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Original research article

Unlocking Mangrove Potential: Sustainable Crab Fisheries in Selindung Sub-watershed, Bangka Island – Indonesia

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ABSTRACT

The identification of mangroves thriving around river estuaries is essential for managing natural resource potential in the Selindung Sub-Watershed. This study evaluates the mangrove resource potential and the livelihoods of crab trap fishermen in the Selindung Sub-Watershed, part of the Baturusa Watershed. Conducted April to June 2024 in Pagarawan Village, Merawang District, Bangka Regency, this research employed a mixed-method approach, integrating qualitative and quantitative analyses, to identify mangrove species and assess the mangrove crab (Scylla spp.) fishery. The results revealed significant natural resource potential in the Selindung Sub-Watershed, encompassing 349 hectares of mangrove forests with dense canopy cover (≥80%), classified as high-quality habitat. Ten mangrove species were identified, including dominant taxa such as Bruguiera gymnorrhiza, Rhizophora mucronata, and Sonneratia alba. The mangrove crab fishery represents a vital livelihood for local fishermen, who supply their catch to Fish Farming Groups (Pokdakan) for fattening purposes. The sustainability of this fishery is closely tied to the health of the mangrove ecosystem. To ensure the long-term preservation of mangroves and their associated resources, sustainable management policies are required, supported by adequate budget allocation, law enforcement, capacity building, equitable supply chain advocacy, stakeholder engagement, and community education. These measures are critical for fostering ecosystem resilience while supporting the socio-economic well-being of local communities.

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Introduction

Effective watershed management requires active participation from all stakeholders, including the private sector, local communities, and non-governmental organizations (NGOs). However, participation, especially from the private sector and non-coastal land users, remains limited (Harmiati et al., 2017). This lack of involvement is particularly concerning in strategic watersheds such as the Baturusa Watershed in Bangka Belitung Islands Province, which plays a vital role in supporting both ecological balance and the local economy. The Baturusa Watershed comprises several sub-watersheds, all draining into the Baturusa River. Among these, the Selindung Sub-Watershed holds significant importance due to its rich mangrove ecosystems and economic contributions to surrounding communities.

The Selindung Sub-Watershed is integral to the coastal ecosystem and supports the livelihoods of local mangrove crab (*Scylla serrata*) fishermen. The area boasts approximately 349 hectares of mangrove forests, with substrates of sandy loam and loamy sand providing ideal conditions for mangrove growth (Ramadhani et al., 2023). These mangroves not only sustain diverse biota but also serve as crucial habitats for economically valuable species such as mangrove crabs. Crab fishing is a primary source of income for local fishermen, contributing to household sustenance and providing opportunities for economic improvement.

However, in recent years, the Selindung Sub-Watershed has experienced significant environmental challenges that threaten the sustainability of its natural resources and local livelihoods. Climate change, land-use changes, pollution, and unsustainable fishing practices pose substantial risks. In particular, artisanal mining activities around the watershed have led to increased sedimentation and pollution, with tin mining waste escalating total suspended solids (TSS) levels in the Baturusa River from mild to moderate pollution status (Mentari et al., 2017). The environmental degradation caused by mining significantly undermines marine tourism and fisheries by reducing the economic benefits derived from coastal and marine ecosystems (Adibrata et al., 2021). Modeling studies indicate that mining activities in shallow waters, with TSS levels of approximately 0–25 mg/L, can impact areas within a radius of up to 16 nautical miles (Pamungkas & Husrin, 2020).

Despite the ecological and economic significance of the Selindung Sub-Watershed, comprehensive studies addressing the interconnections between mangrove resource potential, environmental challenges, and the socio-economic dynamics of mangrove crab fishermen are lacking. Understanding the extent of mangrove resources and the challenges faced by local communities is crucial for developing sustainable management strategies.

This study aims to evaluate the potential of mangrove resources and assess the socio-economic conditions of mangrove crab fishermen in the Selindung Sub-Watershed of the Baturusa Watershed. The findings are expected to provide a foundation for policy development, stakeholder collaboration, and sustainable management practices that balance ecological preservation with economic resilience.

Research methods

Time and place

This study was conducted from April to June 2024, encompassing preparation, field surveys, mangrove identification, interviews with fishermen, measurement of mangrove crabs and water quality, and article preparation. The

research was carried out in the Selindung Sub-Watershed of the Baturusa Watershed, located in Bangka Regency and Pangkalpinang City, Bangka Belitung Islands Province (Figure 1).

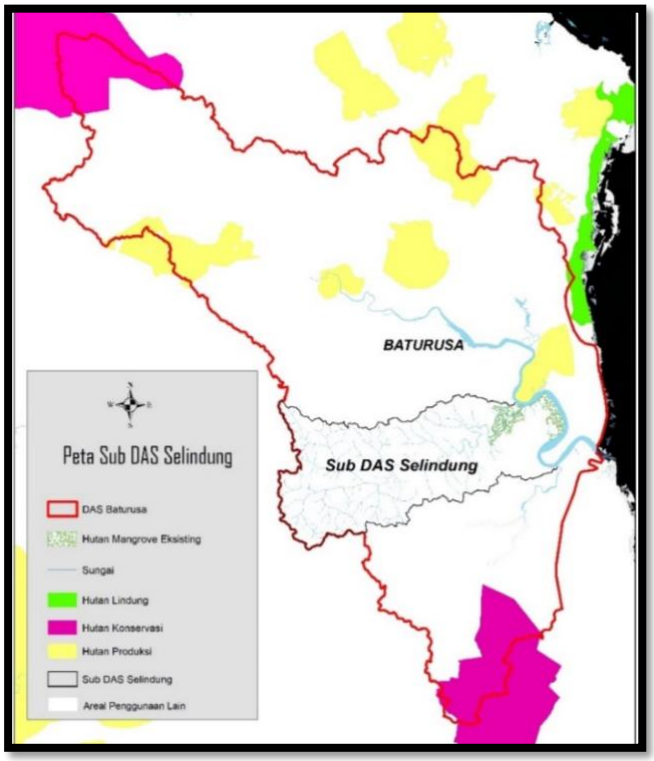

Figure 1. Map of Selindung Sub-Watershed

Tools and Materials

The tools and materials used for data collection related to mangroves and fishermen are listed in Table 1.

Table 1. Tools and materials

No	Tools and Materials	Description
1	Mangrove identification book	To identify mangrove species that serve as habitat for mangrove crabs
2	ArcGIS dan computer system	To digitize maps and measure the area of mangrove coverage
3	Folding crab traps (bubu lipat)	Used as fishing gear for mangrove crab
4	Trash fish (ikan rucah)	Used as bait / feed for crabs
5	Scissors	To cut trash fish and rope.
6	Raffia rope	To tie crabs after capture.
7	Boat and canoe	Transportation aids for navigating the river.
8	DO meter, pH meter, hand refractometer, nitrate, phosphate, and ammonia test kits	To measure water quality parameters.
9	Scales and calipers/ruler	To measure the weight and size of the crabs.

Field Survey and Data Analysis

The identification and classification of mangroves were conducted based on established methodologies outlined in Noor et al. (2006), Pramudji (2017), and Sidik et al. (2019). Field surveys were

carried out to collect comprehensive data on mangrove species and associated habitats in the study area. Additionally, structured interviews were conducted with fishermen using folding crab traps (*bubu lipat*) for catching mangrove crabs (*Scylla serrata*). The interview framework included detailed questions about the demographic profiles of the fishermen, specific techniques and gear utilized in crab fishing, and their economic reliance on this activity.

Data collected were systematically analyzed using a qualitative descriptive approach. This involved organizing, categorizing, and interpreting information to derive meaningful insights. Fishermen's responses were cross-referenced and triangulated with observational data from field surveys to enhance the validity of the findings.

Results and Discussion

Watersheds and Mangroves

A watershed, referred to as Daerah Aliran Sungai (DAS) in Indonesian, is a land area functioning as a unified system with rivers and their tributaries. It collects, stores, and channels rainfall to lakes or seas naturally. Its terrestrial boundaries are defined by topographic divides, while its marine extent includes areas influenced by terrestrial activities (Government Regulation No. 37 of 2012). Another definition explains that a watershed is a region enclosed by mountain ridges, where rainwater falling within the area is captured and flows through small streams to a primary river (Asdak, 2022).

According to the same regulation, watershed management involves regulating the relationship between natural resources and human activities within a watershed. This management aims to ensure ecosystem sustainability, harmony, and long-term utility of resources for human benefit. The Selindung sub-watershed, a part of the Baturusa watershed, exemplifies such potential, being rich in mangrove ecosystem resources and associated biota.

The Selindung sub-watershed plays a significant role in supporting the livelihoods of local communities. Fishermen harvest mangrove crabs, shrimp, mollusks, and various freshwater fish, while aquaculture groups engage in crab fattening programs. However, unsustainable practices, such as cutting mangrove trees for charcoal production, are also observed, which may threaten the ecosystem's health and sustainability.

Mangroves are unique coastal vegetation, characterized by specialized root systems adapted to tidal zones with muddy or sandy substrates (Presidential Regulation No. 121 of 2012). According to Pramudji (2017), mangrove forests thrive in tropical and subtropical coastal environments with high salinity, water saturation, unstable and anaerobic soil conditions, and tidal influences. These adaptations enable mangroves to form a critical habitat for various marine and coastal species.

In the Selindung sub-watershed, particularly in Pagarawan Village, Baturusa District, several mangrove species have been identified, highlighting the area's ecological richness. These species are listed in Table 2, with visual representations provided in Appendix 1.

Table 2. Mangrove Species

No	Mangrove Species	Description
1	*Bruguiera gymnorrhiza*	mangrove in *Rhizopora* zone, height of 6-10 m
2	*Xylocarpus granatum*	mangrove in *Rhizopora* zone, height of 4-7 m
3	*Rhizophora mucronata*	mangrove in *Rhizopora* zone, height of 7-15 m
4	*Soneratia alba / perepat*	mangrove in *Avicennia* zone, height of 3-10 m
5	*Nypa fruticans*	mangrove in *Nipah* zone, height of 3-5 m
6	*Ceriops decandra*	mangrove in *Bruguiera* zone, height of 5-10 m
7	*Lumnitzera racemose*	mangrove in *Bruguiera* zone, height of 3-4 m
8	*Acrostichum aureum*	mangrove in *Nipah* zone, height of 1-4 m
9	*Hibiscus tiliasceus / waru*	mangrove in *Avicennia* zone, height of 5-10 m
10	*Xylocarpus moluccensis*	mangrove in *Rhizopora* zone, height of 7-15 m

Source: Analyzed by research team, 2024

The distribution of mangrove vegetation in Bangka Belitung covers an area of 64,567.915 hectares, as reported by PSSDAL Bakosurtanal (2009) in Pramudji (2017). According to the National Mangrove Map (DKTA, 2021), the Selindung Sub-Watershed has an existing mangrove forest area of approximately ±349 hectares (Team Analysis, 2024), with a dense canopy cover classification. Canopy cover greater than 50%, as defined by Kepmen LH No. 201 of 2004, is categorized as "Good" (Ramadhani *et al.*, 2023). The mangrove forest zonation in the study area can be categorized as follows: (1) Avicennia Zone, characterized by dominant species such as Avicennia sp., Soneratia sp., and Rhizophora sp.; (2) Rhizophora Zone, dominated by species including Rhizophora sp., Bruguiera sp., Xylocarpus sp., and Heritiera sp.; (3) Bruguiera Zone, with Bruguiera sp., Ceriops sp., and Lumnitzera sp. as the predominant species; and (4) Nypa Zone, predominantly consisting of species such as Nypa sp., Derris sp., Acanthus sp., and Acrostichum sp. (Purnobasuki, 2005 in Pramudji, 2017).

Dependency of Crab Fishermen on the Selindung Sub-Watershed

The mud crab fishery in the Selindung Sub-Watershed is a crucial economic activity for local fishermen, providing a primary source of income. Crab fishermen in the surrounding coastal villages of the Baturusa River Watershed (DAS) typically catch 3-5 kg of mud crabs per day. With an average market price of IDR 60,000 per kg, their daily income ranges from IDR 180,000 to IDR 300,000. This underlines the significant role of mud crab fishing as the main livelihood for these communities. Therefore, maintaining the sustainability of the aquatic ecosystem within the Baturusa DAS is critical to preserving the economic stability of the local fishermen.

Impact of Environmental Changes

Environmental changes in the Selindung Sub-Watershed have been shown to adversely affect the aquatic ecosystem, which in turn impacts the mud crab population and the fishermen's catch. The study found rising sea temperatures, erratic rainfall, and declining water quality as key factors contributing to this shift. Dissolved oxygen (DO) levels

ranged from 4.0 to 5.0 mg/L, below the optimal standard of >5.0 mg/L, indicating poor water quality for marine life. Additionally, increased Total Suspended Solids (TSS) from mining activities further exacerbated the habitat conditions for mud crabs, creating an environment less conducive to their growth and survival (Figure 2). These environmental pressures directly threaten the productivity of the mud crab fishery, which is vital for the local economy.

Figure 2. Water measurement and the environmental condition of Selindung Sub-Watershed of Baturusa River

Decline in Mangrove Crab Population

The population of mangrove crabs in the Sub Selindung Watershed (DAS Selindung) has shown a significant decline in recent years, reflected in both the size and weight of the catch. This decline is attributed to various factors, including climate change, environmental alterations caused by mining activities, and unsustainable fishing practices such as overexploitation. Field data indicate that the catch is predominantly composed of small-sized crabs, which account for approximately 50% (10–15 crabs per kilogram), medium-sized crabs at about 35% (5–7 crabs per kilogram), and large-sized crabs at roughly 15% (3–4 crabs per kilogram) (Figure 3). To mitigate this issue, small-sized mangrove crabs could be raised or fattened through aquaculture practices by Fish Farming Groups (Pokdakan). This strategy not only ensures a more sustainable approach to resource management but also provides economic opportunities for fishermen by allowing them to supply crabs of marketable size. Such an initiative highlights the need for integrated solutions that balance ecological preservation and livelihood sustainability.

Economic Challenges

Mangrove mud crab fishermen are facing escalating economic challenges due to a combination of factors. The most significant issue is the decline in mud crab populations, which has directly impacted catch sizes and, consequently, their incomes. In addition to a decrease in population, there has been a noticeable reduction in the size of crabs caught using fold traps (Figure 4). Furthermore, operational costs are rising as fishermen are increasingly required to travel longer

distances to find potential crab habitats. These changes put the long-term sustainability of their livelihoods at risk.

The decline in mud crab populations and the unfavorable environmental conditions, such as reduced oxygen levels and increased water temperature (Figure 2), make the environment less ideal for crab development. This necessitates urgent attention from various stakeholders, including local communities, government, and environmental organizations.

Advocacy is needed to support the economic supply chain of mud crabs, particularly in improving market access for fishermen and local fisher groups (Pokdakan). To address these challenges, policies that protect the productive sectors of the fishing industry must be established. A collaborative approach through consensus is essential to create guidelines and agreements that will safeguard the future of this crucial livelihood.

Figure 3. Catching and measure the mangrove mud crab size

Figure 4. The catch of mangrove mud crab

Environmental Awareness

The study reveals that most mud crab fishermen possess a moderate level of environmental awareness. They recognize the importance of preserving aquatic ecosystems and are keen to contribute to conservation efforts. This awareness provides a strong basis for broader environmental initiatives. It is essential to involve non-fishermen land users in environmental education campaigns. Strengthening this awareness can be achieved through mangrove conservation activities in the Sub DAS Selindung area, environmental education programs for the local community, and the implementation of village-level regulations.

Stakeholder Collaboration

Successful conservation and restoration of the Sub DAS Selindung watershed, alongside the sustainability of the local fishing economy, require collaboration among stakeholders, including government bodies, environmental organizations, fishermen, and local communities. This cooperation is crucial for achieving both conservation and sustainable development objectives. The study emphasizes the importance of ecosystem preservation in maintaining the long-term economic stability of mud crab fishermen. Effective policies and actions are needed to protect the environment and secure the economic future of these communities, ensuring the responsible use of natural resources for future generations.

Policy Recommendations

The study provides several policy recommendations to ensure the sustainability of the mud crab fishing economy in Sub DAS Selindung namely (1) Enforce Land Protection: Strengthen enforcement against illegal land encroachment, especially illegal mining activities (Inkonvensional Mining). (2) Monitor Fishing Practices: Implement stricter monitoring of mud crab harvesting practices to ensure sustainability. (3) Support the Supply Chain: Advocate for better market access and improved supply chain management for local fishermen and fishing groups. (4) Promote Sustainable Practices: Conduct regular education on sustainable environmental management practices for the community. (5) Provide Financial Assistance: Offer financial support to fishermen to help them adapt to environmental changes and maintain their livelihoods. (6) Strengthen Environmental Governance: Allocate sufficient political and financial resources for comprehensive watershed management. Strengthen cooperation between the UPTD KPH, law enforcement, and the community to combat illegal mining activities. Additionally, enhance human resource development to prevent corruption in environmental management systems.

Conclusion

Sub DAS Selindung, as part of the larger DAS Baturusa, holds significant natural resource potential, particularly through its mangrove ecosystem and the associated biota, such as the mangrove crab (*Scylla serrata*). The mangrove forest, which covers approximately 349 Ha and is categorized as having dense canopy cover, provides a crucial habitat for these species. The sustainability of the mangrove crab population directly

depends on the health of the mangrove ecosystem, which is also integral to the livelihoods of local mud crab fishermen who rely on this resource for their income. However, the continuous viability of this ecosystem faces several challenges, including environmental changes that negatively impact water quality and the habitat. Therefore, it is essential to implement sustainable environmental management practices in Sub DAS Selindung. This requires comprehensive policy frameworks, political support for budgeting, effective law enforcement, and the development of human resources for both environmental management and local governance. Moreover, it is critical to strengthen the economic supply chain by advocating for practices that benefit both fishermen and fish farming groups, ensuring that their economic interests align with the preservation of the mangrove habitat. In addition, the active involvement of all stakeholders, including the local community, is essential for creating awareness and securing long-term conservation efforts. Ultimately, ensuring the sustainability of Sub DAS Selindung's natural resources requires an integrated approach that balances ecological preservation with the socio-economic needs of local communities, promoting both environmental health and economic resilience.

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