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Financial Feasibility of Shrimp Fishery Based on Fishing Gear Type in Kuala Langsa, Langsa, Aceh

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ABSTRACT

This study aimed to evaluate the financial feasibility of four types of traditional shrimp fishing gear—namely bottom longline, collapsible shrimp trap, lift net, and modified lift net—used by small-scale fishers in the waters of Kuala Langsa, Aceh. A total of twenty-three shrimp fishermen were interviewed using a total sampling approach, and financial data were analyzed based on key indicators, including Net Profit, Revenue/Cost Ratio (R/C), Payback Period, Net Present Value (NPV), Benefit-to-Cost Ratio (B/C), and Internal Rate of Return (IRR). The results showed that the bottom longline provided the highest financial performance, with the fastest payback period and the highest IRR. However, substantial variation between business units suggests that profitability is highly influenced by differences in operational efficiency, technical skill, or ecological conditions. The collapsible shrimp trap ranked second, demonstrating high profitability and the most consistent performance, as indicated by a narrow interquartile range and the absence of outliers. The lift net and modified lift net were also considered economically viable but exhibited greater variability in outcomes. Distribution analysis using swarmplots and boxplots offered a detailed picture of performance patterns across business units. These results underscore the differences in profit potential and performance stability between gear types and highlight the importance of considering both efficiency and consistency in selecting appropriate technologies for small-scale fishers—particularly in the design of support programs and policy interventions.

INTRODUCTION

Capture fishery is a key sector in providing food and livelihoods for coastal communities, particularly in developing countries. Among these fishery subsectors, small-scale fishery (SSF) plays a crucial role, serving as a major contributor to food security and job creation, especially in developing countries and coastal areas **(Belhabib *et al.*, 2015; Loring *et al.*, 2019; Arthur *et al.*, 2021; FAO, 2022; March & Failler,**

2022). Shrimp is a key commodity that illustrates the strategic role of SSF, due to its high economic value and growing demand in both domestic and international markets **(Bondad-Reantaso *et al.*, 2012; Miao & Wang, 2020)**. This commodity not only supports the economies of coastal communities through SSF but also plays a significant role in the global aquatic food trade, particularly as a high-value export from developing countries **(Bondad-Reantaso *et al.*, 2012; Lira *et al.*, 2021)**. **FAO (2022)** data show that global shrimp and giant prawn catches reached nearly 3.4 million tonnes in 2017, a record high over the last decade. Since then, catch volumes have remained stable at 3.1–3.4 million tonnes annually, reflecting significant economic and social contributions, particularly to developing countries and coastal communities **(Bondad-Reantaso *et al.*, 2012; FAO, 2022)**.

SSF in Indonesia comprises approximately 2.5–2.7 million households and individuals **(Stacey *et al.*, 2021; Saksono *et al.*, 2023)**. This estimate contributes more than 80% of the total national catch **(Ayunda *et al.*, 2018)**. A WRI report showed that 97% of capture fishery operators in Indonesia use small vessels, generally under 10 GT **(Napitupulu *et al.*, 2022)**. According to **Nurantono (2024)**, capture fishery—which includes both marine and inland waters—produces approximately 7 million tons of catch annually and employs about 7 million workers. This industry also meets more than 50% of the nation's animal protein needs. Approximately 90% of operators in this sector are classified as SSF, based on socio-economic and technical criteria. Despite differences in classification and data coverage, various sources consistently emphasize that SSF are a pillar of food security and local economies.

Although SSF plays a crucial role in food security and local economies, fishermen in Indonesia face various challenges, such as lack of capital, limited access to modern technology, and restricted operational capacity. These constraints lead most fishermen to rely on simple and easy-to-operate traditional fishing gear. One area that continues to use traditional shrimp fishing systems is the waters of Kuala Langsa, Langsa City, Aceh Province. In this region, fishermen use various types of traditional fishing gear adapted to shrimp habitat characteristics and household economic capacity. Common types include collapsible shrimp traps (bubu), lift nets (tanggok), modified lift nets, and bottom longlines—passive fishing gear rooted in local wisdom. Their use not only reflects a commitment to tradition but also serves as an adaptive strategy for overcoming technological and capital limitations. Indonesian fishermen generally choose fishing locations based on intuition passed down from one generation to the next **(Picaulima *et al.*, 2024)**.

The four gear types operate without motorized assistance and rely on the natural behavior of target organisms. Various studies have shown that passive fishing gear has several advantages over active gear, including high selectivity by species and size, low discard rates, and minimal impact on benthic habitats **(Suuronen *et al.*, 2012; Petetta *et al.*, 2021)**. Furthermore, this gear is generally cost- and labor-effective, and easily assembled using locally available materials—making it particularly well-suited to the economic conditions of small-scale fishers. These characteristics make passive fishing gear not only a reflection of local wisdom but also an adaptive strategy that supports sustainable fisheries. However, positive ecological impacts must be accompanied by tangible economic benefits for the technology to be widely and sustainably adopted.

Several studies have evaluated the financial viability of traditional fishing gear in small-scale capture fisheries. A study by **Mariappan *et al.* (2025)** on India's southeastern coast showed that traditional fish traps yielded a Benefit-Cost Ratio (BCR) of 1.64, highlighting their economic efficiency and potential to improve fisher welfare. Similarly, a study in Nigeria by **Ashley-Dejo and Adelaja (2021)** recorded a BCR of 1.29, further confirming the financial viability of traditional fishing gear in SSF. In Indonesia, **Welis *et al.* (2023)** found that gillnets used for crab fishing in Pangkajene, South Sulawesi, had a BCR of 1.36 and a Payback Period (PP) of only one year—demonstrating the profitability of traditional fishing in the local context. These findings provide an empirical basis for emphasizing the importance of financial evaluation when developing feasibility models for SSF. Beyond profitability, **Schuhbauer and Sumaila (2016)** argued that economic evaluations of SSF must also integrate social and ecological dimensions, which are often overlooked in conventional analyses.

Although the economic potential of traditional fishing gear in SSF has been widely discussed, no study has specifically assessed the financial viability of various types of traditional shrimp fishing gear in regions such as Kuala Langsa. Therefore, this study aimed to evaluate the financial viability of four traditional shrimp fishing gear types used in the waters of Kuala Langsa, Aceh Province. Financial data play a critical role in designing policies that support the sustainability of SSF. The findings are expected to strengthen current understanding of SSF's economic efficiency and serve as a basis for developing policies that promote resource sustainability and improve the welfare of traditional fishermen. This approach aligns with national policies and global guidelines emphasizing the importance of SSF in achieving sustainable development goals. The **FAO (2022)** SSF Guidelines stress the need to prioritize the sector in decision-making, policy development, and capacity building to support food security and poverty reduction. At the national level, a data-driven approach—such as that proposed by **Napitupulu *et al.* (2022)**—provides a crucial foundation for an evidence-based policy framework that supports ecological sustainability and the social well-being of small-scale fishers.

MATERIALS AND METHODS

1. Study site and respondents

This study used a quantitative descriptive approach to analyze financial feasibility aspects based on fishing gear types in Kuala Langsa Waters, Langsa, Aceh Province (Fig.

1). The location was selected purposively since it is one of the active traditional capture fishery centers on the east coast of Aceh, dominated by small-scale fishers.

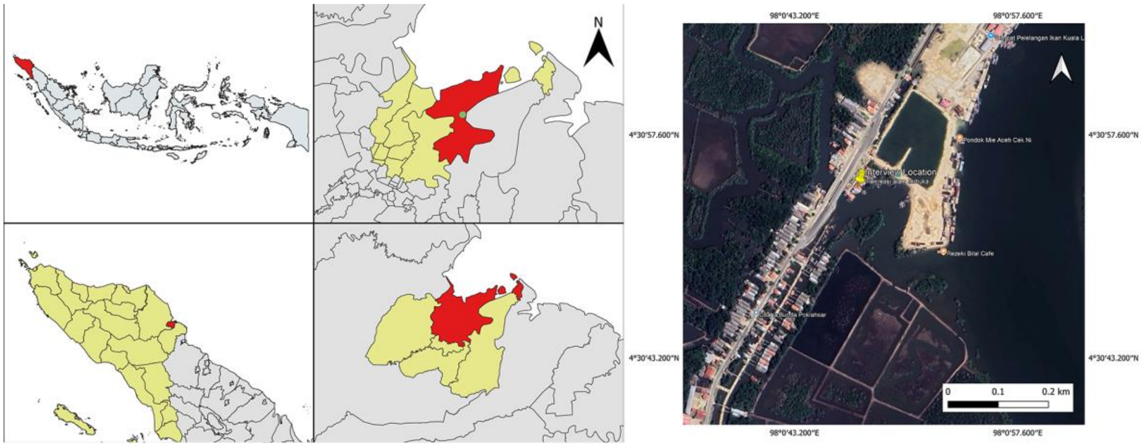

Fig. 1. Map of the study area showing interview locations of shrimp fishers in Kuala Langsa, Langsa, Aceh

Data collection was conducted through structured interviews using a questionnaire administered to the entire population of shrimp fishermen who had been actively operating for at least one year. A total of 23 fishermen met the inclusion criteria. Based on the type of fishing gear used, respondents were grouped into four categories: collapsible shrimp trap (11 people), lift net (7 people), modified lift net (3 people), and bottom longline (2 people). Although the number of respondents for certain gear types—particularly bottom longline—was small, the study was designed as an exploratory financial assessment. As such, the findings are not intended to be statistically generalizable but rather to serve as a valuable foundation for local policy development and future research on small-scale fisheries.

Due to the limited population, a total enumerative sampling technique—also known as consecutive sampling—was employed. This non-probability sampling method involves recruiting all eligible subjects within a specified time frame, ensuring full population representation in small-scale research contexts **(Suresh & Sharma, 2014; Polit & Beck, 2021)**. It is considered one of the most effective non-probabilistic approaches for minimizing selection bias and maximizing representativeness, especially in studies involving limited populations in the field **(Thewes *et al.*, 2018)**.

2. Data collection and sampling

Data collection was carried out in June 2025 using a retrospective approach, reconstructing business activities over the previous one-year period (June 2024–May 2025) based on fishermen's recollections and available records. To minimize recall bias, triangulation was applied by cross-verifying fishermen's responses with written logs, peer interviews, and information from business partners. This methodology is commonly used in small-scale fishery (SSF) studies where historical data are scarce or fisheries are classified as data-limited. Its validity has been demonstrated in prior investigations, such as the Hong Kong capture fishery study by **Cheung and Sadovy (2004)** and the bioeconomic analysis of the sockeye salmon fishery by **Marsden *et al.* (2009)**. Although these studies were conducted in different regions, the retrospective methodology has proven suitable and can be appropriately adapted to SSF contexts in Southeast Asia, including Indonesia.

Most fishermen in Kuala Langsa rely on memory for recordkeeping, while others maintain manual logs. Previous studies have shown that technical and operational information—such as fishing locations, gear types, seasons, and target species—can be reliably used to estimate key financial indicators, including operational costs, revenue, and overall profitability. This type of information is also crucial for supporting effective decision-making in SSF management.

The collected data encompassed all key components required for a comprehensive financial analysis of shrimp fishing operations. These included initial investment costs, operating costs (both fixed and variable), catch volume, revenue, and net profit. The data collection process was carried out digitally using a structured interview form, summarized using spreadsheet software, and served as the foundation for the financial feasibility analysis based on the fishing gear type adopted by each respondent.

3. Financial indicators and analytical framework

The financial feasibility indicators analyzed in this study include Net Profit (NP), Revenue/Cost Ratio (R/C), Payback Period (PP), Break-Even Point (BEP) in rupiah and number of trips per year, Net Present Value (NPV), Benefit/Cost Ratio (B/C), and Internal Rate of Return (IRR).

Net Profit (NP) was calculated by determining the difference between total revenue (TR) and total cost (TC), using the formula:

$$NP = TR - TC \tag{1}$$

The formula reflects the difference between total revenue and business expenditure during the observation period. This approach has been used in the economic evaluation of SSFs, such as in a study by **Sreekanth *et al*. (2016)** in tropical coastal ecosystems in India.

R/C Ratio was calculated by dividing total revenue (TR) by total cost (TC), using the formula:

$$RC\ Ratio = TR / TC \tag{2}$$

An R/C value > 1 shows that business is profitable, while an R/C < 1 implies a loss-making condition **(Saksono *et al*., 2020)**.

Break-Even Point (BEP) was analyzed in two main forms according to the approach used by **Suryono *et al*. (2019)**, namely in units of annual financial value and the number of fishing trips per year.

BEP in rupiah per year was calculated using the formula:

BEP (IDR) = Annual Fixed Costs / [1 – (Annual Variable Costs / Annual Revenue)] (3)

This formula was used to determine the minimum annual income required for business to reach break-even point.

BEP in the form of the number of trips was calculated using the formula:

BEP (Trip) = Annual Fixed Costs / (Revenue per Trip – Variable Costs per Trip) (4)

This formula shows the minimum number of fishing trips that should be made in a year to cover fixed costs by the contribution margin per trip.

Payback Period was calculated as the amount of time (years) required for the cumulative net cash flow to equal the initial investment.

NPV was calculated for a five-year period using the formula by **Dobrowolski and Drozdowski (2022)**:

$$NPV = \Sigma_{t=0}^{n} [(Rt - Ct) / (1 + i)^t] \quad (5)$$

Where R_t = revenue in year t, C_t = cost in year t, t = year (from 0 to n), i = annual discount rate, and n = time horizon (five years).

NPV was used to assess the net economic value of shrimp fishing venture after considering the time value of money and served as one of the main indicators of medium-term financial feasibility.

Benefit-Cost Ratio (B/C) was calculated using the formula:

$$B/C\ Ratio = \Sigma\ PV\ Benefits / \Sigma\ PV\ Costs \quad (6)$$

Where, Σ PV Benefits and Σ PV Costs, respectively, represent the total benefits and costs that have been discounted to the present value according to the discount rate used.

The indicator reflects the ratio between financial benefits and total costs incurred in an investment and is used to assess financial feasibility based on whether the ratio is greater or less than one. A B/C ratio ≥ 1 shows that the benefits obtained exceed the costs incurred, hence, the venture is considered economically viable. This approach has been applied in coastal capture fishery studies, such as that of **Herrera-González *et al*. (2021)** in Colombia, who evaluated the efficiency of environmentally friendly shrimp fishing gear using present value analysis. In addition, **Saksono *et al*. (2020)** assessed financial feasibility of traditional trawl fishing gear in Indonesia.

The IRR is a commonly used measure of investment profitability. It is defined as the discount rate that results in the NPV of different cash flows over the analysis period equal to zero **(Mellichamp, 2017)**. The IRR reflects an investment internal rate of return and serves as a key indicator in assessing business financial viability. When the IRR exceeds the discount rate used, the investment is considered economically viable. The discount rate used in the NPV and IRR analysis was set at 6% per year, referring to the effective interest rate of the People Business Credit (KUR) which has been in effect since January 1, 2020 through the Regulation of the Coordinating Minister for Economic Affairs of the Republic of Indonesia **(Coordinating Ministry for Economic Affairs of the Republic of Indonesia, 2020)**.

IRR was calculated by finding the r value that satisfies the equation **(Mellichamp, 2017)**:

$$NPV = \Sigma_{t=0}^{n} [(Rt - Ct) / (1 + r)^t] = 0 \quad (7)$$

Where R_t = revenue in year t, C_t = cost in year t, r = internal rate of return (IRR), t = year, n = time horizon (five years)

In this study, an aggregate analysis was conducted based on gear type to assess the comparative financial viability of different fishing technologies. The objective is to reduce the influence of individual variability often present in SSF studies, such as differences in experience, scale of operation, and capital capacity. By grouping respondents by gear type, the analysis can focus on comparing financial efficiency of each technology. This approach is consistent with international evaluation practices, such as those applied by **Cashion *et al*. (2018)**, who reconstructed the economic contribution of global fishery based on gear classification, **Prestrelo *et al*. (2019)**, who classified small vessels, and **Roditi and Vafidis (2022)** in the Aegean Sea through the métiers classification. **Herrera-González *et al*. (2021)** also compared two types of shrimp fishing gear to assess investment efficiency in coastal Colombia. Although other technical variables such as vessels, engines, types of shrimp caught, and distribution chains are discussed in the results and discussion sections, gear classification remains the primary basis for evaluating financial viability.

The distribution and variation of values among respondents per fishing gear type were visualized using swarmplots and boxplots. These two graphical visualizations were selected due to the ability to describe the characteristics of small-scale economic data in detail and intuitively. Swarmplots show individual distributions in detail by adjusting the position of data points horizontally along the categorical axis to avoid overlap, thereby providing a clearer and more informative representation of the distribution. This visualization is extremely effective for showing all observations and is often used as a complement to boxplots, which present summary statistics in the form of medians, quartile ranges, and the presence of outliers **(Waskom, n.d.)**. However, boxplots were only applied to fishing gear groups with ≥ 5 respondents, because with very small sample sizes (n < 5), estimates of the interquartile range (IQR) and median can be unstable and biased according to sound statistical principles **(Krzywinski & Altman, 2014; Wilcox, 2017)**.

4. Data processing and visualization

All data were analyzed descriptively using Microsoft Excel software, while statistical visualization was performed in Python using the Matplotlib and Seaborn libraries. Before data collection, all respondents received clear information regarding the study purpose, the type of data collected, assurances of confidentiality, and the right to participate voluntarily. Consent was granted based on the ethical principles of social study as formulated in the Belmont Report **(National Commission for the Protection of Human Subjects in Biomedical and Behavioral Research, 1979)**, as well as Ethical Principles of Psychologists and Code of Ethics of the American Psychological Association **(American Psychological Association, 2022)**. Despite the limited sample size, the methodological rigor of this study is reinforced by the use of detailed financial indicators, gear-specific data aggregation, and alignment with methodological practices from previous international small-scale fishery studies. This design balances the practical constraints of field-based research with a robust and context-relevant assessment of economic feasibility.

RESULTS

Most traditional fishers in Kuala Langsa waters operated shrimp fishing operations individually or on a household scale, as evidenced by the small crew size and the single vessel per fisherman. The average shrimp fishing experience was 10.6 years, with a range of 2 to 35 years, showing accumulated local knowledge of the water conditions and target habitats. The vessels used were generally small wooden 6.4 meters long, approximately 1 meter wide, and equipped with 5.5–13 HP engines powered by Pertalite (Figure 2). New vessel cost between IDR 7–15 million, showing limited capital and adaptation strategies to shallow coastal environments. These characteristics reflect the general pattern of SSF in Indonesia, where small vessels and low-tech fishing gear are used primarily for local consumption and subsistence **(Putri *et al*., 2025)**. A study by **Quimby (2015)** on Banyak Island, Aceh, showed that traditional fishing communities exclusively use small, non-technological vessels to catch seafood in shallow waters such as coral reefs and mangroves. The use of this vessel not only enhances efficiency and affordability but also reflects a commitment to local ecology and adaptive practices within dynamic coastal socio-ecological systems. **FAO data (2022)** showed that over half of Indonesia 700,000 fishing vessels were non-motorized, and around 25% were small wooden (*dugout*).

Fig. 2. Shrimp fishing vessel in Kuala Langsa

The fishing gear used had cost differentiation in terms of unit price and number of operational units per trip. The average price of a lift net (Fig. 3b) and modified lift net (Fig 3a) was around IDR 300,000 per unit, a bottom longline was IDR 1,000,000 (Fig. 3c), and a collapsible shrimp trap (Fig. 3d) was only around IDR 45,000. The quantities used vary significantly, namely one to two units for lift net and variants, one unit for a bottom longline, and 40 to 50 units for collapsible shrimp trap. The bottom longline had the shortest lifespan, averaging 1.2 months, the lift net and modifications had 7 months, and the collapsible shrimp trap had the longest lifespan, at 11.6 months. Despite the low unit price, the need for large quantities and frequent replacements increased pressure on medium-term operational costs. In SSF that rely heavily on limited capital, efficiency in the selection, maintenance, and use of fishing gear is a determining factor for business sustainability **(Sangün *et al*., 2018; Mariappan *et al*., 2025)**. Studies in coastal India have shown that adaptation of fishing gear to the season and target species plays a significant role in business efficiency, affecting fishermen cost structure and catch **(Mariappan *et al*., 2025)**.

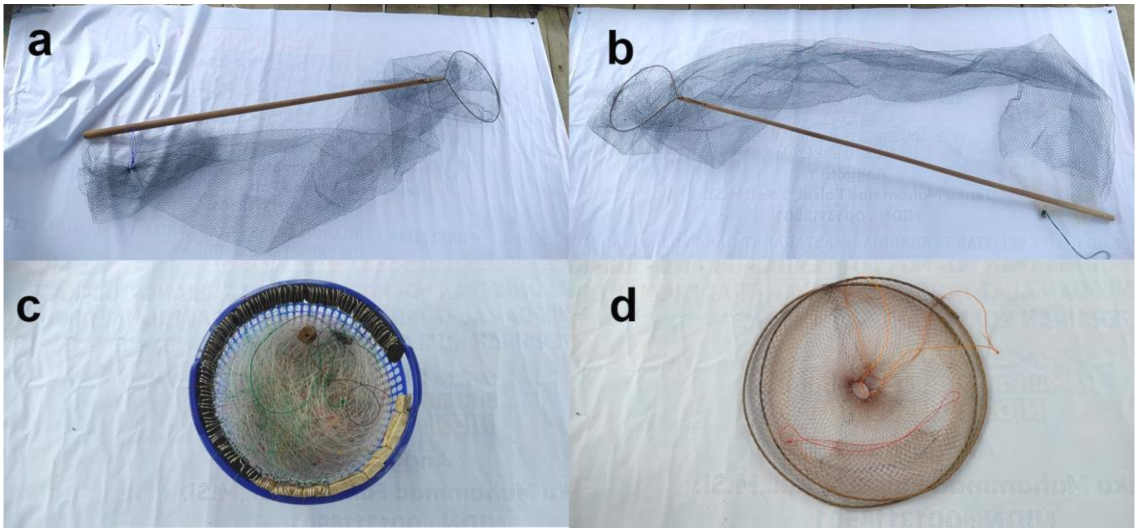

Fig. 3. Shrimp catching tools (a. Modified lift net, b. Lift net, c. Bottom longline, d. Collapsible shrimp trap)

The main types of shrimp caught by traditional fishermen in Kuala Langsa include *Penaeus monodon, Penaeus merguiensis, Penaeus semisulcatus*, and *Litopenaeus vannamei* (Fig. 4a-d). Among fishing gear used, bottom longline tended to be more selective in catching large *P. monodon* (>200 grams), due to the passive nature of operating on the bottom. According to **Öztekin *et al*. (2020)**, bottom longline are generally size-selective, where the design and size of the hook significantly influence the size of catches, with a tendency to select large individuals. The placement in deeper waters also contributes to the success of catching large *P. monodon*. This is appropriate to the ecological characteristics of the species, where adults tend to migrate toward deep waters for spawning **(Motoh, 1985)**. Meanwhile, other fishing gear, such as collapsible shrimp trap and lift net, more often produce small shrimp catches due to the placement in shallow waters. The species and size composition of shrimp caught directly impact the structure of business revenue and the economic efficiency of fishermen **(Nisar *et al*., 2021)**. The presence of *P. monodon* and *L. vannamei* in the Kuala Langsa mangrove area has also been confirmed by **Faisal *et al*. (2019)**, reinforcing the significance of estuarine habitats in supporting small-scale shrimp fishery in this area.

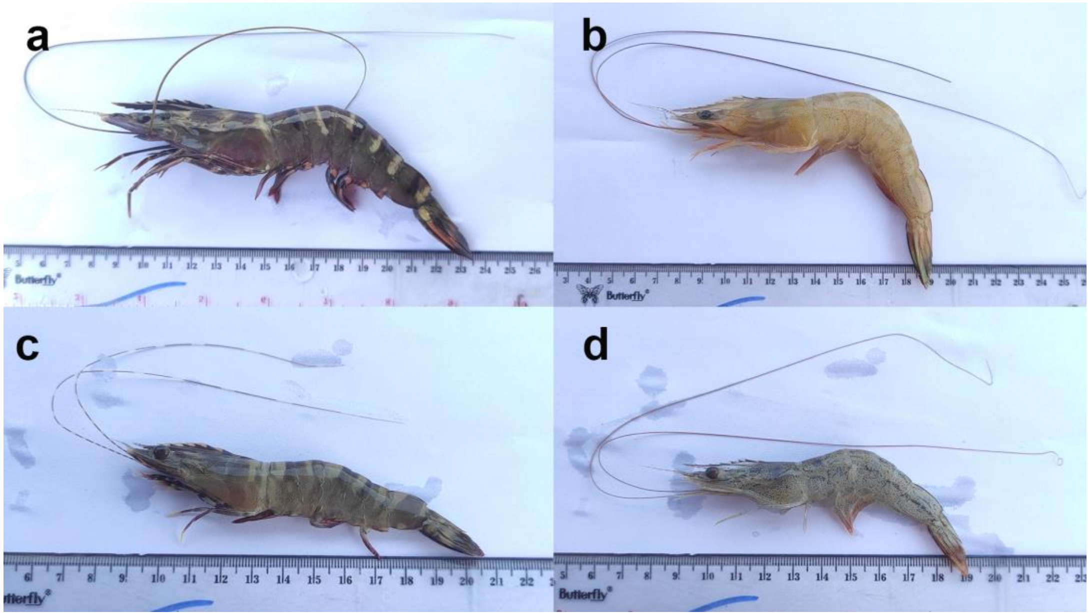

Fig. 4. Shrimp caught (a. *P. monodon*, b. *P. merguiensis*, c. *P. semisulcatus*, d. *L. vannamei)*

Most shrimp fishermen in Kuala Langsa relied on middlemen and collectors as primary channels for marketing catch. This dependence reflects a preference for marketing stability, where the catch can be readily absorbed without the risk of rejection or fluctuations in demand. In this context, middlemen act not only as buyers but also providers of working capital and marketing guarantees, particularly during the lean season **(Thuy *et al*., 2019)**. A similar role was also found in small-scale shrimp value chains in Vietnam, where middlemen facilitate fast transactions, large-volume purchases, and stable market distribution **(Nguyen *et al*., 2021)**. However, these individuals often take a significant portion of fishermen economic margins, contributing to declining net profits **(Szuster *et al*., 2021)**. In the context of traditional shrimp fishing, the marketing stability offered by middlemen is crucial for maintaining operational sustainability, although not always consistent with long-term economic efficiency.

The financial feasibility analysis was conducted based on the calculation of several key indicators described in the methods section, including Net Profit, R/C Ratio, Payback Period, Break-Even Point in terms of value and trips, NPV, B/C Ratio, and IRR (Table 1). All indicators were calculated for each business unit based on field data, and then the average value for each type of fishing gear was estimated. Swarmplots were applied to all fishing gear to show individual distributions, while boxplots were only used for fishing gear with ≥ 5 respondents, namely lift net and collapsible shrimp trap (Fig. 5a-h). Consequently, the quartile and IQR estimates had adequate statistical validity. Through this approach, a comprehensive comparison of economic performance between fishing gear was conducted, both in terms of average values and distribution patterns, as well as the consistency of financial performance between actors.

Table 1. Financial feasibility of traditional shrimp fishing gear in Kuala Langsa, Langsa, Aceh

Fishing Gear	Modified Lift Net	Lift Net	Bottom Longline	Collapsible Shrimp Trap
Net Profit (IDR)	35,957,698	41,122,286	237,005,000	67,629,390
R/C Ratio	2.563	2.157	4.015	2.382
Payback Period (Year)	0.886	0.463	0.085	0.187
BEP (IDR)	18,584,663	14,957,001	26343288	17,330,186
BEP (Trip)	89	65	20	37
NPV (5 years)	153,998,556	173,939,598	1,037,639,426	283,780,817
B/C Ratio (5 years)	2.563	2.157	4.015	2.382
IRR (%/year)	317.842	377.342	1424.838	559.691

Boxplots are effective statistical visualization tools that concisely represent data distributions using five key metrics: minimum, first quartile (Q1), median, third quartile (Q3), and maximum **(Liu, 2008)**. The length of the box represents the interquartile range (IQR = Q3 − Q1), which captures the middle 50% of the data and reflects the degree of internal variation among observations **(Marmolejo-Ramos & Tian, 2010)**. The position of the median within the box, along with the relative lengths of the whiskers, indicates the symmetry or skewness of the distribution. When the median is closer to Q1 and the upper whisker is longer, the distribution is positively skewed; conversely, a median closer to Q3 with a longer lower whisker indicates negative skewness **(Liu, 2008)**. Extreme values that fall outside 1.5 times the IQR from the quartiles are identified as outliers and are plotted individually beyond the whiskers **(Spitzer *et al.*, 2014)**. This makes the boxplot not only a tool for summarizing economic performance but also useful for identifying distribution patterns, outliers, and performance consistency within groups **(Morales *et al.*, 2021)**.

In complementary visualizations such as swarmplots, the spatial distribution of dots provides insights into the density and variation of data. A wide and even spread indicates high variability or heterogeneity among units, whereas a tight clustering suggests greater consistency or homogeneity **(Waskom, n.d.; Minnotte *et al.*, 2008)**. This form of visual density mapping is particularly valuable for uncovering hidden structures, especially in datasets where overplotting can obscure important patterns in low- or high-density regions **(Chen *et al.*, 2025)**. Statistical techniques based on distribution analysis can further validate such visual interpretations, ensuring that observed patterns accurately reflect underlying data structures **(Bertini *et al.*, 2007)**. When combined, swarmplots and boxplots offer a powerful visualization tool, merging detailed individual data points with summary statistics—such as medians and quartiles—to provide a comprehensive overview of both distribution and central tendency **(Waskom, n.d.; Bertini *et al.*, 2007; Minnotte *et al.*, 2008)**.

Among the four gear types, bottom longline demonstrated the strongest financial performance, with an average annual net profit of IDR 237,005,000. The highest Revenue/Cost (R/C) ratio of 4.015 indicated that every IDR 1 spent on operations generated over IDR 4 in revenue. A matching Benefit-to-Cost (B/C) ratio of 4.015 confirmed the gear's superior economic efficiency. The payback period was exceptionally short at just 0.085 years (approximately one month), the fastest among all gear types studied. The annual break-even point (BEP) was IDR 26,343,290, with a BEP in the number of trips at only 19.88, indicating that bottom longline operations reach profitability in the fewest trips. Additionally, the Internal Rate of Return (IRR) was an outstanding 1,424.84% annually, reflecting a highly favorable short-term return on investment.

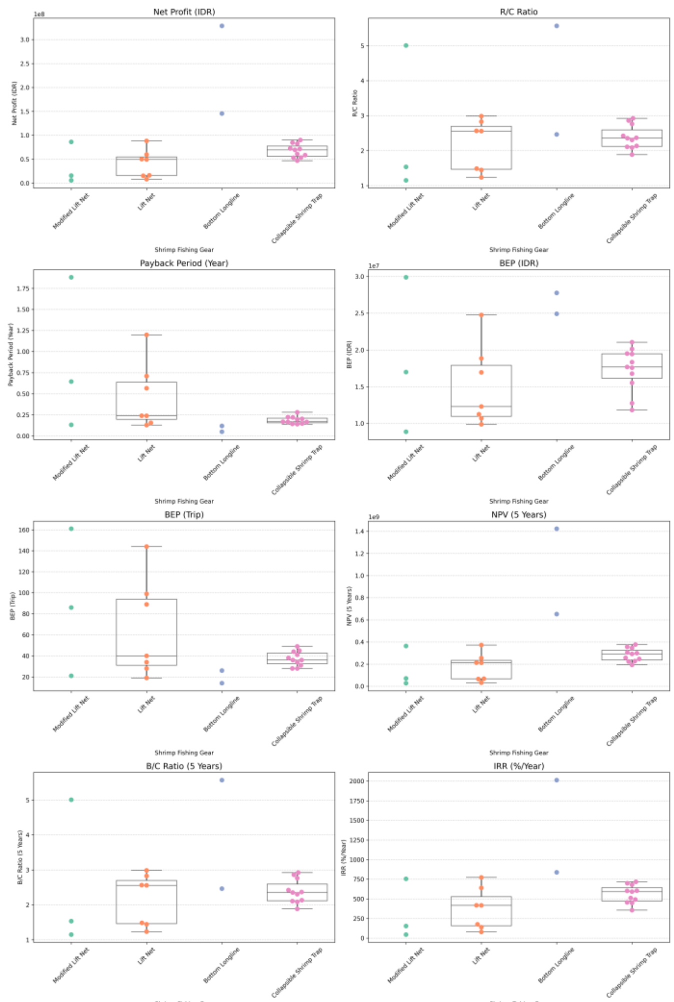

Fig. 5. Financial feasibility indicators per fishing gear: (a) Net Profit, (b) R/C Ratio, (c) Payback Period, (d) BEP (IDR), (e) BEP (Trip), (f) 5-Year NPV, (g) B/C Ratio, (h) IRR

The financial performance distribution of bottom longline fishing gear, based on swarmplot visualizations, reveals varied patterns across indicators, reflecting disparities between business units. Among the eight variables analyzed, Payback Period and Breakeven Point (BEP) exhibited narrow distributions, with all data points in the low category, indicating rapid and stable return on investment. In contrast, indicators such as Net Profit, R/C Ratio, NPV, B/C Ratio, and IRR showed moderate to wide distributions. The swarmplots for these indicators spanned two categories—medium to high—highlighting variability in business performance.

Notably, stark contrasts between the two business units, particularly in the R/C Ratio, B/C Ratio, and IRR, indicate a sharp divide in business efficiency and return on investment. Although some indicators reflect high financial potential, achievements are unevenly distributed among units. These results confirm that while bottom longline has strong economic prospects, its success depends heavily on technical proficiency, ecological conditions, and managerial effectiveness.

The modified lift net, used by only three respondents, demonstrated generally positive financial performance. The average Net Profit was IDR 35,957,698, with a Payback Period of 0.886 years—the longest among all gear types but still within feasible limits for small-scale fisheries (SSF). Both the R/C Ratio and B/C Ratio were 2.563, indicating that benefits clearly outweighed costs. The annual BEP stood at IDR 18,584,740, slightly higher than the regular lift net (IDR 14,958,644). The BEP in trips was 89, suggesting the need for 89 fishing trips to break even. With an IRR of approximately 318%, the gear remained financially viable, though performance disparities among the three units suggest that profitability is heavily influenced by fisher skills and local conditions.

Swarmplot visualizations for the modified lift net revealed moderate to wide distributions across most financial indicators. Variables such as Net Profit, NPV, and IRR were generally low, although one or two units displayed higher values. The BEP (IDR and trip) showed wide variability, reflecting significant differences in cost efficiency and productivity. Notably, for R/C Ratio and B/C Ratio, two units fell into the low category, while one outlier exhibited extremely high performance. Due to the limited sample size (n = 3), boxplots were not used, as quartile calculations would not provide representative insights. Overall, while financially feasible, the modified lift net showed uneven performance and higher risk.

The lift net demonstrated moderate financial performance, though not as strong as the bottom longline or collapsible shrimp trap. The average Net Profit was IDR 41,122,286 per year. An R/C Ratio of 2.157 indicated that every IDR 1 spent yielded IDR 2.157 in revenue. Similarly, the B/C Ratio of 1.157 confirmed that the net benefits exceeded total investment and operational costs. The Payback Period was 0.463 years—faster than the modified lift net—and the IRR reached 377.34% per year. The annual BEP of IDR 14,959,877 and BEP in 64.53 trips reflected higher efficiency compared to the modified lift net.

Swarmplot and boxplot visualizations for the lift net gear showed varied distribution patterns. While Net Profit, NPV, and IRR had moderate distributions, R/C Ratio and B/C Ratio were wider, and BEP (Trip) displayed the widest distribution, reflecting extreme variability. For variables like Payback Period and BEP (IDR), the spread was also wide, indicating inequalities in cost structure and return time. The median for profitability indicators (e.g., Net Profit, NPV, IRR) tended to be closer to Q3, suggesting negative skewness—only a few units achieved high financial performance. Conversely, for efficiency metrics (Payback Period and BEP), the median was near Q1 with a long upper whisker, reflecting that most units were efficient, but some lagged significantly.

The collapsible shrimp trap, used by 11 fishermen, displayed competitive financial performance. The average Net Profit was IDR 67,629,390 per year. An R/C Ratio of 2.382 indicated strong cost efficiency, and a B/C Ratio of 1.382 confirmed the profitability of the gear. The Payback Period was 0.187 years (less than three months), indicating rapid capital recovery. The annual BEP was IDR 17,335,091, and the BEP in 37 trips showed that profitability could be achieved relatively quickly—more efficiently than both lift net and modified lift net. An IRR of 559.69% further supported the gear's strong investment potential.

Swarmplot and boxplot analyses of the collapsible shrimp trap revealed mostly narrow to moderate distributions, indicating stable business performance. Variables such as Net Profit, Payback Period, NPV, and BEP (Trip) had narrow distributions, while R/C Ratio, B/C Ratio, and IRR were moderate. BEP (IDR) exhibited a wider spread. Medians for profitability variables tended toward the upper quartile (negative skew), while some efficiency variables had medians closer to the lower quartile (positive skew). Variations in whisker length reinforced these asymmetries. No outliers were detected, indicating consistent financial performance across units.

The relatively larger sample size for the collapsible shrimp trap group (n = 11) compared to the lift net (n= 7) enhanced the validity of distribution comparisons. Examination of interquartile range (IQR) widths across all eight indicators revealed that the collapsible shrimp trap had more stable and consolidated financial outcomes. In contrast, all variables for the lift net group showed wider IQRs, with Payback Period having an IQR eight times wider—indicating greater internal disparity. The absence of outliers in both groups strengthens these interpretations, confirming that collapsible shrimp trap data are more representative and reliable for illustrating stable financial performance.

Among the four fishing gear types analyzed—bottom longline, collapsible shrimp trap, lift net, and modified lift net—financial feasibility varied based on average performance, consistency, and internal distribution.

- Bottom longline ranked highest across all financial indicators, offering exceptional cost efficiency, rapid capital recovery, and extremely high return on investment. However, performance varied widely across units, suggesting sensitivity to ecological, technical, and managerial factors.
- Collapsible shrimp trap ranked second in overall profitability, with stable and consistent results. Narrow IQRs and no outliers made this gear type the most reliable in terms of business performance across fishers.
- Lift net occupied a middle position, meeting financial feasibility standards but displaying high variability and internal inequality. Wide distributions suggest inconsistent outcomes across users.
- Modified lift net, while still financially feasible, had the most modest average performance and the highest risk due to limited sample size and uneven results. Its viability appears highly contingent on individual skill and local conditions.

In summary, bottom longline is optimal for maximum yield, collapsible shrimp trap stands out in performance stability, lift net offers moderate returns with high variability, and modified lift net is a viable but lower-risk option for fishers with constrained resources.

CONCLUSION

In conclusion, this study showed that each traditional fishing gear used in Kuala Langsa waters demonstrated a varied financial viability profile, both in terms of profitability, investment efficiency, and performance stability between business units. The bottom longline had the highest financial potential, with all indicators at a superior level; however, it was accompanied by high inequality in results between units. The collapsible shrimp trap was the most consistent and stable fishing gear. Lift net and modified lift net showed moderate financial feasibility, but with high levels of variation, particularly in cost structure and profitability. In general, the results emphasized the importance of considering not only potential financial returns but also distribution stability and operational context when selecting appropriate fishing gear for small-scale fishers.

This study provides a strong foundation for developing a more targeted and responsive fisherman empowerment program. Capital interventions and technical training can be focused on the bottom longline to build on its promising financial characteristics identified in this study, accompanied by risk management strategies through increased technical capacity and access to spatial-ecological information. Meanwhile, the development of a collapsible shrimp trap as a fishing gear with stable performance suggests its potential as a model for stable small-scale enterprises, particularly suitable for novice or low-risk fishing groups. The selection of gear in fishing business strengthening programs should be based on a balance between potential profits and consistent results, appropriate to the profile and adaptability of each community. This study contributes to the growing literature on small-scale fisheries by offering a gear-based financial evaluation framework that can be applied to other data-limited coastal contexts in Southeast Asia.

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