



Blood cockle farming on the east coast of Sumatra: a legal and monopoly analysis

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Abstract. Blood cockle (*Anadara granosa*) farming has become one of the most economically important coastal aquaculture activities on the east coast of Sumatra, Indonesia. Despite its significant contribution to local livelihoods, exports, and regional economic growth, the rapid expansion of the industry has generated increasing concerns regarding coastal governance, legal certainty, and market concentration. This study was aimed to analyze the legal and monopoly issues associated with blood cockle farming and their implications for sustainable coastal resource management. A qualitative case study approach was employed using field observations, stakeholder interviews, document analysis, and review of relevant legislation governing coastal areas, fisheries, and marine spatial planning. The findings reveal that blood cockle cultivation is predominantly conducted on state-owned intertidal mudflats where formal tenure rights are generally absent. Ownership claims are largely based on customary occupation and informal local agreements, resulting in frequent disputes over cultivation boundaries, unauthorized harvesting, and restricted public access to coastal resources. The study further identifies overlapping institutional authority and inconsistent regulatory implementation as major obstacles to effective governance. Market analysis indicates increasing concentration of productive farming areas, capital ownership, and export marketing networks in the hands of a limited number of investors and collectors. This condition creates localized monopoly over cultivation grounds and oligopsonistic market structures that weaken the bargaining power of small-scale farmers and increase their dependence on dominant buyers. Consequently, economic benefits are distributed unevenly, while access to productive coastal resources becomes increasingly restricted for traditional fishing communities. The study concludes that sustainable development of blood cockle farming requires integrated coastal governance based on transparent tenure allocation, strengthened legal enforcement, equitable market institutions, and participatory resource management. Such institutional reforms are essential to balance economic development with social equity, environmental sustainability, and long-term resilience of Indonesia's coastal aquaculture sector.

Keywords: *Anadara granosa*, coastal aquaculture, coastal governance, intertidal zone, legal issues, monopoly, oligopsony.

Introduction. Blood cockle (*Anadara granosa*) aquaculture has become one of the most valuable shellfish industries in Southeast Asia due to its high commercial demand, relatively low production costs, and significant contribution to coastal livelihoods. Indonesia possesses extensive intertidal mudflat ecosystems suitable for blood cockle cultivation, particularly along the east coast of Sumatra bordering the Malacca Strait. These coastal ecosystems provide favorable environmental conditions, including muddy substrates, tidal exchange, and nutrient-rich estuarine waters, enabling blood cockle farming to become an important component of the regional blue economy and seafood export sector (Yulinda et al., 2020).

The east coast of Sumatra is recognized as the largest blood cockle-producing region in Indonesia, with the waters of Rokan Hilir Regency, Riau, serving as one of its major production centers. Commercial cultivation has expanded rapidly since

approximately 2010 in response to increasing domestic and international demand. The regency produced approximately 6,492.47 tonnes of blood cockles in 2018, representing 49.67% of the total aquaculture production in the region (Yulinda et al., 2021; Riza et al., 2024). The cultivation area extends across extensive intertidal mudflats in Panipahan, Sinaboi, Bangko, and surrounding coastal districts, where environmental conditions remain highly suitable for shellfish production. Recent environmental assessments indicate that water quality, heavy metal concentrations, and microbiological parameters remain within acceptable limits for sustainable aquaculture, although increasing cultivation intensity has raised concerns regarding ecosystem carrying capacity and long-term environmental sustainability (Smaal et al., 2019; Wijsman et al., 2019; FAO, 2022).

Previous studies have predominantly examined blood cockle farming from biological, environmental, and economic perspectives. Research has focused on production efficiency, water quality, food safety, heavy metal contamination, business feasibility, and economic profitability, consistently demonstrating that blood cockle farming is a financially attractive enterprise capable of improving coastal household incomes (Yulinda et al., 2021; Riza et al., 2024). Likewise, studies on production economics have identified land productivity, production inputs, and allocative efficiency as major determinants of farm performance, while recent investigations have highlighted the increasing economic value of mudflat resources through land-rent analysis (Sujan et al., 2021; Sujan et al., 2025).

Despite the substantial body of literature concerning aquaculture production and environmental management, the legal dimensions of blood cockle farming remain largely unexplored. Along the east coast of Sumatra, particularly in Rokan Hilir Regency, productive intertidal mudflats that legally constitute public coastal resources have increasingly become subject to exclusive control by individuals, local elites, or private business actors. In practice, many cultivation areas are operated through informal tenure arrangements, hereditary claims, or exclusive leasing systems that effectively restrict access by other coastal communities. Consequently, coastal areas that should function as common resources have gradually transformed into privately controlled production zones, creating unequal access to marine resources and generating conflicts among resource users. Although these practices are widely recognized by local communities, they have received very limited scholarly attention from legal and institutional perspectives (Riza et al., 2021).

From the perspective of Indonesian law, coastal areas and small islands constitute natural resources controlled by the State and managed for the greatest prosperity of the people under Article 33 of the 1945 Constitution of the Republic of Indonesia (CRI 1945, 2002) and Law No. 27/2007 concerning the Management of Coastal Areas and Small Islands, as amended by Law No. 1/2014. The legislation emphasizes integrated coastal management, public participation, equitable access, environmental sustainability, and conflict resolution in coastal resource utilization. Nevertheless, implementation at the local level often encounters institutional weaknesses, overlapping administrative authority, unclear tenure arrangements, and inadequate law enforcement, creating opportunities for *de facto* monopolization of public coastal resources. Such conditions challenge the legal certainty of coastal governance and potentially conflict with the constitutional principle that natural resources should be managed for the greatest benefit of society rather than for exclusive private interests.

The emergence of exclusive control over blood cockle farming areas also raises important questions regarding competition policy and monopoly practices. While Indonesian Law No. 5/1999 concerning the Prohibition of Monopolistic Practices and Unfair Business Competition primarily regulates market competition, exclusive occupation of productive mudflats may create significant barriers to entry for small-scale fishers and new aquaculture entrepreneurs. Control over strategic cultivation areas enables dominant actors to determine access to production sites, influence rental values, and strengthen market concentration without formal ownership rights. The recent increase in land-rent values observed in blood cockle farming areas illustrates that access to cultivation space has become an increasingly valuable economic asset whose distribution is not always governed by transparent legal mechanisms.

The intersection between coastal resource governance, property rights, and competition law represents a significant research gap within Indonesian coastal studies. Existing studies have primarily evaluated environmental sustainability and economic performance but have paid limited attention to how informal tenure systems, monopolistic control of cultivation areas, and weak institutional governance influence equitable resource distribution, social justice, and sustainable coastal development (Warren & Steenbergen, 2021; Ananingsih et al., 2026). Addressing these issues is particularly important because blood cockle farming increasingly represents one of the most valuable blue economy sectors in eastern Sumatra, where conflicts over coastal space are expected to intensify alongside expanding commercial aquaculture (Bennett et al., 2019; FAO, 2022; MMAF, 2023). This study investigates blood cockle farming on the east coast of Sumatra through an integrated framework combining coastal law, common-pool resource governance, and monopoly analysis. Unlike previous studies that focus primarily on environmental quality or production economics, this research examines the legal status of cultivation areas, the institutional mechanisms governing access to coastal resources, and the extent to which exclusive control over intertidal mudflats reflects monopolistic practices that may undermine equitable coastal resource management.

Material and Method

Time and place. This study was conducted from July 2024 to December 2025 in five districts - Limau Kapas, Kubu, Kubu Babussalam, Bangko, and Sinaboi - in Rokan Hilir Regency, east coast of Sumatra, Indonesia.

Study design. This study employed a qualitative descriptive research design using a serial field observation, measurement, interview and systematic literature review combined with legal analysis to evaluate blood cockle farming on the east coast of Sumatra, Indonesia. The study synthesized scientific evidence regarding biological, environmental, economic, and legal aspects of blood cockle aquaculture, with particular emphasis on resource governance, land tenure, monopoly issues, and sustainable coastal management. Unlike conventional aquaculture studies focusing solely on production performance, this research integrates environmental science, fisheries economics, coastal governance, and competition law to develop a comprehensive understanding of the sustainability of blood cockle farming. The financial feasibility of blood cockle farming was evaluated using three complementary investment indicators: benefit-cost ratio (BCR), payback period (PP), and net present value (NPV).

Data collection. Primary data were collected from five districts (Limau Kapas, Kubu, Kubu Babussalam, Bangko, and Sinaboi) by measuring water quality (salinity, temperature, pH, dissolved oxygen, alkalinity, and water transparency), and observing cultivation sites (extent and location of blood cockle cultivation areas relative to the coastline and settlements, cultivation systems and technology, and security and safety aspects). These data collection activities were carried out three times in each district. A series of in-depth interviews were conducted with blood cockle farmers (30 individuals), fishermen (30), fish traders (5), government officials (5), and other community figures (5). Secondary data were collected from peer-reviewed scientific publications, government regulations, institutional reports, and international organization databases published between 2000 and 2025. The primary keywords used during the literature search included: *A. granosa*, blood cockle farming, shellfish aquaculture, Rokan Hilir, coastal resource management, monopoly, coastal land tenure, blue economy, intertidal zone, sustainable aquaculture.

Legal framework analysis. The legal analysis employs a juridical-normative approach, examining the consistency of blood clam farming practices with Indonesian laws and regulations governing coastal resources. The primary legal documents analyzed included: Law of the Republic of Indonesia No. 31/2004 concerning Fisheries (LRI, 31/2004), Law of the Republic of Indonesia No. 45/2009 concerning Fisheries (LRI 45/2009), Law of the

Republic of Indonesia No. 32/2009 concerning Environmental Protection and Management (LRI 32/2009), Law of the Republic of Indonesia No. 23/014 concerning Regional Government (LRI 23/2014), Law of the Republic of Indonesia No. 32/2014 concerning Maritime Affairs (LRI 32/2014), Riau Province Regional Regulation No. 8/2014 concerning Environmental Management and Compliance with Environmental Laws in Riau Province (RPRR 8/2014), Riau Province Regional Regulation No. 10/2018 concerning the 2018-2038 Riau Province Regional Spatial Planning (RPRR, 10/2018), and 2023 Performance Report of the Directorate General of Aquaculture of Ministry of Marine Affairs and Fisheries of the Republic of Indonesia (MMAF, 2023).

Data analysis. The obtained data were categorized and organized according to requirements and analyzed descriptively, with reference to established standards and regulations in Indonesia.

Conceptual framework. The conceptual framework assumes that the sustainability of blood cockle farming in east coast of Sumatera, Indonesia is a multidimensional outcome shaped by the interaction of environmental sustainability, economic sustainability, legal governance, and institutional equity. Environmental sustainability provides the ecological foundation for production through adequate water quality, suitable habitat conditions, pollution control, and ecosystem health. Economic sustainability reflects the capacity of farming systems to generate stable returns through productivity, profitability, market access, employment, and value creation. Legal governance establishes the regulatory conditions governing coastal resource utilization through licensing, spatial regulation, property rights, environmental standards, and law enforcement. Institutional equity addresses the distribution of access, rights, participation, and benefits among coastal resource users, including small-scale farmers and local communities.

These dimensions are interdependent: ecological conditions influence productivity and profitability; economic incentives affect resource-use behavior; legal institutions regulate environmental and economic activities; and equitable institutions influence participation, compliance, and benefit distribution. The framework further recognizes potential trade-offs between short-term economic expansion and long-term ecological conservation. Consequently, sustainable blood cockle farming requires an integrated balance between ecological integrity, economic viability, effective governance, and social equity. Within Indonesia's Blue Economy framework, this integrated approach positions blood cockle farming not only as a source of economic value and employment but also as a component of sustainable coastal-resource management and community livelihood resilience.

Results

Overview of blood cockle farming. Blood cockle farming has become the dominant coastal aquaculture activity in east coast of Sumatra, like Rokan Hilir Regency, Riau Province, Indonesia. The culture system is primarily based on semi-intensive bottom culture established on extensive intertidal mudflats along the eastern coast of Sumatra. The major production centers are located in Panipahan (Pasisir Limau Kapas District), Sinaboi, Bagansiapiapi (Bangko District), Kubu, and Kubu Babussalam, where soft muddy substrates, regular tidal inundation, and nutrient-rich estuarine environments provide ideal ecological conditions for cockle growth. The farming cycle generally lasts between six and nine months, with production relying predominantly on naturally collected spat from adjacent coastal waters. Harvested blood cockles supply both domestic markets and international seafood markets, particularly Malaysia, Thailand, and Vietnam, highlighting the importance of this commodity to Indonesia's coastal blue economy.

Commercial cultivation began around 2010 and has expanded rapidly during the last decade in response to increasing export demand. By 2018, blood cockle production reached 6,492.47 tonnes, representing approximately 49.67% of the total aquaculture production of Rokan Hilir Regency (13,072.21 tonnes) (ARRHRFA, 2023). This contribution establishes blood cockles as the most important aquaculture commodity in

the regency and positions Rokan Hilir as the largest blood cockle-producing region in Riau Province. The continuous increase in production reflects both favorable environmental conditions and growing investment in coastal aquaculture.

Cultivation area and farming characteristics. Regency of Rokan Hilir possesses approximately 12,434 ha of coastal mudflat suitable for blood cockle cultivation. However, only about 1,200 ha, representing nearly 10% of the total suitable area, is currently utilized for commercial farming. Approximately 250 cultivators are actively engaged in blood cockle production, with the majority operating in Bangko, Pasir Limau Kapas, Sinaboi, and Kubu Babussalam Districts. The relatively low utilization rate suggests considerable potential for future expansion, provided that environmental carrying capacity and sustainable coastal management are maintained.

Blood cockle farming remains largely traditional despite its commercial importance. Farmers generally collect natural spat from nearby coastal waters (Sungai Daun Village) and distribute them directly onto intertidal muddy flats without artificial feeding or intensive management. Small spat are typically stocked at densities of approximately 2,000 individuals m^{-2} , whereas larger juveniles are stocked at 200-300 individuals m^{-2} . Grow-out periods generally range from 6 to 9 months, with harvesting conducted manually during low tide using hand collection or scoop nets. The dependence on natural recruitment demonstrates that production remains closely linked to the ecological health of surrounding coastal ecosystems (Yulinda et al., 2020; Riza et al., 2024).

Environmental conditions supporting blood cockle farming. Environmental assessments indicate that the culture areas maintain water quality conditions suitable for sustainable blood cockle production. Average salinity is approximately 34 ppt, water temperature ranges between 28.7 and 29.0°C, pH remains close to 8.0, dissolved oxygen varies from 4.4 to 6.1 mg L^{-1} , alkalinity ranges between 120 and 125 mg L^{-1} , and water transparency averages 50-55 cm. These environmental parameters fall within the optimal range reported for blood cockles cultivation in tropical estuarine ecosystems (Mahary et al., 2023; Mahary et al., 2026; Riza et al., 2024).

Economic performance of blood cockle farming. Blood cockle farming represents one of the most profitable livelihood activities available to coastal communities in Rokan Hilir Regency. Economic analyses involving 65 commercial farmers demonstrate favorable financial performance and strong investment potential. Average investment per farming unit is approximately IDR 39,261,544, generating an average production of 27,360 kg per production cycle. At an average selling price of IDR 8,000 kg^{-1} , farmers obtain gross revenues of approximately IDR 218,880,000 per production cycle and average net profits of IDR 142,919,739, equivalent to a monthly income of approximately IDR 20,417,105.

Financial feasibility indicators further confirm the economic attractiveness of blood cockle farming. The reported benefit-cost ratio (BCR) of 1.88 indicates that revenues substantially exceed production costs, while a payback period (PP) of only 1.92 months demonstrates rapid capital recovery. Additional sustainability assessments estimate production potentials ranging from 120,000 to 170,000 kg per harvest, accompanied by positive net present value (NPV) estimates, indicating that blood cockle farming remains financially feasible under current production systems. The profitability of this industry contributes substantially to employment generation, household income diversification, and regional economic development. Export-oriented production also strengthens the role of east coast of Sumatra within Indonesia's fisheries sector and supports the country's participation in international seafood markets.

Sustainability challenges. Despite its strong economic performance, several challenges threaten the long-term sustainability of blood cockle farming in east coast of Sumatra. The most significant constraint remains the industry's heavy dependence on natural spat recruitment, making annual production highly vulnerable to fluctuations in natural spawning success and environmental conditions. The absence of commercial hatchery

technology limits opportunities for production intensification and increases uncertainty in seed availability.

Furthermore, continued expansion of cultivation areas may increase pressure on coastal ecosystems through habitat alteration and intensified resource utilization. The increasing occurrence of anthropogenic garbage contamination, combined with competition for coastal land use among fisheries, aquaculture, transportation, and coastal development sectors, presents additional management challenges. These pressures highlight the importance of implementing integrated coastal zone management strategies that balance economic development with ecosystem conservation.

The considerable proportion of undeveloped mudflat areas also presents a dual challenge. While these areas offer substantial opportunities for expanding blood cockle production, uncontrolled development without adequate environmental planning could accelerate habitat degradation, reduce ecosystem resilience, and increase conflicts over coastal resource use. Consequently, future development should prioritize sustainable hatchery technology, environmental monitoring, ecosystem-based management, and comprehensive coastal governance to ensure the long-term viability of blood cockle aquaculture on the east coast of Sumatra.

Legal issues. The field survey and stakeholder interviews revealed that the rapid expansion of blood cockle farming on the east coast of Sumatra has generated not only significant economic benefits but also complex legal and market governance issues. These findings indicate that the major constraints facing the industry are no longer primarily technical, but institutional, involving coastal tenure, regulatory enforcement, market concentration, and unequal access to coastal resources.

The most prominent legal issue identified during the survey was the absence of formal ownership rights over intertidal cultivation areas. Blood cockle farming is predominantly conducted on state-owned coastal mudflats located within the intertidal zone. Although farmers have occupied these areas for many years, most cultivation plots are not supported by legally recognized land titles or long-term utilization permits. Instead, ownership claims are generally based on local customs, historical occupation, verbal agreements, or recognition by village authorities. Consequently, farmers frequently experience legal uncertainty regarding tenure security, particularly when new investors attempt to occupy adjacent areas or when disputes arise over cultivation boundaries. Similar governance challenges have recently been reported in Rokan Hilir, where regulatory ambiguity remains one of the principal obstacles to sustainable blood cockle development.

Another major issue concerns the privatization of public coastal space. Field observations showed that extensive sections of intertidal mudflats have been demarcated using bamboo poles, wooden markers, or floating boundaries that effectively function as private property. Although these areas legally remain public coastal waters, access by traditional fishermen has become increasingly restricted. Fishermen reported that they are frequently prohibited from passing through or fishing within cultivation areas because farmers regard these zones as private investments. Consequently, common-property coastal resources have gradually been transformed into de facto exclusive production areas without comprehensive legal mechanisms governing access rights or compensation.

Conflicts between blood cockle farmers and traditional fishermen have consequently become more frequent. Interview results indicated that disputes generally involve overlapping cultivation claims, unauthorized harvesting, destruction of boundary markers, and accusations of shellfish theft during harvesting seasons. Since formal legal documentation is often unavailable, conflict resolution usually depends on village leaders or informal negotiations rather than judicial processes. This situation reflects weak enforcement of coastal governance regulations and limited institutional capacity to resolve tenure disputes efficiently.

Respondents also highlighted inconsistencies in government regulation. Several stakeholders indicated that responsibilities for coastal management are divided among fisheries agencies, marine affairs authorities, environmental agencies, and regional planning institutions. This overlapping institutional authority creates uncertainty

regarding licensing procedures, environmental permits, and allocation of new farming areas. Recent policy analyses similarly conclude that regulations governing blood cockle cultivation, seed collection, price stabilization, and coastal land allocation remain inadequate, creating opportunities for conflict and illegal occupation of cultivation sites.

Monopoly issues. Besides legal uncertainty, the survey revealed increasing indications of resource concentration and localized monopoly within the blood cockle industry. Although thousands of coastal households participate in production, economically productive cultivation areas are increasingly controlled by relatively few investors or large-scale operators possessing greater financial resources.

One form of monopoly identified was exclusive occupation of productive mudflat habitats. Because suitable muddy intertidal environments are geographically limited, early investors have secured extensive farming grounds through continuous occupation. These operators subsequently prevent new entrants from accessing suitable cultivation sites by establishing physical boundaries and claiming exclusive harvesting rights. Although these claims are rarely supported by formal legal ownership, they are generally recognized within local communities, creating substantial barriers for new farmers wishing to enter the industry.

The survey also identified capital concentration as an important driver of market dominance. Blood cockle farming requires considerable financial investment for seed procurement, transportation, labor, boundary construction, and harvesting. Small-scale fishermen often lack sufficient working capital and therefore depend on local financiers or large collectors to fund production activities. In return, farmers are commonly required to sell their harvest exclusively to these financiers at predetermined prices. This financing mechanism significantly reduces farmers' bargaining power while strengthening the market position of dominant buyers.

A further manifestation of monopoly occurs within the marketing system. Blood cockles produced along the east coast of Sumatra are exported primarily to Malaysia, Singapore, Thailand, and Vietnam through a relatively limited number of licensed exporters and wholesale collectors. Consequently, numerous small producers sell their products to only a few dominant buyers, creating an oligopsonistic market structure. Under such conditions, farm-gate prices are largely determined by exporters rather than producers, reducing income distribution among farmers despite sustained international demand. Value-chain analyses conducted in Riau Province similarly identify weak farmer bargaining positions, limited access to capital, and dependence on collectors as major governance constraints affecting industry sustainability.

The increasing economic value of blood cockle farming has also contributed to rising land rental values throughout major production areas. Economic surveys in Bangko District demonstrated that the profitability of blood cockle cultivation has substantially increased the rental value of coastal farming plots, making access progressively more difficult for small-scale operators while encouraging consolidation by financially stronger investors. This trend further accelerates resource concentration and may widen socioeconomic inequality among coastal communities.

Discussion. The present study demonstrates that blood cockle farming has evolved into one of the most important coastal aquaculture industries on the east coast of Sumatra. The remarkable expansion of the industry in Rokan Hilir Regency is primarily attributable to the region's extensive intertidal mudflats, favorable hydrographic conditions, and increasing international demand for shellfish products. The production of 7,716.90 tonnes in 2022, accounting for nearly half (66.35%) of the total aquaculture production in the regency, clearly indicates that blood cockle farming has become the dominant coastal aquaculture commodity in Riau Province (ARRHRFA, 2023; Riza et al., 2024). This trend is consistent with the rapid development of blood cockle aquaculture throughout Southeast Asia, where Indonesia, Malaysia, Thailand, and Vietnam collectively contribute a substantial proportion of global blood cockle production (FAO, 2024).

The dominance of blood cockle farming in Rokan Hilir is strongly associated with the ecological suitability of the coastal environment. Blood cockles are suspension-feeding

bivalves that require soft muddy substrates, moderate tidal flushing, and stable estuarine salinity to optimize growth and survival (Nurdin et al., 2006). The observed environmental conditions in the present study, including salinity around 34 ppt, water temperature between 28.7 and 29.0°C, dissolved oxygen concentrations of 4.4–6.1 mg L⁻¹, and slightly alkaline pH, fall within the optimal environmental ranges previously reported for blood cockle aquaculture (FAO, 2024; Riza et al., 2024). These environmental characteristics explain the relatively high productivity observed in east coast of Sumatra and support previous findings that tropical estuarine mudflats represent one of the most productive habitats for blood cockle cultivation.

Sustainability challenges. The farming practices documented in this study further indicate that blood cockle production remains heavily dependent on natural ecosystem processes. Farmers continue to rely almost exclusively on naturally collected spat, while grow-out activities are conducted using traditional bottom-culture systems without artificial feeding. Although this production system minimizes operational costs and maintains relatively low environmental impacts, dependence on natural recruitment introduces significant production uncertainty because spat availability is directly influenced by spawning success, environmental variability, and habitat quality (Broom, 1985). Similar challenges have been reported in Malaysia and Thailand, where declining natural spat abundance has become one of the principal constraints limiting future expansion of blood cockle aquaculture (LRI 32/2014; Ratchatapattanakul et al., 2017; FAO, 2024). Therefore, the establishment of hatchery technology capable of producing reliable seed supplies represents a strategic priority for ensuring long-term production stability in Indonesia.

Economic evaluation further confirms that blood cockle farming constitutes one of the most profitable aquaculture enterprises available to coastal communities. A Benefit-Cost Ratio of 1.88, rapid capital recovery, and average net profits exceeding IDR 140 million per production cycle indicate exceptionally attractive financial performance. These economic indicators exceed those reported for several other small-scale aquaculture commodities in Indonesia, including milkfish and traditional shrimp farming, reflecting the relatively low production costs associated with bottom-culture shellfish systems (Yulinda et al., 2021). Moreover, because blood cockles require no artificial feed, production costs remain comparatively low while export demand continues to generate favorable market prices. Such characteristics make blood cockle farming an effective instrument for coastal poverty reduction and rural economic development (Yurimoto et al., 2014).

However, the economic success of the industry also introduces important governance challenges. The high commercial value of productive mudflat ecosystems has increased competition over coastal land use, particularly in areas where property rights remain poorly defined. Previous studies in Rokan Hilir have demonstrated increasing land-rent values and the concentration of highly productive mudflat areas under limited ownership or long-term lease arrangements (Delwita et al., 2025). Such developments raise concerns regarding equitable access to coastal resources and may reduce opportunities for small-scale fishers to participate in commercially valuable aquaculture activities. Similar patterns of resource concentration have been documented in common-pool coastal resources elsewhere, where weak governance institutions frequently facilitate unequal resource allocation and conflicts among coastal stakeholders (Ostrom, 1990; LRI, 31/2004; LRI 4/2009).

The findings of this study therefore have implications extending beyond aquaculture production alone. The combination of high economic returns, increasing export demand, and limited access to productive cultivation areas creates conditions in which coastal resources become economically concentrated. Although this study primarily evaluates production characteristics, the observed expansion of commercial blood cockle farming provides an important foundation for examining broader questions concerning coastal governance, legal certainty, public resource allocation, and monopoly practices. Under Indonesian constitutional principles, coastal resources constitute public assets that should be managed for the greatest benefit of society through equitable and sustainable utilization (LRI, 27/2007; LRI, 1/2014). Consequently, future policy should ensure that

industry expansion is accompanied by transparent tenure systems, environmental safeguards, effective law enforcement, and equitable access for local coastal communities.

Legal issues. One of the most critical legal problems is the absence of clear property rights over intertidal mudflats, where blood cockles are cultivated. Under Indonesian law, coastal waters and intertidal zones constitute state-controlled resources whose utilization should follow integrated coastal management principles. However, many cultivation areas have evolved through customary occupation, informal agreements, or local recognition rather than legally registered tenure. Consequently, farmers frequently claim exclusive rights over mudflats without possessing formal permits, while neighboring communities continue to regard these areas as open-access fishing grounds. This legal ambiguity has become a major source of disputes among farmers, traditional fishermen, and local governments (FAO, 2012; LR1, 1/2014; RPRR, 10/2018).

Another important issue concerns the conversion of public coastal space into de facto private production areas. As blood cockle farming expands, extensive bamboo markers and boundary poles are installed across intertidal zones to delineate farming plots. Although these structures serve management purposes, they may restrict navigation, shellfish gathering, and fishing activities traditionally undertaken by coastal communities. Such practices gradually transform common-property resources into privately controlled production areas without comprehensive legal procedures or environmental impact assessments.

The governance challenge is further complicated by overlapping institutional authority. Coastal resource management in Indonesia involves multiple government agencies responsible for fisheries, marine affairs, spatial planning, environmental protection, and regional administration. In many districts, inconsistencies between marine spatial plans, local regulations, aquaculture licensing, and environmental permits create uncertainty regarding who possesses the authority to allocate coastal farming areas. These overlapping jurisdictions often delay licensing procedures while simultaneously weakening enforcement against illegal occupation of coastal land. Similar governance deficiencies have been identified in blood cockle farming systems in Riau Province, where regulatory ambiguity and weak institutional coordination reduce investment certainty and encourage conflicts over ownership claims (LRI, 23/2014; Talib et al., 2022).

Environmental compliance represents another significant legal concern. Blood cockle farming depends heavily on healthy estuarine ecosystems characterized by suitable sediment quality, salinity, and water exchange. However, increasing coastal development, river pollution, shipping activities, and upstream land-use changes threaten environmental sustainability. Effective legal frameworks therefore require integration between aquaculture licensing and environmental monitoring to ensure that production expansion does not exceed ecosystem carrying capacity. Failure to integrate environmental governance with aquaculture regulation may ultimately reduce productivity while increasing ecological risks (Halpern et al., 2008; LRI, 32/2009). Law enforcement remains relatively weak. Reports from several farming regions indicate recurring theft of cultured cockles, unauthorized harvesting, and illegal occupation of farming plots. Because ownership boundaries are often poorly documented, legal disputes are difficult to resolve through formal judicial mechanisms, encouraging informal conflict resolution and reducing investor confidence (Satria & Matsuda, 2004; FAO, 2022).

Monopoly issues. Beyond legal challenges, blood cockle farming on the east coast of Sumatra increasingly exhibits characteristics of market concentration and localized monopoly power. Although thousands of coastal households participate in cultivation, control over productive areas, capital, marketing channels, and export networks is often concentrated among relatively few large investors or financially powerful operators.

The first manifestation of monopoly is exclusive control over coastal farming grounds. Since suitable mudflat habitats are geographically limited, early investors frequently secure extensive cultivation areas that effectively exclude new entrants. While formal ownership may not exist, long-term occupation combined with physical boundary markers creates *de facto* exclusive control over public coastal resources. Such concentration reduces equitable access for small-scale fishermen seeking alternative livelihoods (Bennett et al., 2019; FAO, 2022).

A second issue involves vertical integration within the supply chain. Large operators commonly control seed procurement, production financing, harvesting equipment, post-harvest handling, transportation, and access to export buyers. Small-scale farmers consequently become dependent on dominant traders or investors for working capital and market access. This dependency substantially weakens farmers' bargaining positions during price negotiations and often leads to asymmetric profit distribution.

Market concentration is particularly evident in export-oriented production. Blood cockles from Riau and North Sumatra are marketed primarily to Malaysia, Thailand, Singapore, and Vietnam, where relatively few exporters possess the logistical infrastructure, cold-chain facilities, and international trading networks required for cross-border commerce. Consequently, export prices are frequently determined by a limited number of buyers, creating conditions resembling oligopsony, in which numerous producers sell to only a few dominant purchasers. Under these circumstances, farm-gate prices may not accurately reflect international market values, reducing income received by producers despite strong export demand (Shepherd, 2007; Sexton, 2013).

Monopoly tendencies are also reinforced through capital barriers. Commercial blood cockle farming requires substantial investment in seed, boundary construction, labor, harvesting operations, and security. Small-scale fishermen often lack sufficient financial resources and therefore depend on private investors or middlemen for production loans. These financing arrangements frequently oblige farmers to sell harvests exclusively to lenders at predetermined prices, reducing market competition and strengthening buyer dominance (World Bank, 2012; FAO, 2022).

Another concern is the emergence of resource monopolization, whereby large operators continuously expand cultivation areas through informal agreements or political influence. As productive mudflats become increasingly occupied, traditional fishers experience declining access to common fishing grounds, potentially increasing socioeconomic inequality within coastal communities. Similar patterns of enclosure have been reported in other coastal aquaculture systems worldwide, where privatization of common-property resources reduces livelihood diversification and intensifies conflicts among resource users (Hall et al., 2011; Barbesgaard, 2018).

The coexistence of legal uncertainty and emerging monopoly structures indicates that blood cockle farming governance requires institutional reform rather than merely production expansion. Sustainable development should emphasize transparent allocation of coastal farming areas, legally recognized tenure systems, equitable access for local communities, and effective enforcement mechanisms. Marine spatial planning should clearly designate aquaculture zones while protecting public access corridors and traditional fishing grounds. Furthermore, competition policies should encourage farmer cooperatives, transparent marketing systems, and diversified export channels to reduce dependence on dominant intermediaries (Ehler & Douvère, 2009; LRI, 1/2014; FAO, 2022).

A participatory governance framework involving government agencies, local communities, researchers, and private investors would improve legal certainty while minimizing conflicts over coastal resources. Strengthening cooperative institutions, improving licensing transparency, and implementing ecosystem-based coastal management can simultaneously enhance economic efficiency, environmental sustainability, and social equity. Such reforms are essential to ensure that the rapid expansion of blood cockle aquaculture contributes to inclusive blue economy development rather than accelerating coastal resource monopolization and social exclusion (RPRR 8/2014; Mahary et al., 2026; Nyoto et al., 2026).

Conclusions. The increasing commercial value of productive intertidal mudflats has intensified competition over coastal space, creating conditions that may facilitate exclusive control of public coastal resources through informal tenure arrangements, land-rent concentration, and unequal access to cultivation areas. Such circumstances raise important legal and institutional concerns regarding resource equity, transparency, and compliance with Indonesian coastal management legislation. As coastal mudflats constitute public resources under national law, future expansion of blood cockle farming should be accompanied by transparent licensing systems, equitable allocation of cultivation areas, effective law enforcement, and integrated coastal spatial planning to prevent monopolistic control and resource conflicts.

The findings of this study have several important implications for policymakers and coastal resource managers:

1. development of a legal framework for cultivation rights, ensuring transparent, accountable, and equitable allocation of coastal farming areas;
2. implementation of ecosystem-based coastal spatial planning to balance aquaculture expansion with environmental conservation and other coastal uses;
3. investment in hatchery technology to reduce dependence on natural spat recruitment and improve production stability;
4. enhancement of institutional governance and law enforcement to prevent monopolistic control of public coastal resources and ensure that the economic benefits of blood cockle farming are distributed fairly among coastal communities.

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Conflict of Interest. The authors declare that there is no conflict of interest.

Data Availability. The data supporting the findings of this study are available from the corresponding author upon reasonable request.

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