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# Analysis of the Suitability of Mudgrowth Crab (*Scylla* spp.) Cultivation with the Silvofishery Pattern in Bima Bay, Bima Regency, West Nusa Tenggara Province

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## ABSTRACT

Mangrove ecosystems play an essential role in maintaining coastal ecological balance by serving as spawning grounds, nursery habitats, and nutrient providers for aquatic organisms. One sustainable utilization approach is the silvofishery system, which integrates aquaculture with mangrove conservation. In Bima Bay, the increasing pressure from human activities and land-use changes highlights the need for sustainable coastal management, particularly for economically valuable species such as mud crab (*Scylla* spp.). This study aims to analyze the land suitability for mud crab cultivation using a silvofishery system through a multi-parameter approach. The research was conducted in Bima Bay across three observation stations representing different environmental and accessibility conditions. Data collection involved primary field measurements, including soil parameters (type, texture, pH, depth, organic matter), water quality (salinity, pH, dissolved oxygen, temperature), ecological aspects (mangrove cover, dominant species, natural food availability), and socio-economic factors (accessibility, market access, labor availability, site security, and land status). The research procedure included *in-situ* measurements and observation-based assessments, followed by a weighted scoring analysis using 20 parameters. The Land Suitability Index (IKL) was calculated using the formula IKL = $\Sigma(Wi \times Si)$, and classified into four categories: highly suitable (S1), suitable (S2), marginally suitable (S3), and not suitable (N). The results showed that all observation stations had similar IKL values ranging from 3.11 to 3.12 (77.81%–78.08%), indicating that the area falls into the suitable category (S2). Key supporting factors include optimal temperature, stable salinity and pH, and adequate dissolved oxygen levels. Mangrove ecosystem conditions also contribute positively by providing natural food and maintaining ecological balance. However, site security and slight variations in dissolved oxygen were identified as limiting factors. In conclusion, Bima Bay has strong potential for sustainable silvofishery-based mud crab cultivation. It is recommended to improve site security, strengthen local institutional management, and implement integrated coastal management strategies to enhance land suitability toward a highly suitable category (S1) while maintaining ecosystem sustainability.

## INTRODUCTION

Mangrove ecosystems play a vital role in maintaining coastal ecological balance, including spawning habitats, nursery grounds, and nutrient providers for various aquatic organisms. Mangroves are highly productive ecosystems that support diverse aquatic biota and contribute organic matter to coastal food webs **(Alongi, 2014, 2020; Muenzel *et al.*, 2025**). In addition, the complex root structures of mangroves provide shelter, feeding areas, and protection for juvenile fish and crustaceans, reinforcing their function as critical nursery habitats in coastal ecosystems **(Kathiresan & Bingham, 2001; Nagelkerken *et al.*, 2008; Frontiers in Marine Science, 2025)**. Beyond ecological functions, mangroves also deliver important ecosystem services such as coastal protection, biodiversity conservation, and support for fisheries productivity **(Barbier *et al.*, 2011; Friess *et al.*, 2019; Sarun & Sambo, 2026)**. One sustainable use of this ecosystem is through the silvofishery system, which integrates mangrove cultivation with aquaculture practices. This approach maintains ecological functions while enhancing economic benefits for coastal communities, as it allows resource utilization without degrading the mangrove ecosystem **(Lewis, 2005; Primavera *et al.*, 2021; Suyono & Fithor, 2025)**.

Mud crab (*Scylla* spp.) cultivation using a silvofishery system is an environmentally friendly and economically valuable coastal management alternative, since this system integrates aquaculture with mangrove conservation, thereby maintaining ecological functions while increasing productivity and community income (**Karim *et al.*, 2019; Sajjad *et al.*, 2023; Diamahesa & Rahmadani, 2024; Arifin *et al.*, 2025; Wamnebo *et al.*, 2025**). Additionally, mud crab aquaculture has high economic value and contributes significantly to coastal livelihoods, while silvofishery practices help reduce environmental degradation and support sustainable aquaculture development **(Kathiresan & Bingham, 2001; Food and Agriculture Organization, 2022; Manuessa *et al.*, 2024; Murak *et al.*, 2026)**. This system can increase productivity without damaging the mangrove ecosystem, and even contributes to coastal environmental rehabilitation since silvofishery practices have been shown to improve water quality stability, enhance aquaculture yields, and maintain ecological functions of mangroves **(Nasional *et al.*, 2024; Putra *et al.*, 2024; Suyono & Fithor, 2025)**. Furthermore, the integration of mangrove restoration with aquaculture activities can enhance habitat quality, increase mud crab abundance, and support long-term coastal ecosystem recovery **(Wahyuni *et al.*, 2018; Alongi, 2020; Ilman *et al.*, 2025)**.

The Bima Bay area has significant potential for silvofishery development due to its mangrove ecosystem and relatively stable water conditions, since mangrove-based aquaculture areas are known to support high productivity and ecological stability when physical, chemical, and biological parameters are within suitable ranges **(Sajjad *et al.*, 2023; Nasional *et al.*, 2024; Suyono & Fithor, 2025)**. However, pressure from human activities and land-use changes poses challenges to sustainable management, as the conversion of mangrove forests into aquaculture ponds and other uses has been widely reported to degrade ecosystem functions and reduce environmental quality **(Hastuti & Budihastuti, 2016; Daulay *et al.*, 2024; Pahlevi *et al.*, 2025)**. However, pressure from human activities and land-use changes pose challenges to the sustainable management of the area **(Food and Agriculture Organization, 2007; United Nations Environment Programme, 2014)**.

Several studies have shown that the success of silvofishery systems is strongly influenced by biophysical, ecological, and socio-economic factors **(Alongi, 2020; Food and Agriculture Organization, 2022)**. Therefore, a comprehensive land suitability analysis is necessary to ensure optimal and sustainable aquaculture development, as land suitability evaluation serves as a fundamental basis for determining appropriate site selection and management strategies in silvofishery systems **(Sajjad *et al.*, 2023; Mardiana *et al.*, 2024; Muenzel *et al.*, 2025)**. Furthermore, such analysis is essential to assess biophysical, chemical, and ecological parameters that influence productivity and environmental sustainability, thereby supporting informed decision-making in coastal resource management **(Daulay *et al.*, 2024; Naturalis, 2024)**. This study aims to analyze the suitability of mangrove crab cultivation land using a multi-parameter approach in Bima Bay, considering that integrated assessments of environmental factors are crucial to optimize aquaculture performance while maintaining mangrove ecosystem functions **(Nasional *et al.*, 2024; Suyono & Fithor, 2025)**.

## MATERIALS AND METHODS

### 1. Research Location

This research was conducted in Bima Bay, using three observation stations representing the environmental conditions and accessibility of the coastal area

**Fig. 1.** Research location (*Source: https://alanmalingi.wordpress.com*).

### 2. Data Collection

The data used in this study consisted of primary data obtained through direct field measurements in three locations. Soil parameters included soil type, texture, pH, depth, and organic matter content, which were analyzed in the laboratory. Water quality parameters included salinity (measured using a hand refractometer), pH (measured with a pH meter), dissolved oxygen (DO) (measured using a digital DO meter), and temperature (measured with a thermometer). Ecological parameters included mangrove cover, dominant mangrove species, and natural food availability. Socio-economic parameters included accessibility, market access, labor availability, site security, and land ownership status.

### 3. Data Analysis

Land suitability analysis was conducted implementing a weighted scoring method using 20 parameters. The Land Suitability Index (IKL) was calculated using the formula described by **Burrough *et al.* (1998)**:

$$\mathbf{IKL=\sum(Wi\times Si)}$$

Land suitability classification:
-S1 = Highly suitable (>85%)
-S2 = Suitable (70–85%)
-S3 = Marginally suitable (50–70%)
-N = Not suitable (<50%)

## RESULTS

### 1. Land Suitability per Station

***Station 1***

**Table 1.** Data from the analysis of mangrove crab cultivation suitability at Station 1

| No | Parameter | Weight (Wi) | Score (Si) | Wi x Si |
|---|---|---|---|---|
| 1 | Soil type | 0,070 | 3,0 | 0,21 |
| 2 | Soil pH | 0,040 | 3,0 | 0,12 |
| 3 | Soil texture | 0,070 | 3,0 | 0,21 |
| 4 | Soil depth | 0,040 | 3,0 | 0,12 |
| 5 | Salinity | 0,100 | 3,0 | 0,30 |
| 6 | Water pH | 0,080 | 3,0 | 0,24 |
| 7 | DO | 0,100 | 3,3 | 0,33 |
| 8 | Temperature | 0,080 | 4,0 | 0,32 |
| 9 | Soil organic matter | 0,040 | 3,0 | 0,12 |
| 10 | Altitude (m a.s.l) | 0,030 | 3,0 | 0,09 |
| 11 | Tidal frequency | 0,070 | 3,0 | 0,21 |
| 12 | Accessibility | 0,020 | 4,0 | 0,08 |
| 13 | Distance to water source | 0,030 | 3,0 | 0,09 |
| 14 | Mangrove cover | 0,080 | 3,0 | 0,24 |
| 15 | Dominant mangrove species | 0,040 | 3,0 | 0,12 |
| 16 | Natural food availability | 0,040 | 3,0 | 0,12 |
| 17 | Market access | 0,020 | 3,0 | 0,06 |
| 18 | Local labor | 0,020 | 3,0 | 0,06 |
| 19 | Site security | 0,020 | 2,0 | 0,04 |
| 20 | Land status / permits | 0,010 | 4,0 | 0,04 |
| | | 1,000 | Total | 3,12 |
| | | | **%** | 78,08 |

***Station 2***

**Table 2.** Data from the analysis of mangrove crab cultivation suitability at Station 2.

| No | Parameter | Weight (Wi) | Score (Si) | Wi x Si |
|---|---|---|---|---|
| 1 | Soil type | 0,070 | 3,00 | 0,21 |
| 2 | Soil pH | 0,040 | 3,00 | 0,12 |
| 3 | Soil texture | 0,070 | 3,00 | 0,21 |
| 4 | Soil depth | 0,040 | 3,00 | 0,12 |
| 5 | Salinity | 0,100 | 3,00 | 0,30 |
| 6 | Water pH | 0,080 | 3,00 | 0,24 |
| 7 | DO | 0,100 | 3,33 | 0,33 |
| 8 | Temperature | 0,080 | 4,00 | 0,32 |
| 9 | Soil organic matter | 0,040 | 3,00 | 0,12 |
| 10 | Altitude (m a.s.l) | 0,030 | 3,00 | 0,09 |
| 11 | Tidal frequency | 0,070 | 3,00 | 0,21 |
| 12 | Accessibility | 0,020 | 4,00 | 0,08 |
| 13 | Distance to water source | 0,030 | 3,00 | 0,09 |
| 14 | Mangrove cover | 0,080 | 3,00 | 0,24 |
| 15 | Dominant mangrove species | 0,040 | 3,00 | 0,12 |
| 16 | Natural food availability | 0,040 | 3,00 | 0,12 |
| 17 | Market access | 0,020 | 3,00 | 0,06 |
| 18 | Local labor | 0,020 | 3,00 | 0,06 |
| 19 | Site security | 0,020 | 2,00 | 0,04 |
| 20 | Land status / permits | 0,010 | 4,00 | 0,04 |
| | | 1,000 | Total | 3,12 |
| | | | **%** | 78,08 |

**Table 3.** Data from the analysis of mangrove crab cultivation suitability in Bima Bay.

| No | Parameter | Weight (Wi) | Score (Si) | Wi x Si |
|---|---|---|---|---|
| 1 | Soil type | 0,070 | 3,0 | 0,21 |
| 2 | Soil pH | 0,040 | 3,0 | 0,12 |
| 3 | Soil texture | 0,070 | 3,0 | 0,21 |
| 4 | Soil depth | 0,040 | 3,0 | 0,12 |
| 5 | Salinity | 0,100 | 3,0 | 0,30 |
| 6 | Water pH | 0,080 | 3,0 | 0,24 |
| 7 | DO | 0,100 | 3,2 | 0,32 |
| 8 | Temperature | 0,080 | 4,0 | 0,32 |
| 9 | Soil organic matter | 0,040 | 3,0 | 0,12 |

| | | | | |
|---|---|---|---|---|
| 10 | Altitude (m a.s.l) | 0,030 | 3,0 | 0,09 |
| 11 | Tidal Frequency | 0,070 | 3,0 | 0,21 |
| 12 | Accessibility | 0,020 | 4,0 | 0,08 |
| 13 | Distance to water source | 0,030 | 3,0 | 0,09 |
| 14 | Mangrove cover | 0,080 | 3,0 | 0,24 |
| 15 | Dominant mangrove species | 0,040 | 3,0 | 0,12 |
| 16 | Natural food availability | 0,040 | 3,0 | 0,12 |
| 17 | Market access | 0,020 | 3,0 | 0,06 |
| 18 | Local labor | 0,020 | 3,0 | 0,06 |
| 19 | Site security | 0,020 | 2,0 | 0,04 |
| 20 | Land status / permits | 0,010 | 4,0 | 0,04 |
| | | 1,000 | Total | 3,11 |
| | | | **%** | 77,81 |

## DISCUSSION

The biophysical parameters at Station 1 showed a relatively good level of suitability, with an IKL value of 3.12 or 78.08%, which falls into the suitable category (S2). Soil parameters such as soil type, texture, depth, and pH had an average score of 3, indicating that the soil conditions are quite supportive for coastal aquaculture activities.

Similar findings were reported by **Mardiana *et al.* (2024)**, who found that silvofishery pond soils with neutral pH and suitable texture significantly support pond productivity and environmental stability. In addition, **Pahlevi *et al.* (2025)** demonstrated that appropriate soil structure and organic content in mangrove areas enhance the feasibility of silvofishery development, particularly for crustacean cultivation.

Furthermore, water quality parameters such as salinity, pH, and dissolved oxygen (DO) were within optimal ranges (scores of 3–3.3), indicating that the aquatic environment is relatively stable and capable of supporting aquatic organisms. This is consistent with findings by **Nasional *et al.* (2024)**, which showed that stable water quality in silvofishery systems contributes significantly to increased aquaculture productivity and environmental sustainability. Similarly, **Muenzel *et al.* (2025)** emphasized that water quality stability, particularly DO and salinity, is a key determinant in site suitability for mangrove-based aquaculture systems.

Water temperature, which received the highest score (4), is a highly supportive factor, considering its critical role in metabolic processes and growth performance of cultured species. This result aligns with **Suyono and Fithor (2025)**, who reported that optimal temperature conditions in silvofishery ponds significantly enhance growth rates and survival of aquatic organisms. Moreover, recent studies by **Karim *et al.* (2019)** also confirm that temperature stability in mangrove-based systems positively affects the physiological performance of mud crabs (*Scylla* spp.), leading to better production outcomes.

Overall, the findings at Station 1 are consistent with recent studies indicating that the success of silvofishery systems is strongly influenced by the suitability of soil characteristics, water quality stability, and optimal temperature conditions. For instance, **Mardiana *et al.* (2024)** reported that suitable soil properties, particularly neutral pH and adequate organic content, significantly enhance pond productivity and environmental carrying capacity in silvofishery systems. Similarly, **Muenzel *et al.* (2025)** emphasized that stable water quality parameters—especially dissolved oxygen and salinity—are critical determinants in the success of mangrove-based aquaculture site selection.

Compared to previous studies, the relatively uniform parameter values observed at Station 1 suggest favorable environmental conditions for sustainable mud crab cultivation. This finding aligns with **Suyono and Fithor (2025)**, who found that consistent environmental conditions in restored mangrove-based silvofishery systems lead to more stable production outcomes and improved ecosystem resilience. In addition, **Nasional *et al.* (2024)** demonstrated that integrated mangrove–aquaculture systems with stable water quality can significantly increase productivity while maintaining ecological balance.

However, when compared with findings by **Pahlevi *et al.* (2025)**, areas with similar biophysical suitability may still experience suboptimal productivity if management practices such as pond maintenance, water circulation, and ecosystem protection are not properly implemented. This indicates that although Station 1 shows favorable natural conditions, further improvements in management strategies are necessary to optimize productivity and ensure long-term sustainability.

Overall, the findings at Station 1 are consistent with recent studies indicating that the success of silvofishery systems is strongly influenced by the suitability of soil characteristics, water quality stability, and optimal temperature conditions. Compared to previous studies, the relatively uniform parameter values at this station suggest that the area has favorable environmental conditions for sustainable mud crab cultivation, although further management improvements are still required to optimize productivity.

Ecological parameters such as mangrove cover, dominant mangrove species, and natural food availability are in the moderately suitable category (score 3). This condition indicates that the mangrove ecosystem still functions effectively as a provider of nutrients, habitat, and natural productivity support for aquatic organisms. Similar findings were reported by **Suyono and Fithor (2025)**, who found that mangrove-integrated silvofishery systems maintain ecological functionality while enhancing aquaculture productivity through improved nutrient cycling and habitat stability. In addition, **Pahlevi *et al.* (2025)** emphasized that adequate mangrove structure and species composition play a crucial role in sustaining benthic food availability, which directly supports crustacean growth such as mud crab (*Scylla* spp.).

However, the site security parameter shows a lower score (2), indicating potential disturbances such as human activities, resource exploitation, or land-use conflicts. This is consistent with findings by **Muenzel *et al.* (2025)**, who reported that socio-environmental pressure and weak governance are among the main constraints in maintaining sustainable silvofishery areas in coastal ecosystems. Similarly, **Daulay *et al.* (2024)** highlighted that areas with inadequate protection and monitoring systems are more vulnerable to ecosystem degradation despite having suitable biophysical conditions.

Socio-economically, accessibility and land status are considered good (score 4), which can strongly support sustainable cultivation efforts. **Nasional *et al.* (2024)** found that good accessibility and secure land tenure significantly enhance farmer participation and long-term investment in silvofishery systems. Furthermore, **Sajjad *et al.* (2023)** noted that socio-economic stability, particularly in terms of access to markets and legal land use certainty, is a key factor determining the success of mangrove-based aquaculture development.

Overall, these findings indicate that while ecological and socio-economic conditions are generally supportive, governance and site security remain critical limiting factors that must be addressed to ensure long-term sustainability of silvofishery development.

Based on the suitability analysis, Station 1 shows relatively high development potential, although improvements are still required in security management and strengthening of local institutions. Similar findings were reported by **Suyono and Fithor (2025)**, who emphasized that even in areas with favorable biophysical conditions, weak governance and limited institutional capacity can reduce the long-term sustainability of silvofishery systems. In addition, **Muenzel *et al.* (2025)** highlighted that socio-institutional factors, including enforcement of resource management rules and stakeholder coordination, are critical determinants of successful coastal aquaculture development in mangrove ecosystems.

Recent literature consistently shows that the success of coastal cultivation is not determined by a single factor but by a combination of water quality, soil conditions, and mangrove ecosystem support. For instance, **Mardiana *et al.* (2024)** demonstrated that optimal soil characteristics and stable water quality significantly enhance aquaculture productivity in silvofishery ponds. Similarly, **Nasional *et al.* (2024)** found that mangrove presence plays a key role in stabilizing environmental conditions and improving nutrient availability, which directly supports cultured species performance.

Therefore, optimizing ecosystem-based management is crucial to improve the suitability class toward highly suitable (S1). Compared to previous studies, integrated management approaches that combine ecological conservation with strong institutional governance have been shown to significantly increase both environmental quality and aquaculture productivity **(Sajjad *et al.*, 2023; Pahlevi *et al.*, 2025)**. This indicates that improving management practices, particularly in security and institutional coordination, is as important as maintaining biophysical suitability in achieving sustainable silvofishery development.

The analysis results at Station 2 showed an IKL value identical to Station 1, at 3.12 or 78.08%, which also falls into the suitable category (S2). The physical and chemical water parameters were relatively uniform, with an average score of 3 for almost all parameters. This indicates homogeneity in environmental characteristics between locations, particularly in soil and water quality conditions, which are key determinants of coastal land suitability. Similar patterns of environmental homogeneity in silvofishery areas were reported by **Mardiana *et al.* (2024),** who found that relatively stable soil and water parameters across coastal ponds contribute to consistent suitability classifications in aquaculture systems. In addition, **Nasional *et al.* (2024)** demonstrated that uniform salinity, pH, and dissolved oxygen levels in mangrove-associated aquaculture areas support stable productivity and reduce spatial variability in culture performance.

Furthermore, **Muenzel *et al.* (2025)** emphasized that site similarity in biophysical parameters often reflects broader coastal environmental stability, which is beneficial for ecosystem-based aquaculture planning. However, they also noted that such homogeneity does not automatically guarantee optimal productivity if socio-environmental pressures are not properly managed. Therefore, while the observed similarity between Station 1 and Station 2 indicates favorable and stable environmental conditions for silvofishery development, continuous monitoring is still required to ensure long-term sustainability and to detect subtle environmental changes that may affect cultivation performance.

The main difference lies in the slightly lower DO value (score 3), which may indicate slightly lower aquatic productivity or the influence of environmental factors such as water circulation. However, the temperature remains at optimal levels (score 4), Mangrove parameters and natural food availability are also in the moderately suitable category, indicating that the supporting ecosystem is still functioning well and helps maintain the stability of the aquatic environment. Recent studies confirm that mangrove structure and habitat complexity are critical for sustaining mud crab (*Scylla* spp.) populations, as they provide shelter, feeding grounds, and organic matter that supports benthic food webs **(Susiana *et al.*, 2024; Prayoga *et al.*, 2025)**. Similarly, **Fazhan *et al.* (2022)** reported that variations in mangrove density significantly influence the abundance and spatial distribution of *Scylla* spp. within mangrove ecosystems, highlighting the importance of habitat quality in maintaining ecological balance.

In silvofishery systems, **Suyono and Fithor (2025)** found that integrated mangrove–aquaculture areas with moderate to high mangrove cover are associated with enhanced ecosystem stability, particularly in maintaining water quality and supporting natural food availability for cultured organisms. Furthermore, **Karim *et al.* (2020)** demonstrated that silvofishery ponds with well-maintained mangrove vegetation enhance organic matter cycling, which directly contributes to improved growth and survival of mud crabs.

These findings are consistent with the present study, indicating that although the ecosystem at the study site is not in optimal condition, it still provides sufficient ecological support for mud crab cultivation. However, compared to fully restored mangrove systems reported by **Suyono and Fithor (2025)**, the moderate suitability condition suggests that additional ecosystem enhancement—such as mangrove rehabilitation and habitat enrichment is still required to increase productivity and ecological resilience**.**

Socio-economic aspects show a similar pattern to the other stations, with good accessibility and land status, while site security remains a limiting factor. Similar findings were reported by **Sajjad *et al.* (2023)**, who emphasized that socio-economic stability particularly access to markets, land tenure certainty, and local governance plays a crucial role in determining the long-term success of silvofishery development. In addition, **Muenzel *et al.* (2025)** highlighted that weak site security and limited institutional control can increase vulnerability of coastal aquaculture areas to resource conflicts and environmental degradation, even in biophysically suitable locations.

Based on the suitability analysis, Station 3 remains feasible for development; however, it requires special attention to improving water quality and environmental management. Comparable studies by **Mardiana *et al.* (2024)** showed that fluctuations in water quality parameters, particularly dissolved oxygen (DO), can directly reduce aquaculture productivity and carrying capacity in silvofishery systems. Likewise, **Nasional *et al.* (2024)** found that even slight decreases in DO and water stability significantly affect growth performance and survival rates of cultured organisms in mangrove-based aquaculture environments.

These findings suggest that although Station 3 has adequate socio-economic and land suitability conditions, its ecological performance remains sensitive to water quality fluctuations. Therefore, integrated management combining environmental monitoring and institutional strengthening is required to ensure sustainable development of silvofishery systems in the area.

**Suitability for Mud Crab Cultivation Using a Silvofishery System in Bima Bay**

It is recommended that the research results be presented in the form of a map to improve spatial interpretation and provide clearer visualization of land suitability distribution. Spatial representation has been widely recognized as an effective tool in coastal aquaculture planning, because it allows more accurate identification of suitable and unsuitable zones for development **(Mardiana *et al.*, 2024; Muenzel *et al.*, 2025)**.

Overall, the area analysis results indicate an IKL value of 3.11 or 77.81%, which falls into the suitable category (S2). This value reflects the average conditions across all stations, indicating that the area generally has good potential for developing mangrove crab cultivation using a silvofishery system. Similar results were reported by **Nasional *et***

***al.* (2024)**, who found that silvofishery areas with comparable biophysical conditions typically fall within the suitable category due to stable water quality and moderate mangrove support. In addition, **Suyono and Fithor (2025)** emphasized that moderate-to-high suitability classes are commonly associated with mangrove–aquaculture systems that maintain ecological balance while supporting sustainable production.

These findings suggest that the study area has promising potential for silvofishery development; however, spatial variability among stations should still be considered in management planning. Therefore, integrating suitability mapping with field-based assessment is essential to support more effective decision-making in sustainable coastal resource management. Dominant parameters such as temperature (score 4), DO (3.2), and water salinity and pH (score 3) indicate relatively stable and supportive water conditions such as temperature, salinity, and dissolved oxygen strongly influence aquaculture suitability and overall system performance, as these parameters determine metabolic activity, survival, and productivity of cultured organisms **(Mardiana *et al.*, 2024; Muenzel *et al.*, 2025)**. Recent studies in tropical coastal ecosystems in Indonesia also confirm that dissolved oxygen is a critical limiting factor in silvofishery systems, where even moderate fluctuations can significantly affect carrying capacity and aquaculture yield **(Pratiwi *et al.*, 2022; Nasional *et al.*, 2024)**. For example, research in mangrove-based aquaculture ponds showed that maintaining optimal DO levels directly improves growth performance and reduces physiological stress in crustaceans such as mud crab (*Scylla* spp.) **(Faturrohman *et al.*, 2024; Susiana *et al.*, 2024)**. Furthermore, studies conducted in silvofishery systems in Indonesia demonstrate that integrated mangrove aquaculture management can stabilize water quality conditions, particularly DO and organic matter balance, thereby supporting higher ecosystem productivity **(Rinaldy *et al.*, 2023; Suyono & Fithor, 2025)**. In tropical estuarine environments, habitat stability and water quality consistency are consistently identified as key determinants of successful crab cultivation and long-term sustainability of coastal aquaculture systems **(Pratiwi *et al.*, 2022; Muenzel *et al.*, 2025)**. These findings reinforce that maintaining optimal dissolved oxygen and related water quality parameters is essential to ensure sustainable silvofishery development, particularly in tropical mangrove ecosystems such as those found in Indonesia, as shown in Table (3).

Spatial visualization is widely recognized as an effective approach in coastal aquaculture planning since it allows better identification of habitat quality variation and ecosystem potential across locations **(Mardiana *et al.*, 2024; Muenzel *et al.*, 2025)**.

Ecological parameters such as mangrove cover and natural food availability were also in the “fairly suitable” category, indicating that the ecosystem is still capable of supporting natural productivity. Similar findings in Indonesian mangrove ecosystems were reported by **Rinaldy *et al.* (2023)**, who found that moderate mangrove density still provides sufficient organic matter and habitat structure to support mud crab (*Scylla* spp.) populations. In addition, **Susiana *et al.* (2024)** emphasized that natural food availability in mangrove waters is strongly influenced by litter production and benthic community composition, which remain functional even in moderately suitable ecosystems.

Furthermore, **Suyono and Fithor (2025)** reported that silvofishery systems with moderate mangrove cover can still maintain ecological productivity, although not at optimal levels compared to fully restored mangrove stands. These conditions suggest that while the ecosystem is not yet in its best state, it still plays an active role in supporting aquaculture-based productivity and can be further improved through targeted mangrove management and habitat enhancement. A well-maintained mangrove ecosystem is a crucial factor in providing natural nutrients and maintaining ecosystem balance, as mangroves contribute significantly to organic matter production, habitat complexity, and coastal productivity **(Alongi, 2020)**. Recent studies in Indonesian tropical coastal areas further support this finding, showing that intact mangrove forests enhance nutrient cycling and improve ecological stability in adjacent aquaculture systems **(Rinaldy *et al.*, 2023; Susiana *et al.*, 2024)**. In addition, silvofishery-based mangrove systems have been shown to strengthen ecosystem resilience by maintaining water quality and increasing the availability of natural food sources for crustaceans such as mud crab (*Scylla* spp.) **(Suyono & Fithor, 2025)**.

This aligns with research by **Primavera *et al.* (2021)**, which highlights that silvofishery systems can simultaneously improve ecosystem sustainability and aquaculture productivity through integrated mangrove–aquaculture management approaches. Similarly, recent studies in Indonesia demonstrate that mangrove conservation combined with aquaculture activities not only enhances biodiversity but also increases long-term production stability and environmental services **(Arfan *et al.*, 2024; Amien *et al.*, 2025)**. Comparative evidence from tropical mangrove systems also shows that areas with higher mangrove integrity consistently support better ecological and economic outcomes than degraded systems **(Muenzel *et al.*, 2025)**.

However, at each station, site security remains a major constraint, reflected in the lowest score (2). Recent governance-focused studies indicate that weak institutional control, unclear land tenure, and limited enforcement are persistent challenges in Indonesian coastal aquaculture areas, often leading to resource conflicts and reduced sustainability **(Sajjad *et al.*, 2023; Muenzel *et al.*, 2025)**. In addition, national-scale analyses of mangrove governance in Indonesia reveal that overlapping authority and land-use pressure from aquaculture expansion continue to threaten long-term ecosystem stability **(Nasional *et al.*, 2024; Amien *et al.*, 2025)**. This indicates the need to strengthen integrated coastal management systems, including improved monitoring, clearer regulatory frameworks, and enhanced community-based resource protection.

Spatially, there were no significant differences between stations, indicating that the area has relatively homogeneous environmental characteristics. Similar spatial homogeneity in biophysical parameters has also been reported in other tropical mangrove–aquaculture systems in Indonesia, where water quality variables such as temperature, salinity, and dissolved oxygen showed minimal variation across observation stations **(Omoigberale *et al.*, 2020; Mardiana *et al.*, 2024)**. For example, studies in silvofishery ponds in South Sulawesi and Java demonstrated that uniform environmental conditions across stations are commonly associated with stable hydrodynamic conditions and similar sediment characteristics **(Karim *et al.*, 2020; Rinaldy *et al.*, 2023)**.

Furthermore, recent research highlights that spatial homogeneity in mangrove ecosystems often reflects relatively balanced ecological processes, particularly in areas with moderate anthropogenic pressure and intact mangrove structure. **Suyono and Fithor (2025)** reported that restored mangrove silvofishery systems in Indonesia tend to exhibit relatively uniform physicochemical conditions across sites, which support stable productivity of crustaceans such as mud crab (*Scylla* spp.). In addition, **Muenzel *et al.* (2025)** emphasized that environmental uniformity across coastal aquaculture zones is beneficial for ecosystem-based planning because it simplifies zoning strategies and reduces management complexity in large-scale silvofishery development.

From a broader ecological perspective, spatial similarity in environmental parameters has also been linked to consistent nursery habitat functions for crustaceans. Studies on crab nursery habitats show that relatively homogeneous conditions of salinity, dissolved oxygen, and substrate composition support stable distribution patterns of juvenile crabs and enhance habitat suitability **(Fazhan *et al.*, 2022; Susiana *et al.*, 2024)**. This further supports the interpretation that the study area maintains functional ecological connectivity across stations.

Therefore, the observed spatial homogeneity suggests that management strategies can be implemented on an area-based rather than site-specific basis. This approach is consistent with the Integrated Coastal Management (ICM) framework, where development success depends on the synergy between biophysical, ecological, and socio-economic components **(UNEP, 2021; FAO, 2022)**. Recent empirical studies in Indonesian coastal systems also confirm that integrated management approaches improve both ecological sustainability and aquaculture productivity when applied at landscape scale rather than fragmented site-by-site interventions **(Sajjad *et al.*, 2023; Arfan *et al.*, 2024)**.

Thus, this research area demonstrates significant potential for sustainable silvofishery development, particularly for mud crab cultivation. However, as shown in comparative studies across tropical mangrove regions, long-term sustainability still depends on continuous monitoring, governance strengthening, and adaptive management to respond to environmental and socio-economic changes **(Muenzel *et al.*, 2025; Suyono & Fithor, 2025)**.

The results indicate that Bima Bay has environmental conditions that are quite supportive for silvofishery mud crab cultivation. Temperature and water quality parameters such as salinity, pH, and dissolved oxygen (DO) are within optimal ranges, which play a crucial role in supporting metabolic processes, survival, and growth of cultured organisms. Similar findings were reported in silvofishery systems in Indonesia, where water temperatures in the range of 26–30 °C and stable DO conditions (≥4 mg/L) were identified as optimal for mud crab growth and physiological performance **(Hastuti *et al.*, 2020; Mardiana *et al.*, 2024)**. Recent studies in tropical mangrove aquaculture further confirm that stable water quality significantly enhances crab productivity and physiological stability. For example, research in South Sulawesi showed that mud crab cultured in environments with stable salinity (25–30 ppt) and adequate oxygen levels exhibited higher survival rates and better molting performance compared to fluctuating environments **(Karim *et al.*, 2020; Faturrohman *et al.*, 2025)**. In addition, silvofishery-based systems in West Sulawesi demonstrated that mangrove integration contributes to improved water quality stability, particularly in buffering temperature and maintaining dissolved oxygen balance **(Nasional *et al.*, 2024)**. Comparative studies in other Indonesian coastal ecosystems also support these findings. **Rinaldy *et al.* (2023)** reported that mangrove–crab integrated systems in Java and Sulawesi show consistent productivity when water quality parameters remain within optimal biological thresholds. Similarly, **Susiana *et al.* (2024)** found that mud crab populations in mangrove habitats are highly sensitive to DO fluctuations, but thrive under stable physicochemical conditions typical of healthy silvofishery systems. Furthermore, **Muenzel *et al.* (2025)** emphasized that environmental stability, particularly in temperature and water quality parameters, is a key determinant of site suitability in ecosystem-based aquaculture planning. This suggests that Bima Bay's relatively uniform and optimal environmental conditions provide a strong foundation for sustainable silvofishery development. Overall, these findings confirm that the combination of optimal temperature and stable water quality conditions in Bima Bay strongly supports the growth and sustainability of mud crab cultivation systems, consistent with patterns observed in other tropical silvofishery regions in Indonesia. **(Boyd *et al.*, 2020)**.

## CONCLUSION

The land suitability analysis indicates that Bima Bay falls into the moderately suitable category (S2), with IKL values ranging from 3.11 to 3.12 (77.81%–78.08%). Biophysical parameters such as temperature, salinity, pH, and dissolved oxygen are within optimal ranges, while mangrove ecosystem conditions support overall productivity. However, site security and slight variations in DO remain limiting factors. Overall, Bima Bay has good potential for sustainable silvofishery-based mud crab cultivation, provided that management and institutional aspects are improved in line with integrated coastal management principles.

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