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Economic viability and fuel consumption of the anchovy and sardine gillnets operated along the Mangaluru coast off Karnataka

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Abstract
This research examines the economic sustainability and fuel efficiency of anchovy (*Stolephorus indicus*) and sardine (*Sardinella longiceps*) gillnets were evaluated through fisheries activities during January-September 2024 on the Karnataka coast off Mangaluru. The evaluation shows that operating sardine gillnets provides more stable and consistent financial returns than anchovy gillnets. During this study duration, sardine gillnets produced a gross revenue of ₹ 3,59,195.00 with net profits totalling ₹ 3,11,840.00, while anchovy gillnets brought in a gross revenue of ₹ 1,36,357.00 resulting in net profits of ₹ 96,557.00. Profitability trends demonstrated seasonal peaks for anchovy gillnets which surfaced between days 0 to 120 yet sardine gillnets showed steady profitability during the whole study period. The consumption of fuel for sardine gillnets spanned from 30.00 to 33.50 liters per trip at a range of 0.13 to 0.92 liters per kilogram of caught fish. The fuel usage of anchovy gillnets spans between 30.00 to 35.30 liters per trip and their fuel consumption per kilogram varies from 0.20 to 2.76 liters. The research indicates that sardine gillnets provide both reduced fuel expenditures along with enhanced economic long-term viability throughout the entire year. Selection of appropriate mesh sizes alongside fishing methods presents essential findings for reaching maximum fuel efficiency and profitability in small-scale fisheries.

Keywords: Economic viability, fuel consumption, Sardine gillnet, Anchovy gillnet, sustainability

1. Introduction
Local economic stability depends heavily on anchovy and sardine gillnet fisheries although these sectors have suffered numerous effects. The small pelagic fish species function as forage fish which have dual importance for human food security and village economies together with their essential role in maintaining the marine ecosystem. The state of Karnataka retrieved 6,04,000 tons of marine fish during 2023 which marked a decrease of 13% since reaching its peak in 2022. The main sources of these landings came from the significant ports of Mangalore (44%) and Malpe (41%) (CMFRI, 2024) [5]. The decline in fish landings may be attributed to factors such as climatic variations, overfishing pressure and changes in marine ecosystems, which have been reported in previous studies (Pillai, 2011; Schwartzlose *et al.*, 1999) [16, 19]. Recognizing the significance of these fisheries, it is essential to investigate their economic viability and fuel consumption patterns to inform policy decisions and guide the development of more sustainable fishing practices (Gozzer-Wuest *et al.*, 2021; Suuronen *et al.*, 2012;) [9, 22].
Gillnets are crucial fishing gear for capturing both marine and inland fish species in India. They are highly selective and considered one of the most suitable methods for conservation and stock regulation (Thomas, 2010) [25]. In the marine sector, gillnets are commonly employed by traditional and motorized fishing vessels. This gear acts as a passive capture device, typically undetectable by fish until they are caught (Acosta, 1997; Laxmappa & Bakshi, 2014) [1, 14]. It is widely recognized as an important fishing gear worldwide, particularly for catching high-value fish species (He, 2006) [12].
Gillnets are highly selective in terms of both species and size. Compared to certain active fishing methods, gillnetting is considered more eco-friendly. By selecting an appropriate mesh size, overexploitation and juvenile capture can be reduced, while bycatch is minimized as few non-target species are caught (Thomas, 2010) [25]. The ability to reduce bycatch is

particularly significant in the conservation of small pelagic fish stocks, which are highly susceptible to overfishing (Freon *et al.*, 2005) [7].

Gillnets are unique among fishing gear because their mesh size not only catches fish but also selectively targets specific species (Anonymous, 1994) [2]. They are classified based on their method of operation into drift gillnets, set gillnets and encircling gillnets. They are used to capture various groups of fish, including sardines, anchovies, mackerel, hilsa and larger species such as tuna, sharks, seer fish and other large pelagic fishes (Thomas, 2002) [24]. Table 1 presents the classification of different gillnet types based on their target species and operational depth.

Table 1: Classification of Gillnet Types Based on Target Species and Operational Depth

Gillnet Type	Target Species	Operational Depth (m)
Drift Gillnet	Tuna, mackerel, sharks	50-100
Set Gillnet	Sardines, anchovies, hilsa	10-50
Encircling Gillnet	Seer fish, carangids, pomfrets	15-60

Gillnets consume only 0.25 kg of fuel per kilogram of fish caught, compared to 0.8 kg by trawling, making them highly energy-efficient fishing gear (Gulbrandsen, 1986) [11]. Unlike trawling, which disturbs the seabed, gillnets cause minimal environmental impact, apart from the issue of ghost fishing by lost nets. They are also considered highly selective, as very few fish caught differ in length by more than 20% from the optimum (Baranov, 1948) [3]. Gillnet fishing creates economic value through decreased maintenance expenses as well as minimized fuel consumption and maintained productivity of fisheries (Soe *et al.*, 2022) [21].

This research aimed to determine economic performance alongside fuel requirements for sardine and anchovy gillnet fishing operations occurring at the Karnataka off Mangaluru coast. This research investigates the financial output of the two gillnet types to deliver knowledge about sustainable fisheries control practices as well as power-efficient fishing strategies and economic gains for independent fishing professionals.

2. Materials and Methods

2. 1 Study Area

The study was conducted between January and September 2024, covering the coastal waters of Mangaluru, Karnataka. The fishing operations occurred throughout depths of 15 to 20 fathoms between Station I (latitude 12°53’50.3” N, longitude 074°40’09.4” E) and Station II (latitude 12°57'50.5" N, longitude 74°40'10.5" E). Due to its rich biodiversity along with high fish productiveness the area serves perfectly to investigate both economic and ecological sustainability of gillnet fishing.

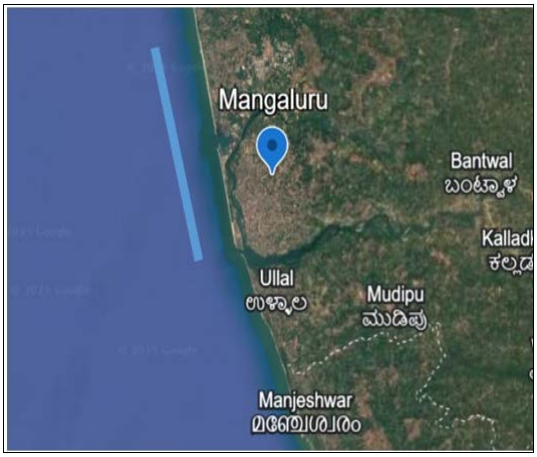

Fig 1: Location of the study area along the Mangaluru coast, Karnataka

2.2 Fishing Vessel and Gear Configuration

The research vessel operated for the study, namely *Shreedevi*, was a 10.2-meter-long Fiber-Reinforced Plastic (FRP) boat with a breadth of 2.13 m, a depth of 1.0 m and a mean draft of 0.65 m, powered by a 9.9 HP YAMAHA outboard engine. The design selection came from fuel-efficient characteristics and exceptional maneuverability while being ideal for small-scale fishing operations. The fishing vessel operated with a three-member crew team performed their fishing trips twice per month throughout the study period.

Two types of monofilament gillnets were used:

- Anchovy gillnet: 20 mm mesh size, designed for targeting small pelagic species such as *Stolephorus indicus*.
- Sardine gillnet: 38 mm mesh size, optimized for catching larger pelagic species like *Sardinella longiceps*.

Gillnets were deployed at early morning and remained floating in the water for 4 to 5 hours on each trip. The fishing strategy implemented passive gear methods to enable fish catch by natural swimming behavior instead of seabed disturbances or bycatch incidents (Freon *et al.*, 2005) [7].

2.3 Data Collection and Analysis

The study recorded detailed data on:

- Total catch weight (kg) per trip
- Fuel consumption (liters per trip)
- Operational costs, including labor and maintenance
- Market price and revenue generation
- Net Profit Margin (NPM) and Return on Investment (ROI)
- Fuel Consumption per Kilogram of Catch (FC/kg)

Catch data were categorized based on species composition and economic parameters were assessed using established

fisheries economic models. Comparative analysis was performed to evaluate the fuel efficiency and economic sustainability of the two gillnet types.

The results were compared with previous studies on fuel efficiency and economic sustainability in Indian and global fisheries, providing a comprehensive understanding of the long-term viability of gillnet operations (Soe *et al.*, 2022; Schwartzlose *et al.*, 1999) [21, 19].

3. Results and Discussion

3. 1 Fuel Efficiency and Economic Performance

The study assessed the economic performance of sardine and anchovy gillnets over a time period of nine months (January to September, 2024). During this time, the total catch from anchovy gillnets amounted to 1,227.75 kg, generates a gross revenue of ₹ 1,36,357.00 against an operating cost of ₹ 39,800.00, which results in a net profit of ₹ 96,557.00. The highest catch (156.95 kg) and peak net profit (₹ 16,843.00) were recorded on the 90th day (Table 2). Consistently positive net profits were observed from day 0 to day 120, with the most profitable period occurring between days 30 and 105. The anchovy catch peaked between February and April, corresponding with the highest profitability. However, after 120 days, a sharp decline in catch rates led to decreased revenues and in some cases, negative net profits were recorded. Notably, day 150 and day 195 resulted in losses of ₹ 277.00 and ₹ 1,208.00, respectively. These trends suggest that anchovy gillnets are most viable during peak fishing seasons (first 120 days), with diminishing returns beyond this period due to reduced catch rates.

Sardine gillnets maintained constant economic stability and profitable earnings throughout the research duration. The total catch of sardines reached 2,167.67 kilograms which generated ₹ 3,59,195.00 gross revenue after operating expenses of ₹ 47,355.00 led to a net profit of ₹ 3,11,840.00. The fishermen achieved their maximum catch of 263.27 kg together with the highest net profit of ₹ 48,868.00 on day 195 (Table 3). Sardines were caught in high numbers between June and September thus boosting profitability. Unlike anchovy gillnets, the profitability of sardine gillnets produced consistent revenue growth during the study period which reached its optimum level from days 150 to 225.

Short-term profit results from anchovy gillnets differ from the sustainable economic stability that sardine gillnets produce for year-round operations. Sardine gillnets achieve superior fishing results because fishing strategies focus on specific species and optimal gear selection combined with high market value of the caught fishes (Geetha *et al.*, 2014) [8]. Gillnet fishing stands out worldwide as a financially profitable system because it demands reduced capital outlay and smaller team staffing compared to other fishing methods (Dar & Thomas, 2015) [6].

3. 2 Catch Composition and Market Value

Market analysis revealed distinct economic patterns based on species classification. Fish species were categorized into five price categories, with values ranging from ₹ 0 to ₹ 250.00 per kg (Table 4). Species classified in category 1, which had negligible or discarded value. Category 2 were generally of low market demand due to their small size or lesser consumer preference. The economic value of category 3, 4 and 5 species (priced between ₹ 101.00 and ₹ 250.00) remained high as they offered valuable features such as better flesh quality and larger size and consumer popularity.

Sardine gillnets (with 38 mm mesh size) achieved the greatest catch rates but anchovy gillnets (with 20 mm size) produced higher amounts of nonspecific catch. Research findings confirm earlier studies indicating smaller mesh dimensions cause increased catch of unwanted species and generate higher discarding and reduced economic efficiency (Gray *et al.*, 2005; Martin & Crawford, 2015) [10, 15].

3. 3 Fuel Efficiency and Energy Consumption

Fuel consumption analysis showed that sardine gillnets were more fuel-efficient than anchovy gillnets. Fuel consumption for sardine gillnet ranged from 30 to 33 liters per trip, with fuel consumption per kilogram of catch varying between 0.13 and 0.92 liters (Table 5). On the other hand, anchovy gillnet required between 30 and 35.3 liters of fuel per trip and fuel consumption per kilogram ranged from 0.20 to 2.76 liters (Table 6).

These findings demonstrates that sardine gillnets provide optimum fuel usage which makes them suitable as sustainable tools for small-scale fisheries. Gillnetting and lining and trap fishing techniques require minimal vessel energy to operate thus they lead to both economic savings and environmental protection (Johnstone and Mackie, 1986; Ben-Yami, 1993) [13, 4].

The scientific studies conducted at Kerala's coastal areas show that gillnets utilize 0.46 kg of fuel while catching one kg of fish but trawls require 0.8 kg of fuel for the same amount of catch (Thomas, 2001; Suuronen *et al.*, 2012) [13, 22]. In this study, the fuel costs were subtracted from the total profits and the remaining amount was split into two equal parts: one for the boat owner and the other for the crew. The boat owner covers all the operational costs, including boat modifications, gear, fuel, ice, food and other incidental expenses. The crew's share is then divided among the members. Previous studies have shown that the crew's share typically ranges from 13% (Silas *et al.*, 1984) [20]. to 32.8% (Rao and Pandey, 1990) [17], with some estimates going as high as 55-60% (Sathiadhas *et al.*, 1991) [18].

Table 2: Economic performance and profitability of the Anchovy Gillnet during the study period from January 2024 to September 2024

Days	Total Catch (kg)	Total Operating Cost (₹)	Gross Revenue (₹)	Net Profit (₹)
0	67.2	1800	5725	3925
15	65.1	2200	6797	4597
30	133.2	3000	15073	12073
45	148.8	2500	19175	16675
60	156	2850	16753	13903
75	153.4	2700	16431	13731
90	156.95	2000	18843	16843
105	122.83	2200	14471	12271
120	53.05	1950	5886	3936
135	35.25	2000	5140	3140
150	19.25	2100	1823	-277
165	16.5	2200	1468	-732
180	18.77	1850	1866	16
195	15.85	2600	1392	-1208
210	17.65	2200	1573	-627
225	15.6	1800	1449	-351
240	18.4	2000	1276	-724
255	13.95	1850	1216	-634
Total	1227.75	39800	136357	96557

Table 3: Economic performance and profitability of the Sardine Gillnet during the study period from January 2024 to September 2024

Days	Total Catch (kg)	Gross Revenue (₹)	Total Operating Cost (₹)	Net Profit (₹)
0	54.35	9121	2170	6951
15	53.7	8979	2500	6479
30	50.9	7793	2000	5793
45	61.15	9616	2135	7481
60	62.98	8832	1800	7032
75	50.65	8469	3000	5469
90	58.03	8513	2250	6263
105	33.87	5985	1950	4035
120	43.2	7187	2200	4987
135	34.49	6295	2300	3995
150	158.15	26237	2170	24067
165	220.9	39114	4500	34614
180	245.23	34842	3000	31842
195	263.27	51468	2600	48868
210	236.8	38166	3000	35166
225	214.6	38878	5000	33878
240	147.1	21807	2280	19527
255	178.3	27893	2500	25393
Total	2167.67	359195	47355	311840

Table 4: Comparison of average price and price categories of fish species caught using Sardine and Anchovy Gillnets

S. No	Species	Sardine Gillnet		Anchovy Gillnet	
		Average price	Price category	Average price	Price category
1	*Sardinella longiceps*	138	3	63	2
2	*Rastrelliger kanagurta*	162	4	_	_
3	*Stolephorus indicus*	54	2	54	2
4	*Megalaspis cordyla*	153	4	_	_
5	*Encrasicholina devisi*	144	3	144	3
6	*Escualosa thoracata*	53	2	25	1
7	*Sardinella albella*	47	1	24	1
8	*Scomberoides tol*	238	5	_	_
9	*Scomberoides lysan*	142	3	_	_
10	*Otolithes ruber*	182	4	_	_
11	*Thryssa hamiltonii*	17	1	18	1
12	*Nematalosa nasus*	91	2	38	1
13	*Caranx heberi*	172	4	_	_
14	*Devexim entum insidiator*	51	2	34	1
15	*Lactarius lactarius*	240	5	_	_
16	*Sillago sihama*	169	4	46	1
17	*Trichiurus lepturus*	30	1	_	_
18	*Sphyraena putnamae*	244	5	90	2

Table 5: Fuel consumption and catch efficiency of fishing trips using Sardine Gillnet

Fishing trips	Duration of Trip (hours)	Fuel Consumption (liters/ trip)	Catch (kg)	Fuel Consumption per kg Catch (liters/kg)
1	4.00	31.30	57.05	0.55
2	4.50	30.00	53.7	0.56
3	5.00	30.50	50.9	0.60
4	5.00	31.60	64.65	0.49
5	4.00	31.80	64.33	0.49
6	5.00	30.00	50.65	0.59
7	4.50	30.00	60.03	0.50
8	4.00	31.00	33.87	0.92
9	4.00	32.00	43.82	0.73
10	4.20	30.00	34.49	0.87
11	5.00	31.70	158.15	0.20
12	5.00	33.00	228.65	0.14
13	4.00	32.10	213.05	0.15
14	5.00	31.00	231.22	0.13
15	4.50	30.50	228.4	0.13
16	5.00	30.70	231.4	0.13
17	4.50	32.00	147.1	0.22
18	5.20	32.90	185.05	0.18
Average	4.58	31.23	118.695	0.42

Table 6: Fuel consumption and catch efficiency of fishing trips using Anchovy Gillnet

Fishing trips	Duration of Trip (hours)	Fuel Consumption (liters/trip)	Catch (kg)	Fuel Consumption per kg Catch (liters/kg)
1	4.00	33.50	60.8	0.55
2	4.60	33.00	65.1	0.51
3	5.00	32.00	126.4	0.25
4	5.30	33.20	162.4	0.20
5	4.00	33.50	156	0.21
6	4.80	31.50	153.4	0.21
7	4.60	33.80	156.95	0.22
8	4.00	30.00	123.38	0.24
9	5.00	30.30	53.05	0.57
10	5.20	33.30	35.25	0.95
11	4.00	34.80	17.55	1.98
12	4.00	31.60	16.5	1.91
13	4.20	31.00	18.77	1.65
14	4.30	35.20	12.75	2.76
15	5.00	34.00	16	2.13
16	4.80	33.00	15.6	2.12
17	4.00	35.30	16.4	2.15
18	4.30	32.90	13.95	2.36
Average	4.51	32.88	67.8	1.17

4. Conclusion

The research proves sardine gillnets offer a better economic value along with ecological stability for small-scale fisheries compared to anchovy gillnets operating in Mangaluru coast. Research shows sardine gillnets generate better profitability and consume less fuel and maintain stable catch rates throughout the year but anchovy gillnets produce variable economic outcomes and need extra fuel usage. The research demonstrates that selecting the appropriate mesh dimension plays a key role in fishing efficiency because sardine gillnets (38 mm) maintain better target species selectivity thus reducing both unwanted catches when compared to anchovy gillnets (20 mm).

The achievement of sustainable fisheries demands policymakers to work on three key initiatives, including the promotion of energy-efficient fishing practices, strict mesh size regulations enforcement and providing economic benefits for low-power fishing technologies. Research in the future needs to investigate different fishing gear inventions together with new power systems and extended fish population monitoring methods for improved fisheries management practices. Sustainable fishing practices together with strategic policies enhance economic durability for fisheries stakeholders who want to protect the sustainability of marine resources in Indian coastal areas.

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