Feasibility analysis of mangrove bio-ecosystem for silvofishery in Dabong Village, Kubu Raya District, West Kalimantan

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Abstract. Studies on bio-ecosystems sustainability and feasibility are urgent because many mangrove ecosystems have been converted into ponds as a source of livelihood. This study aimed to evaluate the sustainability level of the mangrove bio-ecosystem in Dabong Village and formulate the most appropriate strategy in silvofishery development. The method used was a field survey to obtain secondary and primary data. Bio-ecosystem feasibility analysis was carried out descriptively, qualitatively and quantitatively based on data compilation of water quality, soil fertility, macrozoobenthos and mangrove density. SWOT analysis was used in developing the strategies. Based on the study results, the land suitability matrix for silvofishery development in Dabong Village had a very suitable category (69.00%) regarding soil value conditions and water quality. The abundance of macrozoobenthos was 21 individual m$^{-2}$-1 gastropoda, 30 individuals m$^{-2}$-1 bivalves, and eight individuals m$^{-2}$-1 crustaceans. Stand density values of *Rhizophora apiculata*, *Avicennia alba*, and *Sonneratia alba* ranged from 15-25 individuals m$^{-2}$-1, 18-27 individuals m$^{-2}$-1, and 14-24 individuals m$^{-2}$-1, respectively. According to ecosystem characteristics, the strategy for using mangroves in the research site was to increase the bio-ecosystem strength and minimize the damage or degradation risks as a threat to the impact of mangrove ecosystem utilization using the silvofishery model. Its application could be an alternative for sustainable use of the mangrove ecosystem.

1. Introduction
Mangrove ecosystem is a natural resource that has multiple benefits from socio-economic and ecological aspects. This ecosystem function for life can be seen from many animal species that live in the water and its environment. It is also a habitat for living marine biotas such as fish, shrimp, shellfish, and various kinds of crabs with high economic value [1]. The existence of mangrove forests is a strategic asset to be developed based on economic activities for coastal communities' welfare and to increase local revenue. The conversion of mangrove ecosystems into a pond used by the community as a source of livelihood needs some attention, especially related to its sustainability and feasibility aspects in accordance with the ecosystem's carrying capacity. Therefore, it should be done very carefully to avoid some degraded ecosystem performance such as increased sedimentation rate, decomposition of material, the threat of various fauna species in the mangrove ecosystem and its impact on pond production.

The mangrove forest area in Dabong Village is about 4895.5 hectares or about 15% of the mangrove protected forest area in Kubu Raya Regency, West Kalimantan. Based on the Decree of the Minister of Forestry No. 259/Kpts-II/2000, this mangrove forest has been designated as a protected forest. However, some protected forests in this village have been degraded due to forest conversion into 555.45 hectares
of fish ponds and logging activities [2]. The conversion of mangrove forests into ponds in Dabong Village has occurred since 1991 and developed until 2011. The development of ponds in the mangrove protected forest area is inseparable from the 1998-1999 Fishery Product Export Improvement Program (Protekan) from the Pontianak Regency Fisheries Service and The Brackish Water Cultivation Development Program by the Department of Fisheries and Marine Affairs of West Kalimantan Province (2002-2012). It has encouraged the opening of shrimp ponds in areas that turned out to be protected mangrove forest areas. Alternative solutions are needed to bridge the ecological interests (conservation of mangrove forests) with the social and economic interests of the surrounding communities who have lived in the area for a long time before being designated as a mangrove protected forest area. Therefore, further appropriate alternative management policies can be sought. This system is expected to overcome the problems mentioned above, especially the mangrove ecosystem degradation due to the clearing by the community. In addition, in the mangrove ecosystem rehabilitation, the application of the silvofishery system is a technique that has been widely recommended but still often encounters obstacles at the level of implementation.

Silvofishery is a model for utilizing mangrove ecosystems with a pond system that aims to accommodate common interests, namely the protection of mangrove ecosystem resources and economic interests. This provision is expected to be able to establish an ecological balance. By considering the optimization of its functions and benefits, efforts to convert mangroves into ponds must be carried out rationally with an environmental perspective. Therefore, it is necessary to conduct a feasibility study of the mangrove bio-ecosystem and its utilization using the silvofishery model. Research of the feasibility analysis of mangrove bio-ecosystems for silvofishery is related to the suitability of the environment's physical, chemical, and biological conditions. The quality of water, soil, and other elements in the mangrove ecosystem is suitable for pond cultivation to support the maximum quality of cultivated cultivars while considering the sustainability aspect [3].

According to the above background, this study aimed to determine the suitability level of mangrove bio-ecosystem and formulate a strategy of silvofishery development model. Therefore, it is expected that the result of this research could be considered in mangrove ecosystems management, especially by using the silvofishery model.

2. Materials and Method
This research was carried out in the mangrove protection forest in Dabong Village, Kubu Raya Regency, West Kalimantan Province. According to the classification of Schmidt and Ferguson, the climate type is A, with an average annual rainfall of 3000 mm, the highest rainfall of 533.2 mm in October and the lowest rainfall of 144.1 mm in July. Meanwhile, the highest temperature is 33.4°C in May, and the lowest temperature is 22.5°C in August [4].

Dabong Village is located at 00°33' 57.2" SL - 109°15' 29.6" EL. Administratively, this village is included in the Kubu Sub-District, Kubu Raya Regency, West Kalimantan Province. The total area of this village is around 16,600 hectares (166 km²) (Figure 1). Most villagers live as farmers, fishers, and fish farmers, apart from traders, construction workers/builders, civil servants, and the private sector.
2.1. Materials
The materials used in this study were: distilled water, tissue paper, formaldehyde and concentrated H$_2$SO$_4$. While the tools used in this study were: pH meter, thermometer, sample bottle, plastic bag, spectrophotometer, hand refractor, meter instrument, office stationery and wooden boats.

2.2. Method
Primary and secondary data were collected using a survey method. The stages of research activities included: field surveys, data collection, data compilation and processing, data analysis and reporting.

2.2.1. Data collection. Data collection was divided into two, namely primary data and secondary data. Primary data collected included: (a) soil characteristics: texture, pH, organic C, N-total; (b) physical and chemical characteristics of water: salinity, temperature, pH, O$_2$, and TSS; (c) macrozoobenthos; (d) mangrove species: density and abundance; and (e) interviewed the communities around the mangrove protected forest area. The secondary data collected were (a) a literature review related to the silvofishery model and its implication and (b) environmental biophysical data. These secondary data were collected from the Maritime Affairs and Fisheries Service and the Kubu Raya District Forestry Service and various other sources.

2.2.2. Mangrove bio-ecosystem sampling. The sampling method was carried out by purposive sampling [5], based on actual field conditions representing topographic conditions and bio-geophysical characteristics supporting silvofishery development activities.

Water samples were taken in the form of salinity, temperature, pH, brightness and TSS. Water samples for turbidity and TSS were taken with sample bottles to be analyzed in the laboratory. Meanwhile, salinity, temperature, pH and brightness were measured directly in the field. Soil samples were taken as much as 500 g at a depth of 30-50 cm, then stored in plastic bags for further analysis in the laboratory [6]. The observed soil characteristics were texture and organic matter, while soil pH was measured directly in the field.

Macrozoobenthos and mangrove stands were carried out based on the mangrove ecosystem zone, namely the zone near the coast, the zone along the river and the zone around residential areas [7]. In each zone, three observation plots were made. In each plot, there were two subplots, namely 20 x 20 m$^2$ for tree and macrozoobenthos observations and 10 x 10 m$^2$ for sapling observations with a distance between sample plots of 200 meters (Figure 2).
2.3. Data analysis

Soil and social analysis were carried out descriptively and presented narratively. Water quality refers to the Enfluent Quality Standard for Shrimp Pond based on Ministerial Decree No.28/2004 concerning Guidelines for Shrimp Cultivation in Ponds which is then analyzed descriptively with the quality standard for shrimp ponds and marine biota [8]. This study only analyzed the tree strata based on tree density. The condition of mangrove vegetation was analyzed by mangrove cover and density [9]. The mangrove and macrozoobenthos vegetation data were calculated based on the density of each species per m². The secondary data obtained then were compiled and analyzed descriptively and quantitatively. The formula for relative density is based on the species density divided by the total of all species multiplied by 100%.

The results of primary data collection, secondary data, and laboratory analysis were compiled and then used in the analysis phase. Furthermore, the analysis stage is carried out using quantitative methods based on the weighting/scoring of the SWOT analysis [10]. Furthermore, the score is determined according to the land suitability class (score: 0-3), where this score is then multiplied by the weight and the results are summed. Finally, the result of the sum is divided by four and multiplied by 100% with the following formula [10]:

\[ \text{Feasibility value of bioecosystem} = \frac{\sum \text{value}}{4} \times 100\% \]

The final value of this calculation is then matched with the class category level to produce the land suitability level (Table 1).

Table 1. Classification of bio-ecosystem suitability level in silvofishery development [10].

| Land suitability classes | Value (%) |
|-------------------------|-----------|
| Very suitable (S3)      | 70-100    |
| Suitable (S2)           | 51-69     |
| Suitable enough (S1)    | 25-50     |
| Unsuitable (S0)         | 0-24      |

Remarks:
S3 = Very suitable; the land does not have a significant limiting factor for sustainable use
S2 = Suitable; the land has a limiting factor which means that its sustainable use can reduce productivity
S1 = Suitable enough; the land has severe limiting factors for sustainable use and reduced productivity
S0 = Unsuitable; the land has weighty and permanent limiting factors that can hinder its possible use

The strategies formulation for sustainable use of mangrove bio-ecosystems for silvofishery is based on internal factors, including indicators of strengths and weaknesses. In contrast, external factors include indicators of opportunities and threats. This is the basis for formulating strategies by giving weights, ratings and values as benchmarks [11].

3. Results and Discussion

The conversion of the mangrove ecosystem into ponds in this village has occurred since 1992 up to recent using a conventional pond model. The cultivated commodities are tiger prawns or polyculture
with milkfish. The traditional plus system (pond management without silvofishery technology) applies the maintenance pattern, namely the spread of fry and feeding. Based on the interview results, the ponds reached 127 units with an area per unit from 0.3-8.5 ha (the average 2.19 ha unit\(^{-1}\)). The total area of cultivated pond land in this village was around 555.35 ha. The yield per pond unit varies from 400 to 1500 kg. The average yield per pond unit was 577.02 kg cycle\(^{-1}\).

3.1. Water quality
Water quality is an essential requirement for the development of aquaculture ponds in mangrove ecosystems. It is one of the most important determining factors for the environment carrying capacity in developing aquaculture ponds. The suitability of mangrove ponds can be seen in terms of water quality. A good area for pond cultivation has salinity values ranging from 15-30 ppt, temperature 26-32 °C, pH 7.5-8.5 and DO > 4 ppm [7]. Based on laboratory analysis results and field observations, the physical and chemical of water characteristics of the research sites are presented in Table 2.

### Table 2. The physical and chemical water characteristics at the research sites.

| Research site | Salinity (ppt) | Temperature (°C) | pH   | \(\text{O}_2\) (ppm) | \(\text{NH}_4^+\) (ppm) | \(\text{NO}_3^-\) (ppm) | Turbidity (NTU) | TSS (ppm) |
|---------------|----------------|------------------|------|----------------------|------------------------|----------------------|----------------|-----------|
| A             | 24-26          | 26-27            | 6.77-6.98 | 4.72-5.05 | 0.004-0.005 | 0.29-0.33 | 22.64-22.87 | 33.73-34.13 |
| B             | 25-27          | 25-26            | 7.40-7.45 | 4.63-4.98 | 0.006-0.007 | 0.30-0.31 | 22.29-23.23 | 34.45-34.79 |
| C             | 25-27          | 27-28            | 7.03-7.21 | 4.90-4.98 | 0.005-0.008 | 0.30-0.32 | 22.86-22.49 | 34.55-34.70 |

Table 2 shows that the salinity values of the three study sites ranged from 24-27 ppt. The salinity conditions were caused by the river flow, causing a mixture of fresh water and seawater. Thus, there is a dilution of the freshwater salinity flowing through the river. The salinity range affects the species distribution and size of cultured fish, shrimp and crabs. Salinity contains various salts, especially NaCl. Although some aquatic organisms have high adaptability to salt content (euryhaline), their growth depends on their age and requires an optimal range of salinity values. For example, several studies in mangrove ecosystems show that the highest survival rate of *Scylla paramamosain* was at 25 ppt salinity, while *Scylla olivacea* obtained the highest growth at 25 ppt salinity.

Furthermore, the good salinity for mud crab culture ranges from 15-30 ppt. Therefore, the salinity conditions at the study site are very suitable for mud crab cultivation [13]. Furthermore, a research report [14] shows that good salinity for mud crab culture ranges from 15-30 ppt. Therefore, it can be said that the salinity conditions at the research site are very suitable for mud crab cultivation.

Water temperature is related to the value of dissolved oxygen concentration in water and the oxygen consumption rate by aquatic biota. Water temperature is inversely proportional to the saturated concentration of dissolved oxygen but directly proportional to the oxygen consumption rate by aquatic biota. At high temperatures, metabolic processes and chemical reactions in water occur more quickly. The optimal range of water temperatures for the life of cultivators in the tropics is 25-32°C because, in general, cultivators cultivated in tropical waters are in the warm water culture group. In addition, [12] stated that a good temperature for cultivating mangrove ponds is between 26-32°C. The results of the measurement of water temperature at the research site ranged from 26-28°C, which means that all research sites are very suitable for silvofishery activities.

Dissolved oxygen (DO) is the most crucial parameter in water quality for aquatic organisms. The blood capillaries can absorb oxygen dissolved in water at a certain concentration in the gill lamella during the respiration process. The absorbed oxygen is used in metabolic processes to produce energy for movement, growth and replacement of lost/damaged cells. [15] stated that oxygen requirement for culture life for good growth is more than 4.0 ppm. However, [12] stated that the oxygen content of 3 ppm is still suitable for the life of cultivators cultivated in silvofishery ponds. In general, the average
value of dissolved oxygen in the study area ranged from 4.72-4.98 ppm. This means that the range of dissolved oxygen values at all research sites is suitable for pond activities using a silvofishery system.

The condition of coastal marine waters has a relatively stable pH and ranges from 7.7-8.4 [16]. The pH value of seawater is generally alkaline or greater than 7.0 because it contains relatively high dissolved salts, including bicarbonate (HCO₃⁻). Water that contains a lot of free carbon dioxide (CO₂) is usually has a pH lower than 7.0 or acidic and is generally found in freshwater that gets a lot of input from organic matter. Freshwater pH ranges from 5.5-7.0. Under normal conditions, the pH of seawater ranges from 7.5-9.0 and is generally more stable because it contains more carbonate and bicarbonate compounds that act as buffers. Directly aquatic organisms require water conditions with a certain degree of acidity. Indirectly, pH also affects the life of farmers through its influence on other water parameters such as ammonia toxicity which increases at high pH.

Conversely, the toxicity of iron, manganese and aluminum increases at low pH (acidic). The pH in the study sites ranges from 6.77-7.45. In laboratory tests, it was found that the pH level played a role in the survival of the Scally serrata mud crab larvae. The larvae of this species have the best survival in the pH range of 9.1-9.5 [17]. The Segara Anakan mangrove ecosystem shows that the growth of mangrove crabs (S. serrata) had a positive relationship with water pH ranging from 6.2-7.5. At the research site, the pH of the water ranged from 6.77-7.45 [8]. Therefore, the pH of the water at the study site is suitable for cultivars of silvofishery.

High nitrate concentrations in water can stimulate the growth of aquatic plants if supported by other nutrients [18]. Nitrate is an inorganic nitrogen compound that aquatic plants can directly utilize because it is the main nutrient for plant and algae growth. The nitrate content at the study site ranged from 0.29-0.32 ppm, indicating that the nitrate content at the study site tended to be the same. In the Segara Anakan mangrove ecosystem, a range of nitrate was found between 0.053-0.38 ppm [8]. According to the Decree of the Minister of Environment and Forestry No. 51 of 2004, the ammonia standard for marine biota is 0.3 ppm. [12] stated that in the cultivation of mangrove ponds, nitrate levels should not exceed 0.5 ppm. Thus, based on the nitrate content, the research location is still feasible to develop pond activities using a silvofishery system.

The value of water turbidity is one indicator of the level of water pollution. The level of turbidity at the research site due to river flows flowing into coastal waters carries coarse and fine materials. In addition, turbidity is also influenced by the type of mud substrate. Although the level of turbidity at the research site is quite high, it is still in the normal range of 22.29-22.64 NTU. According to [19], the turbidity of the water that reached 50 NTU means heavily polluted water. Meanwhile, the range of turbidity at the study site was lower than in the polluted category. The main product compound of nitrogenous waste in water from aquatic organisms is ammonia. Ammonia in water usually exists in two forms, namely (1) ammonia (NH₃) which is toxic, predominately at high pH, and (2) ammonium ion (NH₄⁺), which is non-toxic, especially at low pH [20].

Ammonia is toxic, so that in high concentrations, it can poison organisms. Cultivation in silvofishery ponds can grow well if the concentration of ammonia in the media is not more than 0.1 ppm. The ammonia content in the study area ranged from 0.004 to 0.008 ppm, meaning that the ammonia value was still suitable for the life of mud crabs, according to the Decree of the Minister of Environment and Forestry No. 51 of 2004 that the quality standard for NH₃ is 0.3 ppm (marine biota). Furthermore, the water physics parameter closely related to turbidity is the total suspended solids (TSS) value. High suspended solids in water can hinder the work of the osmoregulation system and the visibility of aquatic organisms. The turbidity value at the study site ranged from 33.73 to 34.70 NTU.

### 3.2. Chemical and physical soil quality

Land existence is the main medium in pond activities or silvofishery. Organic materials significantly affect the quality of silvofishery ponds production. Organic matter content in the soil will also affect the water quality where the organisms are cultivated. Soil conditions, vegetation, and water fertility affected aquatic organisms such as mangrove crabs. Soil substrate type is one of the factors that can affect the organisms being cultivated. The results of soil chemical and physical characteristics at the research sites are presented in Table 3.
The existence of benthic animals is influenced by biotic factors, including organic matter, which is a food source for benthic animals. Abiotic factors are water physics-chemistry: temperature, current, dissolved oxygen (DO), nitrogen (N) content, water depth, and basic substrate. In addition, leaf litter produced by mangroves causes the abundance of macrozoobenthos to be higher. This is because litter is food for detritus, while detritus itself is food for macrozoobenthos [21]. Based on field observations, three types of macrozoobenthos were found: gastropods, bivalves and crustaceans, with an abundance of 21 individuals m⁻²⁻¹, 30 individuals m⁻²⁻¹, and eight individuals m⁻²⁻¹ respectively. Bivalves are often found in mangrove roots, while gastropods and crustaceans are often found in mangrove substrates. The high value of the abundance of macrozoobenthos is caused by river flows that carry organic matter into the pond area, which causes the waters to become fertile.
3.4. **Mangrove species density**

Mangrove vegetation has a crucial role, namely as a filter in the mangrove ecosystem. Roots function as absorbents of heavy metals found in sediment and pond water and filter pesticides and heavy metals. Therefore, the existence of mangrove stands in silvofishery ponds is positive [22]. However, the measurement of mangrove density at the study site showed that the mangrove density was quite varied. Stand density values in tree strata *Rhizophora apiculata*, *Avicennia alba*, and *Sonneratia alba* ranged from 15-25 individuals m⁻², 18-27 individuals m⁻², and 14-24 individuals m⁻², respectively. Meanwhile, the sapling strata ranged between 27-30 individuals m⁻², 22-25 individuals m⁻², and 10 to 15 individuals m⁻².

The mangrove ecosystem is a habitat for various types of aquatic biota. Therefore, the application of the silvofishery pattern is very suitable. Based on the results of research conducted [23], it was found that the highest milkfish production was produced in *Rhizophora* stands at 155.33 kg 0.5 ha⁻¹, followed by *Avicennia* stands of 129 kg 0.5 ha⁻¹, and the lowest was 70 kg 0.5 ha⁻¹ in ponds without mangroves. This condition also allows the development of mud crab culture using the silvofishery method.

3.5. **The feasibility value of the bio-ecosystem in the development of silvofishery**

Based on the suitability value of soil quality, water quality, macrozoobenthos abundance and mangrove vegetation density, the land suitability matrix for silvofishery development in Dabong Village has a very suitable category (69%). The land suitability value for silvofishery development in Dabong Village is presented in Table 4.

### Table 4. The feasibility value of the silvofishery development bio-ecosystem at the research site.

| Parameter       | Land suitability value | Analysis Result Value | Weight | Score | Value |
|-----------------|------------------------|-----------------------|--------|-------|-------|
| Salinity        | S3 15.0-30.0           | S2 30.1-35.0          | S1 35.1-50.0 | S0 > 50.0 | 24-27 | 0.18    | 4     | 0.72 |
| pH              | Water Quality          |                       |        |       |       |         |       |      |
| O2 (ppm)        | >4.0                   | 3.1-4.0               | 2.1-3.0 | <2.0  | 4.63-5.05 | 0.08 | 2     | 0.16 |
| Temperature     | 26-32°                 | 20-25°                | 15-20° | >32°  | 26-28  | 0.13 | 4     | 0.52 |
| TSS             | < 25                   | 25-80                 | 81-400 | ≥400  | 33.73-34.70 | 0.07 | 3     | 0.21 |
| Salinity        |                        |                       |        |       |       |         |       |      |
| pH              | Soil Quality           |                       |        |       |       |         |       |      |
| C-Organic (%)   | <6.0                   | 6.0-12.0              | 12.1-15.0 | ≥15.0 | 5.98 | 0.12 | 3     | 0.36 |
| N-Total (%)     | >0.5                   | 0.38-0.50             | 0.25-0.37 | <0.25 | 0.04 | 0.07 | 2     | 0.14 |
| Texture         | Clay, silty clay, sandy clay, silty clay loam | Sandy loam, Silty clay | Clay and Silt | Sand | Loam | 0.06 | 1     | 0.06 |

3.6. **Silvofishery development strategy in sustainable utilization of mangrove ecosystems**

Utilization of the mangrove ecosystem for silvofishery in Dabong Village can be developed based on the results of this study. SWOT analysis (Strength, Weakness, Opportunities, Threats) is used in formulating strategies. [10] stated that in preparing to optimize activity objectives, it is necessary to identify internal and external factors. A SWOT analysis matrix can be compiled from identifying external factors (opportunities and threats) and internal factors (strengths and weaknesses), which becomes the direction of strategic planning. Internal and external factors of the research location and their weighting, rating and scoring are presented in Tables 5 and 6.
Table 5. Internal strategic factors based on weight, rating and score.

| No | Internal factor                                                                 | Weight | Rate | Score |
|----|---------------------------------------------------------------------------------|--------|------|-------|
| 1. | The value of the mangrove bio-ecosystem feasibility at the site level for the development of silvofishery is very feasible | 0.30   | 4    | 1.20  |
| 2. | There is a conventional pond that applies wanamina                                | 0.20   | 3    | 0.60  |
| 3. | The farming community has the desire to use the mangrove ecosystem in a sustainable manner | 0.20   | 2    | 0.40  |
| 4. | Positive community understanding regarding conservation efforts                   | 0.15   | 2    | 0.30  |
| 5. | The diversity of mangrove species is quite good in tree strata, namely *R. apiculata*, *A. alba* and *S. alba* | 0.15   | 4    | 0.60  |

**Weakness**

| No | External Factors                                                                 | Weight | Rate | Score |
|----|---------------------------------------------------------------------------------|--------|------|-------|
| 1. | Utilization of the mangrove ecosystem in other uses (settlements, oil palm plantations, other buildings) | 0.20   | 2    | 0.40  |
| 2. | Increase the population                                                          | 0.25   | 3    | 0.75  |
| 3. | The status of the mangrove area as a protected area                              | 0.15   | 2    | 0.30  |
| 4. | Many farmers still use chemical fertilizers to increase their pond production     | 0.20   | 2    | 0.40  |
| 5. | There is still an overlapping of sectoral ego interests in the use of mangrove forests | 0.20   | 1    | 0.20  |

Table 6. External strategic factors based on weight, rating and score.

| No | External Factors                                                                 | Weight | Rate | Score |
|----|---------------------------------------------------------------------------------|--------|------|-------|
| 1. | There are regulations and policies related to mangrove ecosystem management at the central and regional levels | 0.30   | 4    | 1.20  |
| 2. | Establishment of Village Farmers Group                                           | 0.15   | 4    | 0.60  |
| 3. | The positive attitude of the community towards the sustainable use of the mangrove ecosystem | 0.15   | 3    | 0.45  |
| 4. | Diversification of the use of mangrove ecosystems to increase food security      | 0.20   | 2    | 0.40  |
| 5. | Improve the welfare of local communities and open up business opportunities       | 0.20   | 3    | 0.60  |

**Opportunity**

| No | External Factors                                                                 | Weight | Rate | Score |
|----|---------------------------------------------------------------------------------|--------|------|-------|
| 1. | Damage to the mangrove ecosystem is a concern because it influences wildlife and protected habitats | 0.35   | 3    | 1.05  |
| 2. | Logging of mangrove stands for pond land and charcoal wood                       | 0.35   | 2    | 0.70  |
| 3. | Natural disasters such as floods and rising sea levels                            | 0.30   | 2    | 0.70  |

The SWOT calculation results showed that the coordinate value on the internal factor was 1.05, while the external factor was 1.43. These results indicated that the grand strategy of developing silvofishery to utilize sustainable mangrove ecosystems was located in quadrant I, namely using the strength of the mangrove bio-ecosystem by taking advantage of opportunities in the silvofishery-based mangrove ecosystem policy. The grand quadrant of the strategy can be seen in Figure 3.
Figure 3. Grand strategy for developing silvofishery in the mangrove forest area in Dabong Village.

Based on Figure 3, the silvofishery development strategy formulation at the research site is in quadrant I, where the appropriate silvofishery development strategy is using strengths and taking advantage of opportunities with coordinate values (1.43; 1.05) by determining the appropriate silvofishery pond model, improving community empowerment and skills (in developing silvofishery), and developing mangrove ecosystems use based on the carrying capacity of the environment. Furthermore, priority programs that must be carried out are: revitalizing the existing pond system with a silvofishery pond system or model; increasing community participation in mangrove forest management; and it is necessary to apply the science and technology of rehabilitation and restoration, especially in maintaining the integrity of the biodiversity of the mangrove ecosystem. According to [24], the silvofishery system application is an alternative solution for mangrove ecosystem management. All stakeholders and the community have agreed that silvofishery-based mangrove ecosystems are one of the efforts in achieving conservation strategies to achieve sustainable utilization goals.

4. Conclusion

Based on the suitability value of soil conditions and water quality, it can be concluded that the land suitability matrix for silvofishery development in Dabong Village has a very suitable category (69.00%). The abundance of macrozoobenthos was 21 individuals m$^{-2}$-1 gastropoda, 30 individuals m$^{-2}$-1 bivalves, and 8 individuals m$^{-2}$-1 crustaceans. Stand density values of Rhizophora apiculata, Avicennia alba and Sonneratia alba ranged from 15-25 individuals m$^{-2}$-1, 18-27 individuals m$^{-2}$-1 and 14-24 individuals m$^{-2}$-1, respectively.

According to the ecosystem characteristics, the strategy for mangroves in Dabong Village, Kubu District, Kubu Raya Regency, West Kalimantan must increase the strength of the bio-ecosystem and minimize damage or degradation as a threat to the impact of the mangrove ecosystem utilization using the silvofishery model. The formulation of the silvofishery development strategy is to utilize land suitability at the research site as a strength and take advantage of opportunities as a basis for developing mangrove ecosystems based on the silvofishery model. The strategic formulation is in quadrant I with coordinate values (1.43; 1.05) with several priority activities: revitalizing the existing pond system with a silvofishery pond system or model; increasing community participation in the management of mangrove forests and applying science and technology for rehabilitation and restoration, especially in maintaining the integrity of the biodiversity of the mangrove ecosystem.
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