih *et al*., 2023)**. The type of transport used to catch crabs, such as boats or fishing vessels, needs to be appropriate for the depth of water in which the crabs live, while the speed and efficiency of the transport can minimize the time between capture and landing on land, which impacts the quality and selling value of the crabs **(Rangga & Tyas, 2023)**. The catching equipment carried by the transportation is also influential, as are the handling conditions during transportation. In addition, good transportation also supports the management of fisheries resources by assisting the distribution of catches and maintaining the availability of crab supplies in the market. Sustainability aspects are also taken into consideration by choosing environmentally friendly transportation to support the sustainability of fisheries resources **(Satria, 2014)**.

6. Social dimension

The sustainability status of the social dimension is less sustainable with an index of 27.75 (Fig. 3). Attributes for analyzing the sustainability status of the economic dimension are: 1) Eucation level; 2) Influence of local leaders; 3) Level of conflict between fishermen. The attributes that strongly influence sustainability in the social dimension are the level of education and the influence of local leaders.

The education level of fishers can have a significant impact on the sustainability of crab resources. More educated fishers tend to be more aware of the importance of preserving marine resources and implementing sustainable fishing practices. They may also be better able to understand information on the condition of the crab population and fishing regulations issued by the government. In addition, more educated fishers are also likely to have better access to resources and information that can assist them in sustainable fishing practices, such as more environmentally friendly fishing technologies or more efficient fishing methods. Thus, the education level of fishers can contribute positively to resource sustainability **(Wahyudin *et al*., 2019)**.

There is a correlation between the level of damage to the coastal environment and the level of education and income of coastal communities. This is explained by **Primyastanto *et al*. (2010)**, who stated that the economic level is less established due to the low level of education of fishermen, resulting in a lack of public awareness to protect the coastal environment from damage. This is in line with the results of **Siswanto and Nugraha (2016)**, who conveyed that the average education level of fishing communities in the Madura coastal area is only at the elementary school level. Increasing economic demands cause coastal communities to exploit as many resources as possible without taking into account the impact of damage and sustainability of resources for the future. Based on the results of interviews conducted with fishermen, it shows that the education level of crab fishermen in Bone district on average does not observe the elementary school level, so it is given a score of 0.

Indigenous leaders can play a role in local wisdom-based community development by accelerating community empowerment efforts, creating new sources of livelihood, and involving local communities in development. The influence of modernization can affect local wisdom, including in the management of natural resources and the environment. Community leaders can play a role in facing this challenge by supervising and guiding indigenous peoples and the younger generation to maintain their local wisdom **(Damayanti *et al.*, 2020)**. Local leaders can also play a role in developing and applying local wisdom in fisheries resource management. Local wisdom is knowledge and practices acquired from generation to generation and related to local culture and environment. In some cases, the presence of local leaders can assist in developing more effective and sustainable fisheries resource management strategies, as well as increasing community awareness of the importance of sustainable fisheries resource management **(Lakoy & Goni, 2021)**.

Local leaders play an important role in maintaining the sustainability of fisheries resources through knowledge, community education, traditional arrangements, co-management, and cultural preservation. With their support, sustainable practices can be promoted in local communities, safeguarding fisheries resources for the future **(Ibad, 2017)**. Based on the results of fishermen interviews, the influence of local leaders on crab management in Bone district does not exist because there are no local leaders in 3 sub-districts in the research location so it is given a score of 0.

7. Institutional dimension

The sustainability status of the institutional dimension is less sustainable with an index of 28.14 (Fig. 3). The attributes used are: 1) The level of community compliance with blue swimming crab management rules; 2) Monitoring and supervision; 3) Existence of community institutions in blue swimming crab management and 4) Existence of blue swimming crab management rules. The results of the leverage analysis obtained attributes that have the highest sensitivity to the institutional sustainability index, namely the existence of community institutions for blue swimming crab management and monitoring supervision (Table 3). Monitoring and surveillance of crab is essential to ensure the sustainability of the resource. Effective surveillance can help reduce the overfishing activities, ensure a sustainable utilization, and sustain a good environmental quality. Stakeholder participation is also very important in raising awareness and commitment to resource sustainability **(Ramdhani *et al*., 2022)**.

Monitoring and surveillance of crab is essential to maintain the sustainability of the crab population by monitoring the level of crab fishing, governments and regulatory agencies can control the amount of crab taken from the population. This helps prevent overfishing, which can threaten the sustainability of the crab population. Monitoring and surveillance help ensure that fishers and fishing companies comply with established regulations, such as the minimum size of crab that can be caught, the allowed fishing season, and the fishing gear that can be used. This is important to keep the crab population sustainable **(Abidin *et al.*, 2014)**. According to **Yuliana *et al.* (2024)**, through monitoring and supervision, governments and regulatory agencies can raise awareness about the importance of crab sustainability among fishers and local communities. This can help change behavior and more sustainable fishing practices. Data collected through monitoring and surveillance can also be used to strengthen scientific research on the crab populations and more effective fisheries management. Based on the results of interviews with fishermen and fisheries supervisors, it was found that monitoring and surveillance of crab in Bone district has not been effective so a score of 0 was given.

Community organizations play an important role in the sustainability of crab management in Indonesia. One example is the Association of Indonesian Crab Management, which has a crab management program located in Betahwalang Village. Association of Indonesian Crab Management is engaged in saving crab which is the main commodity in the area by conducting counseling, building facilities and infrastructure for crab hatcheries, and striving for village regulations that have been made later into local regulations of Demak Regency to be implemented to realize sustainable crab management **(Kusuma & Dewi, 2017)**. Community institutions can assist in crab management by providing input and aspirations for environmental and socio-economic issues faced by crab fishermen, this input can be used in the preparation of crab fisheries management plans **(Putra *et al.*, 2023)**. Community organizations can also emphasize the importance of monitoring and law enforcement on the presence of fishing gear and other activities that damage crab fisheries resources, this can help maintain the sustainability of crab fisheries resources. With the involvement of community organizations in the management of crab, it is expected that the management of crab fisheries can be carried out in a sustainable manner, so as to provide maximum benefits for the preservation of crab resources and improve the livelihoods of crab fishermen. Based on the results of interviews with fishermen and fisheries extension workers in Bone district, there are no community institutions in the management of crab, thus the score is 0.

The index value of crab fisheries in Bone Regency falls into the less sustainable category (Fig. 2). This is due to the fact that crab fishermen still catch immature crabs in addition to the low education level of fishermen, transportation facilities, and the absence of community institutions in crab management. The results of the analysis of each dimension can be seen in the kite diagram. Kite diagrams can illustrate the status of sustainability in an integrated manner between various dimensions. Kite diagrams are often called “radar” diagrams where the closer the distance of the analysis to the zero point, the lower the sustainability. Conversely, the farther away from the zero point indicates high sustainability **(Fauzi, 2005)**. The results of the multidimensional analysis of the sustainability of crab fisheries in Bone Regency obtained a combined value of 38.43% in the less sustainable category. Efforts are needed to improve sensitive attributes in dimensions that have a less sustainable index value (ecological, economic, technological and social dimensions) in order to increase the sustainability index value in that dimension. Policies on improvement should not rule out other dimensions, so that these conditions are maintained.

In order to address the current challenges facing crab fisheries in Bone Regency, several recommendations have been proposed for effective crab management. First, there is a crucial need to educate and guide fishermen on adhering strictly to existing regulations, particularly ensuring that crabs are caught only when they reach adult size, in accordance with KP Regulation No. 17 of 2021. Second, it is essential to provide training and guidance to collectors and crab processing companies to enforce the regulations, preventing the purchase of crabs below specified sizes and weights outlined in the regulation.

Furthermore, improving transportation facilities is identified as a priority, given that many crab fishermen currently rely on motorboats under 5 GT. Implementing programs aimed at upgrading fishing transportation options can significantly enhance efficiency and sustainability in crab harvesting activities. Additionally, establishing local community-based institutions dedicated to crab management can foster better coordination and governance at the grassroots level.

Lastly, there is a critical need to bolster supervision and monitoring efforts related to crab management. This includes increasing the number of human resources within the fisheries supervisory agency in Bone Regency to ensure strict adherence to regulations and sustainable crab harvesting practices. By implementing these recommendations, stakeholders can work toward ensuring the long-term sustainability and viability of crab fisheries in Bone Regency while meeting the needs of current and future generations.

REFERENCES

Abidin, Z.; Bambang, A. N. and Wijayanto, D. (2014). Manajemen kolaboratif untuk introduksi pengelolaan rajungan yang berkelanjutan di Desa Betahwalang, Demak. J. Fish. Resources Utilization Management and Technology., 3(4): 29-36. [In Indonesian].

Adrianto, L.; Habibi, A.; Fahruddin, A.; Azizy, A.; Susanti, H. A. and Musthofa, I. 2014. Modul Indikator untuk Pengelolaan Perikanan Dengan Pendekatan Ekosistem. Penerbit: Kementerian Kelautan dan Perikanan Republik Indonesia. Jakarta. [In Indonesian].

Afzaal, Z.; Kalhoro, M. A.; Buzdar, M. A.; Nadeem, A.; Saeed, F.; Haroon, A. and Ahmed, I. (2016). Stock assessment of blue swimming crab *Portunus pelagicus* (Linnaeus, 1758) from Pakistani waters (Northern, Arabian Sea). Pakistan. J. . Zoology., 48(5).

Agus, S. B.; Zulbainarni, N.; Sunuddin, A.; Subarno, T.; Nugraha, A. H.,; Rahimah, I. and Rachmi, R. (2016). Distribusi spasial rajungan *(Portunus pelagicus)* pada musim timur di perairan Pulau Lancang, Kepulauan Seribu. J. Ilmu Pertanian Indonesi., 21(3): 209-218. [In Indonesian].

Alder, J.; Pitcher, T. J.; Preikshot, D.; Kaschner, K. and Ferriss, B. (2000a). How good is good: A rapid appraisal technique for evaluation of the sustainability status of fisheries of the North Atlantic. Fish. J. Cent. Res. Rep., 8(2): 136-182.

Alder, J.; Pitcher, T. J.; Preikshot, D.; Kaschner, K. and Ferriss, B. (2000b). How good is good: A rapid appraisal technique for evaluation of the sustainability status of fisheries of the North Atlantic. Fish. J. Cent. Res. Rep., 8(2): 136-182.

Anam, A.; Redjeki, S. and Hartati, R. 2019. Sebaran ukuran lebar karapas dan berat rajungan *(Portunus pelagicus)* di perairan Betahwalang Demak. J. Marine Research., 7(4): 239-247. [In Indonesian].

Annisa, A. 2017. Sustainability Status of Mangrove Crab (*Scylla serrata* - Forskal, 1775) Resource Management in Mangrove Ecosystem of Subang Regency [thesis]. Bogor (ID): Bogor Agricultural University [In Indonesian].

Anwar, N. and Saraswati, E. (2019,). A technique of assessing the status of sustainability of resources. In IOP Conference Series: Earth and Environmental Science 250(1): 20-80. IOP Publishing.

Ayyub, F. R.; Rauf, A. and Asni, A. (2018). Strategi pengelolaan ekosistem terumbu karang di wilayah pesisir Kabupaten Luwu. J. Pendidikan Teknik Pertanian., S56-S65 [In Indonesian].

Aswar, R. 2017. Kerapatan vegetasi, model arsitektur akar, serta simulasi Hidrodinamika Rhizophora Apiculata di Teluk Bone, Sulawesi Selatan. Tesis. Institute Pertanian Bogor [In Indonesian].

Cendrakasih, Y. U.; Yudha, I. G.; Febryano, I. G.; Rochana, E.; Supono, S., Nugroho, T. and Karim, M. (2023). Margin dan Pangsa Pasar Rajungan Portunus pelagicus (Linnaeus, 1978) di Wilayah Pesisir Timur Lampung. J. Tropc. Marine. Sci., 6(1): 1-10 [In Indonesian].

Damayanti, N. R.; Soedarwo, V. S. D. and Susilo, R. K. D. (2020). Peran Tokoh Masyarakat Adat Dalam Pembangunan Masyarakat Berbasis Kearifan Lokal (Studi Interpretatif Pada Masyarakat Kota Ternate). Istoria: J. Pendidikan dan Sejarah., 16(2): 1-20 [In Indonesian].

Ernawati, T.; Kembaren, D. D. and Wagiyo, K. (2015). Penentuan status stok sumberdaya rajungan (*Portunus Pelagicus* Linnaeus, 1758) dengan metode spawning potential ratio di perairan sekitar Belitung. J. Penelitian Perikanan Indonesia., 21(2): 63-70 [In Indonesian].

Fauzi A, S. and Anna. 2005. Pemodelan Sumberdaya Perikanan dan Kelautan untuk Analisis Kebijakan. PT Gramedia Pustaka Utama. 343 hal [In Indonesian].

Febrisa, 2020. Analisis factor produksi dan pendapatan unit penangkapan rajungan (*Portunus pelagicus*) dengan bubu di Kabupaten Bone. Skripsi. Universitas hasanuddin [In Indonesian].

Hamid, A.; Wardiatno, Y.; Batu, D.T.F.L. and Riani, E. (2017). Pengelolaan rajungan *(Portunus pelagicus)* yang berkelanjutan berdasarkan aspek bioekologi di Teluk

Lasongko, Sulawesi Tenggara. J. .Kebijakan. Perikanan. Ind., 9(1): 41-50. DOI: http:// dx.doi.org/10.15578/jkpi.9.1.2017.41-50 [In Indonesian].

Hanum, H. H. 2022. Indeks Kesehatan Laut di Kawasan Teluk Bone Tahun 2008-2019 Berdasarkan Parameter Fisika Oseanografi. Tesis. Institut Pertanian Bogor [In Indonesian].

Ibad, S. (2017). Kearifan lokal pemberdayaan masyarakat dalam pengelolaan dan pembangunan sumberdaya perikanan yang berkelanjutan (Studi Kabupaten Situbondo). *Samakia*: J. Ilmu Perikanan., *8*(1): 24-31 [In Indonesian].

Ihsan, I. (2014). A study of biological potential and sustainability of swimming crab population in the waters of Pangkep Regency South Sulawesi Province. International J. of Sci: Basic and Applied Research (IJSBAR)., 16(1): 351-363.

Intyas, C. A.; Putritamara, J. A. and Haryati, N. (2022). Dinamika Agrobisnis Era VUCA: Volatility, Uncertainty, Complexity, Ambiguity. Universitas Brawijaya Press. [In Indonesian].

Irwan, I.; Irwansyah, I.; Surachmat, A.; Jamil, K.; Supryady, S. and Lasikada, H. (2019). Kajian Kondisi dan Komposisi Vegetasi Hutan Mangrove di Wilayah Pesisir Kabupaten Bone. Prosiding Simposium Nasional Kelautan dan Perikanan, 6 [In Indonesian].

Kavanagh P. (2004a). Implementing Microsoft Excel Software for Rapfish: A Technique for the Rapid Appraisal of Fisheries Status. Fisheries Center Research Reports. Colombia (CO): University of British Columbia. 12(2).

Kavanagh P. (2004b). Implementing Microsoft Excel Software for Rapfish: A Technique for the Rapid Appraisal of Fisheries Status. Fisheries Center Research Reports. Colombia (CO): University of British Columbia. 12(2).

Kurnia, R., and Boer, M. (2014). Biologi populasi rajungan *(Portunus Pelagicus)* dan karakteristik lingkungan habitat esensialnya sebagai upaya awal perlindungan di Lampung Timur. J. Ilmu Pertanian. Indonesia., 19(1): 22-28 [In Indonesian].

Kusuma, B. T., and Dewi, D. M. (2017). Peran Kebijakan dan Lembaga Perikanan dalam Pengelolaan Rajungan (Portunus pelagicus) Sehingga Menjadi Perikanan Yang Berkelanjutan. Prosiding Pusat Riset Perikanan, 67-77 [In Indonesian].

Khongkhon, B.; Tokrisna, R. and Jankarnkij, P. (2017). Bioeconomic Analysis of Blue Swimming Crab (*Portunus pelagicus*) Fishery in the Gulf of Thailand. WMS J. of Management., 6(2): 17-28.

Lai, J.C.Y.; Ng, P.K.L. and Davie, P.J.F. (2010). A revision of the *Portunus pelagicus* complex (Crustacea: Brachura: Portunidae), with the recognition of four species. The Raffles Bulletin of Zoology 58: 199-237.

MMAF. (2015). Decree No. 1/Permen-kp/2015 on the capture of lobsters (*Panulirus spp*.), crabs (*Scylla spp*.), and crabs (*Portunus pelagicus spp.*) Ministry of Marine Affairs and Fisheries

MMAF. (2022a). Volume and Value of Marine Fishing Production in Bone Regency. 127 pp.

MMAF. (2022b). Volume and Value of Marine Fishing Production in Bone Regency. 127 pp.

Mughni, F. M.; Susiana, S. and Muzammil, W. (2022). Biomorfometrik Rajungan (*Portunus pelagicus*) di Perairan Senggarang. J. Marine Research., 11(2): 114-127 [In Indonesian].

Nabila, A. N.; Wiryawan, B. and Riyanto, M. (2022). Stock conditions and status of blue swimming crab (*Portunus pelagicus*) in Demak water area, the northern coast of Central Java. *Depik*, 11(3): 347-454.

Nugraheni, D.I.; Achmad, F. and Yonvitner. 2015. Carapace Width Variation and Abundance of Crab (*Portunus pelagicus* Linnaeus) in Pati Regency Waters. J. Tropical Marine Sci. and Technology., 7(2): 493-510

Nurhayani, N. and Hodijah, S. (2018). Kemiskinan dan kondisi pemukiman nelayan tradisional (studi di Kelurahan Kampung Nelayan Kecamatan Tungkal Ilir Kabupaten Tanjung Jabung Barat). J. Paradigma Ekonomi., 13(2): 55-64 [In Indonesian].

Pitcher, T. J. and Preikshot, D. (2001a). RAPFISH: A rapid appraisal technique to evaluate the sustainability status of fisheries. Fisheries Center, University of British Columbia, Vancouver. Canada., 49 (3): 255-270.

Pitcher, T. J. and Preikshot, D. (2001b). RAPFISH: A rapid appraisal technique to evaluate the sustainability status of fisheries. Fisheries Center, University of British Columbia, Vancouver. Canada., 49 (3): 255-270.

Primyastanto, M.; Soemarno, A. Efani and S. Muhammad. 2012. Kajian ekonomi rumah tangga nelayan payang di Selat Madura, Jawa Timur. Wacana., 15 (2): 12-19 [In Indonesian].

Putra, A. H.; and Sondita, M. F. A. (2023). Penilaian kualitas data uang dibutuhkan untuk penyusunan rencana pengelolaan rajungan berkelanjutan di Teluk Jakarta. Marine Fisheries: J. Marine Fish. Technology. and Management., 14(1): 1-11.

Romadhani, M., and Boesono, H. (2016). Analisis Pendapatan Nelayan Rajungan Alat Tangkap Jaring Pejer (Bottom Set Gill Net) Dan Jaring Gondrong (Trammel Net) Di Desa Sukoharjo Kecamatan Rembang Kabupaten [In Indonesian].

Siswanto, A. D. and Nugraha, W. A. 2016. Permasalahan dan potensi pesisir Kabupaten Sampang. J. Kelautan., 9 (1): 12-16 [In Indonesian].

Sukma, F. R. and Dimyati, A. (2021). Penegakan hukum terhadap penangkapan benih lobster secara illegal. J. Universitas Swadaya Gunung Jati., 2 (1) [In Indonesian].

Suresha Adiga, M.; Ananthan, P.S.; Ramasubramanian, V. and Divya Kumari, H.V. (2015). Validating RAPFISH sustainability indicators: Focus on multi-disciplinary aspects of Indian marine fish. Marine. Policy., 60(1): 202–207.

Susilo, S. B. 2003. Sustainability of small island development: a case study of Panggang Island and Pari Island, Thousand Islands, DKI Jakarta. [dissertation]. Bogor (ID): IPB.

Syarifuddin, M. and Bhakti, F. K. (2022). Kajian Pengelolaan dan Pola Pemanfaatan Ekosistem Lamun Perairan Pantai Teluk Bone Kabupaten Luwu. Fish. Of Wallacea J., 3(2): 91-100 [In Indonesian].

Tahmid M. 2016. Ecological-Economic Study of Mangrove Crab (*Scylla serrata* - Forsskal, 1775) in Mangrove Ecosystem of Bintan Bay, Bintan Regency [thesis]. Bogor (ID): Bogor Agricultural University.

Tesfamichael, D. and Pitcher, T. J. (2006). Multidisciplinary evaluation of the sustainability of Red Sea fisheries using Rapfish. Fisheries Research., 78(2-3): 227-235.

Wahyudin, I.; Kamal, M. M.; Fahrudin, A., and Boer, M. (2019). Analisis keberlanjutan perikanan elasmobranch di tanjung luar kabupaten Lombok Timur. J. Ilmu dan Tekn. Kel. Tropis., 11(1): 103-116 [In Indonesian].

Webley, J.A.C.; Connolly, R.M. and Young, R.A. (2009). Habitat selectivity of megalopa and juvenile mud crabs (*Scylla serrata*): implications for recruitment mechanism. J. Mar. Biol., 156: 891-899.

Yasir, L. O. M. and Fujii, M. (2020). Assessment of coral reef ecosystem status in the Pangkajene and Kepulauan Regency, Spermonde Archipelago, Indonesia, using the rapid appraisal for fisheries and the analytic hierarchy process. J. Marine Policy., 118, 104028.

Yuliana, E.; Setijorini, L. E.; Putra, A. A. M. S.; Sadjati, I. M., and Winata, A. (2024). Pemberdayaan nelayan penangkap rajungan di Desa Segara Jaya, Kecamatan Taruma Jaya, Kabupaten Bekasi. *Diseminasi:* J. Pengabdian kepada Masyarakat., 6(1): 33-42 [In Indonesian].

Zairion. 2015. Pengelolaan berkelanjutan perikanan rajungan *(Portunus pelagicus*) di Lampung Timur [disertasi]. Bogor (ID): Institut Pertanian Bogor [In Indonesian].