Economic Comparison of Wood and Fiberglass Fishing Vessels Produced in Traditional Yards

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Wooden boats are commonly considered to be more cost effective compared to fiberglass boats, and no study has described the economic disparities between the two vessel types. Therefore, this study aimed to provide a comprehensive economic comparison between wooden and fiberglass boats, including the return-on-investment timelines and the potential profitability. A qualitative method was used in this study, and the data were collected through survey techniques. The economic analysis results showed that the average Net Present Values of wooden and fiberglass boats were IDR 72,935,055 and IDR 84,511,500 respectively. The average Net Benefit-Cost Ratio and the average Internal Rate of Return for both vessel types were 1 and 11%. The average Payback Period was approximately 6.6 years for wooden boats with a profit of IDR 8,902,000, and 6 years for fiberglass boats with a profit of IDR 11,936,944. In conclusion, the use of both vessels was not only acceptable but feasible for operation.

KEY WORDS

~ Economical comparison
~ Wooden ships
~ Fiberglass boats

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doi: 10.7225/toms.v13.n01.w06

Received: 27 Jun 2023 / Revised: 7 Oct 2023 / Accepted: 9 Jan 2024 / Published: 20 Jan 2024

1. INTRODUCTION

The increasing demand for tall ships requires fishermen in Aceh to be more observant in the selection of boats that are cost-effective, durable, and easy to repair or maintain. This pertains to factors encompassing material availability, maintenance and repair expenses, as well as the frequency of maintenance cycles (Rizwan et. Al., 2023a). Addressing this challenge assumes paramount significance as it enables the selection of the most suitable boat for use in the Aceh waters, whether wooden or fiberglass.

Traditional boats are commonly used by local communities on the coast to support transportation needs (Dewi, 2020). In general, the fishing vessels owned by the Aceh fishermen are traditional wooden boat designs (Rizwan et.al. 2023b). According to Sugiarto (2020), the intrinsic wisdom entrenched in this design has long served coastal fishermen as the main means of fishing. The raw material for crafting wooden boats mandates specific attributes, such as resistance to marine organisms, ample structural strength, and waterproof property. Typically, aged and elongated pieces of wood are favored. It is relevant to note that the availability of suitable wood for boat construction is diminishing, posing sustainability challenges to the practice of logging for shipbuilding. Issues related to wood quality and technological limitations often compromise the safety and cost-efficiency of wooden fishing boats, consequently reducing fisheries productivity. However, contemporary alternatives have emerged, with certain boats adopting materials other than wood, specifically fiberglass.

A fishing boat made of fiberglass is one type of ship used in the fishing industry. A study conducted by the Indonesian Maritime and Fisheries Research Center (PSDKP) highlighted its advantages over traditional wooden boats, primarily in terms of superior durability and lower maintenance costs. Fiberglass boats have higher speeds and can cover longer distances, enabling fishermen to catch more fish in shorter timeframes. However, several challenges impede its seamless implementation in the fishing industry. A notable challenge is cost, as they are more expensive than their traditional counterparts. These initial expenses tend to be offset by the long-term efficiency offered by these boats.

Wooden and fiberglass boats have contrasting characteristics, particularly in terms of production cost. Decisions regarding repair interventions are contingent upon the extent of damage incurred. Repair feasibility depends on technical compatibility with existing repair methods, with the size and location of damage exerting significant influence. Shipyards typically offer varying prices for repair services (Arif, 2022). Despite prevailing assumptions that wooden boats are more cost-effective, few comprehensive studies outline the cost components, encompassing variable and operational costs for both boat types. A holistic assessment of quality and efficiency is imperative to ascertain the more economically viable option.

A fishing boat, in essence, serves the purpose of fishing, traversing from a base point area to designated fishing grounds. In the context of this study, a 5 GT ship with an 11-meter length (see Table 1) was observed and analyzed for 1 year. Comprehensive data were obtained through interviews conducted with users of wooden fishing boats at PPI Ulee Lhee Banda Aceh and fiberglass fishing boats in Sabang City. The study aimed to provide the economic comparison between wooden and fiberglass fishing boats as well as to determine their investment period and profits.

No.	Nama Kapal	length (m)	width length (m)	height (m)
1	KM. Atalon 04 (woods)	11	2.2	1.8
2	KM. Dara Barona (woods)	11	2.2	1.8
3	KM. Amazon 02 (woods)	11	2.2	1.8
4	KM. Mutiara Makmur 01 (FRP)	11	1.75	1.45
5	KM. Mutiara Makmur (FRP)	11	1.75	1.45
6	KM. Mutiara Rezeki (FRP)	11	1.75	1.45

Table 1. Specifications of the size of the vessel observed

2. RESEARCH METHODS

2.1. Time and place

This study was conducted between March and April 2023 in various locations, specifically focusing on wooden fishing boats at the Ulee Lhee Fish Landing Base (PPI), Meuraxa District, Banda Aceh. The fiberglass fishing boats in Sabang City encompassed three diverse locations: firstly, Jurung Ulee Krueng, Gampong Balohan, Sukajaya District; secondly, Kramat Neighborhood, Gampong Teupin Calok, Sukakarya District; and thirdly, CT 3 (three) in Gampong Kuta Timu Prikanan, Sukakarya District.

2.2. Data Analysis

2.2.1. Economic Aspects

Fisheries economic performance can be assessed through economic and financial analyses. These two methodologies differ in their treatment of capital costs, with financial analysis rooted in explicit company expenditures and economic analysis based on the opportunity costs of production factors (Pokki et. Al, 2018). The economic aspect involved income analysis, drawing from the respondents' data such as investment costs, operational costs, and profits. The data were subsequently used to compute the cost of both fishing vessel types, facilitating a comparison to determine which was more economical.

Cost fundamentally signifies the trade-off measured by the price or monetary value allocated for obtaining, producing, or maintaining goods and services. The assessment of the benefit-to-cost ratio could aid in evaluating the direct advantages accrued by road users through a given program (Faathir, 2022). Various costs were required throughout the development implementation, spanning from the conception of the idea and feasibility studies to planning, execution, and maintenance. According to (Ariesta, 2018), several analyses were requisite to attain optimal results in business analysis. In the economic analysis, these costs were categorized into various components to facilitate the calculation process.

a) Investment Cost

Investment costs are expenditures made to prepare a business for proper operation. It is often considered the basic capital of a business, encompassing the preparation and construction of infrastructure as well as the development and improvement of human resources. Investment costs predominantly pertain to the construction and development of physical infrastructure.

b) Operating costs

Operational costs are expenditures incurred to operate a system. This includes project operational costs, encompassing variable costs that fluctuate in number with changes in production or annual sales volumes. The elements constituting operational costs for ships include crew (ABK) expenses, repair, maintenance and supply (RMS) outlays, costs for fresh water, lubricating oil, fuel, cooling media, among others (Udiin, 2020).

Business feasibility analysis is used to evaluate the viability of a business to be operated from the perspective of entities or individuals investing capital and direct interest in a business activity. Technical designs should align with economic feasibility to guide accurate investment decisions (Abad, 2022).

The formula was used as follows:

a) Net Present Value (NPV)

The mathematical representation is provided in the formula below:

$$\text{NPV} = (\text{Rate}; \text{Value1}; [\text{Value2}]\ldots) \quad (1)$$

Information:
Rate = discount during the investment period
Value1, Value2, - predict the annual order of the cash inflows during the investment walk.

The criteria for accepting or rejecting an investment plan using the NPV method are as follows:
The project proposal is accepted when NPV > 0
The project proposal is rejected when NPV < 0, and when NPV = 0, it is likely the project is accepted or the company value remains the same even when the project proposal is accepted or rejected (Choliq et al., 1999).

b) Net Benefit-Cost Ratio (Net B/C)

The mathematical representation is provided in the formula below:

$$NetB/C = \frac{\sum_{i=1}^{n} \overline{NB_i}(+)}{\sum_{i=1}^{n} \overline{NB_i}(-)} \quad (2)$$

Information:
NB (+) = positive net benefit
NB (-) = negative net benefit
i = prevailing interest rate
n = length of time period

With decision criteria:
The project is deemed feasible when Net B/C > 1, and infeasible when Net B/C < 1
The project signifies a break-even business when Net B/C = 1 (Choliq et al., 1999)

c) Internal Rate of Return (IRR)

The mathematical representation is provided in the formula below:

$$\text{IRR} = \text{value}\ (\text{value}(\ldots) \quad (3)$$

Information:
Value = cash flow
A business project is feasible if IRR > prevailing bank interest (Choliq et al., 1999).

d) Payback Period (PP)

The mathematical representation is provided in the formula below:

$$\text{PP} = \frac{\text{initial investment value}}{\text{cash flow}} \text{ x 1 Year} \quad (4)$$

The assessment criteria are as follows:
The investment proposal is accepted when the payback period is greater than the economic life of the investment and rejected when it is lesser.

3. RESULTS AND DISCUSSION

3.1. Comparison of Economic Analysis of Wood and Fiberglass Fishing Boats

Table 2 shows the results of the economic analysis of wooden fishing boats at PPI Ulee Lhee Banda Aceh, namely KM. Atalon 04, km. Dara Barona, Amazon 02, as well as fiberglass boats in Sabang City, namely KM. Mutiara Makmur 01, KM. Mutiara Makmur and KM. Mutiara Rezeki, each vessel measuring 5 GT with a length of 11 meters for 1 year.

Name of fishing vessel	Fishing vessel materials	Economic analysis					
		NPV		Net B/C		IRR	
		Value (IDR)	Category	Value	Category	Value	Category
KM. Atalon 04	wood	69,748,403	accepted	1	worthy	11 %	worthy
KM. Dara Barona	wood	79,358,359	accepted	1	worthy	11 %	worthy
KM. Amazon 02	wood	69,698,403	accepted	1	worthy	14 %	worthy
KM. Mutiara Makmur 01	fiberglass	88,798,137	accepted	1	worthy	11 %	worthy
KM. Mutiara Makmur	fiberglass	82,438,182	accepted	1	worthy	13 %	worthy
KM. Mutiara Rezeki	fiberglass	82,298,182	accepted	1	worthy	12 %	worthy

Table 2. Economic Analysis of Wooden and Fiberglass Ships

The table above presents an economic analysis for both wooden and fiberglass boats. The results showed that both fishing vessels yielded favorable outcomes in terms of net present value (NPV), net benefit-cost ratio (Net B/C), and internal rate of return (IRR), thereby confirming the feasibility of the project proposal. The discount factor or BI interest rate used for this analysis was 5.75%, as of March 15-16, 2023 (Bank Indonesia, 2023).

Investment costs were incurred for every purchase of boats, machinery, fishing gear, lights, and hatches. According to Apu *et al*. (2021), these expenses are the initial capital issued to initiate or manage a business. Wooden and fiberglass boats used by the fishermen were all new. Faustinus (2013) underscored the need for a comprehensive set of criteria when selecting the main engine to obtain a satisfactory solution. Accordingly, the vessels KM. Atalon 04 and KM. Dara Barona were each equipped with a Yanmar TS 230 engine, while KM. Amazon 02 utilized the Yanmar TF 300 engine. For each of the fiberglass fishing vessels, i.e., KM. Mutiara Makmur 01, KM. Mutiara Makmur, and KM. Mutiara Rezeki, a 23-HP Yanmar engine was used. The fishing gear employed by both fishing vessels varied from hand line to longline and more. The lighting systems also varied, with KM. Atalon 04 using 10 pieces of 20 W lamps, KM. Dara Barona employing 7 pieces of 12 W lamps, and KM. Amazon 02 using 6 pieces of 10 W lamps. Conversely, the fiberglass fishing boats, i.e., KM. Mutiara Makmur 01 utilized 8 pieces of 20 W lamps, KM. Mutiara Makmur, 6 pieces of 10 W lamps, and KM. Mutiara Rezeki, 10 pieces of 20 W lamps. Both fishing vessels were outfitted with holds, each with a capacity of 2 tons.

Name of fishing vessel	Engine	Fishing gear	Light (pcs)	Fuel (liters)	Lubricating oil (liters)	Price of ice block (IDR)	Cash retribution (IDR)
KM. Atalon 04	Yanmar TF 230	Hand line	10	500-600	6	26,000	90,000
KM. Dara Barona	Yanmar TF 230	Hand line	7	500-600	6	26,000	90,000
KM. Amazon 02	Yanmar TF 300	Hand line	6	500-600	9	26,000	90,000
KM. Mutiara Makmur 01	Yanmar 23 HP	Long line	8	600-700	6	35,000	30,000
KM. Mutiara Makmur	Yanmar 23 HP	Long line	6	600-700	5	35,000	30,000
KM. Mutiara Rezeki	Yanmar 23 HP	Long line	10	600-700	5	35,000	30,000

Table 3. Investment costs

Determining the price of wood for ship materials is determined by local government regulations. Wood prices are determined based on the type of wood, its grade and durability. Moreover, the government also determines the type and class of wood for vessels, regulated through the 1990 Indonesian Wooden Ship Classification Board. The increase or decrease in annual prices for materials cannot be predicted. Meanwhile, the price of fiberglass material is determined by the factory according to the production costs. The production should not be separated from the need for labor. Labor wages for shipbuilding in each region can vary. This is based on differences in the regional minimum wage standards. However, labor costs cannot be ignored. A boat made of wood or fiberglass can basically last 6 to 7 years with regular minor repairs. Otherwise, the vessel must undergo major maintenance, e.g., major repairs on wooden ships such as replacing the wood on the deck floor or hull, etc. However, if the wood used to build the vessel is low-grade wood (not in accordance with the provisions of the Indonesian Classification Board), then the ship will not last for long. This means that there will be a lot of costs involved in repairing the ship.

Operational costs are expenses incurred per trip throughout the fishing process, encompassing vessel maintenance, fuel, supplies, lubricating oil, fresh water, cooling media, cash retribution, and profit sharing. Wooden fishing boats were maintained every month as they encountered daily exposure to heat and constant immersion in seawater, which could cause accelerated hull degradation. A recurrent issue was the accumulation of polluting organisms (sea animals and plants) along the hull, necessitating weekly maintenance to prevent increased resistance, reduced speed, and heightened fuel consumption (Rahman, 2019). Fiberglass boats, on the other hand, required maintenance only once every 3-5 months, involving moss cleaning activities for the fiberglass lamination. This process reduced skin friction resistance and helped enhance speed and efficiency. The absence of water absorption in the hull contributed to sustained dry weight and ultimately reduced fuel consumption (Sunardi, 2016).

Regarding fuel consumption, there was a slight disparity, where wooden boats used around 500-600 liters of fuel, and fiberglass boats used approximately 600-700 liters. A transition to alternative fuel sources can induce lower cruising speeds (Kouzelis, 2022). Supplies for both boats also varied based on the requirements of each fisherman to conduct fishing operations.

The lubricating oil capacities for wooden fishing vessels, i.e., KM. Atalon 04 and KM. Dara Barona, as well as KM. Amazon 02 were 6 liters, and 9.8 liters respectively. For fiberglass vessels, i.e., KM. Mutiara Makmur 01, KM. Mutiara Makmur, and KM. Mutiara Rezeki, the oil capacity was 6 liters. Dionysiou (2022) emphasized the pivotal role of the lubricating oil system in ensuring the safe and reliable operation as demonstrated by the recent incidents analyzed through considerations of safety, reliability, and availability.

The availability of freshwater depended on the needs of each fisherman to carry out fishing operations. Ice blocks loaded by wooden fishing boats in Banda Aceh were more economical, priced at IDR 26,000 per unit,

compared to fiberglass boats in Sabang City, which required additional shipping costs of IDR 35,000 from Banda Aceh. Cash retribution was essential for each vessel and was disbursed to the local handler to cover docking and electricity expenses. The price was Rp. 30,000 per trip and Rp. 30,000 per month for wooden and fiberglass boats respectively. Profit sharing is the distribution of production proceeds. It entailed the deduction of operational costs from the income, which was subsequently divided between the owner and the remaining proceeds allocated to the two fishermen involved.

3.2. Investment Period and Profits of Wood and Fiberglass Fishing Boats

The investment period was calculated to determine the duration required for the return on investment and the resultant profit after a year of investment. The table also shows that the fiberglass boats are superior due to their faster return period and higher profits compared to their wooden counterparts. One of the influencing factors was the distance covered during fishing operations. Sooner or later, the profits obtained by fishermen will certainly have a big impact on the continuity of the fishing business owned by the fishermen themselves.

Name of fishing vessel	Payback Period (PP)	Profit
KM. Atalon 04	7th year	IDR 8,385,000
KM. Dara Barona	6 th year	IDR 8,991,000
KM. Amazon 02	7 th year	IDR 9,330,000
KM. Mutiara Makmur 01	6 th year	IDR 11,443,077
KM. Mutiara Makmur	6 th year	IDR 11,240,769
KM. Mutiara Rezeki	6 th year	IDR 10,372,308

Table 4. Results of economic analysis of the two vessels as well as their investment period

4. DISCUSSION

4.1. Comparison of Economic Analysis of Wooden and Fiberglass Fishing Boats

The use of wooden and fiberglass boats has different investment costs evident in the type of investment goods and the overall expenditure laid out by shipbuilding business actors (Samuel, 2013). Operational costs also differ due to the expenses incurred in each phase of the fishing operations (Wijayanto, *et al*., 2016). According to Simamora et. al (2016), in calculating vessel production costs, it is necessary to calculate the cost of ship rafters (ship materials), vessel engine installation costs, and labor costs, when a vessel construction is carried out. Table 5 provides a comprehensive overview of the total investment and operation of both boat types, where these two costs are the results of interviews during the research.

Types of fishing vessels	Total investment (IDR)	Total operating costs (IDR)
Wooden fishing boats	235,896,667	222,352,000
Fiberglass fishing boat	266,820,000	209,513,333

Table 5. Comprehensive overview of the total investment and operation costs of both boat types

The economic analysis was carried out to determine the feasibility of the business. In the comparison between both fishing vessels, the ensuing economic analysis entailed the calculation of Net Present Value (NPV), Net Benefit Cost Ratio (Net B/C), and the Internal Rate of Return (IRR). These calculations are presented in Table 6.

Economic analysis	Wooden fishing boats	Fiberglass fishing boats
Net Present Value (NPV)	IDR 72,935,055	IDR 84,511,500
Net Benefit Cost Rasio (Net B/C)	1	1
Internal Rate of Return (IRR)	11%	11%

Table 6. Economic analysis results of wooden and fiberglass boat types

a) Net Present Value (NPV)

The Net Present Value (NPV) is the current value of the difference between benefits and costs at a discount rate, and to calculate the present value, the relevant interest rate is determined. According to Dai (2022), the NPV serves as a simple and direct measurement for evaluating investments. It accounts for the time value in calculations, converting future money into its present value equivalent. A project is deemed feasible when the NPV > 0, signifying a recommendation to proceed or establish a new business of a similar nature. Conversely, when the NPV < 0, the project is considered infeasible, warranting discontinuation or rejection of business establishment. The NPV is the summation of the present value of cash flows resulting from investing a specific amount of capital into a business. This definition underscores the distinction between the present value of capital expenditures and the present value of investment benefits (Potts, 2002).

The analysis yielded a net present value of IDR 72,935,055 and IDR 84,511,500 for wooden and fiberglass boats respectively. The NPV values for both vessels were greater than 0, signifying the acceptance of the project proposals. It was also evident that fiberglass boats exhibited a higher value compared to their wooden counterparts.

b) Net Benefit-Cost Ratio (Net B/C)

The Net Benefit-Cost Ratio (Net B/C) is an analysis of the balance between revenues and costs, resulting from the division of business profits by expenses. According to Polhaupessy (2020), it entails a comparison between the present value of positive net profits and that of negative net profits. Ramadan *et al*. (2016) emphasized this ratio delineating the comparison between the level of gross income earned and the total costs incurred.

The analysis yielded a Net B/C value of 1 for both fishing vessels. The project is deemed worthwhile when Net B/C > 1. Interestingly, the Net B/C value had the same value of 1 for both vessels.

c) Internal Rate of Return (IRR)

The Internal Rate of Return (IRR) was defined as the interest rate at which the present value of capital expenditures in an investment or development business is equal to the present value of the initial investment costs and benefits. The IRR is best utilized in conjunction with other analyses to assess projects, allowing users to determine their accuracy in relation to other benchmarks (Patrick, 2016). The business or investment calculation method entails comparing the interest rate of a given year with the obtained internal rate of return. A feasible IRR is achieved when the business value exceeds the interest rate of that specific year (Wismaningrum *et al*., 2013).

The analysis yielded an IRR of 11% for both fishing vessel types, with a discount factor ratio of 5.75%. They also exhibited an IRR > bank interest, indicating the feasibility of the business project. Interestingly, the Net B/C shared the same value of 11%.

4.2. Investment Period and Investment Returns on Wood and Fiberglass Fishing Boats

Economic analysis	Wooden fishing Boats	Fiberglass fishing boat
Payback Period (PP)	6.6 th year	6th year
Profits	IDR 8,902,000	IDR 11,936,944

Table 7. Calculation of the investment period, including the payback period (PP) and profits

a) Payback Period (PP)

The payback period denotes the timeframe needed for a net cash flow to recoup the incurred investment costs, and the time (in years) that an investment will take to recuperate. The project was accepted when this period is shorter than the predetermined threshold, but rejected when the period is higher. The payback period is expressed in years, and a shorter duration is preferable as it implies reduced risk.

The analysis yielded a payback period of 6.6 and 6 years for wooden and fiberglass boats respectively. This revealed that the payback period for the fiberglass boats was shorter.

b) Profit

Profit is the surplus income resulting from income exceeding the expenditures or the initial capital issued. The analysis yielded a profit value of IDR 8,902,000 and IDR 11,936,944 for wooden and fiberglass boats respectively. This indicated that the fiberglass boats recovered the capital investment more swiftly.

5. CONCLUSION

The economic comparison between the wooden boats and fiberglass boats in terms of NPV, net B/C, and IRR values has shown that the NPV of wooden boats was obtained at 69,748,403; 79,358,359; and 69,698,403, while the NPV of fiberglass boats was obtained at 88,798,137; 82,438,182, and 82,298,182. The NPV value obtained means that the business proposal has been accepted. The net B/C value for all types of boats, both wooden and fiberglass, is 1. This value indicates a break-even point for the business. The IRR values for wooden boats are 11%, 11%, and 14%, while the IRR values for fiberglass boats are 11%, 13%, and 12%. The IRR value states that a business project is feasible. Based on the results of the payback period calculation, new wooden boats will be able to return the capital in the 7th year for the boats KM. Atalon 04 and KM. Amazon 02. However, KM. Dara Barona can return the capital more quickly, i.e., in the 6th year. Meanwhile, all fiberglass boats can return the capital in the 6th year. Judging from the profits obtained, fiberglass boats also have profits in the range of IDR 10 to 11 million, as a difference from wooden boats, which have IDR only around 8 to 9 million.

CONFLICT OF INTEREST

The authors declared no potential conflicts of interest with respect to the research, authorship and publication of this article.

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