Feasibility and productivity analysis of *arad* (mini trawl) fisheries in Cilincing North Jakarta

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Abstract. In 2019, fish production landed at TPI Cilincing weighed 1,476,750 kg, with a value of IDR 47,501,137,000.00. One of the fishing gears used in Cilincing is mini trawl nets. This fishing gear is categorized as illegal by the ministry of marine affairs due to its destructive nature. However, many fishermen still operate this fishing gear and refuse to switch into more environmentally friendly fishing gears. This research aims 1.) to determine the feasibility of the mini trawl in Cilincing, North Jakarta; and 2.) to determine the productivity of mini trawl fishing units and compare it to more environmentally friendly fishing gears. This research was conducted from January - May 2024. The data analyses used were both qualitative and quantitative to provide an overview of mini trawl productivity and financial analysis. The results show that NPV was positive, with B/C >1 (2,21), and an IRR value of 38%. This result shows that mini trawl fishery is beneficial because the return on capital is faster and the profits are higher compared to more environmentally friendly fishing gears. In addition, the productivity value of mini trawl per trip was 0.32 tons/trip and the mini trawl net had a much higher productivity value compared to bottom gillnets (*rampus*) and blue swimming crab gillnets.

1 Introduction

Jakarta Bay boasts abundant fishery resources. This is evidenced by its high capture fishery production. One of the prominent areas contributing to this high production is the Cilincing Fish Auction Site (TPI Cilincing). TPI Cilincing is renowned for its diverse fish resources. In 2019, the fish landed at TPI Cilincing weighed 1,476,750 kg, with a market value of IDR 47,501,137,000. This high production is driven by various fishing activities, including set nets, guiding barriers (*sero*), crab nets/traps, gillnets, bottom seine nets (*dogol*), and mini trawls (*arad*).

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Trawls are used to catch demersal fish, as well as non-fish species such as clams. Trawls catch economically valuable species such as squid, cuttlefish, mantis shrimp, white pomfret, crabs, and several types of shrimp including banana prawn, jinga shrimp, and giant tiger prawn [1]. Bycatch, which has a lower economic value, includes species such as ponyfish, silver pomfret, dark-banded goatfish, hairtail, barracuda, stingray, and spotted butterfish (Indonesian: *Kiper*).

The annual fish catch by trawl net fishermen varies due to several factors, including fishing seasons and weather conditions. These fluctuations impact productivity as a result of the vessel's ability to capture fish annually.

Key factors to consider in mini trawl fisheries include the vessel, crew, and fishing trips, all of which significantly influence the mini trawl fishery business. Effective fisheries management in Cilincing, supported by well-functioning cooperatives, can enhance the fishery's performance and positively impact the ecosystem. However, intense fishing activities without environmental conservation measures can deplete fish resources. Furthermore, mini trawls are categorized as illegal by the Indonesian Ministry of Marine Affairs and Fisheries due to their destructive nature and impact on the ecosystem. Besides that, mini trawl fishermen are also reluctant to substitute their gear with other fishing gears that are more environmentally friendly. Therefore, it is essential to conduct research on mini trawl fisheries in Cilincing. The objectives of this research are: (1) Determining the feasibility of the mini trawl net fishery business in North Jakarta's Cilincing area, and (2) Assessing the productivity of the mini trawl net fishing units and comparing it with bottom gillnet (*rampus*) and blue swimming crab gillnet fisheries which operate mostly in the same fishing grounds.

2 Material and method

2.1 Research location and times

The research has been conducted from January to May 2024 in the waters of Cilincing (Figure 1). The stages of the research were as follows: (1) Preliminary Survey Conducted in October to familiarize the research team with the study location; (2) Primary Data Collection conducted from January to February 2024, focusing on three aspects: economic, social, and institutional; (3) Secondary Data Collection; (4) Data Analysis.

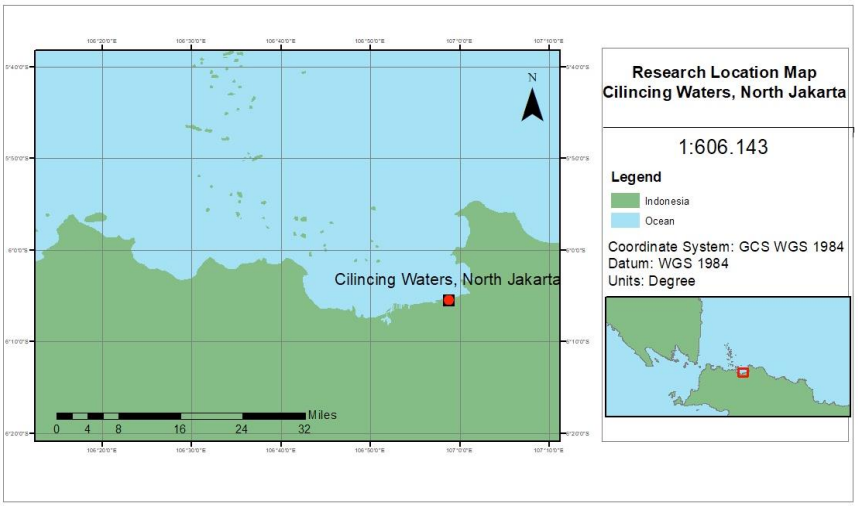

Fig. 1. Map of Cilincing, showing its location in North Jakarta.

2.2 Tools and materials

The tools and materials used in this research are listed in Table 1.

Table 1. Tools.

No	Tools	Function
1	Questionnaire	Contains questions for respondents

2.3 Research methodology

The survey method involved observation or obtaining detailed information on a specific issue. The data used in this study consist of primary and secondary data. Primary data collected include operational costs, fixed costs, variable costs, types of catch, fish prices, vessels' tonnage, number of crew, engine power and fishing trips. Primary data was obtained through interviews with a group of mini trawl net fishermen. Respondents were selected deliberately, considering their positions and roles in their daily activities, using purposive sampling [2]. The respondents included 15 fishermen and collectors. Additionally, secondary data was obtained from government agencies and published research on mini trawl nets, such as the Provincial Fisheries and Marine Affairs Agency and the Ministry of Marine Affairs and Fisheries, as well as scientific publications on mini trawl fisheries.

2.4 Data analysis method

Analysis of data in terms of economic analysis was conducted through quantitative analyses, i.e.:

a) Financial Analysis to determine the feasibility of the business venture. This analysis included feasibility analysis using investment criteria such as Net Present Value (NPV), Net Benefit Cost Ratio (Net B/C), and Internal Rate of Return (IRR) [3]. Long-term analyses such as NPV, Net B/C, and IRR can be used to ascertain the benefits and costs of utilizing fisheries resources. This analysis offers insights into the benefits derived from the exploitation of fisheries resources [4].
b) Productivity analysis of mini trawl nets, bottom gillnets, and blue swimming crab gillnets in Cilincing.

- **NPV (Net Present Value)**

$$NPV = \sum_{t=1}^{n} \frac{(Bt-Ct)}{(1+i)^t} \quad (1)$$

B : Benefit
C : Cost
i : Discount rate
t : Year of operation

In the NPV method, there are three investment assessments [5]:

1) NPV ≥ 0 (feasible): This indicates that financially, the venture is feasible to be undertaken because the benefits outweigh the costs.
2) NPV = 0 (break even): This means financially the venture is at a break-even point because the benefits obtained are equal to the costs incurred.

3) NPV ≤ 0 (not feasible): This indicates that financially, the venture is not feasible to be undertaken. This is because the benefits obtained are less than the costs/incurred, and they are insufficient to cover the expenses.

- **PP (Payback Period)**

The Payback Period (PP) can be determined using the formula:

$$Payback\ Period = \frac{Investment}{Benefit} \quad (2)$$

- **IRR (Internal Rate of Return)**

The Internal Rate of Return (IRR) can be determined using the formula below [6]:

$$IRR = i + \frac{NPV}{NPV - NPV'}(i' - i) \quad (3)$$

Information:

i' : first trial value for the discount rate;
i″ : second trial value for the discount rate;
NPV : first net present value;
NPV″ : second net present value.

- **B/C Ratio (Benefit Cost Ratio)**

The Net Benefit Cost (Net B/C) ratio is a comparison between the present value of benefit flows and the present value of cost streams. This figure indicates the level of additional benefits for each additional unit of cost in terms of currency. The criterion used for selecting the Net B/C ratio measure for project benefits is to choose all projects with a Net B/C ratio of one or more if the benefits are discounted at the opportunity cost rate. However, if the Net B/C ratio is less than 1, the project is deemed not feasible [3]. The formula used is as follows:

$$Net\frac{B}{C} = \frac{\sum_{t=1}^{n} \frac{(Bt-Ct)}{(1+i)^t}}{\sum_{t=1}^{n} \frac{(Ct-Bt)}{(1+i)^t}} \quad (4)$$

Information:
Net B/C : Benefit Cost Ratio
Bt : Benefit year t
Ct : Cost Year t (IDR)
n : Time period (year)
i : Discount rate (%)
t : Period (year)

The general formulas for calculating the productivity of fishing gear are as follows [7]:

$$Productivity\ of\ Fishing\ Vessel = \frac{\sum Catch(tons)}{\sum Gross\ Tonnage(GT)} \quad (5)$$

$$Productivity\ of\ Crew = \frac{\sum Catch(tons)}{\sum Crew(person)} \quad (6)$$

$$Productivity\ of\ Mini\ Trawl's\ Engine = \frac{\sum Catch(tons)}{\sum Engine\ Power(HP)} \quad (7)$$

$$Productivity\ of\ Fishing\ Trip = \frac{\sum Catch(tons)}{\sum Fishing\ Trip(Trip)} \quad (8)$$

3 Results and discussion

Arad fisheries, or mini bottom trawls, are primarily used for catching shrimp. However, they are controversial due to their low selectivity and potential for environmental damage. *Arad* fishing is associated with challenges like bycatch, a high percentage of fish caught being younger than their length at first maturity, and socio-economic issues for fishermen, who often have lower education levels. Regulations have been introduced to ban *arad* nets and encourage the use of more environmentally friendly alternatives, but adoption rates can be low due to factors like the perceived lower value of substitute gear.

3.1 NPV

Net Present Value (Net Present Value = NPV) is the total profit over the life of the business that has been multiplied by a discount factor. The results of the analysis of the feasibility of the mini trawl business show a NPV of 40,843,137 IDR. As the NPV has a positive value, this shows that the mini trawl business is worth continuing. This is in accordance with the statement of Umar [5], who mentioned that a business is said to be feasible if the NPV value > 0.

3.2 Payback Period (PP)

Payback period is the rate of return on capital or the length of time used to cover the original investment costs. The faster the return on investment of a business, the better the business pattern because the smoother the capital turnover [8]. The PP value in *arad* fisheries is 2 years and 6 months. Thus, *arad* business units in Cilincing have a rate of return on investment costs that fall into the fast category, because the *arad* business units in Cilincing waters have a payback period of less than 3 years.

3.3 IRR

The internal rate of return (IRR) is an investment calculation method in which an interest rate that equates the present value of an investment with the present value of future receipts is calculated [4]. The result of the analysis shows that the value of the internal rate of return (IRR) is 38%, which means it provides a profit of 38% per year from all investments invested during the 10-year fishing life.

3.4 B/C ratio

The ratio of receipts and costs (B/C) is a comparison of total receipts with total costs (operational costs and fixed costs). The B/C ratio in *arad* fisheries is 2, meaning that the businesses of *arad* fisheries exceed 0 and have met the requirements for an economically beneficial activity.
The feasibility of the *arad* fishery business is based on favourable NPV, Net B/C and IRR values. The result of the business feasibility analysis is shown in Table 2.

Table 2. Results of the Business Feasibility Analysis of the *arad* fishery

Criterion	Value	Information
NPV	IDR 40,843,137	Worthy, NPV value > 0
Net B/C	2.21	Worthy, net value B/C > 1
IRR	38%	Feasible, IRR value > Interest Rate (8.55%)
PP	2.54 yrs	2 years and 6 months until investment costs are returned

Positive NPV, B/C > 1, and IRR value greater than the interest rate used, which is 10%, show that the *arad* fishery business is financially feasible because the return on capital is faster and the profit is higher than the interest rate. This is in accordance with Pinkerton [9], who mentioned that fishing businesses with a high level of feasibility can support the independent economic development of local fishermen.

3.5 Mini trawl fisheries productivity

Based on the obtained data of catches landed at TPI Cilincing for the 2022-2023 period, we can calculate the productivity of mini trawl nets. There are four productivity calculations using the obtained data, namely; the productivity of fishing vessel, crew, engine and fishing trip.

- **Productivity of fishing vessel**

The value of vessel productivity is determined by landed catch data and vessel tonnage. The size of the trawl net ship is known to be 7 GT. In this way, the productivity value of the Trawl vessel can be calculated. The results showed that one unit of mini trawl vessel has a catch productivity value of 148.58 tons/GT of the vessel.

$$Productivity\ of\ Mini\ Trawl's\ Vessel = \frac{\sum 1.040\ tons}{\sum 7GT} = 148.59\ tons/GT \quad (9)$$

The productivity value of mini trawl net vessels in Cilincing waters is relatively lower when compared to the productivity value of trawl net vessels in Pandeglang waters, namely 1326/7 = 189.42 tons/GT [10]. The productivity value of this trawl fishing gear tends to be far below the minimum limit value [10]. The productivity obtained is the overall productivity where the catch still consists of main and bycatch. The main catch in trawl nets is generally less than the by-catch [13].

- **Productivity of crew**

Based on the obtained data of catches landed at TPI Cilincing for the 2022-2023 period, combined with data on the average number of ship crew members obtained through questionnaire interviews, the productivity value of mini trawl net crew members can be determined. The results of the interviews showed that the average number of crew members on the trawl boats at TPI Cilincing was 3 people. The research results show that the annual productivity value of trawl net crew members is 346.70 tons/person.

$$Productivity\ of\ Mini\ Trawl'sCrew = \frac{\sum 1.040\ tons}{\sum 3\ person} = 346.70\ tons/person \quad (10)$$

This value tends to be lower when compared to the annual productivity of mini trawl net crew members in Pandeglang waters, namely 442 kg/person [10]. Differences in productivity values can be influenced by many things such as the number of fishing trips, capital and number of crew members. The productivity can be determined by energy, the number of workers and the fishing ground [11]. Apart from that, crew skills also play an important role in increasing productivity values. Workers play a central role in defining and achieving decent work [12].

- **Productivity of fishing engines**

Based on the obtained data of catch landed at TPI Cilincing for the 2022-2023 period, combined with data on ship engine power obtained through questionnaire interviews, the productivity value of trawl net machines can be determined. Interview results showed that the average trawl vessel at TPI Cilincing is powered by a 24 HP engine. The results showed that the productivity of trawl fishing engine is 43.34 tons/HP.

$$Productivity\ of\ Mini\ Trawl's\ Engine = \frac{\sum 1.040\ tons}{\sum 24\ HP} = 43.34\ tons/HP \quad (11)$$

Engine power is vital for the mini trawl fishing unit because mini trawls are an active fishing gear in which a net is pulled to sweep the bottom of the sea. Apart from that, auxiliary engines are also needed to pull the net onto the ship during the hauling process. Trawl net boats have two engines where the main engine functions to run the ship and drag the gear during fishing operation, whilst the auxiliary engine is used to pull the net during the hauling process [13]. Without the help of machines, the hauling process will be slower and of course reduce fishing productivity.

- **Productivity of fishing trip**

Based on the obtained data of catches landed at TPI Cilincing for the 2022-2023 period, combined with fishing trip data obtained through questionnaire interviews, the productivity value of mini trawl net fishing trips can be determined. The mini trawl productivity value per trip is 0.32 tons/trip. This value is greater than trawl productivity per trip in Pemalang waters which is only 0.012 tons/trip [13]. This significant difference in mini trawl productivity per trip can be caused by the availability of resources, fishing grounds and fishermen's experience. Low value of mini trawl productivity is thought to be an indication that the shrimp population in the research area is starting to decline [13].

$$Productivity\ of\ Mini\ Trawl'sFishing\ Trip = \frac{\sum 1.040\ tons}{\sum 3.300\ Trip} = 0.32\ ton/trip \quad (12)$$

We also calculated the productivity value of bottom gillnets (*rampus*) and blue swimming crab gillnets as a comparison. Based on the obtained data of catches landed at TPI Cilincing, the productivity values of ships, crew, engines and fishing trips was calculated. The fishing productivity of trawls, bottom gillnets (*rampus*) and blue swimming crab gillnets can be seen in Table 3.

Table 3. Productivity of mini bottom trawls (trawl), bottom gillnets (*rampus*) and blue swimming crab gillnet.

No	Productivity	Productivity Score		
		Trawl	*Rampus*	Blue Swimming Crab gillnet
1	Ship	148.59	26.80	20.73
2	Crew	346.70	134	51.82
3	Engine	43.34	11.17	8.64
4	Trip	0.32	0.08	0.06

The results show that overall mini trawl nets have a much higher productivity value compared to *rampus* nets and blue swimming crab gillnets. This difference in productivity values is thought to be caused by the active nature of mini trawl nets compared to the passive nature of rampus and blue swimming crab gillnets. Trawl nets are a fishing method that actively catches fish at the bottom of the water, while *rampus* and blue swimming crab gillnets tend to be passive and wait for the target to come and be caught in the net. Gillnets are usually operated passively in waters, and have a lower productivity value than seine nets and trawls due to their passive nature [14]. However, this makes gillnets more environmentally friendly than trawls as they do not have an impact on the seabed ecosystem [15].

4 Conclusion

The conclusion of this study are

1. The feasibility of the mini trawl fishery business has been shown based on NPV, Net B/C and IRR values. Positive NPV, B/C greater than one, and an IRR value greater than the interest rate used, which is 10%, imply the mini trawl business is financially feasible and show that the *arad* fishery business is financially suitable because the return on capital is faster and the profit is higher.
2. Mini trawl nets have a much higher productivity value compared to bottom gillnets and blue swimming crab gillnets. This difference in productivity values is thought to be caused by the active nature of trawl nets compared to the passive nature of bottom gillnet and blue swimming crab gillnets.

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Conflict of Interest

The authors declare that there is no conflict of interest.

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