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Site Suitability Assessment for Shellfish Bottom Culture in Maitara Coastal Area

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Abstract

Shellfish aquaculture has experienced significant growth in recent years. Several countries, including Indonesia, have successfully developed shellfish farming species. One area with potential for development is the coast of Maitara Island. This study aims to assess the land suitability for shellfish aquaculture development using the bottom culture method in Maitara Island. The research was conducted in the waters of Maitara Village. Observed parameters included substrate type, water depth, water temperature, salinity, DO, accessibility, and distance to settlements. The collected data were analyzed for water suitability, followed by visualization as a cultivation site map. The substrate type observations showed that the dominant substrate consisted of sand, gravel, and rocks. Water depth ranged from 2–22 meters, water temperature ranged from 29.40–28.70°C, salinity was 32 ppt, DO ranged from 3.25–3.70 mg/L, accessibility ranged from 0.07–0.52 km, and distance to settlements ranged from 0.02–0.63 km. Land suitability analysis indicated that the area is highly suitable for shellfish farming using the bottom culture method, with a total area of 24.8 hectares. The study concludes that the coastal area of Maitara Island is suitable for the development of shellfish farming using the bottom culture method.

Keywords: *Bottom culture, shellfish aquaculture, site suitability analysis, Maitara island*.

INTRODUCTION

Over the past few years, the production of marine shellfish commodities has continued to show an increasing trend (Laama & Bachari, 2019). The Food and Agriculture Organization (FAO) reported that total production reached 17.5 million metric tons (live weight) in 2018 and increased to 18.9 million tons in 2024. Asia remains the major contributor to global shellfish production, accounting for more than 92% or approximately 17.5 million tons in 2024. This indicates that mollusks hold a strategic position as one of the key commodities in the aquaculture sector (FAO, 2024).

Mollusks are considered one of the key species for 21st-century aquaculture development. Mollusk production contributes to increasing the seafood supply and enhances coastal communities' socio-economic well-being (Michele et al., 2013). This is particularly relevant for archipelagic countries like Indonesia, which possess ideal aquatic environments for shellfish aquaculture. Several economically valuable species, such as *Perna viridis*, *Amusium pleuronectes*, *Pinctada* spp., and *Anadara granosa*, have become priority commodities that are widely cultivated across Indonesian waters (Rejeki et al., 2021; Syahidah, 2022; Mahary et al., 2023; Soffa et al., 2024).

The coastal waters of Maitara Island, located in Tidore Islands City, are among the areas with high potential for shellfish farming. Approximately 6,300 hectares of marine area have been identified as suitable zones for shellfish aquaculture development (Radiarta et al., 2010). Previous studies have reported that the waters around Maitara Island are highly ideal for aquaculture activities, including the grow-out of humpback grouper (*Cromileptes altivelis*) (Umaternate et al., 2020). This indicates that the area's environmental characteristics also support other types of aquacultures, such as shellfish cultivation.

Site suitability assessment is a critical step before aquaculture development

(Ghobadi et al., 2021). Optimal production can only be achieved if the farming location meets environmental, economic, and infrastructural criteria (Bagdanavičiūtė et al., 2018; Rusdi et al., 2024; Tamrin et al., 2024). Determining suitable zones not only ensures optimal biological growth but also guarantees the long-term sustainability of aquaculture practices (Aghmashhadi et al., 2022). This study aims to assess the site suitability for shellfish aquaculture development using the bottom culture method in the coastal waters of Maitara Island, as part of efforts to sustainably optimize local aquaculture potential.

METHOD

This study was conducted in April 2025. Data collection took place in the coastal waters of Maitara Village, North Tidore District, Tidore Islands City, North Maluku Province, Indonesia. The observed water area covered 24.8 hectares. The research location is shown in Figure 1. The observed data in this study consisted of water quality parameters and infrastructure-related variables. The water quality parameters included substrate type, water depth, temperature, salinity, and dissolved oxygen (DO). Infrastructure parameters included accessibility and distance to settlements. Substrate was visually observed, depth was measured using a measuring tape, water temperature was measured with a thermometer, salinity was measured using a refractometer, and DO was measured in situ using a DO meter. Meanwhile, data on accessibility and distance to settlements were obtained ex-situ using satellite technology via Google Earth.

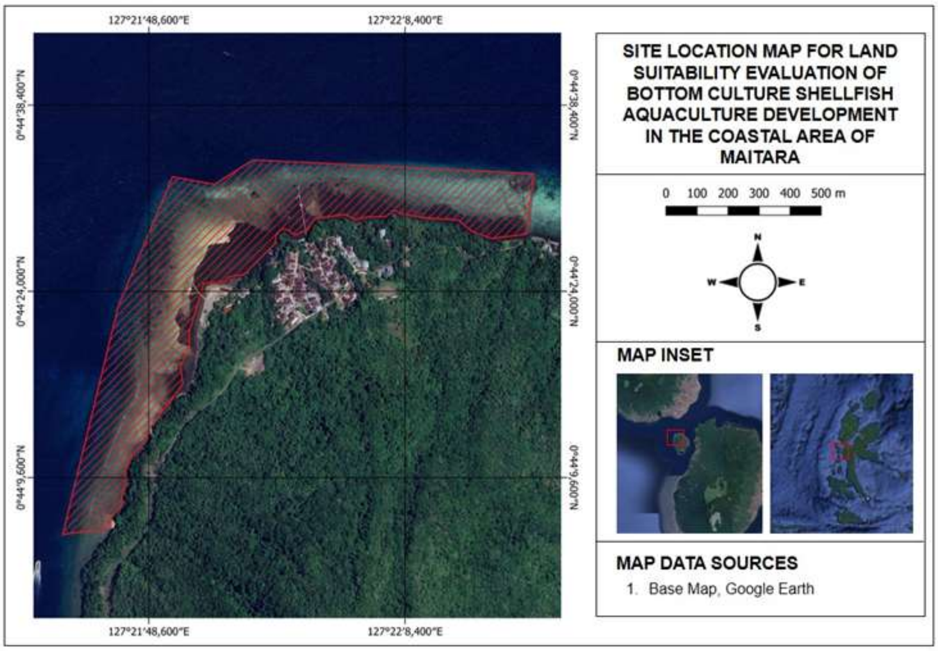

Figure 1. Research location.

Site suitability analysis was carried out using a Geographic Information System (GIS)-based approach. The collected water quality and infrastructure data were analyzed using a marine site suitability analysis. Suitability criteria in this study were categorized into three classes: highly suitable (S1), moderately suitable (S2), and not suitable (N). These classes were assigned scores of 5 for S1, 3 for S2, and 1 for N. Furthermore, each parameter was assigned a weight as shown in Table 1. The final site suitability score was obtained by summing the products of the scores and weights for all assessed criteria. Mathematically, the site suitability index can be expressed with the following formula:

Total site suitability score =

$$\Sigma(\text{Weight x Score})$$

Subsequently, the total site suitability score was used as the basis for determining the feasibility level for shellfish aquaculture development using the bottom culture method, as shown in Table 2. After obtaining the site suitability data, the results were visualized in the form of an aquaculture zoning map using Quantum GIS (QGIS) software.

Table 1. Site suitability criteria for shellfish aquaculture using the bottom culture method.

Parameter	Range	Score (A)	Weight (B)	Total Score (AxB)	Reference
Substrate type	Sand, sand with gravel, or rocky bottom Silt Clay and mud	5 3 1	15	75 45 15	Bagdanavičiūtė et al. (2018)
Water depth (m)	3 – 10 10 – 20 > 20 and < 3	5 3 1	15	75 45 15	Radiarta et al. (2011)
Water temperature (°C)	28 – 30 31 – 32 < 28 and > 32	5 3 1	20	100 60 20	Andalus dan Sambah (2021)
Salinity (ppt)	32 33 – 35 < 32 and > 35	5 3 1	15	75 45 15	Andalus dan Sambah (2021)
Dissolved Oxygen (mg/L)	> 5 1 – 5 < 1	5 3 1	15	75 45 15	Radiarta et al. (2011)
Accessibility (km)	< 6 6 – 12 > 12	5 3 1	10	50 30 10	Bagdanavičiūtė et al. (2018)
Distance to settlement (km)	< 4 4 – 6 > 6	5 3 1	10	50 30 10	Radiarta et al. (2011)

Table 2. Classification of site suitability for shellfish aquaculture using the bottom culture method.

Total Score	Suitability Classification
367 – 500	Highly Suitable (S1)
233 – 366	Moderately Suitable (S2)
100 – 232	Not Suitable (N)

RESULTS AND DISCUSSION

Result

The parameters of substrate type, water depth, water temperature, salinity, dissolved oxygen (DO), accessibility, and distance to settlement are presented in Table 3. Observations on substrate type showed that the seabed was predominantly composed of sand with gravel and rocks. Water depth ranged from 2 to 22 meters, water temperature varied between 29.40–28.70 °C, salinity was 32 ppt, DO ranged from 3.25 to 3.70 mg/L, accessibility ranged from 0.07 to 0.52 km, and the distance to the nearest settlement ranged from 0.02 to 0.63 km. Based on these parameters, the site suitability of Maitara coastal waters is classified as highly suitable (S1) for shellfish aquaculture using the bottom culture

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method, with a total potential area of 24.8 hectares (Figure 2).

Table 3. Parameters of substrate type, water depth, water temperature, salinity, DO, accessibility, and distance to settlement for bottom culture shellfish aquaculture in Maitara coastal waters.

Parameters	Observation Results
Substrate type	Sand, sand with gravel, or rocky bottom
Water depth (m)	2.00 – 22.00
Water temperature (°C)	29.40 – 28.70
Salinity (ppt)	32.00
Dissolved Oxygen (mg/L)	3.25 – 3.70
Accessibility (km)	0.07 – 0.52
Distance to settlement (km)	0.02 – 0.63

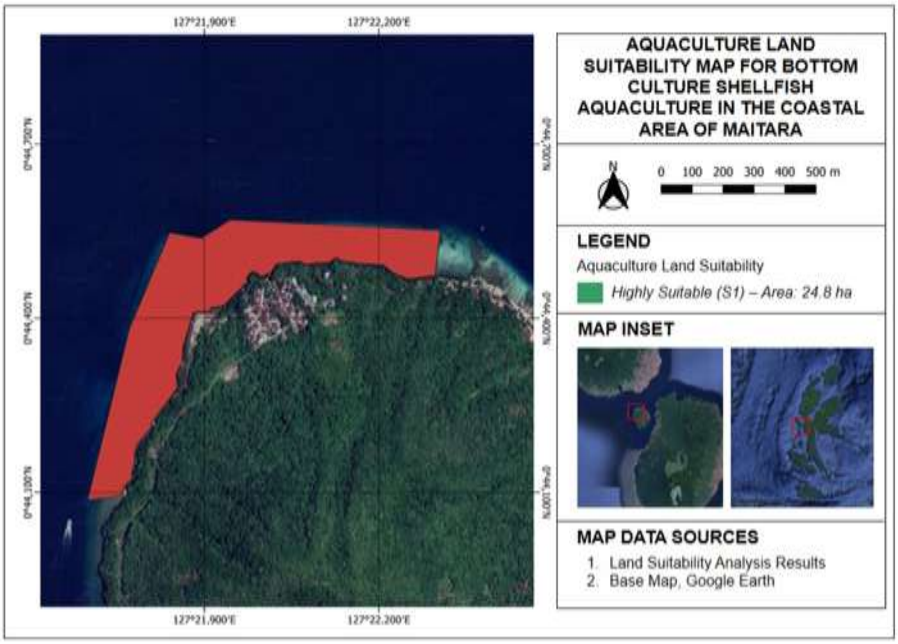

Figure 2. Site suitability for bottom culture shellfish aquaculture in the coastal area of Maitara

Discussion

Initial assessment of the suitability of shellfish aquaculture areas focuses primarily on land suitability as a key indicator. This suitability plays a crucial role in ensuring the success of aquaculture operations, as it is directly linked to environmental carrying capacity, production efficiency, and the sustainability of farming activities. Previous studies have shown that the physical and chemical characteristics of the aquatic environment serve as the basis for determining land suitability levels (Achmad et al., 2020; Mustafa et al., 2022; Purnomo et al., 2022). Evaluation of these parameters allows for a more accurate identification of potential areas using a measurable scientific approach (Hardjana et al., 2024).

The type of aquatic substrate significantly influences the survival, growth, and adaptive mechanisms of shellfish in aquaculture habitats. Observations indicate that the substrate in the Maitara coastal waters is predominantly composed of sand mixed with gravel and rocks. Such substrate characteristics are highly suitable for bottom culture methods, considering the ability of shellfish shells to attach or adapt optimally to coarse and stable substrates (Zhang et al., 2022; Liang et al., 2025). This suitability strengthens the area's potential as a location for intensive bottom-based shellfish aquaculture (Bagdanavičiūtė et al., 2018).

Water depth is a limiting parameter that also determines the effectiveness of aquaculture structure placement and the physiological comfort of the cultured organisms (Dunham and Marshall, 2012; Cranford, 2019). Measurements show a depth range of 2–22 meters, with most areas falling within the ideal depth range for bottom culture, which is 3–10 meters (Radiarta et al., 2011). This depth is potentially stable throughout the year, although still influenced by tidal fluctuations commonly observed in tropical coastal regions (Sultan et al., 2020).

Water temperature is a critical factor regulating metabolism, tissue growth, and reproduction in shellfish. The temperature range of 28.70–29.40 ℃ recorded in Maitara waters indicates thermal conditions highly suitable for the physiological needs of tropical shellfish (Masanja et al., 2023). This range falls precisely within the optimal temperature bracket of 28–30 ℃, as reported by Andalus and Sambah (2021), thereby supporting optimal growth and resilience of shellfish.

Salinity is a key parameter influencing osmotic balance, growth, and physiological tolerance of shellfish during cultivation (Silvestre et al., 2021). Measurements indicate a salinity level of 32 ppt, which corresponds with the ideal reference values noted by Andalus and Sambah (2021). The stability of salinity at this level suggests that the Maitara coastal waters possess favorable oceanographic characteristics for the cultivation of stenohaline organisms such as shellfish.

Dissolved oxygen (DO) levels ranged between 3.25–3.70 mg/L. Although this falls below the ideal standard of >5 mg/L (Radiarta et al., 2011), shellfish are still capable of adapting at this level, particularly since the lower physiological stress threshold is recorded at <2 mg/L (Guntur et al., 2019). The availability of sufficient DO allows for normal respiration, filtration, and shell formation processes (Song et al., 2024).

Site accessibility is a key factor influencing operational efficiency in aquaculture, as it affects the speed of production input distribution and harvest marketing (Tan and Zheng, 2020). The distance from the farming sites to the main activity centers ranges from 0.07–0.52 km, significantly below the ideal threshold of <6 km as stated by Bagdanavičiūtė et al. (2018). This condition reflects excellent logistical potential, particularly for the transport of seed, feed, and harvests to markets or processing facilities.

The distance between the cultural site and residential areas ranges from 0.02 to 0.63 km. This range falls within a safe threshold for minimizing the risk of direct pollution from domestic activities, especially given the recommended safe distance of less than 4 km (Radiarta et al., 2011). The relatively proximity still allows for effective environmental quality control, provided there is no direct discharge of household waste into the farming area. The site is considered strategic for the development of community-based aquaculture without compromising water quality standards essential for sustainable shellfish production (Marčeta et al., 2022).

Evaluation of environmental parameters such as temperature, salinity, dissolved oxygen, depth, bottom substrate, site accessibility, and proximity to settlements provides a comprehensive assessment of aquaculture site suitability. This stage serves as a fundamental basis for planning sustainable aquaculture development. Similar studies have been conducted in grouper farming areas in Sabang Bay, Weh Island, covering 51.85 ha, and the Laut Island cluster in South Kalimantan with a coverage of 74.18 ha (Anhar et al., 2020; Fatmawati and Baharuddin, 2021). These practices demonstrate that environmentally based site assessments are a key indicator of long-term success in coastal aquaculture development.

The analysis results for the Maitara coastal waters indicate that all assessed parameters meet the ideal criteria for bottom culture-based shellfish farming. The classification of "highly suitable" (S1) designates an area of 24.8 hectares as possessing the full set of ecological and physical attributes necessary to support optimal shellfish growth. The S1 status signifies that the area is viable for development into a major aquaculture production center (Macias et al., 2019). This site suitability identification strengthens the recommendation to designate Maitara's coastal zone as a priority area for bottom culture-based shellfish aquaculture development.

CONCLUSIONS

The land suitability assessment of the coastal waters of Maitara Island indicates that all parameters fall within the ideal range. The assessment results categorize the Maitara coastal area as highly suitable (S1) for the development of bottom culture shellfish aquaculture, with a total area of 24.8 hectares.

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