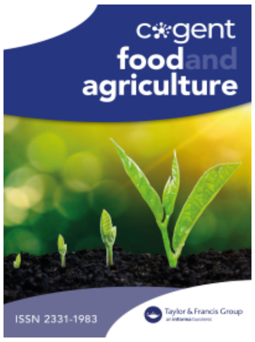
Aquaculture in Mozambique: current status, challenges, opportunities, and adaptive lessons learned from Brazil



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Aquaculture in Mozambique: current status, challenges, opportunities, and adaptive lessons learned from Brazil

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ABSTRACT
Aquaculture in Mozambique is an emerging but highly promising component of the national fisheries sector, which remains largely dominated by extractive activities. Despite being at an early stage of development, the country benefits from favourable natural conditions and significant potential for expansion. This article presents a concise assessment of the current status, key challenges, and opportunities of Mozambican aquaculture, while drawing adaptable lessons from Brazil, one of the world's most successful aquaculture industries. The analysis begins with an overview of the fisheries sector, followed by an examination of recent developments in aquaculture. Although progress has been achieved, the subsector continues to face major constraints, including poor seed and feed quality, limited availability of locally adapted technological packages, restricted access to finance, weak biosecurity frameworks, underdeveloped value chains, insufficient extension services, and increasing exposure to climate-related risks. By comparing Mozambique's context with Brazil's experience, the article identifies transferable strategies, such as strengthening research and extension systems, promoting sustainable and diversified production models, encouraging private-sector participation and cooperativism, and the development of aquapark models. The article concludes with strategic recommendations aimed at unlocking the subsector's potential and positioning aquaculture as a key driver of sustainable development and economic resilienc in Mozambique.

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1. Introduction

The global demand for proteins from animal origin is increasing due to population growth and changing diets. Aquaculture and fisheries are vital pillars of global food and nutrition security, providing both protein and essential micronutrients to billions of people. In low-and middle-income countries, especially in Asia and Africa, aquaculture plays a critical role in ensuring affordable nutrition while supporting rural livelihoods and poverty reduction (FAO, 2024a; Hasimuna et al., 2025a; Hasimuna et al., 2025b). At the global level, aquaculture has now overtaken capture fisheries as the primary source of aquatic food, with 94.4 million tonnes produced in 2022 representing 51% of total aquatic food production (FAO, 2024a). This rapid growth underscores aquaculture's central role in meeting future food demand, advancing sustainability, and strengthening resilience in the face of climate change and population growth. Aquaculture has been growing steadily across Africa, driven by increasing demand for fish, technological

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advancements, and government initiatives to enhance food security (Iheanacho et al., 2025; Langi et al., 2024; Mphande et al., 2023; Siavwapa et al., 2022). The African continent possesses substantial potential for aquaculture expansion, driven by its extensive water resources, favourable climatic conditions, and a growing trend of public and private investment in the subsector. In contrast, capture fisheries are increasingly challenged by the adverse effects of climate change, overfishing, and habitat degradation (Hasimuna et al., 2025a). These pressures underscore the urgency of transitioning toward more sustainable and resilient aquatic food production systems.

Mozambique is situated in southeastern Africa along the Indian Ocean coastline, encompassing a total land area of ~799,380 km^2, with 4,445 km of land borders and a coastline extending ~2,700 km (FAO, 2016; Mafuca et al., 2024; Meeuws, 2004). Administrative divisions exist within the country; eleven provinces, with Maputo as its capital, hold provincial status. Extensive natural resources, including diverse aquatic ecosystems, endow Mozambique. The country's climate varies from tropical and subtropical in the northern and central regions to semi-arid steppe and arid desert in the south (Cambaza, 2023). The country shares thirteen major rivers with neighbouring countries and has two large lakes which are Lake Malawi/Niassa and Lake Chiura as well as numerous coastal and inland lagoons and floodplains (Companhia, 2012; FAO, 2016). The groundwater potential is substantial, primarily stored in alluvial formations along various rivers, with renewable water resources estimated at ~217.1 billion m^3 per year (Maulu et al., 2024).

Mozambique's abundant water resources support the fisheries industry with immense growth potential, offering opportunities to enhance economic development, food security, employment, and poverty reduction. The country's fisheries production potential is estimated at over 385,000 tonnes per year from capture fisheries and an additional 78,000 tonnes from aquaculture (MIMAIP, 2022; World Bank, 2019). Despite this abundance, capture fisheries face increasing pressures from overfishing, habitat degradation, climate change, and socio-economic constraints, highlighting the need for sustainable management strategies. In this context, the Mozambican government has identified aquaculture as a strategic complement to capture fisheries, offering a means to meet growing domestic and regional demand for fish, diversify livelihoods, and reduce pressure on wild stocks (MIMAIP, 2020).

The country has an estimated 258,000 hectares suitable for freshwater aquaculture and an additional 120,000 hectares for marine aquaculture development (Muhala et al., 2021a). Mozambique's natural conditions are highly conducive to aquaculture expansion, featuring a tropical and subtropical climate, fresh aquatic environments, vast natural resources, and relatively low population pressure on water bodies. Additionally, native fish species with high aquaculture potential are available, further supporting the subsector's growth (Chirindza, 2010; Mapfumo, 2009; Muhala et al., 2021a). In line with this potential, the former Ministry of the Sea, Inland Waters and Fisheries (MIMAIP) introduced the Aquaculture Development Strategy (2020–2030), aiming to promote sustainable aquaculture growth, optimise national resources, and alleviate pressure on capture fisheries (MIMAIP, 2020).

Despite these opportunities, research on Mozambique's aquaculture subsector remains limited. Early studies by Menezes (2001) focused on commercial shrimp farming, while Ribeiro (2007) conducted an inventory of small-scale mariculture, identifying sectoral constraints and opportunities. Subsequent studies explored various aspects of aquaculture, including economic analysis, environmental impact assessments, and surveys of small-scale aquaculture activities (Banze, 2005; Chirindza, 2010; Companhia, 2012; Salia, 2008). More recently, Muhala et al. (2021a) assessed aquaculture production in Gaza province, while Muhala et al. (2021b) conducted an investigation regarding the impacts of Cyclones Idai and Kenneth on fisheries and aquaculture subsectors in the Sofala and Zambezia provinces.

Although aquaculture in Mozambique has attracted various reports and project-based assessments, the literature remains fragmented and largely localised, with no comprehensive, national-level analysis of the subsector's status, challenges, and opportunities, making it difficult to include statistical information at various levels that could ensure greater understanding. However, the data presented in this research provides a positive insight into the status of fishery and aquaculture in Mozambique, complemented by comparative information from Brazil.

Brazil was chosen as a reference due to its well-established aquaculture sector and its relevance to Mozambique, given similar agro-ecological conditions, abundant water resources, extensive coastlines, and comparable socio-economic challenges. Historical and linguistic ties between the countries further facilitate technical exchange and the adoption of best practices. International cooperation initiatives, notably the Postgraduate Student Agreement Programme (PEC-PG), have enabled many Mozambican professionals to be trained in Brazil, acquiring skills that strengthen the local subsector. Consequently, Brazil's experience provides useful insights into policies, production systems, biosecurity, certification, and marketing, highlighting barriers, opportunities, and practices that can inform sustainable aquaculture development in Mozambique.

2. Methodology

This study adopts a thematic analysis literature review approach to explore the historical-to-contemporary development of Mozambican's fishery and aquaculture subsectors. The methodology followed systematic and scoping review protocols to ensure transparency and rigor in the processes of literature searching, screening, and data synthesis.

2.1. Literature search strategy

A comprehensive and structured literature search was conducted across three major scientific databases—Web of Science, Scopus, and Google Scholar, as well as government and institutional repositories. These databases were selected based on their extensive repositories of peer-reviewed articles, technical reports, and conference proceedings relevant to aquaculture and fisheries. In constructing the search strategy, careful attention was paid to avoid overly narrow terms that could limit the scope of this review.

The search terms were selected to cover a wide range of information regarding fisheries and aquaculture (in both countries), with Boolean operators used to combine terms and enhance search inclusivity. The search included the following terms: 'Mozambique' AND 'Brazil', 'fisheries AND Mozambique' AND 'aquaculture production' OR 'fish farming' OR 'aquaculture', 'aquaculture AND Mozambique', 'climate change' OR 'aquaculture animal health' OR 'biosecurity' OR 'fish feed' OR 'fish seed' OR 'production systems' OR 'food security' OR 'value chains' OR 'markets' OR 'genetic enhancement' OR 'aquaparks' OR 'associativism'.

2.2. Inclusion and exclusion criteria

To ensure the selection of relevant, high-quality studies, stringent inclusion and exclusion criteria were applied. Studies were included if they were peer-reviewed articles, literature review, government reports, and documents from international organizations, such as the Food and Agriculture Organization (FAO), World Bank, Mozambique Fisheries and Aquaculture Bulletin, and key industry references such as Peixe BR. No strict timeframe was applied to government and policy reports; in contrast, peer-reviewed articles published between 2000 and 2025 were prioritized to reflect recent policy and industry trends and no language restrictions were applied. The review primarily examines Mozambican's fishery and aquaculture sectors. Beside this, the research also incorporates comparative literature from other African nations to provide additional context.

Exclusion criteria were set to omit studies that did not meet the requirements and focus of this review. Studies published before 2000 were omitted to focus on more recent advances in aquaculture, Paywalled articles without open-access versions were also excluded to prioritize accessibility. Duplicates were removed, and studies with abstracts that did not align with the scope of this review were excluded after a preliminary screening.

2.3. Search and screening process

The initial search yielded over 150 articles. A preliminary relevance screening was then conducted, prioritizing high-impact, peer-reviewed journals on aquaculture, fisheries, environmental science, water, agriculture to ensure quality. After rigorous screening, only 90 unique articles were selected for full evaluation.

Each article was thoroughly reviewed based on methodological rigor, outcomes related to aquaculture and fisheries, and relevance to the objective of this review.

2.4. Data extraction and analysis

After the screening process, a structured data extraction form was used to extract key information from the selected studies included in the review. For each document, details were recorded on publication type, geographical focus, study design, production systems, main findings, challenges, opportunities, and any policy or technical recommendations relevant to aquaculture in Mozambique or Brazil.

To ensure consistency, two reviewers independently extracted data from an initial sample of studies, compared their results, and refined the extraction template. All remaining documents were then processed using the updated framework. Each study was assessed for quality based on clarity of the objectives, transparency of methods, reliability of the data presented, and relevance to the review's aim.

The extracted information was analysed using descriptive, thematic, and comparative methods. Quantitative data (such as production figures or economic indicators) were summarised to highlight general trends across the sector. Qualitative findings were coded to identify common topics, including constraints such as feed shortages, limited seed supply, climate pressures, market challenges, research and extension services, and governance gaps. Comparative analysis was then used to identify practices and innovations from Brazil that could be adapted to Mozambique.

This combined approach enabled the review to synthesise evidence on the current state of aquaculture in Mozambique, highlight key constraints and opportunities, and identify practical lessons from Brazil that may support sector development.

2.5. Secondary data collection and analysis

In addition to the thematic literature review, we compiled and analysed secondary quantitative data to provide a comprehensive overview of fisheries and aquaculture trends. Data were obtained from authorized sources, including the FAO FishStat database, Peixe BR, Sindirações, World Bank, and national fisheries statistics from the MIMAIP. Relevant time-series data on production, production shares, and trade volumes were extracted using predefined criteria to ensure consistency and relevance. Data validation included cross-checking figures across multiple sources and identifying any discrepancies or outliers. Analytical procedures involved aggregating production by species and sector, calculating relative shares, and summarising temporal trends to generate descriptive statistics presented in the results section.

2.6. Limitations

Despite efforts to capture a comprehensive overview, some limitations remain. The availability of literature varies across different aspects of the sector, with limited data on the role of the private sector, small-scale aquaculture, and unpublished industry assessments. Additionally, some policy reports and trade documents are restricted, making it difficult to obtain detailed insights into certain regulatory and market dynamics.

2.7. Definition and harmonisation of terms

Terminology related to fisheries and aquaculture varies between national and international sources. To ensure consistency, this review harmonised definitions by cross-referencing categories from the MIMAIP with those used by the FAO.

2.7.1. Fleet segments

- Artisanal: Small-scale vessels (<10 m long) often non-motorized or lightly motorized, typically operating in nearshore waters, using low-technology gear and limited mechanisation.

- Semi-industrial: Medium-sized vessels with partial mechanisation and greater range (size used is 10–20 m long) and motorized vessels (<350 hp).
- Industrial: Fully mechanised vessels (vessels over 20 m long and motors of up to 1,500 hp) capable of offshore fishing.

2.7.2. Aquaculture production systems

Production systems reported by MIMAIP were harmonised using FAO aquaculture system definitions. Systems were therefore grouped into:

- Extensive: Low-input systems that rely mainly on natural food and low stocking densities, with minimal management or intervention.
- Semi-intensive: Medium-input systems that combine natural productivity with supplementary feed and basic management (e.g. fertilisation, simple water exchange).
- Intensive: High-input systems with high stocking densities, complete formulated feeds, and strong management control (e.g. aeration, monitoring, water quality management) to maximise production.

2.7.3. Species groups

Species were categorised following FAO's standard statistical classification of aquatic animals and plants (e.g. tilapias, catfishes, marine finfish, crustaceans), with MIMAIP species lists cross-mapped to these broader groups to ensure comparability.

Where inconsistencies arose between sources, FAO's terminology was adopted as the overarching framework, with MIMAIP data aligned accordingly. This harmonisation ensured uniformity in the analysis and improved comparability across datasets.

3. Overall status of fisheries in Mozambique

3.1. Fish production

Mozambican's fishery sector is comprised of four key segments: artisanal, semi-industrial, industrial fisheries, and aquaculture (Capaina, 2021). In 2022, total fisheries production in Mozambique including both extractive fisheries and aquaculture was estimated at 455,543 tonnes generating a monetary value of MZN 35,3 billion (USD 551,2 million) (Table 1), with the artisanal sector contributing ~90% of the country's total output (Costa et al., 2020, MIMAIP, 2022). The dominance of artisanal fisheries underscores their critical role in food security, employment, and livelihoods, particularly in coastal and rural communities. Aquaculture remained a minor contributor, producing only 1% of total fish production.

Figure 1 illustrates the trajectory of fishery production from 2010 to 2022, showing that capture industrial and semi-industrial fisheries have plateaued, while aquaculture production has expanded significantly over the past one decade.

Table 1. Sectoral production and value of fisheries sector, Mozambique (2022).

Fishery sector	Quantity (tonnes)	Value (MZN, 1000)	Value (USD$, million)
Industrial fisheries	8,404	1,087,653	17.1
Semi industrial fisheries	8,981	425,810	6.7
Artisanal fisheries	432,639	33,321,026	520.6
Industrial aquaculture	2,832	237,671	3.7
Small-scale aquaculture	2,688	204,913	3.2
Total	455,544	35,277,073	557.6

Conversion rate of 14 October 2025: 1 USD$ = MZN63.27 (https://www.bancomoc.mz).
Source: MIMAIP (2022): Fisheries and Aquaculture Statistical Bulletin, 2010–2022.

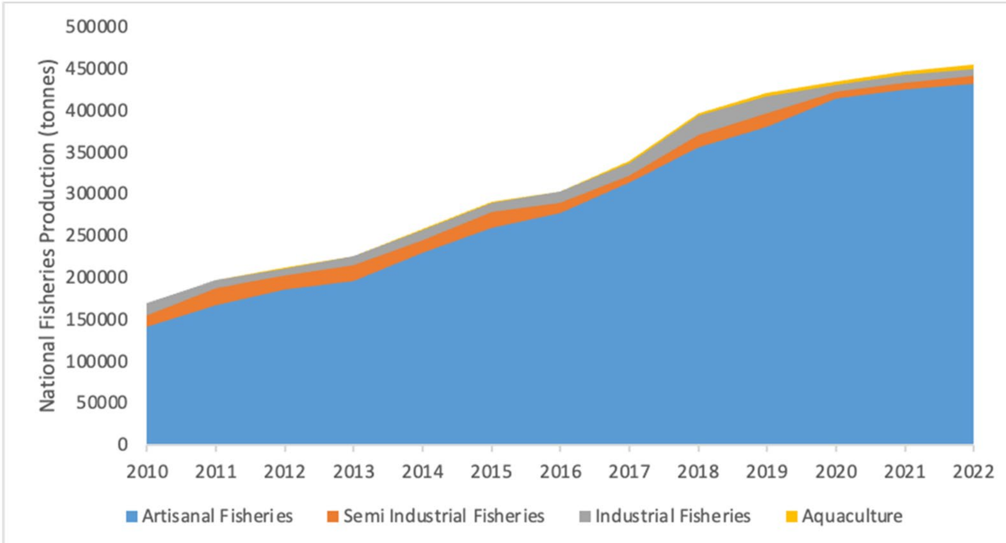

Figure 1. Fisheries and aquaculture production 2010–2022.
Source: MIMAIP (2022) Fisheries and Aquaculture Statistical Bulletin.

3.2. Fisheries species

The distribution of fisheries and aquaculture production segmented by species groups from 2010 to 2022 is presented in Table 2. Industrial fisheries consisting largely of crustaceans (prawns, deepwater shrimp, crayfish, lobsters, and crabs), marine fish (demersal and pelagic species mainly grouper, snapper, emperor, and sea bream also high migratory tuna species of yellow fin, big eye and albacore, swordfish, and shark) and cephalopods and molluscs (squid, octopus, sea cucumbers, bivalves). Marine fish, shrimp, and tuna comprised over 69.4% of the total catch (FAO, 2024b; MIMAIP, 2022). In semi-industrial fisheries, the main species captured is the Lake Tanganyika sardine, locally known as Kapenta (accounts 87.5% of the total catch), caught in the Cahora Bassa Dam (FAO, 2024b; Sitoe, 2022). Artisanal fisheries, by contrast, are multi-species, targeting shallow-water crustaceans such as shrimp and crab, small pelagic, larger pelagic, and demersal fish, as well as freshwater species, mainly tilapia (which comprised over 87.6% of the total catch). In aquaculture, the production is dominated by Nile tilapia (*Oreochromis niloticus*) and the Giant tiger prawn (*Penaeus monodon*) (FAO, 2024b; MIMAIP, 2022).

3.3. Catch profile

Mozambique's capture fisheries rely on a wide variety of fishing gear and vessel operations, distributed across multiple fishing zones. Industrial fishery involves large vessels flagged in Mozambique, that are over 20 m in length equipped with freezers to preserve the catch. The main gear used are mechanically advanced longline, gillnet, and bottom trawl nets (FAO, 2024b; Mafuca et al., 2024). The semi-industrial fishery is usually conducted with medium-sized vessels ranging from 10–20 m in length, mainly small trawlers, which typically operate for up to a week in coastal and oceanic waters. For artisanal fishing, activities are developed by individuals or small groups of fishers, operating with or without boats and gear, and engaged in subsistence or small-scale commercial fishing using traditional or simple methods. Where boats are available, they are generally <10 m in length, most use oars or sails, with a minority equipped with engines below 100 HP. The most common vessels are dugout canoes ('chata') and dhows. Fishing gear, used manually, includes beach seines, gillnets, mosquito nets (illegal but still widespread), handlines, fence traps ('chicocota'), and baited traps. Non-motorised craft are usually restricted to 24 h of operation and up to 3 nautical miles from shore, while motorised boats may reach up to 12 nautical miles. This sector also covers harvesters of coastal invertebrates and other resources, as well as divers using harpoons. Catches are typically preserved through ice, salting, smoking, or drying (FAO, 2024b; Mafuca et al., 2024; Sitoe, 2022).

Table 2. Mozambique fisheries and aquaculture species production by segments from 2010 to 2022.

Species	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
	Industrial fisheries production (tonnes)												
Lobster	98	204	192	574	262	290	172	237	203	251	125	136	160
Crab	208	82	50	73	94	186	221	195	146	367	183	168	179
Prawn	1,261	1,288	1,899	1,813	1,718	1,526	2,043	1,934	1,697	1,404	1,269	1,239	1,055
Fish	623	275	667	788	654	1,312	1,505	1,650	11,182	12,174	2,989	2,266	2,468
Shrimp	4,806	4,017	2,005	2,078	3,556	2,897	2,406	3,720	3,354	2,868	2,093	2,507	2,180
Crayfish	94	145	130	139	173	201	184	143	105	195	96	110	161
Cephalopods	89	103	115	404	331	330	229	357	514	193	162	392	548
Tuna	6,640	2,861	2,700	3,009	3,924	3,412	3,061	4,577	4,477	1,217	927	194	234
Bycatch	437	660	1,243	1,451	1,870	1,571	2,532	2,287	1,708	1,508	1,068	1,404	1,419
Total	14,256	9,635	9,001	10,329	12,582	11,725	12,353	15,100	23,386	20,177	8,912	8,416	8,404
	Semi-industrial fisheries production (tonnes)												
Fish	905	963	940	841	870	913	738	574	648	507	422	483	713
Shrimp	896	605	513	385	481	539	423	557	988	412	280	253	381
Lake Tanganyika Sardine (Kapenta)	11,518	18,330	13,707	16,645	13,714	16,615	11,922	6,969	13,368	15,163	7,125	6,926	7,287
Bycatch	450	455	480	446	601	561	400	706	441	391	401	527	600
Total	13,796	20,353	15,640	18,317	15,666	18,628	13,483	8,806	15,445	16,473	8,228	8,189	8,981
	Artisanal fisheries production (tonnes)												
Lobster	166	211	225	159	106	116	155	1,050	1,171	1,076	767	932	963
Crab	734	1,270	1,350	1,346	1,966	2,894	1,554	3,587	8,142	7,866	9,300	90,999	9,162
Marine fish	86,828	99,542	115,269	110,874	142,952	162,272	168,127	191,469	217,550	231,292	254,783	258,932	263,296
Freshwater fish	33,318	55,094	53,515	68,215	70,137	76,405	84,211	90,052	94,491	98,797	113,999	119,855	121,325
Tuna	0	0	0	0	0	0	0	6,299	5,937	8,599	10,437	10,955	12,276
Shrimp	4,320	1,858	3,360	3,020	3,166	5,240	5,203	6,295	5,659	4,860	4,969	5,270	4,152
Acutes	2,458	2,316	2,016	2,241	1,990	2,462	7,771	3,533	2,805	4,720	6,020	6,387	4,613
Cephalopods	1,234	1,265	2,035	1,671	1,847	1,772	2,283	4,125	4,955	4,508	5,915	6,001	6,600
Shark	369	431	489	653	854	1,298	1,786	1,969	4,313	7,825	5,338	5,472	5,519
Others	2,929	1,131	4,816	4,557	1,582	2,638	3,731	4,381	3,194	4,621	385	368	511
Bycatch	8847	3,400	3,139	3,319	4,234	4,276	1,543	1,703	6,370	6,159	2,110	2,384	4,221
Total	141,230	166,518	186,214	196,055	228,834	259,373	276,364	314,463	354,587	380,323	414,023	507,555	432,638
	Industrial aquaculture production (tonnes)												
Black tiger shrimp	667	506	39	10	0	0	0	0	21	33	150	260	190
Nile Tilapia	0	0	85	67	237	276	241	408	569	1,279	1,304	1,943	2,642
Total	667	506	124	77	237	276	241	408	590	1,312	1,454	2,203	2,832
	Small-scale aquaculture production (tonnes)												
Nile Tilapia	177	284	409	514	792	857	939	1,427	2,654	2,458	1,858	1,920	2,688
Total	177	284	409	514	792	857	939	1,427	2,654	2,458	1,858	1,920	2,688

Source: MIMAIP (2022): Fisheries and Aquaculture Statistical Bulletin, 2010–2022.

The majority of fishing activities take place in the Indian Ocean, particularly along the central coast, the Sofala Bank region, where most of the fishing resources are found (Capaina, 2021). In addition to this region, there is Delagoa Bay in the south of the country, which also makes a large contribution to the country's fishing industry (Mafuca et al., 2024; MIMAIP & INE, 2024; Sitoe, 2022). Inland water resources are distributed across rivers, lakes, lagoons, and reservoirs. The landing sites are located around Lake Malawi/Niassa and Cahora Bassa Dam without any major landing sites to be identified (FAO, 2024b).

3.4. Contributions of the fisheries sector in Mozambique

The fisheries sector plays a crucial role in Mozambique's food security, economic development, and cultural heritage, providing key sources of employment, nutrition, and trade revenue. It not only makes significant contribution to domestic food production but also supports export markets, sustains coastal livelihoods, and generates considerable economic value.

3.4.1. Employment and livelihoods

The fisheries and aquaculture industries provide direct employment to a considerable segment of Mozambique's workforce, particularly in coastal and rural areas. Approximately 563,000 people were directly engaged in the fisheries sector in Mozambique in 2024 (FAO, 2024b). Women play a significant role, with some 200,000 actively involved mainly in the artisanal fishing and shellfish gatherers and a large part involved in macroalgae production in northern Mozambique (Msuya et al., 2022). In total, an estimated 2.4 million people depend, at least in part, on fisheries or subsistence fishing for their livelihoods. These types of jobs can be categorized as direct (those in the main fisheries and aquaculture activities) and indirect (in support activities or linked to fisheries and aquaculture activity) (Capaina, 2021). In Mozambique, the minimum monthly wage for workers employed in the fisheries sector is estimated at around USD 105, reflecting the 2025 national wage adjustments.

3.4.2. Food security

Fisheries make a vital contribution to food and nutrition security in Mozambique. Fish is an affordable and nutritious source of animal protein, supporting the diets and livelihoods of millions of people. Fish accounts for roughly 50% of the population's total animal protein intake, with an even greater share in coastal areas where alternative protein sources are limited. Per-capita fish consumption in Mozambique was estimated at 16.2 kg/year in 2022, considered below the global average (20.7 kg/year in 2024) (FAO, 2024b; MIMAIP, 2022). These values further support the importance that fish offers for food security in many parts of the world and in Mozambique.

3.4.3. Trade performance

Mozambique has a high overall demand for fish, yet availability from capture fisheries and aquaculture combined with population growth are deficient. Overall, the general trend in African countries, including Mozambique, is to import more fish than they export in terms of volume. Typically, low-value fish are imported for domestic consumption, while high-value fish are exported (Mapfumo, 2022). In 2022, fisheries total imports were USD 116 million, while exports reached USD 60 million as illustrated in Figure 2. Mozambique imports frozen fish and other fish products from Spain, Portugal, South Africa, Namibia, South Korea, Japan, China, and New Zealand to meet domestic demand. The main import product is frozen mackerel from Namibia, which accounts for 86% of Mozambique's fish imports. On the other hand, Mozambique has been exporting fish and shrimp to other countries, especially Malawi, Zambia, South Africa, Zimbabwe, Democratic Republic of Congo, Spain, Portugal, Japan, and China. The main export products are shrimp (frozen) and kapenta (dried), accounting for 24 and 21% of Mozambique's fish exports, respectively (FAO, 2024b; MIMAIP, 2022).

3.5. Fisheries management practices

In Mozambique, commercial and artisanal fishing require a licence, with the exception of subsistence fisheries. The introduction of the co-management system marked a new approach to fisheries

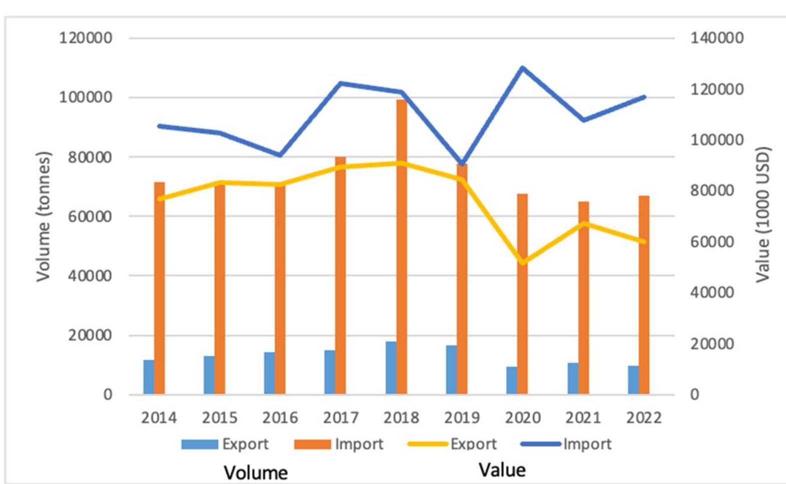

Figure 2. Exports and imports of aquatic products in Mozambique 2014 to 2022.
Source: MIMAIP (2022) Fisheries and Aquaculture Statistical Bulletin.

management in Mozambique, involving the organisation and active participation of Community Fisheries Councils in the planning and sustainable use of fishing resources. As a result, management responsibilities are largely in the hands of these co-management bodies (FAO, 2024b).

Since the implementation of Fishing Rights, no foreign vessels have been licensed to catch tuna or tuna-like species within Mozambique's Exclusive Economic Zone (EEZ). The shallow-water shrimp fishery, along with the industrial and semi-industrial fleets, is currently managed through annual licensing based on Total Allowable Effort (TAE) criteria. A closed season has also been implemented for the industrial and semi-industrial shallow-water shrimp fishery to protect juvenile shrimps, covering ~6 months from mid-October to March. The rocky-bottom demersal industrial and semi-industrial fleets are currently managed using a Total Allowable Catch (TAC), with quotas allocated to each fishing zone according to the industrial fleet's share and the presence of the semi-industrial fleet. There are no fishing effort restrictions for artisanal fleets, although fishing licenses are required. Inland fisheries remain open-access, although co-management is considered a potential management approach in these areas (FAO, 2024b; Mafuca et al., 2024).

Overall, the fisheries in Mozambique faces several challenges to ensure sustainable development such as illegal, unregulated and unreported fishing, which is a significant problem affecting the marine ecosystem and those who depend on it for survival (Petrossian, 2015; Selig et al., 2022), costing Mozambique USD 36–67 million a year (FAO, 2024b), overfishing by large industrial fleets, the rapid expansion and intensification of artisanal fisheries, increased fisheries effort, continued use of harmful fisheries gear such as mosquito nets (FAO, 2024b); competition for maritime space with oil and gas exploration, as well as tourism (Wabnitz et al., 2023).

4. Status of aquaculture in Mozambique

Aquaculture in Mozambique remains a relatively nascent industry, despite the country's considerable potential for development. The sector is still characterised by fragmented practices and is predominantly dominated by small-scale community-based aquaculture, with limited participation from commercial producers (FAO, 2024b; Mapfumo, 2009; MIMAIP & INE, 2024; Muhala et al., 2021a). The origins of aquaculture in Mozambique can be traced back to the 1950s when landfill ponds were constructed for fish farming to support agricultural workers in the provinces of Nampula, Zambézia, and Manica. By the early 1960s, the colonial administration had established three research and demonstration centres in Umbeluzi, Sussundenga, and Chókwè to promote and support the sector's growth (Companhia, 2012; Mapfumo, 2009).

Presently, aquaculture in Mozambique is classified into industrial and small-scale operations, each serving distinct objectives (MIMAIP, 2020). Freshwater aquaculture is primarily centred on integrated fish farming systems aimed at enhancing food security, while marine aquaculture is oriented towards both domestic protein supply and the production of high-value commodities for export (FAO, 2024c). The subsector plays a vital socio-economic role, providing employment to ~8,852 individuals (MIMAIP & INE, 2024).

Despite the subsector's progress, aquaculture production in Mozambique remains significantly below its estimated potential of 4 million tonnes per year. However, the industry has exhibited notable growth in recent years. In 2022, total aquaculture production reached 5,520 tonnes, with industrial aquaculture contributing 2,832 tonnes and small-scale aquaculture accounting for 2,688 tonnes (Figure 3) (MIMAIP, 2022; World Bank, 2024). These figures underscore the need for continued investment in infrastructure, technology, and policy frameworks to enhance production capacity and fully capitalise on the country's vast aquaculture potential.

4.1. Farmed species

Mozambique's aquaculture sector encompasses a diverse range of farmed species, including crustaceans, fish, macroalgae, and bivalve shellfish. Industrial marine aquaculture primarily focuses on the cultivation of giant tiger prawn with 190 tonnes produced in 2020 (MIMAIP, 2022). In freshwater aquaculture, species from the *Cichlidae* family, particularly Nile tilapia, is widely farmed (Banze, 2005; Companhia, 2012; World Bank, 2024). Nile tilapia has emerged as the dominant species cultivated by both commercial enterprises

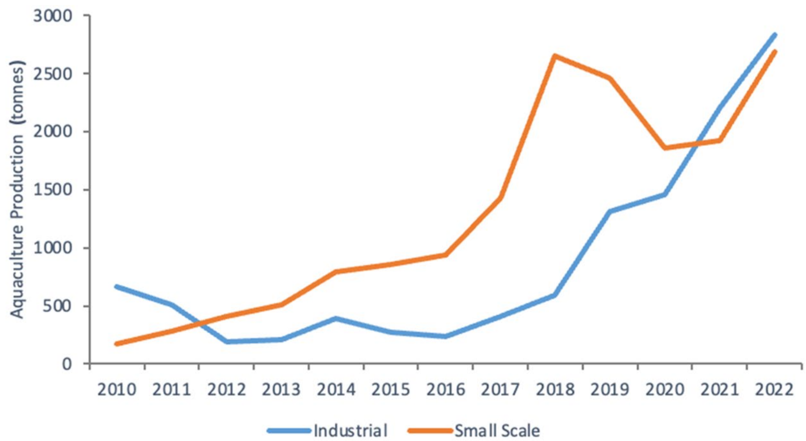

Figure 3. Aquaculture production 2010–2022.
Source: MIMAIP (2022) Fisheries and Aquaculture Statistical Bulletin.

and small-scale producers, making it the largest contributor to total aquaculture production in the country with 5330 tonnes produced in 2022 (FAO, 2024c; MIMAIP, 2022).

Beyond shrimp and tilapia, Mozambique has also pursued the cultivation of macroalgae (*Eucheuma spinosum* and *Kappaphycus alvarezii*), Molluscs (mussels-*Perna perna*), and sea cucumbers (*Holothuria edulis*) through targeted projects designed to restore coastal ecosystems and provide alternative income sources for fishing communities (FAO, 2024c; Javane & Maleco, 2020; World Bank, 2024). Although production volumes for all these species are still low, producers have expressed confidence. These initiatives have played a crucial role in supporting livelihoods while promoting sustainable aquaculture practices. Additionally, laboratory trials have demonstrated the feasibility of cultivating the rock oyster (*Saccostrea cuculata*), further highlighting the potential for expanding shellfish aquaculture in the country (Marcelino et al., 2023).

4.2. Aquaculture production systems

Aquaculture production in Africa including Mozambique is highly diverse, reflecting variations in technology, natural resources, and value chain structures. The majority of production around 82% takes place in inland waters (Hinrichsen et al., 2022).

Production systems in Mozambique can be categorised as extensive, semi-intensive, or intensive based on production scale, capital investment, labour requirements, and management practices (Companhia, 2012; FAO, 2024c). The main production infrastructures are earthen ponds (91.2%) mostly for semi-intensive production, cages (7.5%), and long-line systems (1.3%) (MIMAIP & INE, 2024). Earthen ponds vary considerably in size: those used for fish production range from under 100 m^2 to more than 1,000 m^2, while land-based shrimp ponds usually extend over 5–10 ha (FAO, 2024b; MIMAIP & INE, 2024). Cage culture is also widely practised for fish rearing, utilising diverse materials such as stainless steel, aluminium, galvanised iron, nickel mesh, and plastic. Floating devices, including empty oil barrels, are commonly used to support cage structures (FAO, 2024b; Muhala et al., 2021a; World Bank, 2024).

In addition to finfish production, Mozambique also engages in macroalgae and mussel cultivation using long-line systems. Macroalgae cultivation is conducted in shallow coastal areas, where long lines are installed to facilitate growth. Mussel farming, on the other hand, involves suspending mussel bags from rope structures supported by floating buoys and anchored to the seabed using concrete blocks (FAO, 2024b; Javane & Maleco, 2020).

4.3. Governance (institutional and legal framework for aquaculture)

4.3.1. Institutional framework

The Minister of Agriculture, Environment and Fisheries, created by Presidential Decree 01/2025 of January 16 (result of merging several formerly separate ministries namely: the Ministry of Agriculture and Rural

Development, the Ministry of Land, Environment and Rural Development and the Ministry of the Sea, Inland Waters and Fisheries) is a central state body that directs, coordinates, plans and ensures the execution of policies, strategies and activity plans in the areas of the agriculture, environment and fisheries, including aquaculture. The institutional framework of the aquaculture subsector is currently made up of the following institutions (Table 3):

4.3.2. Legal framework

The legal framework for the aquaculture subsector in Mozambique is based on a set of policy documents and strategies, which form the bulk of the efforts to develop the activity:

- Fisheries Law: Law no. 22/2013 of November 1;
- Water Law: Law no. 18/91 of August 3rd;
- Aquaculture Regulation: Decree no. 99/2021 of December 31;
- Animal Health Regulations: Decree No. 26/2009 of August 17th;
- Regulation for the Hygiene and Health Control of Fishery Products: Decree no. 80/2020, of September 8;
- Legal Regime for the Use of National Maritime Space: Decree no. 21/2017 of May 24;
- Marine Aquaculture Reserve: Decree No. 71/2011 of December 30;
- Fisheries Policy: Resolution No. 11/96, of May 28;
- Fisheries Master Plan II (2010–2019);
- Specific Rules for the Sanitary Certification of Food Products of Aquatic Origin–Ministerial Diploma no. 135/2011 of May 27;
- Government's Five-Year Programme 2025-2029
- National Development Strategy (ENDE) 2015–2035
- Strategy for the Development of Aquaculture 2020–2030 (Resolution no. 48/2020, of August 25);
- Strategy for the Health of Aquatic Organisms and Biosecurity 2024–2033 (Resolution no. 54/2023 of December 29).

Strengthening collaboration between public and private actors, focus on mutual value creation, shared responsibility, and institutionalized engagement mechanisms is essential for sustainable and competitive aquaculture development. This can be achieved effectively through the establishment of clear and inclusive policy frameworks, multi-stakeholder platforms involving government, private companies, and producer organizations to guide sectoral planning, promote public private partnerships in infrastructure development, such as hatcheries, feed mills, cold chains, and processing facilities, promotion of co-funded farmer field schools, apprenticeships, and technical workshops tailored to real-world farm needs and formation of aquaculture clusters, cooperatives, and associations that can collectively engage with government, research institutions, and financial providers.

Another way of improving governance would be to set up an Aquaculture Desk or platform between the private and public sectors. The role of this platform would be to provide information on potential areas for aquaculture practice, investment opportunities, licensing of aquaculture projects, administrative and regulatory obligations of aquaculture production structures, and offer direct support for new and ongoing activities.

5. Analysis of aquaculture constraints in Mozambique

Aquaculture has been considered as a critical subsector in ensuring food security, rural livelihood improvement, and economic development. However, despite its potential, the growth of aquaculture is hindered by several systemic challenges and among them, lack of quality inputs (seeds and feed), limited marketing, knowledge and market access, inadequate research and weak extension services, limited access to credit and climate change (FAO, 2024c; Muhala et al., 2021a; Ribeiro, 2007; World Bank, 2024). As these are connected challenges, it is important to combine coordinated actions in order to integrate the innovative process, public and private policies, and strengthen and train the local workforce.

Table 3. Institutional framework of the aquaculture subsector.

Institution	Role
National Fisheries Administration (ADNAP, IP)[a]	Drawing up proposals to define policies and strategies for the development of fisheries and aquaculture; Drawing up strategies and promoting economic, social and technical studies with a view to increasing production and productivity levels in fisheries and aquaculture; Monitoring of aquaculture activities in accordance with national legislation, standards and procedures relating to production and the protection of ecosystems; Regulation and licensing of fisheries and aquaculture activities
Institute for the Development of Fisheries and Aquaculture (IDEPA, IP)[b]	Preparation of specialized statistical studies on fisheries activities and for the development of infrastructure to support small-scale fisheries and aquaculture, as well as proposals for policies and strategies, plans and programs on the development and extension of fisheries and aquaculture; Promoting the development of fisheries and aquaculture, with a view to increasing the capacity of operators in the production, management and marketing of small national fisheries producers; Promoting actions aimed at setting up infrastructures to support the production, processing, conservation and marketing of fishery and aquaculture products; Monitoring and evaluation of programs and projects to support the development of fisheries and aquaculture.
Blue Economy Development Fund (ProAzul)[c]	Encouraging and directing private investment towards priority Blue Economy projects and actions; Raising and making available internal and external financial resources for projects and actions of the organic units of the Ministry responsible for the sector, as well as other public and private institutions involved in the activities of the Blue Economy value chains; Financing and ensuring the administrative and financial management of programs and projects aligned with the principles of the Blue Economy; Support in the formulation of business plans and the design, development, adaptation and economic-financial analysis of projects for public sector institutions, Sectoral economic and financial advice on matters related to the Blue Economy.
National Fish Inspection Institute (Fish Inspection, IP)[d]	Health licensing for production units and operators processing and handling fishery products and by-products; Certification of fishery products intended for export, internal circulation and import; Conducting research programs and providing services as a result of official controls; Carrying out sanitary control and inspection actions
Mozambique Oceanographic Institute (InOM)[e]	Investigation and research into diseases as well as epidemiological surveillance in aquatic species; Research and monitoring to maintain species in captivity; Research to subsidize the promotion of sustainable aquaculture in the country; Research into aquaculture feed; Certification of the quality of broodstock, fingerlings, feed and matrices of species produced in the country; Issuing authorization to import matrices in order to guarantee the biosecurity of aquaculture activities; Promoting the protection of national aquatic genetic material, in coordination with other entities; Development of improved methods aimed at increasing aquaculture productivity and genetic improvement of species with potential for aquaculture.
National Institute for Development and Infrastructure Management (INFRAPESCA, IP)[f]	It carries out all the acts necessary for the development, regulation, coordination and proper management of infrastructures and equipment to support fisheries and aquaculture, including auctions, sub-auctions and marinas.

[a]Decree no. 90/2019 of November 27.
[b]Decree no. 3/2016 of February 10.
[c]Decree no. 91/2019 of November 27.
[d]Decree no. 71/2019 of August 26.
[e]Decree no. 87/2021, of October 18.
[f]Decree no. 8/2018, of March 9.

5.1. Fish seed

Fish seed (fry, fingerlings, or juveniles) is a critical input in aquaculture. Any bottleneck in its production, quality, or distribution directly limits the growth, sustainability, and profitability of the sector. Fish seed do not represent a large proportion on the total production cost; however, they are a strategic link in the production chain, and only quality seed can produce adult species suitable for marketing (Sidonio et al., 2012). The price, the lack of coordination between hatcheries and producers, and the availability of high quality seed are still a challenge in national aquaculture production (Mapfumo, 2009; World Bank, 2024). The price of tilapia fingerlings, for example, ranges from 0.078 to 0.11 USD per unit and is significantly higher when compared to some countries such as Tanzania, Zambia, and Uganda (World Bank, 2024).

The country has 20 tilapia seed production units, 19 of which are privately owned, 10 of which are located in the central region (MIMAIP & INE, 2024), where many of these units operate well below their installed capacity (World Bank, 2024). However, the country faces a significant gap in the supply of quality broodstock and consequently quality fingerlings. This challenge stems from factors such as weak genetic management and the decline in genetic quality of parent populations (Hinrichsen et al., 2022). In addition, hatchery practices are not standardised and government institutions provide limited quality control over seed production. Biosecurity measures to prevent contamination are also minimal or absent in many hatcheries.

5.2. Fish feed

Feed represents the largest cost associated with aquaculture production (50–70% of the total cost), and >70% of production depends on formulated feed (Ansari et al., 2021; Hasimuna et al., 2020; Llagostera et al., 2019). The use of balanced, good quality feed is essential for achieving high productivity rates, as it improves feed conversion rates (Sidonio et al., 2012).

One of the primary challenges hindering the development of aquaculture in Mozambique is the lack of dedicated feed mills for aquatic species, even though there are some feed mills serving terrestrial animals. Although some producers try to produce feed for aquaculture, most are inefficient or offer low quality (Moyo & Rapatsa, 2021; World Bank, 2024). Inadequate feed quality can have a significant effect throughout the aquaculture value chain, particularly affecting fish growth rates, seed demand including prolonged grow-out cycles and lower turnover rates, and market competitiveness due to the higher production costs, inconsistent product quality, and loss of buyer confidence.

The cost of feed in Mozambique varies between 1.30 and 2.35 USD/kg, and is mostly imported, making it unaffordable for small-scale producers (Muhala et al., 2021a; World Bank, 2024). The fact that small-scale aquaculture in Mozambique is carried out in an integrated way with some agricultural activities allows producers to use by-products from livestock or plant production to feed the fish or to resort to the production of homemade feed, often under inadequate technical conditions, resulting in reduced growth and lower yields.

5.3. Market access

Markets play a central role in driving fisheries and aquaculture development, yet value chains are often underdeveloped and fail to capitalise on value addition opportunities (Mapfumo, 2022).

Although Mozambique produces significant quantities of fish, its distribution remains very limited, with the national system for fresh fish particularly underdeveloped (FAO, 2024b). Most of the fish produced in Mozambique is sold through informal channels, with direct sales usually made in the production units or in nearby markets by women (World Bank, 2024). Furthermore, fish sales markets are concentrated in densely populated regions, where buyers and sellers can negotiate the price, and as more traders sell the same product, prices tend to fall. However, the informal structure that characterizes the Mozambican scenario, although accessible, does not facilitate entry into various markets, which partly reduces the visibility of income, making it difficult to track and control the product in terms of quality. The main reasons include poor investment in public infrastructure such as road networks, water, and energy supplies and sanitation alongside weak research capacity and the use of unsuitable technologies (Mapfumo, 2022). Therefore, it is important to create formal trade platforms that guarantee more opportunities for stakeholders, facilitating to some extent their entry into regional and/or international markets.

5.4. Research and extension services

Aquaculture is a technology-dependent subsector that relies on modern tools to enhance seed production, aquafeeds, genetic resources, and other key areas of the industry (Mapfumo, 2022).

Research and extension services play a vital role in technology development, dissemination of best practices, and capacity building for farmers (Maulu et al., 2021c). Their limitations thus serve as significant constraints to sustainable aquaculture development.

Aquaculture in Mozambique is an emerging subsector predominantly dominated by artisanal actors and faces considerable challenges due to limited technical knowledge and inadequate training among local fish farmers (World Bank, 2024). The subsector's growth is further hindered by insufficient funding, inadequate infrastructure, and a shortage of experienced personnel, all of which constrain research and innovation (FAO, 2024c; Mapfumo, 2009). Aquaculture research is primarily conducted by public institutions, including fisheries departments, universities, and research institutes, typically with a primary focus on resource assessments, low-cost diet production, zootechnical performance, and environmental studies, often relying on external laboratories due to domestic limitations in research capacity and infrastructure. Collaboration between aquaculture research institutions and private businesses remains limited, although some medium-scale farms are increasingly engaging in on-farm research initiatives in partnership with local universities (Mapfumo, 2022).

Extension services in aquaculture remain weak and insufficient. Historically, extension workers from the Ministry of Agriculture have been the main promoters of aquaculture in the provinces. A study carried out by Mapfumo (2009) identified the shortage of qualified aquaculture professionals in Mozambique as one of the main obstacles to the sector's development. Since then, various efforts have been made to fill this gap, including the introduction of degree courses in Aquaculture and the implementation of medium-level technical courses. Despite these advances, the training of specialized professionals has not been sufficient to meet the growing demands of the subsector. The absence of adequate and consistent technical assistance is a major barrier, particularly affecting small-scale aquaculture producers in Mozambique (Muhala et al., 2021a), resulting in poor management practices, low productivity and survival, impacting the economic return and sustainability of the activity (World Bank, 2024).

5.5. Access to credit and incentives for development

As in any African country, mobilizing significant resources to finance aquaculture ventures or accessing risk capital from financial institutions in Mozambique is difficult (Jaoui et al., 2022). Aquaculture in Mozambique is considered a relatively unknown business and is therefore considered risky, requiring guarantees that mainly small producers do not have (Mapfumo, 2009).

In Southern Africa, many governments view aquaculture development as a key tool for poverty alleviation. In Mozambique, for instance, action plans have been established with a primary focus on reducing hunger by increasing aquaculture production (Moyo & Rapatsa, 2021). The low volume of funding applied to aquaculture contrasts with the activity's potential. The subsector faces challenges, especially with regard to the availability of investments, high cost of credit, as access to loans is limited by high interest rates and short pay-back periods (Gebregziabher et al., 2023; Mapfumo, 2022), with little exploited potential compared to other major producing countries with less water availability and species diversity. The lines of financing made available by the Blue Economy Development Fund (ProAzul) through cooperation partners are an option for producers, but there is a need for substantial investment, as well as greater professionalization of the production chain.

Despite the packages of economic acceleration measures announced by the government in 2022 to boost the private sector (Gebregziabher et al., 2023), the aquaculture subsector is currently still not large enough to enjoy industrial levels of supply and demand (World Bank, 2024).

5.6. Aquatic animal health management and biosecurity

Diseases pose a significant challenge to global aquaculture production, with the incidence of pathological agents, emerging and re-emerging diseases increasing over the past two decades (Maulu et al., 2021a; Subasinghe et al., 2023). The economic impact of aquatic diseases is substantial, with annual losses estimated at ~6–10 billion dollars due to infectious outbreaks (Maezono et al., 2025; Shinn et al., 2015).

In the past decade, outbreaks of White Spot Syndrome Virus (WSSV) in Mozambique have nearly wiped out the once-thriving shrimp aquaculture industry, causing significant social impacts and production losses estimated at US$5 million (Mondlane-Milisse et al., 2022). More recently, in 2023, the presence of Epizootic Ulcerative Syndrome (EUS) was confirmed in wild populations of freshwater fish, further highlighting the vulnerabilities in aquatic animal health management (WOAH, 2023).

Despite these challenges, Mozambique's aquaculture industry has limited measures—including weak diagnostic capacity, inadequate farm-level biosecurity, insufficient regulatory enforcement, limited coordination and data sharing, and low farmer awareness—in place designed to prevent, detect, and respond to aquatic animal diseases, which poses a threat to the sector's sustainability and expansion (World Bank, 2024).

Although biosecurity requirements are included in the regulations for licensing aquaculture establishments, their implementation remains inconsistent, particularly in small-scale production units (WOAH, 2023). The Fish Inspection authority, which serves as the competent body for aquatic animal health, lacks the capacity for independent disease diagnosis and relies on the Biotechnology Centre at Eduardo Mondlane University for polymerase chain reaction (PCR) tests (Level III diagnostics). However, the centre itself does not have the capacity to conduct Level II diagnostics (which include microbiological and histological examinations) (Bondad-Reantaso et al., 2021; WOAH, 2023). This gap in diagnostic capacity underscores the urgent need for investment in Mozambique's aquatic animal health infrastructure to enhance disease surveillance, early detection, and effective response mechanisms.

Implementing effective farm-level biosecurity measures (pond preparation by drying and sunlight exposure to eliminate residual pathogens and aquatic crustaceans in soil, strict quarantine measures, egg disinfection, traffic control, water treatments, clean feed, and disposal of mortalities), use of specific pathogen-free (SPF) and specific pathogen-resistant (SPR) broodstock, and disease management strategies are therefore essential to securing the sustainability and long-term viability of the aquaculture industry (Hasimuna et al., 2020; Walker & Mohan, 2009). Additionally, effective prevention and control of fish diseases involves strategies such as phytotherapeutics, nanotherapeutics, probiotics, prebiotics, phage therapy, vaccination, antimicrobial peptides, biosurfactants, bacteriocins, and diagnostic-based treatments (Assefa & Abunna, 2018; Elgendy et al., 2024).

5.7. Climate change

The Global Climate Risk Index 2021 identified Mozambique as the most climate-vulnerable country in Africa (Eckstein et al., 2021). This vulnerability is attributed to its geographical location, characterized by an extensive coastline and vast lowland areas that encompass the deltas of 13 major regional rivers. As a result, Mozambique is highly susceptible to various natural disasters, including floods, cyclones, storms, and droughts. Over the past 35 years, Mozambique has faced 75 officially declared disasters, including 13 droughts, 25 floods, 14 tropical cyclones, and 23 epidemics (USAID, 2019). These extreme weather events have had far-reaching consequences on local communities, infrastructure, and economic stability.

The heavy reliance on fish for protein, coupled with limited alternative food sources, employment opportunities, and a fragile economy, exacerbates the socio-economic and ecological susceptibility of Mozambique and other African nations to climate-related disruptions in the fisheries and aquaculture industries (Barange et al., 2018; Hasimuna et al., 2023; Maulu et al., 2021b; Williams & Rota, 2011). Extreme climatic events, such as Cyclones Idai and Kenneth, resulted in extensive damage to aquaculture infrastructure (including the loss of 227 ponds, 206 cages, and around 900,000 fingerlings), leading to significant declines in production and overall productivity (Muhala et al., 2021b). The destruction of fish farms, hatcheries, and fishing equipment further compounds food insecurity and economic hardships, underscoring the urgent need for climate adaptation strategies.

Several scholars have proposed targeted measures to enhance the resilience of aquaculture to climate change, emphasizing the need to strengthen the adaptive capacity of both fish farming communities and the ecosystems that sustain them (Barange et al., 2018; Galappaththi et al., 2020; Hasimunaet al., 2025a; Maulu et al. 2021b; Reid et al., 2019; Yadav et al., 2024). These adaptation strategies include improving early warning systems, implementing climate-smart aquaculture practices (such as Integrated Multi-Trophic Aquaculture, Recirculating Aquaculture Systems, selective breeding and resilient strains, salinity-tolerant and low-water use species, waste management and circular economy approaches, and digital tools and precision aquaculture), diversifying income sources for fishers and aquaculturists, and reinforcing aquaculture infrastructure to withstand extreme weather events. Additionally, ecosystem-based approaches, such as mangrove restoration and integrated coastal zone management, have been identified as critical interventions to mitigate the adverse effects of climate change. Strengthening policy frameworks and enhancing research collaborations on climate-resilient aquaculture practices will be essential in ensuring the long-term sustainability of the sector amidst escalating climate risks.

6. Opportunities for aquaculture development in Mozambique through adaptable lessons from Brazil

With countless natural resources, Brazil is one of the largest markets to drive the global increase in consumption and to realize large-scale fish production (Bueno et al., 2021; Saint-Paul, 2017; Valenti et al., 2021). Aquaculture development in Brazil began in the early 1900s, but production growth remained relatively modest during the early years (Pincinato & Asche, 2016). Currently, Brazil is the third largest aquaculture producer on the American continent, producing 738,000 tonnes in 2022, and is among the 15 largest fish producers in the world (FAO, 2024c).

Mozambique and Brazil, despite being on opposite sides of the Atlantic, share a unique set of natural, environmental, and socio-economic characteristics that make aquaculture a high-potential subsector for both countries. A retrospective examination of the Brazilian aquaculture subsector reveals significant parallels with the current developmental challenges faced by Mozambique. The Brazilian experience may serve as a valuable comparative model, offering practical insights for the formulation of context-specific strategies in Mozambique. By identifying convergences in developmental paths, Mozambique can both capitalize on emerging opportunities and proactively address foreseeable constraints. This section outlines key aspects of aquaculture development linked to national industry challenges, drawing on Brazil's experience to extract applicable lessons that could be adapted to enhance Mozambique's aquaculture subsector.

6.1. Species enhancement and diversification through sustainable long-term breeding programs

Aquaculture is an activity that requires technology to improve species, generate and select healthy animals, and optimize growth and survival rates (Maulu et al., 2019; Sidonio et al., 2012). Brazil has developed extensive long-term selective breeding programmes for tilapia, shrimp, and native freshwater species such as tambaqui (*Colossoma macropomum*). Led by universities, private hatcheries, and research institutions such as the Brazilian Agricultural Research Corporation (EMBRAPA), these programmes focus on improving growth rate, disease resistance, and feed efficiency. At present, Brazil cultivates over 64 species of aquatic organisms for human consumption, alongside ~250 species of ornamental fish, invertebrates, and aquatic plants (Pincinato & Asche, 2016; Valenti et al., 2021). The majority of genetically enhancement aquatic organisms utilized in aquaculture have been developed through conventional genetic enhancement techniques, such as selective breeding, crossbreeding, and hybridization (Hulata, 2001), with hybridization being one of the most widely used in Brazil for native species (Hashimoto et al., 2012).

Currently, six species are cultivated in Mozambique (see 4.1), and only one species (*Oreochromis mossambicus*) is in the process of genetic enhancement (Norges Vel, 2022). Mozambique relies mainly on wild-caught or imported seed, with limited institutional capacity and fragmented research. Most smallholders continue traditional production methods without improved genetic stock. Enhance diversification of species and farming systems may boost aquaculture in Mozambique, where several species with potential for domestication have already been identified: mangrove crab (*Scylla serrata*), Indian white shrimp (*Fenneropenaeus indicus*), kuruma shrimp (*Penaeus japonicus*), freshwater shrimp (*Macrobrachium rosenbergii*); freshwater fish: Tilapia *rendalli*, African catfish (*Clarias gariepinus*), grass carp (*Ctenopharyngodon idella*), silver carp (*Hypophthalmichthys molitrix*), and common carp (*Cyprinus carpio*); marine fish (mullet *Mugil cephalus*, grouper *Epinephelus spp*., goldlined seabream *Rabdosargus sarba* and snappers *Lutjanus* spp). Other important species are seaweed, echinoderms (sea cucumber and holothurians), and bivalve molluscs such as oysters, mussels, scallops, and clams (Mapfumo, 2009; Menezes, 2001; MIMAIP, 2020; World Bank, 2024). Pullin (2016) suggests that the most effective approach to diversification could be to expand the farming of species already produced on a small quantity.

Species diversification can drive aquaculture growth in several ways, such as meeting rising market demand where consumers value a wide variety of aquatic foods, improving efficiency through polyculture, support the conservation of aquatic biodiversity, and making use of different farming environments and resources. Nevertheless, rather than dispersing efforts across many species, focusing on the most promising ones is often a more effective approach, particularly in emerging aquaculture subsectors that lack the necessary capacities, such as entrepreneurship, technical expertise, and supply chains to expand through diversification. The diversification must be underpinned by rigorous risk assessment both for non-native introductions and the management of native farmed varieties supported by stronger policies, greater awareness, and targeted training (Cai et al., 2023; Metian et al., 2020; Oboh, 2022; Sonesson et al., 2023).

6.2. Aquafeed production

The Brazilian aquafeed market features a mix of multinational and regional players, which offer a range of feed products tailored to various aquaculture species and production systems. Feed mills in Brazil benefits from integrated mills producing species-specific feeds using local ingredients, research-based formulations, and rigorous quality control standards. Approximately 100 companies manufacture feed for fish, including around 15 that additionally produce diets for marine shrimp; a limited number produce feeds for frogs, while only a single company specializes in feed production for freshwater prawns (Valenti et al., 2021). In 2024, Brazil produced and marketed ~1.87 million tonnes of aquafeeds, reflecting the scale of its aquaculture feed industry (Sindirações, 2024). Mozambique as many other African countries, in contrast, depends heavily on imported animal feed and ingredients (Hinrichsen et al., 2022; Ogunji & Iheanacho, 2021; Thiao & Bunting, 2022), has few domestic mills, and limited technical capacity, with small-scale producers relying on low-efficiency homemade feeds.

The limited availability of high-quality, affordable feed for farmed species represents a potential barrier to the Mozambican aquaculture subsector's growth (Iheanacho et al., 2025). Attracting feed mill producers is critical to reducing import dependency and involves creating a favourable business environment, identifying and addressing market gaps, and promoting investment opportunities. Mozambique should strengthen the animal feed sector, replicating Brazil's experience through technology transfer, investment in research and development, capacity-building, and policy support. Alternatively, Mozambican aquaculture must rely on fishmeal substitutes such as plant proteins, animal by-products, insect meals, and microbial or single-cell protein (SCP)—to support ecologically and socially sustainable long-term growth (Ndebele-Murisa et al., 2024; Ogueji et al., 2020; Ogunji & Iheanacho, 2021; Talwar et al., 2024). Additionally, some actions can be adopted as provide tax holidays for new feed mill projects, offer duty-free import of machinery and raw material for feed production, implement VAT exemptions on feed production inputs, establish and promote agro-industrial parks with ready access to land, electricity, water, and roads, support contract farming models linking feed mills with local maize and soybean farmers and streamline business registration and licensing processes for agro-processing investors.

6.3. Government support for research and extension services

Sustained growth and success in aquaculture depend on strategic investment in applied research and extension services, facilitated through collaborative efforts between public and private sector stakeholders. According to Valenti et al. (2021), Brazil offers a comprehensive educational framework for aquaculture, comprising ~45 undergraduate programs, 30 specialization courses, 30 master's degrees, and 13 doctoral programs, thereby establishing a robust scientific foundation for sector development. Government support in Brazil is robust, with institutions like EMBRAPA providing training, technical assistance, and integrated extension services. Additionally, research initiatives are predominantly supported by federal agencies such as National Council for Scientific and Technological Development (CNPq), Coordination for the Improvement of Higher Education Personnel (CAPES), which provide financial resources and scholarships to researchers across academic, extension, and development institutions nationwide. Complementing these federal efforts, individual states maintain their own funding bodies that allocate resources to localized research projects (Vasconcelos et al., 2021).

Mozambique's government support is limited, research institutions are underfunded, and extension services are poorly coordinated, particularly in rural areas. The development of technological packages is a weakness, but also an opportunity for the aquaculture subsector in Mozambique. As this is a relatively new area, there are great prospects for progress. However, it is necessary to concentrate research on a few well-structured projects restricted to a few potential species, to avoid scattering efforts and resources on a large number of initiatives with limited impacts and results. Investing in research and development fosters innovation in fish breeding, disease control, and sustainable aquaculture practices. Advancing genetic research to develop disease-resistant strains and enhancing hatchery technology can secure consistent, high-quality production. Furthermore, stronger collaboration among government bodies, universities, and the private sector will help close knowledge gaps and raise industry standards (Obi et al., 2025).

In Mozambique, aquaculture extension services are provided by IDEPA and the District Services for Economic Activities and NGOs on an *ad doc* basis (Mapfumo, 2009; World Bank, 2024) however, despite the effectiveness of these services, many extension workers lack training in aquaculture, and do not have the technical knowledge necessary to sustain the transfer of technology and the continuous improvement of aquaculture operations (Ribeiro, 2007). Mozambique could strengthen extension services and establish research and training centers focusing on key ecosystems: freshwater, coastal, and brackishwater, using Brazilian best practices to train Mozambican aquaculture farmers and extension officers. Aquaculture extension services are essential for planning and executing projects that promote the sustainable development of aquaculture, as they help to disseminate knowledge, technology, and good practices, leading to increased production and productivity (Awuor et al., 2021; Ayisi et al., 2016; World Bank, 2024).

6.4. Development, validation, and replication of sustainable production models adapted to the different species, regions of the country, and climate change

The expansion of aquaculture in Brazil is underpinned by diversified production systems tailored to regional variations in climate, topography, economic factors, skilled labour availability, and consumer demand. Freshwater fish species are cultivated nationwide, while freshwater prawn farming occurs in 19 states across all regions. Bivalve production, including mussels and oysters, is established in all coastal states. Marine shrimp aquaculture is predominantly concentrated in the Northeastern states, whereas cultivation of macroalgae, marine fish, and amphibians such as frogs is primarily located in the Southeastern region. These species are produced in different structures and production systems, such as earthen ponds, net ponds, raceways, continuous flow ponds, and climate-smart aquaculture practices such as recirculation systems (RAS), biofloc system (BFT), Aquaponics, and Integrated Multi-Trophic Aquaculture (IMTA) (Bueno et al., 2021; Queiroz et al., 2005; Valenti et al., 2021). Many aquaculture production units operate with a predominantly horizontal integration model; however, certain enterprises have adopted partial or full vertical integration, encompassing proprietary hatcheries, grow-out facilities, feed manufacturing operations, and processing plants (Valenti et al., 2021).

Mozambique relies primarily on extensive, low-input systems with low productivity and limited replication of proven models, leaving it vulnerable to climate-related risks. The aquaculture subsector remains in its early stages, presenting significant opportunities to implement diverse production systems and models that leverage the country's species diversity, water resources, and varied climatic zones. Although the adoption climate-smart aquaculture could significantly boost national fish production, successful large-scale implementation requires active engagement from governments and stakeholders to promote these practices (Abisha et al., 2022; Cortes et al., 2025).

6.5. Aquatic animal health management

Aquatic animal health management in Brazil is supported by disease monitoring programmes, veterinary services, biosecurity protocols, reinforced by strong regulatory frameworks. The regulatory and institutional framework encompass federal agencies which oversees national animal health policies, regulates environmental impact and licensing, monitors public health and food safety, including residues in fish products, and key normative instruments which establishes procedures for aquatic animal health surveillance and control, defines notifiable aquatic diseases, and provide import requirements and biosecurity for aquatic organisms (MAPA, 2025).

Mozambique has limited veterinary support, weak regulatory enforcement, and minimal diagnostic capacity. The regulation, approved by Decree No. 26/2009 of 17 August, is the main legal instrument that establishes the standards for animal health, extensive to aquatic animals. The approval of the Aquatic Animal Health and Biosecurity Strategy 2024–2033 represents an important step towards strengthening disease management frameworks. However, limited diagnostic capacity, the lack of a structured surveillance system, and inadequate biosecurity practices at the farm level remain major constraints. Transferable lessons include implementing basic biosecurity protocols, disease monitoring, and farmer training, while national-level disease surveillance remains unfeasible without substantial capacity building. Brazil's disease management protocols could be piloted in selected Mozambican farms with technical and laboratory support.

6.6. Establishing an enabling environment to foster private investment and enhance small producer engagement

The private sector constitutes a critical driver in the advancement of aquaculture across numerous countries and is indispensable in complementing governmental initiatives aimed at fostering sustainable industry growth (Hasimuna et al., 2025b; Zhang et al., 2024a). However, its level of contribution largely depends on the presence of a favourable investment climate and well-defined policies that provide a clear framework for private sector engagement. In Brazil, for example, the aquaculture industry supplies most of the equipment and inputs required for production, except for certain specialized equipment used in ornamental and marine aquaculture (Valenti et al., 2021). Additionally, Brazil has implemented targeted credit programs offering relatively low interest rates specifically designed to finance aquaculture activities, complementing broader agricultural financing schemes that provide extended support to the subsector (Leite et al., 2024; Valenti et al., 2021). The recent approval of Brazil's National Aquaculture Development Plan (2022–2032) marks a significant policy milestone, as it outlines governance strategies and long-term planning initiatives aimed at attracting investment and fostering sustainable aquaculture development in the country over the next decade (MAPA, 2022).

Aquaculture in Africa faces multiple challenges, the most significant being limited access to finance, poor infrastructure, insufficient technical expertise, and a shortage of skilled labour (Hasimuna et al., 2025b; Mphande et al., 2023; Wuor & Mabon, 2022). Partnerships for innovation, technology, and knowledge transfer are vital for overcoming these challenges and advancing the sustainable growth of aquaculture (Murekezi et al., 2024). In Mozambique, aquaculture remains an emerging industry that has yet to reach full consolidation, presenting a significant opportunity for public–private partnership (PPP) model to leverage resources, expertise, and knowledge. Moreover, adopting inclusive business models such as buyer-driven, producer-driven, and intermediary-driven approaches can further strengthen these initiatives (Kaminski et al., 2020). The success of PPP depends on addressing challenges such as weak or absent regulations governing aquaculture partnerships and the high cost of financing, largely driven by elevated interest rates on borrowed funds for PPP projects (Murekezi et al., 2024).

6.7. Development of aquaparks

The term aquapark denotes an organizational framework for aquaculture that aims to support and empower small-scale producers across all stages of the value chain. This model involves integrated planning and zoning, coupled with the development of essential infrastructure including transportation networks, water supply, and electricity, as well as provision of critical production inputs, extension services, and improved market access (Joffre et al., 2019; Ma & Liu, 2023; Touraki et al., 2012; Zhang et al., 2024b). Aquaparks in Brazil provide shared infrastructure, technical support, and market access, backed by public and private investment. By 2015, Brazil had established and licensed 139 aquaparks, 117 in freshwater and 22 in marine environments featuring production configurations that vary from a limited number of large-scale operations to numerous small-scale family units (Bueno et al., 2015; Lima et al., 2018). These aquaparks were set out following comprehensive geographical, environmental, social, and economic assessments to evaluate support capacity and establish zoning parameters (Bueno et al., 2015), and they are distributed across four major river basins and along the Brazilian coastline—in the Northeast, Southeast, and South regions—encompassing 12 federal states (Lima et al., 2018). The implementation of aquaparks, mainly for tilapia, has led Brazil to increase its production from just over 12,000 tonnes in 1995 to 579,080 tonnes in 2023 (Pedroza Filho et al., 2020; Peixe, 2024; Schulter & Vieira Filho, 2017).

The establishment of aquaparks in Mozambique has the potential to enhance the organization of aquaculture producers, facilitate access to technical services and production inputs, and strengthen the value chain to improve market competitiveness and resilience against climate change risks. This, in turn, can contribute to local socioeconomic development by generating income and stimulating economic activity. Effective implementation of aquaparks will necessitate alignment with national aquaculture development policies, alongside coordinated investment from both public sector entities and private enterprises.

The Salinized Lands Aquapark in Chókwè, Gaza province, is the first in the country, covering 6000 ha; however, its model is facing some difficulties in its operation, and after a decade, it has failed to attract sufficient investment from the private sector, with only a few production units starting activities (World Bank, 2024). The basic principles for planning, implementing, and managing aquaparks are described in detail in Zhang et al. (2024b). To implement aquaparks, basic studies need to be carried out to survey the landscape, the distribution of water bodies, roads, the electricity grid, and other support facilities. In addition, an ecosystem approach is required when planning the aquapark, based on the results of the feasibility study and the condition of natural resources and social development in the planned area.

Transferable strategies from Brazil include developing small-scale regional clusters with shared technical and processing infrastructure, while fully equipped large-scale parks are not immediately feasible.

6.8. Associativism and cooperativism

Associativism and cooperativism in Brazil are well-established, enabling small producers to pool resources, access credit, and collectively market products, supported by training networks.

An aquaculture association can be defined as a collective organization comprising individual aquaculturists and/or producer groups, established to enhance the coordination of sectoral activities and to build institutional capacity for addressing common challenges and operational constraints faced by its members (Stutzman et al., 2017). Associativism plays a significant role in the development of aquaculture by fostering collaboration, knowledge sharing, facilitating market access, and collective problem-solving among stakeholders (Perolo & Hough, 1999; Stutzman et al., 2017). Brazilian aquaculture is characterised by a strong network of associations, the most successful being the Brazilian Shrimp Breeders Association (ABCC), which is responsible for the orderly and sustainable development of farmed shrimp in Brazil (Ostrensky et al., 2007). The Association promotes and encourages the creation of state shrimp breeders' associations as a way of strengthening both the local representativeness of producers and the subsector's own representativeness, and at international level, it participates in the Board of the Global Aquaculture Alliance.

In addition to the ABCC, there are other associations linked to aquaculture, in particular the Brazilian Association of Breeders of Aquatic Organisms (ABRACOA), which aims to bring together aquaculturists, fishermen, technicians, researchers and all individuals and companies involved or interested in the breeding of aquatic species; the Brazilian Association of Pathologists of Aquatic Organisms (ABRAPOA), which aims to bring together all those interested in the pathology of aquatic organisms; Brazilian Association of Fish Farmers and Fishermen (ABRAPPESQ), which aims to help fish farmers and fishermen by supporting research, encouraging courses and appointing specialized professionals in the area to solve problems faced by its members; Brazilian Fish Farming Association (PEIXE BR), which promotes the fish production chain; Brazilian Association of Aquaculture (ABRAq), which covers all activities in the aquaculture area;

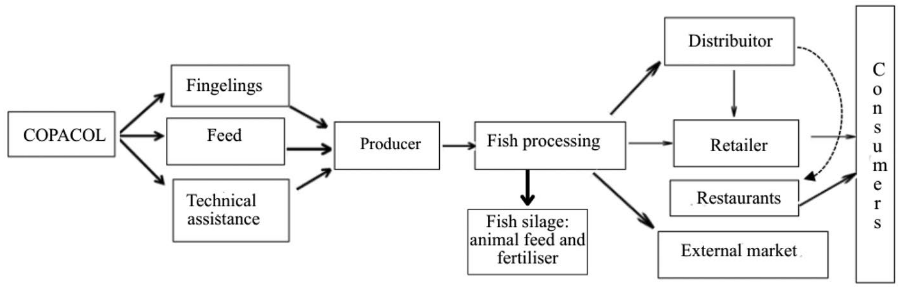

Figure 4. COPACOL's integration system for tilapia production.
Source: Adapted from Brum and Augusto (2015).

Table 4. Lessons from Brazilian aquaculture for Mozambique: comparative analysis and recommended actions.

Area	Brazilian experience	Current situation in Mozambique	Recommended action/ adjustment
Species enhancement and diversification	Long-term selective breeding programmes for tilapia, shrimp, and native species (e.g. tambaqui), focusing on growth, disease resistance, and feed efficiency.	Minimal or absent; reliance on wild-caught or imported seed; limited institutional capacity.	Pilot selective breeding programmes for high-value species with technical support; scale up gradually.
Aquafeed production	Integrated feed mills producing species-specific feeds using local ingredients; strict quality control.	Limited domestic feed production; heavy reliance on imports; small-scale farm-made feeds of variable quality.	Develop small- to medium-scale feed mills using local ingredients; provide training in feed formulation and quality management.
Research and extension services	Government-academia-private sector networks providing training, technical support, and demonstration farms.	Weak extension coverage; underfunded research institutions; limited technical support in rural areas.	Establish province-level integrated hubs linking government, academia, and private sector; deliver targeted technical support and farmer training.
Sustainable production models	Semi-intensive ponds, polyculture systems, recirculating aquaculture systems (RAS); climate adaptation integrated into site selection and species choice.	Predominantly low-input, extensive systems; limited replication of proven models; high vulnerability to climate risks.	Adoption of climate-smart aquaculture practices tailored to specific species and regional conditions across the country.
Aquatic animal health management	Disease monitoring, biosecurity protocols, veterinary support, vaccination programmes.	Limited veterinary services; weak regulatory enforcement; minimal diagnostic capacity.	Implement basic biosecurity and disease monitoring; provide farmer training; pilot lab-supported disease management programmes.
Private investment and producer engagement	Credit lines, tax incentives, insurance schemes; strong producer associations linking smallholders to markets.	Limited access to credit and insurance; poor market linkages.	Support district-level cooperatives, small-scale credit schemes, and value-chain development.
Aquaparks	Integrated aquaparks providing shared infrastructure, technical support, and market access.	No functional aquaparks; production dispersed and fragmented.	Develop small-scale regional clusters with shared technical and processing infrastructure.
Associativism and cooperativism	Well-established associations and cooperatives enabling pooled resources, collective marketing, and access to finance.	Weak, fragmented, and under-resourced cooperatives; limited experience with collective marketing.	Form national technical association and district-level cooperatives for specific species with technical training support.

and Brazilian Association of Aquaculture and Aquatic Biology (AQUABIO), formed by technicians and researchers to provide technical and scientific support to aquaculturists (Ostrensky et al., 2007).

Mozambique currently has two formal aquaculture associations: the Mozambican Aquaculture Association (AMAQUA) and the Mozambique Aquaculture Association (AAM). AMAQUA has seven members who represent 80 percent of Mozambique's aquaculture production due to the larger commercial farm members. AAM focuses mainly on small-scale aquaculture and its members represent many players in the three southern provinces of Mozambique (World Bank, 2024). As the global aquaculture subsector continues to expand, producer associations will play an increasingly critical role in facilitating stakeholder engagement, advocating for evidence-based policy reforms, and promoting the adoption of sustainable production practices.

Cooperativism, akin to associativism, refers to the organizational model in which individuals unite to form cooperatives member-owned and member-operated entities established to pursue shared economic, social, or productive interests for mutual benefit (Novkovic, 2008; Reddy, 2023). In the context of aquaculture, cooperativism serves as a critical mechanism for advancing industry development, particularly by strengthening the participation and competitiveness of small- and medium-scale producers. In Brazil there are fish production cooperatives such as *Cooperativa Agroindustrial Consolata* (COPACOL), *Cooperativa Agroindustrial* (C.Vale) and *Cooperativa dos Piscicultores do Alto e Médio São Francisco* (Coopeixe), which implement an integrated system for fish production with the aim of supplying national demand, following a vertical strategy (Figure 4) where the cooperative maintains control of the entire product and business process, thus ensuring its competitiveness in the market (Brum & Augusto, 2015), standing out with production models that can be implemented in Mozambique, taking into account the particularities of the subsector and the country. In developing countries, aquaculture cooperatives have been used to enhance economic performance and enable smallholders to engage in global value chains by counterbalancing the market power that is often concentrated both upstream and downstream of production (Kaminski et al., 2020; Kassam et al., 2011; Vincent & Morrison-Saunders, 2013).

In summary, Table 4 provides a synthesis of key lessons from Brazil's aquaculture subsector and assesses their relevance for Mozambique. For each thematic area, it outlines the Brazilian experience, identifies the current situation and gaps in Mozambique, and presents the recommended actions or adjustments required.

7. Conclusions

This study shows that, despite Mozambique's abundant natural resources and considerable aquaculture potential, the subsector remains underdeveloped and contributes only marginally to national fish supply, socio-economic development, and poverty alleviation. The study identified key constraints, including limited technical capacity, inadequate infrastructure, restricted access to market and finance, and insufficient adoption of best practices in biosecurity, feed management, and production efficiency. At the same time, significant opportunities exist, such as applying lessons from Brazil's successful feed mill, farmed species diversification, production models, and strengthening public–private partnerships to encourage investment and knowledge transfer. Based on these findings, the study recommends targeted strategies to advance Mozambique's aquaculture subsector: investment in training and capacity-building, modernisation of production systems and models, improvement of policy and regulatory frameworks, and promotion of market-oriented production. By addressing these constraints and capitalising on identified opportunities, Mozambique can expand sustainable aquaculture, increase domestic fish production, and enhance its socio-economic impact.

Additionally, future research should focus on climate-resilient production systems, socio-economic impacts on livelihoods, market and value chain improvements, technological innovations, policy and governance evaluation, environmental sustainability, and opportunities for regional and international cooperation.

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Data availability statement

Data sharing is not applicable to this article as no data were created or analysed in this study.

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