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Dried Fish and Fishmeal as Commodities: Boosting Profitability for Artisanal Fishers in Namibe, Angola

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Abstract

Artisanal fishing is a central pillar of the Angolan economy, particularly in the southern province of Namibe, where it serves as the primary economic activity for numerous coastal communities. However, these communities face significant challenges, including competition from expanding industrial fisheries and inadequate infrastructure at fishing centers, which hampers the storage, preservation, and transportation of catches. These limitations contribute to post-harvest losses and the reduced market value of products, despite the region's rich diversity of pelagic and demersal resources. This study evaluated the economic viability of artisanal fishing in Namibe under three production scenarios, varying in catch levels and the inclusion of fish processing activities such as dried fish and fishmeal production. Scenario A (pessimistic) assumed a 10% reduction in production compared to the best estimates; Scenario B (intermediate) was based on average reported catches; and Scenario C (optimistic) considered a 10% increase in catches, accounting for seasonal and environmental variability. Results indicated that artisanal fishing was economically viable under all scenarios, with the Internal Rate of Return (IRR) consistently exceeding the Minimum Attractive Rate of Return (MARR) of 7.5%. IRR values ranged from 34.30% (Scenario A, without by-product commercialization) to 106.28% (Scenario C, with dried fish and fishmeal production and sales), representing a more than threefold increase in profitability. This substantial gain underscores the transformative potential of processing by-products into higher-value commodities, enabling integration into larger-scale and more liquid markets. Such value addition supports the concept of a proximity economy by promoting short production cycles, reducing intermediaries, and strengthening local value chains. Beyond financial returns, the findings suggest broader socioeconomic benefits, including local economic growth, job creation, and the preservation of traditional production knowledge. The payback period was less than four years in all cases, decreasing to 1.94 years in the most favorable scenario. By-products such as dried fish and fishmeal exhibit commodity-like characteristics due to their higher commercial value, increasing demand, and potential integration into regional and animal feed markets. In conclusion, diversifying marketing strategies and maximizing the use of fish resources can significantly enhance the economic sustainability of artisanal fishing, foster socioeconomic inclusion, and support the development of artisanal fishing communities in Namibe.

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1. Introduction

Artisanal fishing is a vital economic activity for coastal communities in developing countries, playing a central role in food security, income generation, and socioeconomic sustainability [1]. In Angola, this activity is particularly relevant in the provinces of Namibe, Benguela, and Luanda, standing out as one of the economic pillars of the coastal region. The country benefits from an Exclusive Economic Zone (EEZ) rich in pelagic and demersal species, with an estimated annual catch of over 400,000 tons of fish, and potential for sustainable growth through effective marine resource management [2].

The Angolan Atlantic coast, stretching approximately 1650 km, offers favorable conditions for the development of artisanal fisheries, characterized by the use of small-scale vessels and traditional fishing methods [3]. Artisanal fishing is a central pillar of Angola's coastal economy, especially in Namibe Province, where it constitutes the main economic activity for many traditional communities [2]. Beyond its economic relevance, artisanal fishing has deep social, cultural, and nutritional implications, contributing significantly to local identity, food security, and social justice. Despite its importance, the sector faces structural challenges that undermine its sustainability and call for appropriate public policies to enhance and strengthen it.

Artisanal fishing in Angola faces a combination of structural and institutional challenges that threaten its long-term sustainability. One of the most pressing issues is the rapid expansion of industrial fishing, frequently conducted by foreign fleets, which exerts considerable pressure on marine resources and creates conflicts with artisanal fishers due to overlapping fishing grounds [4]. Simultaneously, inadequate infrastructure at landing sites undermines the preservation, storage, and transportation of fish, resulting in significant post-harvest losses and a consequent reduction in product value [5]. These constraints are compounded by the absence of robust public policies, which limit investment, technical training, and access to markets [6]. This institutional neglect deepens the social and economic marginalization of vulnerable communities, where artisanal fishing remains an essential source of livelihoods [7].

Beyond its role as an economic activity, artisanal fishing holds profound social, cultural, and ecological significance. Recent studies have expanded the understanding of its contributions to human well-being, highlighting benefits that extend beyond conventional economic indicators [6]. In Angola, the sector directly engages more than 50,000 people, with fishers' wives playing a central role in post-harvest processes such as fish processing and marketing [5]. These activities position artisanal fishing as a multifunctional and multidimensional system, encompassing food provision, income generation, gender equity, local ecological knowledge, and participatory governance. Recognizing these diverse functions is crucial for the development of effective and equitable public policies, particularly in countries like Angola, where artisanal fisheries act as spaces of economic, cultural, and ecological resilience [6].

This multidimensional importance is further reflected in the sector's alignment with the United Nations Sustainable Development Goals (SDGs). By ensuring access to affordable, high-quality protein, artisanal fishing contributes directly to SDG 2 (Zero Hunger and Sustainable Agriculture), strengthening food security in 325 coastal communities [1]. In the context of SDG 5 (Gender Equality), the prominence of women in post-harvest activities, particularly in dried fish and fishmeal production, is noteworthy. These roles,

predominantly carried out by women, underscore the need for targeted measures to expand access to financing, technical training, and ownership of production means [8,9], thereby enhancing women's economic autonomy and advancing gender equity in the fisheries sector. Furthermore, artisanal fishing contributes to SDG 14 (Life Below Water) through sustainable practices grounded in traditional ecological knowledge and community-based marine resource management [1,10]. The promotion of value-added products through low-impact technologies, such as drying and fishmeal production from processing residues, not only reduces waste but also fosters a circular economy that aligns environmental sustainability with local economic development [11,12]. Collectively, these attributes illustrate the sector's potential to serve as a strategic driver for achieving national development goals while preserving marine ecosystems and strengthening community resilience.

Beyond its economic contribution, artisanal fishing plays a crucial role in ensuring access to affordable animal protein, reinforcing food security, and promoting nutritional autonomy in coastal communities [2]. However, the contributions of artisanal fishing go beyond economic indicators, encompassing social, cultural, environmental, and nutritional dimensions that are often overlooked in public policy analysis and decision-making processes [6]. Recognizing and incorporating these multiple dimensions is essential for the development of fairer and more sustainable policies, especially in contexts marked by high socio-environmental vulnerability, as is the case of many coastal communities in Angola. Among the practices associated with artisanal fisheries in Angola, the production of dried fish and the transformation of fish waste into fishmeal stand out. These activities not only add value to the catch but also increase the utilization of fish resources and diversify the income sources of fishers [4]. Dried fish production, based on solar dehydration, is a traditional technique widely used in the provinces of Benguela, Namibe, and Luanda; this practice enables fish preservation in areas with limited refrigeration infrastructure and facilitates its commercialization in local and cross-border markets [13]. Simultaneously, fishmeal, obtained through the drying and grinding of fish residues, has gained prominence within the blue economy due to its application in the aquaculture, animal feed, and agro-industrial sectors [14]. In Angola, artisanal fishers have been seeking to enter this emerging market, although they face challenges related to standardization, access to appropriate technologies, and compliance with sanitary regulations [15].

Despite the significant economic and nutritional importance of artisanal fishing, a comprehensive understanding of production dynamics, logistical constraints, and marketing channels is essential to inform public policies that can strengthen the sector and promote the sustainable development of coastal communities. In this context, the present study assesses the economic viability of artisanal fishing in Namibe Province by comparing different production scenarios, with and without the incorporation of dried fish and fishmeal production and commercialization. This analysis seeks to identify the main challenges, opportunities, and socioeconomic impacts associated with these value-adding practices. The central hypothesis is that, although the inclusion of by-product processing requires higher initial investments, it can substantially enhance profitability, thereby improving the economic sustainability and resilience of artisanal fisheries in the region.

2. Materials and Methods

2.1. Study Area

Namibe Province, located in southwestern Angola, is one of the country's 21 provinces, covering an area of approximately 57,091 km^2. Its administrative division includes nine municipalities: Moçâmedes, Tômbwa, Saco-Mar, Lucira, Bibala, Camucuio, Virei, Iona, and Cacimbas, of which only the first four have coastal access. The province has a coastline of about 450 km, accounting for approximately 27% of Angola's maritime border. This coastal

strip is characterized by high fishery potential, with a wide variety of marine resources, including pelagic and demersal species, as well as crustaceans and mollusks such as crabs, cuttlefish, octopus, and squid [2].

The territory of Namibe is predominantly arid desert, with a low population density. Most inhabitants are concentrated in the coastal municipalities of Tômbwa and Moçâmedes, as well as in Lucira, a locality with a strong fishing tradition. In this context, artisanal fishing, primarily for subsistence, constitutes the main economic and food-related activity in the region [16,17].

2.2. Characterization of the Small-Scale Fleet and Estimation of Fishery Production

Between July 2024 and March 2025, semi-structured interviews were conducted in the artisanal fishing communities of Namibe Province (Figure 1) to obtain technical and economic information on the types of vessels, engines and gear used; fish production data; and processes involved in drying fish and producing fishmeal. A snowball sampling technique was employed, where initial respondents referred new participants until the saturation point was reached, when new interviews no longer yielded novel information [18]. In total, 112 artisanal fishers were interviewed.

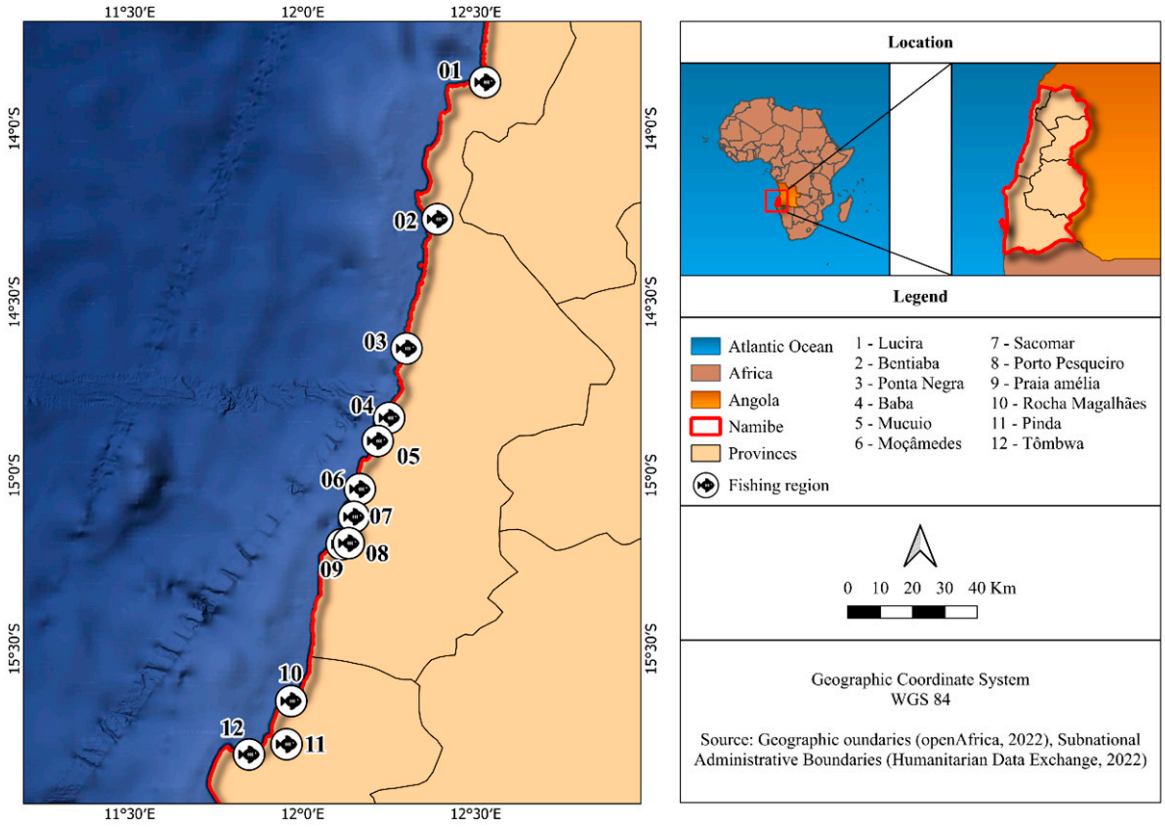

Figure 1. Main fishing localities along the Namibe coastal region. Source: Geografic oundaries (open Africa, 2022), Subnational Administrative Boundaries (Humanitarian Data Exchange, 2022).

To characterize the fishing fleet and the stakeholders involved, the most frequently observed values (mode averages) were used based on the collected field data. Information included vessel size and construction material, engine power, fishing gear, operational dynamics, activity costs, crew composition (fisher and assistant), and the market prices for fish. Additionally, monthly capture data on marine resources in the region were obtained from the Provincial Fisheries Office of Angola, the official entity responsible for fisheries' production records in the country.

2.3. Economic Viability Analysis of Artisanal Fisheries

2.3.1. Estimation of Production Costs

The economic viability of artisanal fishing was assessed based on estimates of production costs, return on investment, and profitability indicators [19,20], with adaptations to the artisanal fishing context in Namibe. The cost structure was divided into three categories:

(a) Effective Operating Cost (EOC): includes expenses directly related to fishing activity, such as fuel, engine oil, vessel and gear maintenance, and labor (fisher and assistant) compensation;
(b) Total Operating Cost (TOC): comprises the EOC plus financial charges, estimated as an annual interest rate applied to 50% of the EOC value, as well as depreciation of the vessel, engine, and fishing gear;
(c) Total Production Cost (TPC): includes the TOC plus annual interest for the capital initially invested in the activity.

2.3.2. Investment Return and Profitability Indicators

The profitability of the activity was evaluated using the following indicators: Net Present Value (NPV), Annualized Net Present Value (ANPV), Internal Rate of Return (IRR), Modified Internal Rate of Return (MIRR), and Payback Period (PP).

The NPV was calculated based on a projected cash flow over a 10-year period. Positive NPV values indicate that the activity is economically viable, as returns exceed the capital invested. The ANPV was employed to express the economic return of the project on an annual basis, enabling comparisons between investments of different durations in artisanal fishing.

The IRR is defined as the annual percentage return rate that equates the present value of future revenues to the initial investment. For its calculation, capital evolution over time was considered using a Minimum Attractive Rate of Return (MARR) set at 7.5% per year [21], based on interest rates from Angolan financial institutions (such as the Angola Development Bank and the Angolan Investment Bank) offering subsidized credit lines for the agriculture and fisheries sectors. The IRR reflects the investment's efficiency in generating net revenue, considering upfront payments and cash flows. The MIRR, on the other hand, assumes reinvestment at a realistic rate, offering a more accurate estimate of long-term project profitability [22].

The PP was estimated as the time required to recover the invested capital, excluding depreciation over time. Though simplified, this method enables rapid decision making and is particularly useful when returns are realized in the short term [23].

Based on the annual cash flow of the fishery activity, the following profitability indicators were also used [24]:

(a) Gross Revenue (GR): product of production volume and average selling price per kilogram of fish;
(b) Operating Profit (OP): difference between GR and TOC, i.e., $OP = GR - TOC$;
(c) Gross Margin (GM): expresses profitability relative to TOC, calculated as $GM = (GR - TOC)/TOC) \times 100$;
(d) Profitability Index (PI): percentage of operating profit in relation to GR, calculated as $PI = (OP/GR) \times 100$.

The annual production estimate was based on data provided by interviewees during fieldwork and on official fishery production data from the Provincial Fisheries Office of Angola, considering average capture volumes.

2.4. Sensitivity Analysis

Sensitivity analysis was conducted to evaluate the behavior of economic indicators (NPV, ANPV, IRR, and MIRR) in response to variations in fish production. Three scenarios were modeled: Scenario A (pessimistic): 10% reduction in catches, considering seasonal and environmental factors; Scenario B (baseline): maintenance of average production reported by fishers; Scenario C (optimistic): 10% increase in production, based on the highest capture estimates throughout the year (Table 1).

Table 1. Fishery production data and revenues per vessel from the commercialization of artisanal fishery products in Namibe, Angola, under the following scenarios: A (pessimistic), B (baseline conditions), and C (optimistic).

Fishing Resource	Scenario A (Pessimistic)		Scenario B (Baseline Conditions)		Scenario C (Optimistic)	
	kg/Week	USD [1]	kg/Week	USD [1]	kg/Week	USD [1]
Scomber japonicus	162	174.15	180	193.50	198	212.85
Spondyliosoma cantharus	27	30.96	30	34.40	33	37.84
Pomatomus saltatrix	9	43.54	10	48.37	11	53.21
Pseudotolithus typus	9	52.24	10	58.05	11	63.85
Dentex macrophthalmus	216	325.08	240	361.20	264	397.32
Pagellus bellottii	54	48.37	60	53.75	66	59.12
Epinephelus aeneus	14	79.82	15	88.69	17	97.56
Total/week	491	754.16	545	865.68	600	952.25
Total/month	1962	3016.64	2180	3351.82	2398	3687.01
Total/year	23,544	36,199.69	26,160	40,222.88	28,776	44,244.07

[1] Values expressed in USD (1.00 Angolan Kwanza = USD 0.0011); Source: Research data.

Additionally, a specific condition was analyzed involving the diversification of the commercialization of *Scomber japonicus* (chub mackerel). In this case, production was divided between whole fish sales (for consumption) and processed products (dried fish and fishmeal), also utilizing viscera and other fish processing residues (Figure 2, Tables 2 and 3).

Figure 2. Fish viscera for boiling and fishmeal production (**left**); boiled viscera laid out for drying on racks (**right**). Fonte: Hanamulamba, M.

Table 2. Production data and processing estimates of exploited resources and revenues generated per vessel from the commercialization of fish from artisanal fisheries in Namibe, Angola, Africa.

	100–0% [1]		90–10%		80–20%		70–30%		60–40%		50–50%	
	kg/Week	USD	kg/Week	USD	kg/Week	USD	kg/Week	USD	kg/Week	USD	kg/Week	USD
Scomber japonicus (Consumption)	180	193.50	162	174.15	144	154.80	126	135.45	108	116.10	90	96.75
S. japonicus (Processed)	0	-	18	31.85	36	63.71	54	95.56	72	127.41	90	159.27
Spondyliosoma cantharus	30	34.40	30	34.40	30	34.40	30	34.40	30	34.40	30	34.40
Pomatomus saltatrix	10	48.37	10	48.37	10	48.37	10	48.37	10	48.37	10	48.37
Pseudotolithus typus	10	58.05	10	58.05	10	58.05	10	58.05	10	58.05	10	58.05
Dentex macrophthalmus	240	361.20	240	361.20	240	361.20	240	361.20	240	361.20	240	361.20
Pagellus bellottii	60	53.75	60	53.75	60	53.75	60	53.75	60	53.75	60	53.75
Epinephelus aeneus	15	88.69	15	88.69	15	88.69	15	88.69	15	88.69	15	88.69
Total/week		837.96		676.31		862.96		875.47		887.97		900.48
Total/month		3351.82		3401.84		3451.85		3501.87		3551.88		3601.90
Total/year		40,221.88		40,822.06		41,422.25		42,022.43		42,622.62		43,222.80

[1] (Consumption%–Processed%) Source: Research data.

Table 3. Production data and processing estimates of exploited resources and revenues generated per vessel from the commercialization of fish from artisanal fisheries in Namibe, Angola, Africa.

	40–60% [1]		30–70%		20–80%		10–90%		0–100%	
	kg/Week	USD	kg/Week	USD	kg/Week	USD	kg/Week	USD	kg/Week	USD
Scomber japonicus (Consumption)	72	77.40	54	58.05	36	38.70	18	19.35	0	-
S. japonicus (Processed)	108	191.12	126	222.98	144	254.83	162	286.68	180	318.54
Spondyliosoma cantharus	30	34.40	30	34.40	30	34.40	30	34.40	30	34.40
Pomatomus saltatrix	10	48.37	10	48.37	10	48.37	10	48.37	10	48.37
Pseudotolithus typus	10	58.05	10	58.05	10	58.05	10	58.05	10	58.05
Dentex macrophthalmus	240	361.20	240	361.20	240	361.20	240	361.20	240	361.20
Pagellus bellottii	60	53.75	60	53.75	60	53.75	60	53.75	60	53.75
Epinephelus aeneus	15	88.69	15	88.69	15	88.69	15	88.69	15	88.69
Total/week		912.98		925.48		937.99		950.49		962.99
Total/month		3651.92		3701.93		3751.95		3801.96		3851.98
Total/year		43,822.99		44,423.17		45,023.36		45,623.54		46,223.72

[1] (Consumption%–Processed%). Source: Research data.

For this value-adding scenario, the initial investments and specific operational costs of the transformation activities were incorporated into the model, including materials and inputs such as pans, sieves, pallets, salt, gas, treading poles, and packaging.

3. Results

3.1. Characteristics of the Fishing Activity

Vessel Typology and Fishing Gear Used

The vessels used in artisanal fishing in the region exhibit typical characteristics of this productive segment, being mostly small-scale boats (Figure 3). They are constructed from wood, with average dimensions of 5.55 m in length, 1.80 m in width, and 90 cm in height. These boats are powered by 40 HP two-stroke outboard engines, which consume an average of 80 L of gasoline and 4 L of oil per fishing trip. Notably, no navigation or communication equipment is present on board, highlighting the operational vulnerability and risks associated with the activity.

Figure 3. Small-scale artisanal fishing vessel, "Chata" (**left**), and gillnet used along the Namibe coast (**right**). Source: Hanamulamba, M.

Regarding fishing gear, traditional methods predominate, particularly gillnets (Figure 3), along with the use of hand lines and hooks. This gear is employed to capture various commercially and nutritionally valuable species, such as *Spondyliosoma cantharus* (black seabream), *Pomatomus saltatrix* (bluefish), *Pseudotolithus typus* (croaker), *Dentex macrophthalmus* (large-eye dentex), *Pagellus bellottii* (red pandora), *S. japonicus* (Chub mackerel), and *Epinephelus aeneus* (white grouper).

The replacement or maintenance of fishing gear, especially gillnets, occurs according to material wear, typically on an annual basis. This time frame was adopted as the reference for estimating equipment maintenance costs. The frequency of fishing trips depends on weather conditions, generally occurring three times per week. Each trip lasts between 5 to 8 h and involves a crew composed of a vessel master and four assistants.

The catch is primarily sold directly, still fresh, immediately after landing. Part of the fish may undergo artisanal salting and drying processes (Figure 4), a practice that extends shelf life and facilitates distribution in areas with limited refrigeration infrastructure. The viscera resulting from this processing are used in fishmeal production, adding value to the fishery by-products.

Figure 4. Chub mackerel (*Scomber japonicus*) processed into dried fish. Source: Hanamulamba, M.

In cases of surplus catches, commercialization may also occur through intermediaries or by supplying restaurants, thereby expanding marketing channels.

3.2. Economic Viability of Artisanal Fishing

The economic viability analysis was based on cost data reported by fishers, including investments made in acquiring vessels, engines, and fishing gear. Additionally, a second analytical scenario was considered, incorporating fish processing stages such as dried fish (Figure 4) and fishmeal production (Figure 5). In the case of fishmeal, the viscera were subjected to drying and grinding (pounding) processes to produce a by-product intended for animal feed. This simulation enabled estimation of the impact of value addition on revenue, highlighting the economic potential of full fish utilization.

Figure 5. Viscera after drying and grinding (**left**) and finished fishmeal (**right**). Source: Hanamulamba, M.

The estimated initial investment for traditional artisanal fishing was USD 14,650.00. When incorporating dried fish and fishmeal production systems, this value increased by approximately 1.43%, as shown in Table 4, reflecting additional costs related to inputs and specific equipment required for artisanal processing.

According to the interviews carried out, it is observed that the remuneration of labor in artisanal fishing occurs after deducting the direct costs of capture, that is, the operational expenses generated during the fishing activity. The remaining net amount is distributed according to a traditional profit-sharing system: 50% is allocated to the vessel owner; 36% is divided among the crew, typically composed of three to four fishers, resulting in an individual share of approximately 9% to 12%; and the remaining 14% is assigned to the vessel master, who is responsible for navigation and operation coordination.

Operational costs considered in the analysis included expenditure on fuel, lubricating oil, crew food, maintenance of the hull and engine, bait purchases, and replacement of fishing gear, as well as lines and hooks. In the second scenario, which included dried fish and fishmeal production, additional costs for gas, salt, and packaging materials used in processing and storing the products were incorporated.

Based on the collected data, the total annual operating cost (TOC) of artisanal fishing was estimated at USD 28,844.28. When dried fish and fishmeal production were included, this value was adjusted to USD 30,392.72, as shown in Table 5.

Table 4. Investment required to operate a typical artisanal fishing vessel in Namibe, Angola, Africa, May 2025 [1].

Item	Quantity	Total Price	Useful Life (Replacement) [2]	Annual Depreciation (a)	Annual Interest on Capital [3] (b)	Total (a) + (b)
Fishing structure						
Boat–"Chata"	1	7000.00	20 (0)	350.00	262.50	612.50
40 HP 2-Stroke Outboard Engine	1	6000.00	6 (0)	1000.00	225.00	1.225.00
700 m Gillnet	1	1000.00	3 (3)	333.33	37.50	370.83
Fish drying and fishmeal production system						
Cooking pot	3	100.00	2 (4)	50.00	3.75	53.75
Drying rack	1	60.00	4 (2)	15.00	2.25	17.25
Draining box	3	20.00	4 (2)	5.00	0.75	5.75
Pounding stick	4	30.00	3 (3)	10.00	1.13	11.13
Vessel and personnel documentation						
Registration Roll + Sailor IDs	1	150.00			11.25	11.25
Documentation	3%	500.00			37.50	37.50
Total (without drying and fishmeal system)		**14,650.00**		**1683.33**	**573.75**	**2257.08**
Total (with drying and fishmeal system)		**14,860.00**		**1763.33**	**581.63**	**2344.96**

[1] Values expressed in USD (1.00 Angolan Kwanza = USD 0.0011); [2] Useful life in years; [3] Rate of 7.5% per year on initial capital; Source: Research data.

Table 5. Annual operational costs, financial charges, and total production cost of artisanal fishing with and without fish drying and fishmeal production in Namibe, Angola, Africa, May 2025 [1].

Item	Effective Operational Cost (EOC)	Financial Charges [2]	Total Operational Cost (TOC)	Other Fixed Costs	Total Production Cost (TPC)
Fishing structure					
Labor (skipper)	1670.54	62.65	1733.19		1733.19
Labor (fishermen)	4295.68	161.09	4456.76		4456.76
Gasoline (80 L)	4000.00	150.00	4150.00		4150.00
Oil	1200.00	45.00	1245.00		1245.00
Ice	150.00	5.63	155.63		155.63
Food expenses	1500.00	56.25	1556.25		1556.25
Boat maintenance (every 6 months)	500.00	18.75	518.75		518.75
Engine maintenance (monthly)	160.00	6.00	166.00		166.00
Bait	7000.00	262.50	7262.50		7262.50
Gillnet maintenance (1 panel every 15 days)	300.00	11.25	311.25		311.25
Purchase of line and hook	4500.00	168.75	4668.75		4668.75
Navigation license + AGT fees	150.00	5.63	155.63		155.63
Fishing license	200.00	7.50	207.50		207.50
Depreciation of fishing structure			1683.33		1683.33
Interest on invested capital—without fishmeal				573.75	573.75
Fish drying and fishmeal production system					
Labor (skipper) 14%	1821.12	68.29	1889.41		1889.41
Labor (fishermen) 36%	4682.87	175.61	4858.48		4858.48
Gas (fishmeal) (4 per month)	300.00	11.25	311.25		311.25
Sieve	350.00	13.13	363.13		363.13
Salt (28 kg per week)	150.00	5.63	155.63		155.63
Packaging	70.00	2.63	72.63		72.63
Depreciation of fish drying and meal system			80.00		80.00
Interest on invested capital—with fishmeal				581.63	581.63
Totals Without fish drying and meal production	25,626.22		28,270.53		28,844.28
With fish drying and meal production	27,033.99		29,811.10		30,392.72

[1] Values expressed in USD (1.00 Angolan Kwanza = USD 0.0011); [2] Rate of 7.5% per year on half EOC; Source: Research data.

The analyzed economic indicators demonstrated the viability of artisanal fishing under all three scenarios (A, B, and C). Both the Internal Rate of Return (IRR) and the Modified Internal Rate of Return (MIRR) exceeded the Minimum Attractive Rate of Return (MARR), set at 7.5%, across all simulated conditions. IRR and MIRR values ranged from 31.32% and 16.84%, respectively, in Scenario A (least favorable, without by-product commercialization), to 112.27% and 31.86% in Scenario C (most favorable, with inclusion of dried fish and fishmeal production and sales), as presented in Table 6.

Table 6. Profitability indicators and investment payback period for artisanal fishing in Namibe, Angola, Africa, May 2025 [1].

	Scenario A		Scenario B		Scenario C	
	Without Fishmeal	**With Fishmeal**	**Without Fishmeal**	**With Fishmeal**	**Without Fishmeal**	**With Fishmeal**
Gross Revenue—GR	36,199.69	34,720.95	40,221.88	42,061.81	44,244.07	46,267.99
Operating Profit—OP	7929.16	4909.86	11,951.34	12,250.72	15,973.53	16,456.90
Gross Margin—GM (%)	28.05	16.47	42.27	41.09	56.50	55.20
Profitability Index—PI (%)	21.90	14.14	29.71	29.13	36.10	35.57
Internal Rate of Return—IRR (%)	53.37	31.32	81.37	83.43	108.97	112.27
Modified Internal Rate of Return—MIRR (%)	22.58	16.84	27.71	28.03	31.47	31.86
Net Present Value—NPV (7.5%)	39,776.37	19,051.67	67,384.99	69,439.90	94,993.61	98,311.47
Annualized Net Present Value—ANPV (7.5%)	5794.86	2775.56	9817.04	10,116.42	13,839.23	14,322.60
Payback period (year)	2.85	3.98	2.23	2.20	1.92	1.89

[1] Values expressed in USD (1.00 Angolan Kwanza = USD 0.0011); Source: Research data.

Consistently, Net Present Value (NPV) and Annualized Net Present Value (ANPV) followed similar trends. The NPV increased from USD 19,051.67 in Scenario A to USD 98,311.47 in Scenario C, reflecting gains from value addition to the fish. The ANPV ranged from USD 2775.56 (Scenario A) to USD 14,322.60 (Scenario C), reinforcing the economic attractiveness of by-product integration.

The Payback Period also showed significant improvement across scenarios, decreasing from 3.98 years in Scenario A to 1.89 years in Scenario C. These results indicate that the inclusion of fish processing stages enhances the profitability of the activity, making artisanal fishing in Namibe even more attractive from an economic standpoint.

Figure 6 illustrates a relatively balanced distribution between direct consumption and processed fish products, highlighting the greater profitability associated with processed items such as dried fish and viscera-based fishmeal. Projected growth in these segments suggests that, despite the additional costs involved in processing, the market prices of these by-products tend to be higher, which may encourage their large-scale production. In this context, dried fish and fishmeal assume commodity-like characteristics due to their significant commercial value, increasing demand, and potential integration into broader markets, particularly within the animal feed supply chain. These results underscore the potential for fish value enhancement through processing, revealing opportunities for the better utilization of fishery resources and the need to further investigate the market dynamics influencing this allocation.

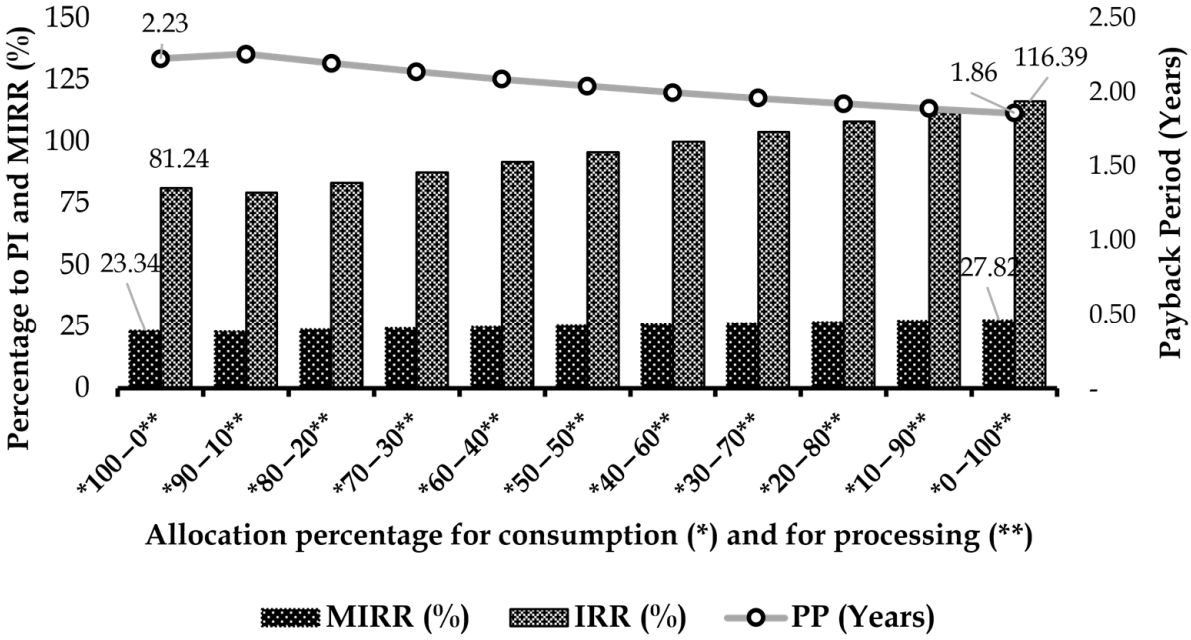

Figure 6. Modified Internal Rate of Return (MIRR), Profitability Index (PI), and Payback Period (PP) under different production and commercialization scenarios for fresh fish sold for human consumption and processed into dried fish and fishmeal. Source: Research data.

4. Discussion

Artisanal fishing remains a cornerstone of Angola's coastal economy, particularly in Namibe Province, where it constitutes the primary livelihood for numerous traditional communities [2]. Beyond its measurable economic contributions, the sector holds deep social, cultural, and nutritional significance, shaping local identity, enhancing food security, and promoting social equity [2]. These multidimensional benefits highlight the role of artisanal fisheries not merely as economic enterprises but as complex socioecological systems. However, the sustainability and resilience of the sector are increasingly threatened by structural challenges that remain insufficiently addressed. One of the most critical pressures arises from the expansion of industrial fishing, often carried out by foreign fleets, which places intense strain on marine resources and fuels tensions with artisanal fishers through the overlap of fishing zones [4]. These conflicts expose underlying power asymmetries and the absence of effective governance mechanisms to safeguard the access rights of small-scale fisheries. The exclusion of artisanal fishers from decision-making processes further compounds their vulnerability and undermines the long-term sustainability of shared resources.

A parallel challenge lies in the chronic lack of infrastructure at landing sites, which continues to constrain the development of local value chains [15]. Inadequate facilities for fish preservation, storage, and transportation result in significant post-harvest losses, diminishing market value and reducing the competitiveness of the sector [5]. These inefficiencies not only weaken household incomes but also hinder the broader economic performance of artisanal fisheries. Exacerbating these constraints is the absence of coherent public policies designed to address the sector's specific needs, which limits access to investment, technical capacity building, and market integration [6]. This institutional neglect perpetuates social exclusion and reinforces the precarious living conditions of communities heavily reliant on artisanal fishing [7].

Recognizing artisanal fisheries for their broader functional roles, supporting well-being, equity, ecological knowledge, and participatory governance, is essential, as these dimensions are frequently overlooked in conventional fisheries management frameworks.

A more inclusive and integrated policy approach is needed, particularly in countries like Angola, where artisanal fishing represents a form of resistance to economic and ecological marginalization [6]. The sector's alignment with the United Nations Sustainable Development Goals (SDGs) underscores its strategic relevance. By providing accessible, high-quality protein, artisanal fishing directly supports SDG 2 (Zero Hunger and Sustainable Agriculture), reinforcing food security in coastal communities [1]. In relation to SDG 5 (Gender Equality), women play a pivotal role in post-harvest processing, especially in drying fish and producing fishmeal. These gendered labor patterns emphasize the need for targeted interventions to enhance women's access to financing, technical training, and productive assets [8,9], thereby fostering economic empowerment and gender equity within fishery systems.

Moreover, artisanal fisheries exemplify the principles of SDG 14 (Life Below Water) through sustainable practices grounded in traditional ecological knowledge and community-based marine resource management [1,10]. The promotion of value-added production using low-impact technologies, such as fish drying and fishmeal production from processing residues, demonstrates viable pathways toward a circular economy. These approaches not only reduce waste but also contribute to environmental sustainability and generate local economic value [11,12].

The economic feasibility analysis of artisanal fishing in Namibe Province, with and without value addition through dried fish and fishmeal production, demonstrated strong financial return potential, as evidenced by the NPV, ANPV, IRR, MIRR, and Payback indicators. Production diversification through by-products such as fishmeal, made from viscera and waste, transforms discards into marketable resources, especially for aquaculture and animal feed industries [12]. This strategy is not only environmentally responsible but also socially inclusive, reinforcing community resilience to economic and regulatory constraints [5]. However, the fishmeal value chain still operates largely informally, with limited penetration into formal markets and low levels of collective organization. The absence of formal cooperatives restricts access to credit and institutional programs [8], yet it also highlights the role of social capital and community trust in sustaining these productive networks. In such contexts, strengthening community organizations and valuing local knowledge are crucial to empowering stakeholders, particularly women, and building public policies aligned with the principles of the 2030 Agenda [1,25].

Replicating policies rooted in territorial experiences, such as that of Namibe, can consistently contribute to poverty reduction, income generation, gender equity, and marine ecosystem conservation. Investing in artisanal fisheries with a multidimensional focus is not only a matter of economic viability, but also an initiative of social and environmental justice aligned with global commitments under the SDGs [26]. Strengthening community organizations, such as cooperatives and fisher associations, is considered an essential strategy to promote the sustainable development of artisanal fisheries. These structures enhance bargaining power, access to public policies, and integration into more competitive markets [26]. Technical training programs are also key to adopting best fishing practices and improving environmental sustainability [27].

In terms of nutrition and market demand, fishmeal presents significant advantages over other protein supplements, such as soybean meal, due to its high protein content and essential amino acids [28]. This scenario is reinforced by the growing demand for alternative protein sources for aquaculture and intensive livestock production, positioning fishmeal as a strategic product with high growth potential in Angola.

In Namibe, the profitability of artisanal fishers depends not only on fishing itself, but also on their ability to add value and diversify products. The commercialization of dried fish and fishmeal operates in local circuits based on proximity economies, where community

trust and social capital play a central role, similar to experiences with the live bait trade by artisanal fishers in Brazil [20]. In this context, artisanal fishing in Namibe can also be understood through the lens of the "proximity economy," which prioritizes economic relationships based on territorial ties, mutual trust, and direct exchanges between producers and consumers. This approach strengthens local dynamics by reducing intermediation and logistical costs, favoring income circulation within the territory and enhancing the resilience of fishing communities to volatile markets and asymmetric globalization processes [29,30]. The local dried fish and fishmeal marketing networks observed in Namibe align with this logic by promoting solidarity-based and sustainable forms of productive organization that increase value capture by fishers and artisanal processors. Furthermore, the proximity economy reinforces the role of social capital and territorial identities as economic and strategic assets for rural and coastal development [31], which is particularly relevant in contexts marked by informality and the lack of structural public policies.

5. Conclusions

The valorization of dried fish and fishmeal emerges as an impact strategy for increasing household incomes, reducing post-harvest losses, and strengthening the sustainability of artisanal fishing communities. By integrating these value-added products into local economies, artisanal fisheries can diversify income sources, enhance food security, and generate broader socioeconomic benefits. This study shows that production models incorporating dried fish and fishmeal outperform fresh fish sales in terms of economic viability, underscoring their potential to drive profitability and inclusion. While persistent barriers such as informality, infrastructure deficits, and limited technology access remain, targeted investments in training, value chain development, and enabling policies could transform Angola into a regional leader in artisanal fish valorization. The approach outlined here is replicable. With locally adapted policies grounded in technical assistance and traditional ecological knowledge, other sub-Saharan African countries could leverage similar strategies to strengthen small-scale fisheries, promote sustainable resource use, and integrate artisanal production into higher-value regional and international markets.

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References

1. FAO. *The State of World Fisheries and Aquaculture 2024: Blue Transformation in Action*; FAO: Rome, Italy, 2024. [CrossRef]
2. Hanamulamba, P.L.; Medeiros, T.V.; Lourenço, I.H.; Dos Anjos, M.R.; Duarte, L.F.A. The small-scale fisheries sector in a developing country: Assessing SWOT and recommendations for sustainability in Namibe (Angola). *Fish. Sci.* **2025**, *91*, 1–11. [CrossRef]
3. Kirkman, S.P.; Nsingi, K.K. Marine biodiversity of Angola: Biogeography and conservation. In *Biodiversity of Angola*; Huntley, B., Russo, V., Lages, F., Ferrand, N., Eds.; Springer: Cham, Switzerland, 2019; pp. 41–58. [CrossRef]
4. Albino, L.E. *A Economia Do Mar e o Impacto da Pesca Industrial em África (PALOP) Versus Pesca Artesanal em Angola*; ISCTE—Instituto Universitário de Lisboa: Lisboa, Portugal, 2024. Available online: https://www.proquest.com/openview/7ef020b9cd9b995734307e3e60983ff7/1?pq-origsite=gscholar&cbl=2026366&diss=y (accessed on 10 July 2025).
5. EU–Angola Dialogues. Diagnóstico Sectorial Do Sector da Pesca em Angola, Com Enfoque na Pesca Artesanal e de Pequena Escala. 2023. Available online: https://dialogosue-angola.org/acoes/diagnostico-sectorial-do-sector-da-pesca-em-angola-com-enfoque-na-pesca-artesanal-e-de-pequena-escala/ (accessed on 23 June 2025).
6. Basurto, X.; Gutierrez, N.L.; Franz, N.; Smith, H.; Cohen, P.J.; Allison, E.H. Illuminating the multidimensional contributions of small-scale fisheries. *Nature* **2025**, *637*, 875–884. [CrossRef]
7. Hilborn, R.; Ovando, D. Reflections on the success of traditional fisheries management. *ICES J. Mar. Sci.* **2014**, *71*, 1040–1046. [CrossRef]
8. Chuenpagdee, R.; Jentoft, S. Transforming the governance of small-scale fisheries. *Marit. Stud.* **2018**, *17*, 101–115. [CrossRef]
9. World Bank. *Blue Economy Development Framework: Toward a Sustainable Ocean Economy in Africa*; World Bank: Washington, DC, USA, 2020. Available online: http://hdl.handle.net/10986/42988 (accessed on 15 May 2025).
10. Béné, C.; Barange, M.; Subasinghe, R.; Pinstrup-Andersen, P.; Merino, G.; Hemre, G.I.; Williams, M. Feeding 9 billion by 2050—Putting fish back on the menu. *Food Secur.* **2016**, *7*, 261–274. [CrossRef]
11. Zugarramurdi, M.A.; Parin, G.A.; Carrizo, L.; Gadaleta, G.; Lupin, H.M. Investment and production costs for fishmeal plants in developing and developed countries. *Int. J. Prod. Econ.* **2002**, *76*, 53–59. [CrossRef]
12. Fréon, P.; Durand, H.; Avadí, A.; Huaranca, S.; Moreyra, R.O. Life cycle assessment of three Peruvian fishmeal plants: Toward a cleaner production. *J. Clean. Prod.* **2017**, *145*, 50–63. [CrossRef]
13. Mustapha, M.K.; Ajibola, T.B.; Salako, A.F.; Ademola, S.K. Solar drying and organoleptic characteristics of two tropical A frican fish species using improved low-cost solar driers. *Food Sci. Nutr.* **2014**, *2*, 244–250. [CrossRef] [PubMed]
14. Tacon, A.G.J.; Metian, M. Feed matters: Satisfying the feed demand of aquaculture. *Rev. Fish. Sci. Aquac.* **2015**, *23*, 1–10. [CrossRef]
15. SADC. *Blue Economy Strategy for Southern Africa*; Southern African Development Community: Gaborone, Botswana, 2021. Available online: https://www.sadc.int/latest-news/sadc-has-potential-develop-fisheries-and-blue-economy-businesses-new-heights-sadc (accessed on 20 June 2025).
16. Potts, W.M.; Inácio, L.A.; Santos, C.V.; Richardson, T.J.; Sauer, W.H.H. Aspects of the biology and fisheries of *Dentex macrophthalmus* in the Namibe province, Angola. *Afr. J. Mar. Sci.* **2010**, *32*, 601–611. [CrossRef]
17. Gindre-Chanu, L.; Warren, J.K.; Puigdefabregas, C.; Sharp, I.R.; Peacock, D.C.P.; Swart, R.; Poulsen, R.; Ferreira, H.; Henrique, L. Diagenetic evolution of Aptian evaporites in the Namibe Basin (south-west Angola). *Sedimentology* **2015**, *62*, 204–233. [CrossRef]
18. Parker, C.; Scott, S.; Geddes, A. Snowball sampling. *SAGE Res. Methods* **2019**, *1*, 1–121. [CrossRef]
19. Souza, K.M.; Casarini, L.M.; Henriques, M.B.; Arfelli, C.A.; Lopes, R.G. Viabilidade econômica da pesca de camarão-sete-barbas com embarcação de pequeno porte na praia do Perequê, Guarujá, SP. *Inf. Econ.* **2009**, *39*, 30–37.
20. Da Silva, S.M.; Amorim, A.F.; Castilho-Barros, L.; Silva, N.J.R.; Henriques, M.B. How the commercialization of live bait impacts the profitability of artisanal fishing in a Brazilian estuary: A proximity economy approach. *Reg. Stud. Mar. Sci.* **2025**, *83*, 104057. [CrossRef]
21. Engle, C.R.; Pomerleau, S.; Fornshell, G.; Hinshaw, J.M.; Sloan, D.; Thompson, S. The economic impact of proposed effluent treatment options for production of trout *Oncorhynchus mykiss* in flow-through systems. *Aquac. Eng.* **2005**, *32*, 303–323. [CrossRef]
22. Ehrlinch, P.J.; Moraes, E.A. *Engenharia Econômica: Avaliação e Seleção de Projetos de Investimento*; Atlas: São Paulo, Brazil, 2005; p. 186.
23. Henriques, M.B.; Castilho-Barros, L.; Souza, M.R.; Barbieri, E.; Silva, N.J.R.; Nunes, F.A.A.; Sanches, E.G. Is the small-scale aquaculture of *Deuterodon iguape* for live bait in recirculating systems economically profitable? *Aquaculture* **2021**, *546*, 737335. [CrossRef]
24. Martin, N.B.; Serra, R.; Oliveira, M.D.M.; Angelo, J.A.; Okawa, H. Sistema integrado de custos agropecuários—CUSTAGRI. *Inf. Econ.* **1998**, *28*, 7–28.
25. Phillipson, J.; Salmi, P.; Linke, S.; Svels, K.; Budzich-Tabor, U. Fisheries local action groups, small-scale fisheries and territorial development. *Sociol. Ruralis.* **2024**, *64*, 399–414. [CrossRef]
26. FAO. Nova Fase do Projeto de Pesca Artesanal e Aquicultura Lançada para Aumentar a Segurança Alimentar em Angola. 2025. Available online: https://www.fao.org/angola/news/detail/new-phase-of-the-artisanal-fishing-and-aquaculture-project-launched-to-enhance-food-security-in-angola/pt (accessed on 19 June 2025).

27. Sossae, F.C. Mulheres na atividade pesqueira: Um estudo na comunidade de Nzeto-Angola. *Rev. Bras. Multidiscip.* **2020**, *23*, 68–85. [CrossRef]
28. OECD. *The New Rural Paradigm: Policies and Governance*; Organisation for Economic Co-Operation and Development (OECD): Paris, France, 2016. [CrossRef]
29. UNDP. *Human Development Report 2021–2022: Uncertain Times, Unsettled Lives*; UNDP: New York, NY, USA, 2022. Available online: https://hdr.undp.org/content/human-development-report-2021-22 (accessed on 30 June 2025).
30. Torre, A.; Wallet, F. *Regional Development and Proximity Relations*; Edward Elgar Publishing: Cheltenham, UK, 2014; 392p.
31. Kolding, J.; Béné, C.; Bavinck, M. Small-scale fisheries: Importance, vulnerability and deficient knowledge. In *Governance of Marine Fisheries and Biodiversity Conservation: Interaction and Coevolution*; Wiley: Hoboken, NJ, USA, 2014; Volume 1, pp. 317–331. [CrossRef]

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