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Scaling aquaculture for food security and employment in Africa: Insights from Egypt, Kenya and Nigeria

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Abstract

Aquaculture is the fastest growing food sector in the world and now accounts for more than half of the fish consumed globally. However, the sector in Africa remains in its infancy, with the notable exception of Egypt, one of the world's largest producers. This paper provides a thorough analysis of the sector in the selected countries of Egypt, Kenya and Nigeria to help identify investment and policy priorities that can sustainably advance aquaculture across Africa to boost income and employment, rural development and food security. The analysis focuses on nine themes to ensure a comprehensive overview of the sector and to better understand the relative strengths and weaknesses in each country: sector trends, national policy frameworks, government institutions, natural resources to support aquaculture, sector-specific innovation, feed and seed, market access, public-private partnerships, and sectoral impacts. With these in mind, the paper provides a series of recommendations for African policymakers and investors aimed at improving sectoral development across the continent. Among other factors, the recommendations highlight the need to not only increase productive capacity but also linkages to markets and consumers, adopt national policies that provide targeted support to high-potential areas, increase local research capacities and scaling of research results, decentralize seed and feed production for improved access, and promote sustainably produced fish as a promising source of animal-derived protein.

Acknowledgments

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1 Introduction

Aquaculture is the fastest growing food sector in the world, now contributing more than 50% of the fish consumed by humans (Rocha et al., 2022; Subasinghe et al., 2009). The sector is a driving force behind the recent surge in global aquatic animal production, characterized by a 609% expansion in annual outputs and an average growth rate of 6.7% per year between 1990 and 2020 (FAO, 2022). Aquaculture is increasingly recognized as a crucial pillar of global food security and has led the FAO to call for better integration of the sector into food system strategies and policies (FAO, 2022).

To date, African aquaculture remains in its infancy and expansion of the sector offers much potential to drive improvements in development and food security indicators. In terms of regional aquaculture production, the continent ranks behind Asia, the Americas, and Europe, but ahead of Oceania. African capacity is heavily concentrated in Egypt, Nigeria, and, to a lesser extent, Uganda. These three countries alone accounted for 86% of regional production in volume and 75% in value in 2018 (FAO, 2023a). Egypt clearly dominates both in terms of production volume (68% of total African production) and value (56%). Recent trends in regional growth rates are driven by the dominant role of Egypt and Nigeria. In 2020, Africa was the only global region to experience a decline in aquaculture production, but this decline was largely driven by falling production levels in Egypt and Nigeria while the rest of Africa was seeing a 14.5% growth (FAO 2022).

Vastly divergent levels of aquaculture capacity across the African continent demonstrate the potential for the sector to make economic and food security impacts in countries with poorly developed fish farming sectors. The shift needed to transform Africa's aquaculture sector from subsistence to commercial levels depend upon sound policy guidance, natural resources, technology and research, seed and feed development, diversification and intensification of production systems, development of competitive products and access to markets (Cai et al., 2017; Musinguzi et al., 2019; Murekezi et al., 2020). A strong private sector is key to take these issues forward, supported by effective public-private partnerships (Adeleke et al., 2021; Aanyu et al., 2020; Walakira, 2020). Along these general themes, this study aims to identify investment and policy priorities that will sustainably advance the aquaculture sector in Africa to boost income and employment, rural development and food security.

With an eye to ensuring diverse representation across the continent, Egypt, Kenya and Nigeria were chosen as case study countries for this study.[1] The three countries are geographically, historically, and culturally divergent, with differing approaches to aquaculture. As key players in the African aquaculture sector, Egypt and Nigeria can provide useful lessons for other countries seeking to scale production. Kenya, on the other hand, is a comparatively small player, but with significant growth potential, thus offering an interesting forward-looking case study on how to develop the sector to take advantage of the available opportunities.

With a total live weight of around 1.6 million MT worth over USD 3 billion in 2021 (Figures 1 and 2), Egypt is by far the continent's largest aquaculture producer, contribution 68% of total African production volumes and 56% of vaule (FAO, 2023a). Egypt has a long-documented relationship with aquaculture stretching back millennia. It also has strong domestic demand for fisheries products, with tilapia making up the dominant species produced by fish farms. A deep dive into Egypt's aquaculture reveals much that can be useful for other African countries looking for strategies to boost domestic production. For example, the government has gone to great lengths to create an enabling environment for the sector to grow, which has attracted strong private sector investments. While Egypt still struggles on some fronts—such as meeting health and safety standards to reach export

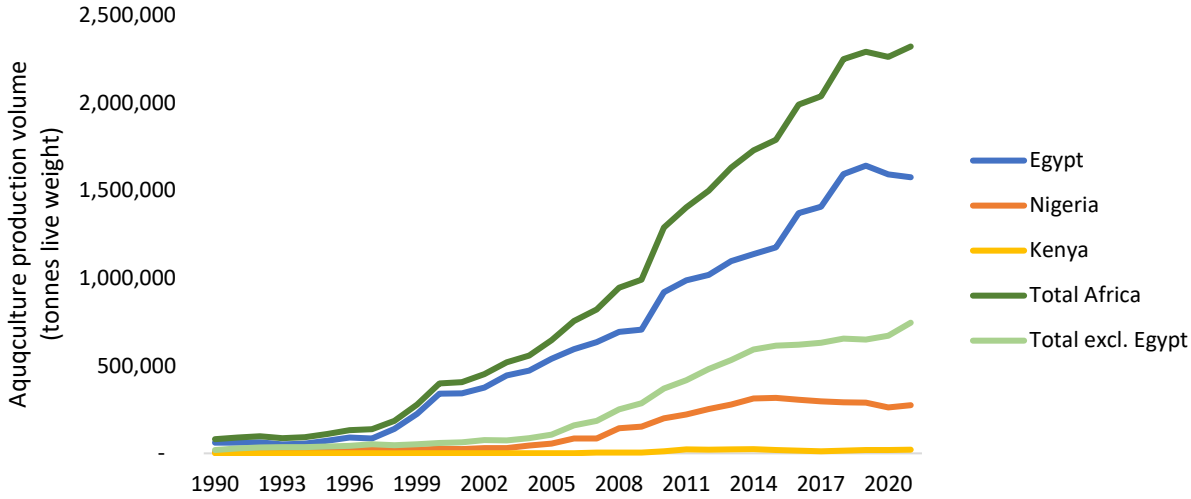
[1] See Hinrichsen et al. (2022) for further details on various aquaculture-related indicators that informed the selection.

markets in Europe—ensuring it has the resources to meet strong domestic demand has allowed the sector to thrive.

In contrast to Egypt, Kenya's total live weight of less than 140,000 MT valued at around USD 60 million in 2021 places it as the continent's eighth largest producer (FAO, 2023a) (Figures 1 and 2). Similar to Egypt, tilapia is the dominant species in the sector followed by African catfish. While the East African country produces only a fraction of Egypt's aquaculture outputs, Kenya is a notable case study as it has achieved strong relative growth over the past decade, driven in large part by cage fisheries. Demand for sectoral products has been relatively strong in the past, but Kenya has struggled to keep up with demand. Domestic logistics are one area in need of support, as aquaculture producers, especially in rural areas, struggle to efficiently bring products to market. Frozen imports—especially from China—have, thus, been expanding to meet demand at lower prices. Nevertheless, opportunity for sectoral growth exists due to projected growth in population, incomes, awareness of the health benefits of fish consumption and changes in lifestyles and consumer preferences (Ogello and Munguti, 2016; Obiero et al., 2019a).

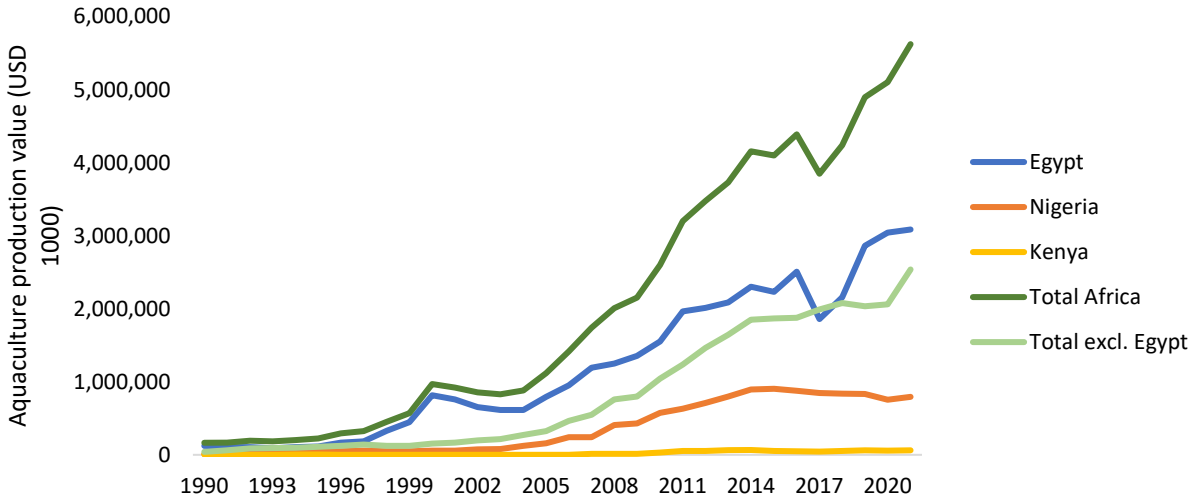
With just over 275,000 MT of total live weight production worth around USD 800 million in 2021, Nigeria is Africa's second largest producer of aquaculture products—firmly behind Egypt in terms of production, yet far ahead of Kenya (FAO, 2023a) (Figures 1 and 2). Unlike the other two case study countries, which focus on tilapia, Nigeria's aquaculture sector mainly produces African catfish, primarily due to local preferences. Nigeria offers an interesting example of a country with extremely high demand (and high population) that is unable to be satisfied by its domestic fisheries industry and imports combined. Clearly there is room for increased aquaculture activity in the country, but sectoral growth is limited by a lack of sector specific support from government and competing industrial priorities, particularly by oil and gas operations in coastal areas. The private sector has played a leading role in the growth of aquaculture in Nigeria, but further support from government in the form of public-private partnerships would help spur further growth.

Figure 1: Aquaculture production volume in the study countries (1990-2021)



Data source: FAO (2023a)

Figure 2: Aquaculture production value in the study countries (1990-2021)



Data source: FAO (2023a)

The case studies were developed through an in-depth evaluation of existing literature related to sustainable aquaculture development and technological and innovation systems in Africa. Qualitative data was gathered from key stakeholders in the fisheries sector and service providers. Additional data was collected through Key Informant Interviews and Focus Group Discussions (FGDs) with various actors in the value chain. Further details on the case study indicators and means of measurement are provided in the Annex.

The following paper is divided into country-specific sections featuring key insights from Egypt, Kenya and Nigeria. The sections are structured around nine common themes: the current sectoral trends; existence of aquaculture-specific policy frameworks or national strategies; aquaculture-specific government organs tasked with developing the sector; natural resources capable of supporting the sector; research and technology capacity; access to feed and seed; access to markets; public-private partnership development; and sectoral impacts on food security, employment, and household incomes. The concluding section then draws out cross-country lessons related to the strengths and weaknesses of the countries' approaches to developing their aquaculture sector, which can offer valuable learnings for African policymakers and investors.

2 Egypt

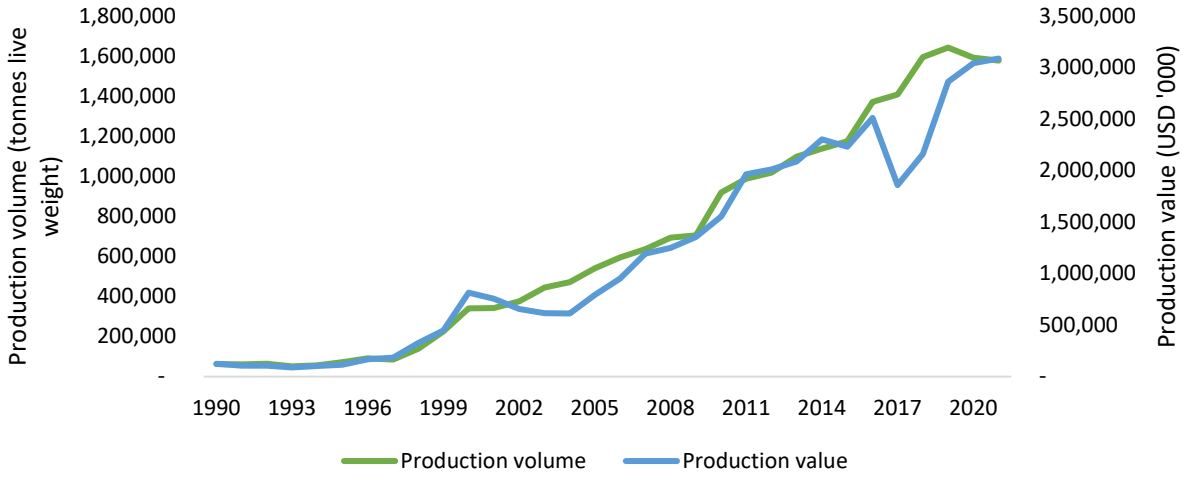
Egypt boasts Africa's most productive aquaculture sector. The country stands head and shoulders above other case study countries and, indeed, is one of world's largest contributors to the sector. Given its massive contribution, including data from the country can skew perceptions of Africa's overall aquaculture production levels (see Figures 1 and 2). Naturally, much can be learned from Egypt's expertise in the sector, but not all processes are easily transferrable. This is especially the case when it comes to existing policy frameworks and national strategies. In this area, Egypt is particularly advanced and policymakers will have to consider carefully whether other countries are equipped with governance structures that can successfully adopt and maintain the approach that is working well in Egypt.

2.1 Aquaculture production trends

Aquaculture production in Egypt has been growing rapidly since the turn of the century. While there have been slight contractions in recent years, Egypt's aquaculture sector is on an overall upward trajectory. According to FAO data, Egypt's aquaculture sector expanded from around 376,000 MT in 2000 worth USD 800 million to almost 1.6 million MT at a value of USD 3.1 billion in 2021 (Figure 3). Aquaculture is clearly driving overall production growth from fisheries (Figure 4). While the aquaculture sector has grown rapidly, capture fishery production volumes have remained largely unchanged over time. By 2021, aquaculture accounted for 79% of total fisheries production, up from 47% in 2000.

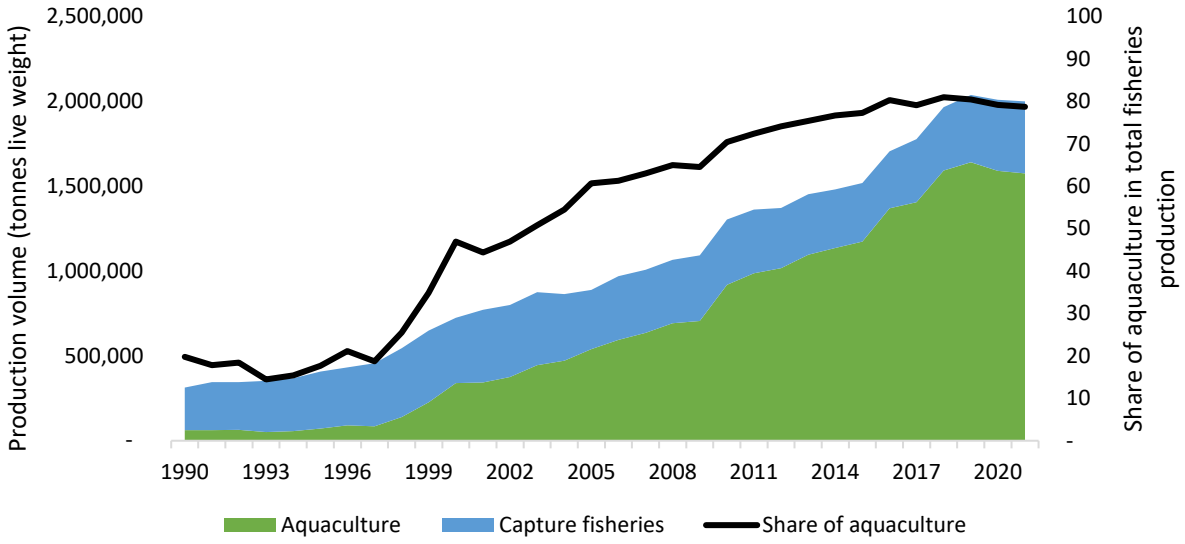
Tilapia is the most common fish produced in Egypt's aquaculture sector, accounting for 61% of total aquaculture production volume and 44% of the production value in 2021 (FAO, 2023a). While higher-value mullet production had increased almost as fast as Tilapia in the early years, peaking in 2006 with a share of 39% of total production volume (compared to 44% for tilapia), production dropped significantly afterwards. This drop was due to a finite natural supply of fingerlings given that the artificial production of mullet fingerlings has not been commercially closed. Since 2015, growth rates picked up again and by 2021 mullet contributed 22% to the total production volume and 29% to the value generated. In contrast to the other two case study countries, catfish is only rarely farmed in Egypt.

Figure 3: Aquaculture production volume and value in Egypt (1990-2021)



Data source: FAO (2023a)

Figure 4: Fisheries production from aquaculture and capture fisheries in Egypt (1990-2021)



Data source: FAO (2023a)

2.2 Policy frameworks and national strategies

With as many as ten aquaculture-specific policies that have been supported by specific laws and decrees, Egypt is a notable example of government's careful involvement in the sector. Not only do national policies exist in Egypt, they are well developed, in line with international and regional policies, and enforced by government appointed regulatory bodies. The laws govern a range of aquaculture-related issues, which often overlap with broader fisheries-related regulations. Still, it is notable that the regulations that relate to aquaculture are sector-specific, rather than broadly related to the fisheries sector.

Egypt's aquaculture policies are also notable, as they are aligned with a number of global and regional policies. Policies are aligned with 11 out of the 17 Sustainable Development Goals (SDGs), the Comprehensive Africa Agriculture Development Programme (CAADP), the Policy Framework and Reform Strategy for Fisheries and Aquaculture in Africa, and the government has made significant progress towards CAADP indicators. Egypt participated in the Consultation on the Application of Article 9 of the FAO Code of Conduct for Responsible Fisheries in the Mediterranean Region, which led to the development of an Action Plan for the Promotion of Responsible Aquaculture in the Mediterranean region.

The Egyptian strategy for fisheries and aquaculture focuses on conservation and sustainable resource use, small-scale fisheries development, sustainable aquaculture development, the creation of an attractive business environment for fish feed manufacturers, responsible and equitable fish trade and marketing, strengthened regional and sub-regional cooperation, awareness enhancing and human-capacity development, and high seas fisheries.

While the strategy does not explicitly target specific genders or age groups, the number of women interested in aquaculture and fisheries in Egypt has increased, particularly in the educational field. However, age and sex-disaggregated data are insufficient to fully reflect the reality of women and youth working in the industry.

Despite the robust regulatory environment in Egypt, there are areas where regulations are holding back industrial growth. While the establishment and regulation of fish farms in Egypt have led to increased investment and job opportunities in the sector, non-compliance with EU residue monitoring

requirements is hindering export of Egyptian aquaculture products to the EU. Furthermore, despite the private sector leading more than 95% of aquaculture activities in Egypt, private sector hatcheries are at a disadvantage due to legislation prohibiting their use of freshwater (hatcheries operated by the state are exempt from this).

Environmental issues related to the aquaculture industry are regulated by Environment Law No. 4/1994, which requires a license for the discharge of materials causing pollution into inland waters and seawater. Fish farmers must follow environmental conditions and requirements outlined in the law, and periodic inspections are conducted by the Ministry of Environmental Affairs. Egypt's legislation also addresses biodiversity protection, requiring a permit from the General Authority for Fishery Resources Development for the use or introduction of foreign fish spawn. The country's environment policy emphasizes the preservation of natural resources, including marine and wild resources, and collaboration between government and non-government authorities at both national and local levels.

While Egypt is not on track when it comes to implementing the Malabo Declaration on Agriculture transformation in Africa, it is set to achieve three out of the seven Malabo Declaration commitments (enhancing investment finance in agriculture, halving poverty through agriculture by 2025, and boosting intra-African trade in agricultural commodities and services).

2.3 Governance structure

Egypt’s policies governing the aquaculture sector are overseen by sector-specific government bodies, which are crucial to ensuring that the vision of the sector—as outlined by the national policies—can be achieved. They are an important element of what makes Egypt’s sector so successful. Perhaps the most important of these government instruments for the aquaculture sector in Egypt is the Lakes & Fish Resources Protection & Development Agency (LFRPDA) established in 2021 affiliated to the Prime Ministry. It consists of representatives of the different concerned Ministries as well as representatives of the Cooperative Union for Water Resources and the General Union of Agricultural and Fishing Workers. The agency replaced the General Authority for Fish Resources Development (established in 1983) under the Ministry of Agriculture. LFRPDA is responsible for all planning and control activities related to fish production, including aquaculture. Responsibilities include, among others, overseeing fisheries laws, establishing pilot projects, alignment with international and regional regulations, and private sector cooperation. This broad mandate, combined with high-level support, offers a useful governance model for other countries to consider.

Other examples of government instruments include the General Organization for Veterinary Services (GOVS), the Central Laboratory for Fisheries Research (CLAR), the Ministry of Environment and the Egyptian Environmental Affairs Agency (EEAA), the National Institute of Oceanography and Fisheries (NIOF), and the Ministry of Water Resources and Irrigation (MoWRI). GOVS was established to protect livestock and human health by preventing infectious diseases. It oversees quarantine facilities for live animals (including fish) and is responsible for certifying food safety conditions for fishery product exports to the EU. CLAR focuses on sustainable development of aquaculture and fisheries, conducting research, providing training and technical support, and promoting self-sufficiency in fish protein production. The EEAA formulates environmental policies, and fish farmers must obtain EEAA approval through an environmental impact assessment. The NIOF maintains, conserves, and studies aquatic areas and their resources, using modern technologies for exploration and monitoring. Finally, the MoWRI is responsible for regulating water use and providing licenses for fish farms through inspection departments and the Authority for Shore Protection.

2.4 Natural resources

Egypt's ability to maintain a robust aquaculture sector despite its arid environment is a testament to the possibilities that exist for sectoral growth elsewhere. While the country boasts a 2,740 km coastline along the Mediterranean, Red Sea and along the Suez Canal, semi-intensive systems in earthen ponds is, by far, the most common approach to farming (Shaheen et al., 2013). Access to fresh water can be a challenge in Egypt due to its highly arid environment, high evaporation rate, and limited annual precipitation. And while Egypt does have inland bodies of water, including the Nile River and eleven lakes in three distinct natural environments, the virtual absence of permanent surface water over large parts of the country means that fresh water is a scarce resource.

In October 2021, Law No. 147 promulgating the Water Resources and Irrigation Law was issued which requires a licence to possess or use any machines, equipment, or tools for raising water inside lakes, their boreholes, or on their shores, or the lands owned by individuals covered by water and connected to Egyptian waters. The executive regulations specify the conditions and procedures for issuing a license, which stipulates that there will be no fees required of citizens regarding licenses. The aim of the law is the protection of lakes and development of fisheries, in recognition of their economic and environmental importance.

2.5 Technology and innovation

Technological innovation in Egypt's aquaculture sector is relatively well developed. Egypt boasts several national and international aquaculture training and research institutions. These labs, institutes, universities and research organizations primarily target Egyptians engaged in the sector. Increases in training have resulted in fish farmers and workers employing best aquaculture practices in their work.

Nevertheless, despite the adoption of modern technologies and improved fish strains, there remains a strong need for more intensive use of modern technologies and the adoption of improved strains. There is only one genetically improved strain in Egypt (Genetically Improved Abbassa Nile Tilapia or "GIANT") and its adoption has been increasing steadily. However, production of fingerlings of this variant requires high technological inputs and investments.

The large majority of Egypt's aquaculture producers make use of extensive and semi-intensive systems in earthen ponds—an approach that does not require major technological investments. The other aquaculture producers make use of cage aquaculture and, less commonly, technology-intensive approaches, such as aquaponics and raceways-in-ponds systems. Cage aquaculture is not a technologically demanding approach, but remains a new innovation that allows for intensive fish production in open waters. This approach is becoming more widely used in Egypt, particularly for producing tilapia in the Nile Delta region.

2.6 Feed and seed

The high cost and quality of feed poses significant challenges to Egypt's aquaculture sector. Feed costs account for 81% of fish production costs and have been identified as one of the major obstacles to sustainable and profitable aquaculture (Dickson et al., 2016). Importing feed ingredients is a common practice in Egypt due to limited domestic production. In recent years, the prices of fish feed have increased dramatically without a corresponding increase in fish prices, burdening the aquaculture industry. Despite this, the sector's reliance on imported feed has changed little over the past decade. To cope with the rising costs, some fish farmers have resorted to using cheaper local ingredients, such as poultry and cattle feed, which can affect the growth rate and quality of the fish produced.

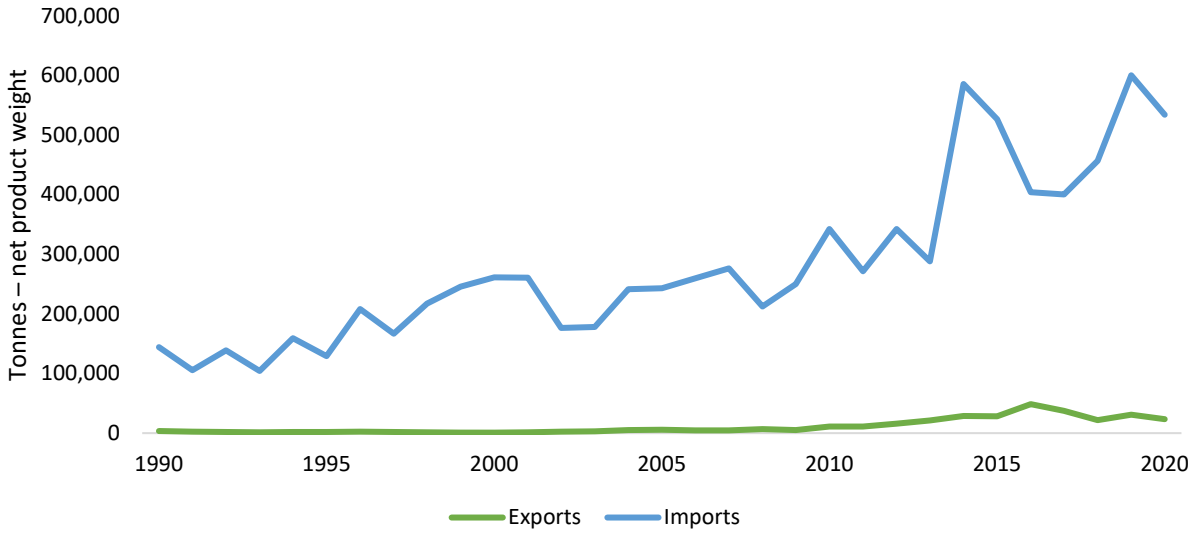
After feed costs, sourcing fish fry represents the next most significant expense for the aquaculture sector in Egypt (accounting for some 8% of operational costs) (Dickson et al., 2016). To meet the growing demand of the rapidly expanding industry, the number of fish hatcheries in the country has grown significantly, from 14 in 1998 to over 600 (GAFRD, 2019). The large majority of these hatcheries are unlicensed private operations while the remainder is made up of licensed private hatcheries and a few government hatcheries. However, lack of quality fry remains a concern, notably for marine aquaculture where illegally caught wild fry is putting pressure on stocks and hence the long-term sustainability of the sector while creating competition with capture fisheries (Kaleem and Bio Singou Sabi, 2021). The importation of live fry, fingerlings or adult fish is prohibited by Egyptian authorities due to biodiversity and biosecurity concerns.

With regard to genetic improvement programs, only one has been approved. Initiated by WorldFish in 2001, the program aimed to develop a genetically improved strain of Nile tilapia, the most important and widely farmed fish in the country. The strain—known as GIANT or Genetically Improved Abbassa Nile tilapia—exhibits fast growth and has high survival rates, which are desirable traits for tilapia farmers. The GIANT strain was tested against the commonly used Kafr El Sheikh strain and was found to grow about 30% faster (Ibrahim et al., 2013). An impact assessment of the dissemination showed that on average fish farms using GIANT achieved higher fish yields (by 19%), lower feed conversion ratios (by 16%), and higher returns from fish sales (7%) compared to farms using non-improved commercial strains (albeit with large regional variations) (Ibrahim et al., 2019).

2.7 Markets

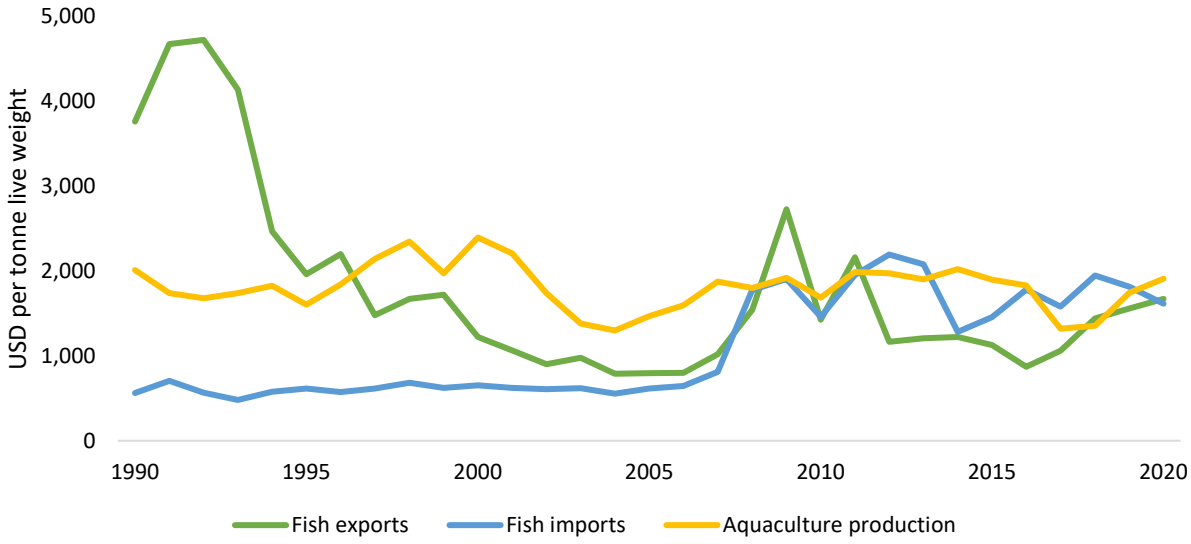
High domestic demand is at the core of Egypt's robust fisheries sector. Fish is a traditional and important component of the Egyptian diet—only second to milk in terms of animal protein sources. Egyptians export only 2% of the fish they produce and consume the other 98% domestically (GAFRD, 2019). The 2 million MT of domestically-produced fish that Egyptians consume represented only around 80% of domestic consumption while the rest was imported to satisfy demand (Figure 5), in particular mackerels and herrings (FAO, 2023a). Fish imports originated mainly from Europe (65%) and Asia (31%) in 2020 while just 1% came from other African countries (FAO, 2023a).

Figure 5: fisheries exports and imports in Egypt (1990-2020)



Data source: FAO (2023a)

Figure 6: Value (per tonne) of aquaculture production and fisheries trade in Egypt (1990-2020)



Data source: FAO (2023a)

Following shortcomings found by the European Commission's health and safety unit, Egypt is currently not permitted to export farmed fish to the EU. The EU is the largest single global market, accounting for one-third of the global value of aquatic imports in 2020 (FAO, 2022). Thus, while domestic demand accounts for the vast majority of aquaculture production, expansion of the industry is hindered somewhat by this lack of an export market.

2.8 Private sector role and public-private partnerships

The private sector plays a pivotal role in Egypt's aquaculture sector, supported by a conducive policy environment. The private sector accounts for the vast majority of Egypt's aquaculture production. In 2019, aquaculture was carried out on about 120,000 hectares of land, with 97% owned by the private sector and 3% by the public sector (GAFRD, 2019). Importantly, the public sector plays a leading role in training and capacity building through institutions such as GAFRD, CLAR, NIOF, universities, and other government organizations. Additionally, the government has established public-private partnerships with the private sector and foreign organizations, including the African Union, FAO, WorldFish, JICA, and USSEC, for research projects and training initiatives, further boosting fish productivity. In this way, Egypt presents an exemplary model for positive public-private relationships that have been instrumental in development of the aquaculture sector in the country.

2.9 Food security and employment

While not a major influence on Egypt's GDP (contributing just 0.76% in 2021), aquaculture makes a higher contribution to the country's GDP than the global average (0.29%).[2] Perhaps more importantly, the sector is providing food security to its citizens, which consume more fish on average (27 kg per person in 2020) than the global (20.5 kg) and African (9.6 kg) average (FAO, 2023b). Fish and seafood cover approximately 29% of the animal-sourced protein demand of the Egyptian population, which is higher than that for beef (13%), poultry (23%) and milk (19%) (FAO, 2023b).

[2] Calculated using data from FAO (2023a) and World Bank (2023).

The sector also provides direct and indirect full-time jobs through the broader aquaculture value chain and this trend is on an upswing. Employment in the sector increased from 193,022 full time equivalent (FTE) in 2010 to 321,165 FTE in 2019 (GAFRD, 2019). Additionally, other employment opportunities include seasonal workers during harvesting and other periods of intensive activity, as well as indirect employment in the fish trade, transport, processing, retailing, and boat and net manufacturing sectors. In general, while the sector plays an important role in employment, it is difficult to determine its contribution to household incomes, as data is an unknown subset of agricultural activities in general. Moreover, gender disaggregated data would help to better understand how women are benefitting from opportunities in the sector. Moving forward, Egypt should consider collecting this data.

3 Kenya

Kenya is the eighth most productive aquaculture producing country in Africa by total production volume. While it is the least productive of the three case study countries presented in this paper, it does provide valuable insights due to its relatively large sectoral expansion over the past two decades and its potential for growth. Nevertheless, Kenya's aquaculture output has been volatile in recent years. The sector grew rapidly between 2010 and 2014, but experienced a significant drop in the subsequent four years following the end of a government led initiative to establish pond farmers. Production has been on the rise again since 2019 due to increased domestic demand and new large-scale commercial interests in the sector. However, cheap frozen imports, especially from China, have created a challenging economic environment for aquaculture producers. Kenya stands as a useful example of the challenges the sector faces when government policies and organs do not specifically address the aquaculture sector. Policies that support private sector engagement in the sector and address logistical challenges for national producers would be helpful short-term solutions that could boost production and help secure the benefits that come along with sectoral growth.

3.1 Aquaculture production trends

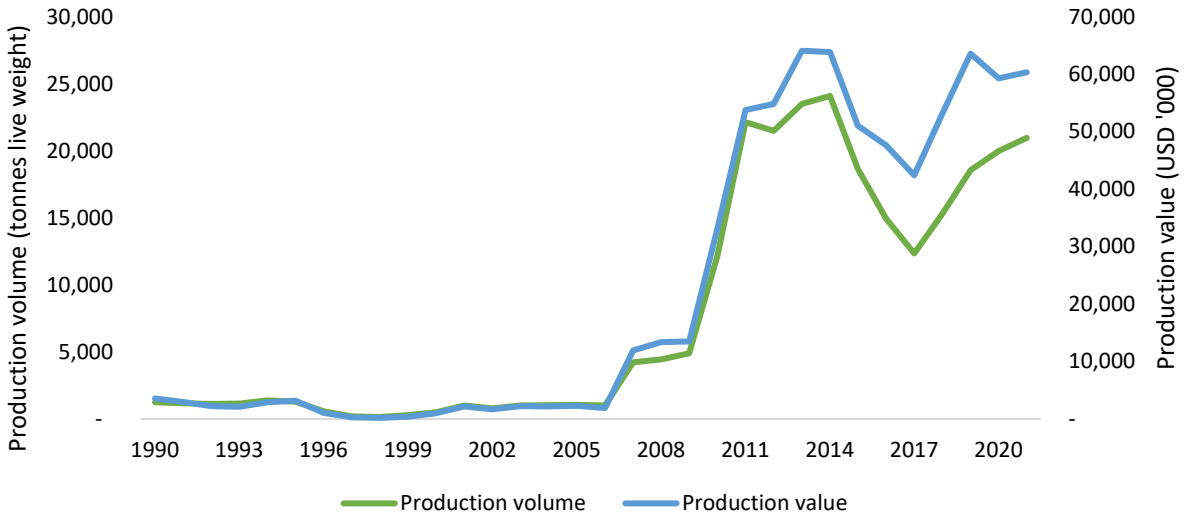
Although Kenya is not among the top aquaculture producers in Africa, it has made significant strides in advancing its aquaculture industry over the past two decades. Recognizing the potential, Kenya has incorporated the expansion of the sector into its Vision 2030 development strategy. The country has also established legal, policy and institutional frameworks that acknowledge aquaculture as a means to enhance food security, reduce poverty and create employment opportunities.

With supportive government policies and substantial public investments, aquaculture production in Kenya experienced rapid growth from less than 1,000 MT in 2006 to 24,000 MT in 2014 (Figure 7), even in regions where fish production and consumption were previously limited. Much of the growth was driven by the government's Economic Stimulus Program (ESP), implemented in 2009, which generated immediate and short-term demand for approximately 28 million certified tilapia and catfish fingerlings, along with over 14,000 MT of formulated fish feeds. This program prompted farmers to construct their own ponds, leading to an increase in demand for seed fish and feed, reaching over 100 million fingerlings and 100,000 MT, respectively.

Production volumes receded again in the years following the end of the ESP. The decline has also been attributed to the devolution in governance structures starting in 2013 when responsibility for aquaculture development shifted to the counties—many of which were less inclined to invest in the sector (Munguti et al., 2021). Aquaculture production started to rebound in 2019 and production volumes were back up to around 21,000 MT in 2021. The development in economic returns mirror this trend, but with less significant relative losses since 2014, suggesting a shift towards higher value products (Figure 7). Despite these developments, aquaculture continues to make up less than 15% of total fisheries production in Kenya (Figure 8).

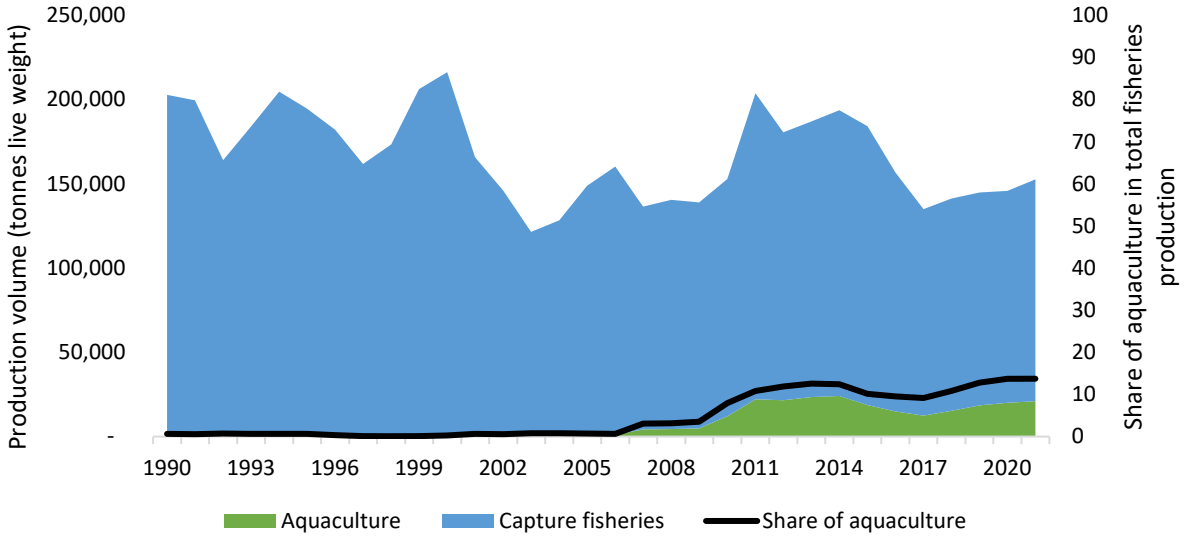
Similar to Egypt, the main species cultivated in freshwater aquaculture is Nile tilapia (77% in 2021) (FAO, 2023a). The second most common fish is African catfish (16%) and minor production of common carp and rainbow trout can also be found (3% each). The shares of these species in production value mostly follow a similar trend. The higher-value trout cultivation is limited to regions with temperatures below 19°C, primarily in the Mt. Kenya area.

Figure 7: Aquaculture production volume and value in Kenya (1990-2021)



Data source: FAO (2023a)

Figure 8: Fisheries production from aquaculture and capture fisheries in Kenya (1990-2021)



Data source: FAO (2023a)

3.2 Policy frameworks and national strategies

Kenya has a number of policies and instruments with aquaculture-related components, however, there is a dearth of targeted sector-specific policies. Generally, aquaculture policy tends to fall under initiatives targeting agriculture or fisheries, such as the Agriculture Sector Transformation and Growth Strategy and the Fisheries Management and Development Act. There are some overarching national policies that have an impact on the sector, such as Kenya's Vision 2030, a development program that aims to raise the average standard of living in Kenya to middle income by 2030. Vision 2030 aims to expand fish farming from the current high potential areas to Arid and Semi-Arid Lands (ASALs) as well as to develop needed infrastructure and strengthen monitoring, control and surveillance systems. Importantly, the initiative recognizes aquaculture as a source of food security, poverty reduction and

employment creation in alignment with Sustainable Development Goal 2 (end hunger, achieve food security and improved nutrition and promote sustainable agriculture).

Other notable policies in Kenya include the Agriculture Sector Transformation and Growth Strategy, which includes a framework for the creation of jobs and opportunities in aquaculture that is both gender responsive and sensitive to opportunities for the youth. This approach is in line with several international policy initiatives, including the Malabo Declaration and SDG 5. Additionally, the Strategy is aligned with the CAADP through its goals to increase incomes for small-scale farmers, pastoralists and fisherfolk; increase agricultural outputs and value; and boost household food resilience.

Kenya's Fisheries Management and Development (FM&D) Act of 2016 has a number of items that are relevant to aquaculture, although impacts are often implied, rather than deliberate. For example, Article 62 of the Act emphasizes ecological sustainability and rational use of fisheries in general, which is in line with the African Blue Economy Strategy and SDG 14. Article 63 also acknowledges the need for aquaculture development to not negatively affect the livelihood, culture and traditions of local communities and ensure their access to fishing grounds are not affected by development of the sector (in line with: Article 9 of the FAO Code of Conduct for Responsible Fisheries).

Overall, while Kenya has a number of policies linked to aquaculture, there is a missed opportunity by not enacting legislation that could specifically target the sector and trigger growth, especially in areas of the country with few job opportunities. Moreover, environment-related policies targeting the unique needs of the sector will help ensure that any future growth will be sustainable and environmentally sensitive.

3.3 Governance structure

The Government of Kenya has a number of disparate organs charged with implementing policies and strategies related to fisheries in general and some are more specific to aquaculture than others. Kenya's State Department for the Blue Economy and Fisheries (SDBEF) is the primary government body responsible for fisheries in Kenya (Republic of Kenya, 2023). With the establishment of the SDBEF in January 2023, fisheries-related topics were shifted from the former Ministry of Agriculture, Livestock, Fisheries and Co-operatives to the newly established Ministry of Mining, Blue Economy and Maritime Affairs. It remains to be seen how this shift will influence priority-setting with regard to fisheries and in particular aquaculture. There are some concerns that aquaculture may receive less attention than other Blue Economy activities, such as capture fisheries, tourism and maritime transport. As of August 2023, the government was working on a Blue Economy Strategy which will shed further light on the future of the sector.

The SDBEF is made up of two technical directorates, i.e. the Directorate of Fisheries and Aquaculture Development and the Directorate of Blue Economy Development. It is responsible for a wide range of issues related to fisheries, including developing and reviewing policies, issuing licenses, promoting sectoral development, marketing, quality assurance, establishing a policy framework for the maritime blue economy, and developing legal and regulatory frameworks. With regard to aquaculture, specifically, the SDBEF is responsible for the overall policy for exploitation of aquaculture resources, capacity building for sustainable exploitation of aquaculture; and promoting Kenya as a centre for the aquaculture-based blue economy.

Kenya's Marine and Fisheries Research Institute (KMFRI) is a state corporation with a history stretching back to 1979 when it was established by the country's Science and Technology Act. It is charged with providing research in fisheries, including the aquaculture sector. The Institute houses the Kegati Aquaculture Centre, which undertakes aquaculture research with an eye to introduce commercially viable lake basin indigenous fish species, fish seed and feed production.

Kenya's Fisheries Service (KeFS) is responsible for setting standards and overseeing aquaculture activities, as well as coordinating research on fisheries and aquaculture in collaboration with the Kenya Marine and Fisheries Research Institute. The Fishing Industries Corporation (KFIC) focuses on exploiting fishery resources and promoting the establishment and development of fishing businesses, including the operation of facilities for fish capture, preservation, processing, and marketing. The Fisheries Advisory Council (KFAC) advises the government on fisheries management policies, including allocation of resources, intergovernmental agreements, research, education, and capacity development.

The Fish Levy Trust Fund provides additional funding for fisheries management, development, and capacity building. The Kenya Wildlife Service (KWS) is responsible for managing marine protected areas and conserving marine biodiversity. The Kenya Maritime Authority oversees the regulatory aspects of the maritime sector, ensuring safety, security, and environmental preservation. The Fish Marketing Authority (KFMA) enforces national and international fisheries trade rules and is involved in marketing activities related to fisheries.

An important governance change took place in 2013 when fisheries and agriculture was devolved to County Governments, with specific responsibilities related to extension services, fish breeding, fish trade licensing, and enforcement of fisheries regulations. This shift has created certain challenges, such as a lack of extension staff at the county-level and poor coordination and monitoring of fish feed quality standards (Munguti et al., 2021).

3.4 Natural resources

Kenya’s natural resource endowment offers significant potential for aquaculture production. The total area thought to be suitable for marine and freshwater aquaculture production is estimated at around 255,000 km^2 which is equivalent to about half of Kenya’s land cover area (Munguti et al., 2021). However, despite Kenya’s 640 km coastline along the Indian Ocean, which extends to 850 km when all bays and inlets are measured, marine aquaculture accounted for only 18% of total aquaculture production in 2019) (Munguti et al., 2021). Instead, production originates mainly from freshwater sources. Lake Victoria generates the largest share of aquaculture output (75% in 2019) while other lakes are less extensively used, including Lake Turkana (6%) and Lake Naivasha (3%).

3.5 Technologies and innovation

Kenya's aquaculture industry is transitioning from traditional to modern systems, but it faces limitations due to various factors such as resource constraints, environmental concerns, limited space for expansion, and increased disease occurrences. To ensure sustainable growth, Kenya needs to upgrade its technologies, innovations and management practices in the aquaculture sector. This includes developing model aquaparks, intensive recirculating aquaculture systems, tank-based systems, hydroponics, aquaponics, and high-density production cages in lakes and reservoirs. These needs can be grouped into five categories: culture systems, fish breeding and genetics, feeds and nutrition, fish health and disease control, and value addition techniques.

To spread awareness and knowledge about these innovations, stakeholder workshops are conducted, and demonstrations and training are provided at research stations and farms. Mass media platforms like newspapers, radio, television and social media are also utilized to disseminate basic information and simple technologies. Print publications, such as brochures, pamphlets, handouts, manuals, and bulletins are produced by institutions like KMFRI and county governments and distributed to farmers.

Farmers often seek extension services for hatchery operations, nursery rearing, pond and cage management, on-farm feed formulation, fish diseases, and information on new technologies and

management practices. The adoption of these practices has resulted in improved production in the sector. Additionally, there are thirteen universities offering degrees in aquaculture fields and three Technical Vocational Training Institutes providing certificate and diploma programs in aquaculture.

3.6 Feed and seed

One of the main challenges facing aquaculture in Kenya is the lack of efficient and affordable feeds for different stages of fish development. Feed is estimated to account for 60% of production costs in aquaculture (Munguti et al. 2021). Local manufacturing capacities are not able to meet the growing demand. The high cost and lack of availability of ingredients are hampering the expansion of the feed manufacturing sector. Instead, the gap in demand is met with imported feed, which is often too expensive for small-scale producers.

Similarly, access to quality fingerlings slows down the growth of the sector, hindered by large distances to hatcheries, high costs and poor infrastructure (Munguti et al., 2021). Following the decline of aquaculture production in 2014, some hatcheries were forced to close down as demand for fingerlings dropped. Emerging cage farming in Lake Victoria is expected to increase demand in the coming years, thereby incentivising future investments in hatcheries.

While significant progress has been made in genetic improvement programs for livestock, the genetic resources in aquaculture are often similar to or inferior to wild stock, as many hatcheries still rely on brooders captured from the wild. In response to growing demand, the Kenya Marine and Fisheries Research Institute (KMFRI) has initiated selective breeding programs for Nile tilapia and African catfish. Furthermore, KMFRI is actively involved in the domestication and breeding of indigenous species, both for conservation purposes, such as ningu, and for introducing them as culture species, such aslungfish and tilapia.

To diversify production, pilot-scale farming has been conducted for various freshwater species, including Nile perch, Largemouth bass, carp and lungfish (Munguti et al., 2021). In recent years, research efforts have focused on the commercial and conservation cultivation of indigenous tilapia species, such as Singidia tilapia, Victoria tilapia, blue spotted tilapia, and Tilapia jipe. The production and international trade of freshwater ornamental fish in Kenya are dominated by non-indigenous species, including various types of goldfish, Koi carp, Swordtail, and Mollies.

3.7 Markets

New technologies and innovations are leading the expansion of aquaculture production in Kenya, which has extended market opportunities for aquaculture products. However, there has been a concurrent decline in catch from Kenya's capture fisheries, resulting in a decline in overall fisheries production since 2010. Since this time, imports have increased to meet local demand (Figure 12), which widened the scope and choice of fish available to consumers, but still only contribute a small share of total fish supply (12% in 2020; FAO, 2023a). While some of this increase in variety has resulted from expanded aquaculture and technological innovations, wholesalers and retailers are increasingly able to source fish from around the world, especially from Asia (84% of fisheries imports in 2020) and notably China (70%), as distance becomes less of a barrier to trade (FAO, 2023a; Obiero et al., 2019). Among the three case study countries, the share of African fish in overall imports is highest in Kenya with 15% in 2020, primarily from Tanzania.

Fisheries exports from Kenya have been in decline over the past decade (Figure 9), but domestic demand has been increasing. While this can be challenging, as noted in the case of Egypt, domestic demand in the absence of export markets can still nurture a robust aquaculture industry. This point is even more notable given Kenya's reliance on imports, which presents an opportunity for aquaculture

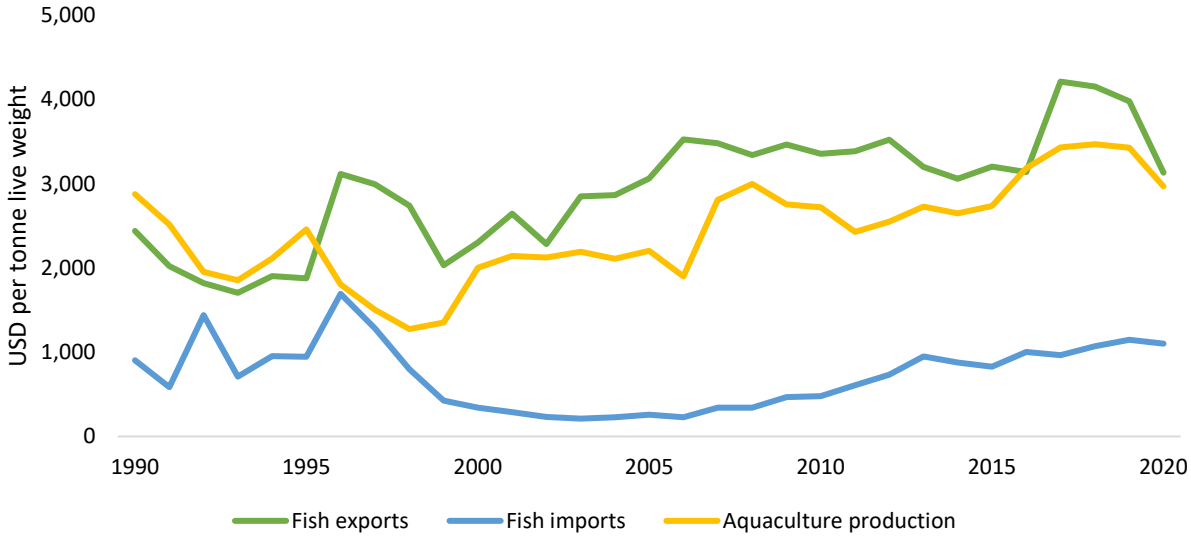
producers. Half of fisheries imports in 2020 were composed of frozen Nile tilapia (FAO, 2023a), the most common species produced by Kenya's aquaculture industry. Expansion of existing systems should therefore be a short-term priority for policymakers in the country.

Additionally, because fish mongers rely on imported frozen fish due to ease of availability, steady supply and price, logistical concerns should be addressed to ensure local producers are more easily able to get products to market. Supply chains are increasingly creating a dependency on the supply of imported frozen tilapia sold in major cities and other markets at lower prices (Obiero et al., 2019b). In 2020, frozen tilapia was imported at a value of around USD 1000 per tonne, compared to USD 2'900 per tonne of Nile tilapia produced by the Kenyan aquaculture sector (FAO, 2023a) while wholesale prices ranged between USD 2'900 and USD 3'300 per tonne in 2021/2022 (Gatsby Africa, 2022). This increased reliance on imports has both environmental sustainability challenges and has economic implications for fish farmers. However, there are economic and job benefits along the supply chain.

Figure 9: Fish exports and imports in Kenya (1990-2020)

Data source: FAO (2023a)

Figure 10: Value (per tonne) of aquaculture production and fisheries trade in Kenya (1990-2020)



Data source: FAO (2023a)

3.8 Private sector role and public-private partnerships

In Kenya, public-private partnerships in agriculture are often supported by the government and international cooperation agencies. However, there is little evidence of a coordinated approach by the government to private sector development in the aquaculture sector specifically. Collaborative partnerships do play an important role in establishing reliable channels for delivering technology and knowledge to the aquaculture sector. These partnerships can effectively bridge the gap between the unique strengths and capabilities of the public and private sectors, enabling them to better address the needs of fish farmers. However, it is not clear that the value of private sector actors in the sector is fully recognized by the Government of Kenya. While these partnerships appear to be supported by government and international cooperation agencies in the broader agriculture sector, an aquaculture-specific approach could have notable benefits in expanding production.

3.9 Food security and employment

Average fish and seafood consumption is still low in Kenya (2.9 kg per person) and only contributed 6% of per capita protein intake from animal sources in 2020, much lower than protein derived from milk (53%) and beef (14%) (FAO, 2023b). However, the relative importance of the commodity as a protein source differs by income groups. Wild-caught fish and fish from ponds are significant contributors to the total protein in particular among lower-income consumers (Ole-Moiyoi, 2017). As households become wealthier, the consumption of terrestrial sources of animal protein (i.e., chicken, beef, mutton, and pork) increases while fish consumption decrease. This indicates that fish plays a more crucial role in the protein intake of poorer households and is an important contributor to food security in Kenya. With regard to aquaculture, specifically, Obiero et al. (2019b) note that despite challenges in the fish supply chain, aquaculture has provided significant food security benefits, even for poor Kenyan families.

To bring up fisheries supply up to the average African per capita consumption of 9.6 kg / person, an additional 353,000 MT of fish would be required.[3] Thus, further development of the aquaculture sector has the potential to unlock meaningful opportunities to advance food security and generate income. However, there are still economic constraints that need to be addressed in order to develop the sector. Access to these opportunities has been hampered by lack of capital, insufficient training, low literacy levels and market barriers. The low uptake of aquaculture by women and youth is a threat to the social sustainability of aquaculture (Obwanga and Lewo, 2017).

Additionally, the aquaculture value chain in Kenya has generated employment opportunities and increased household incomes (Rampa and Dekeyser, 2020). For the fisheries sector as a whole, most people engage in the fish value chain as fish mongers (89%), 4% as fishers and less than 3% each in boat repairing, fish scaling and fish cooling (Munene and Wanjiku, 2020). Employment in processing accounted for just 0.7%. Disaggregated data is not available. The numbers show, however, that an increase in aquaculture production would not only create jobs in fish farming, but would also have significant multiplier effects along the value chain.

[3] Calculated using data from FAO (2023a).

4 Nigeria

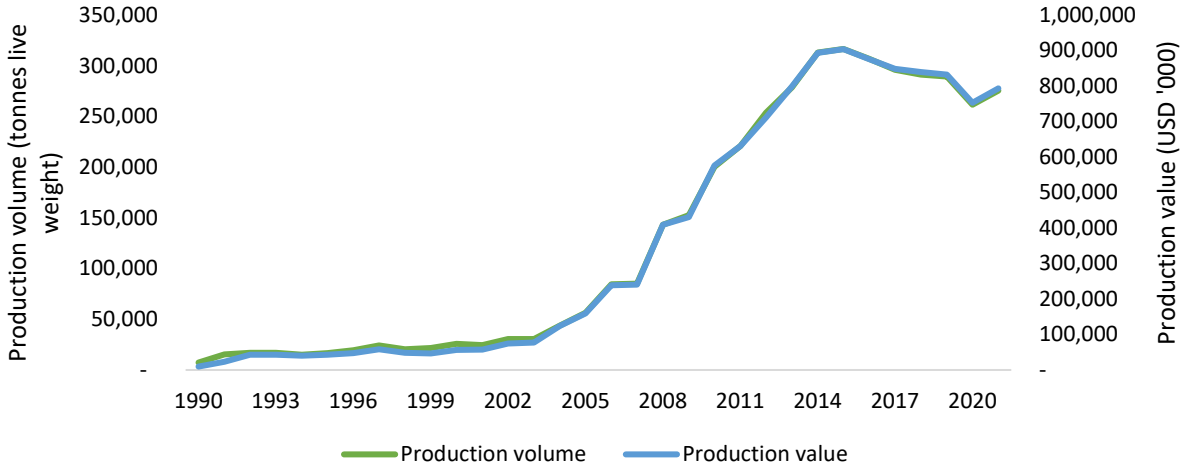
Nigeria is the second largest aquaculture producer in Africa. However, despite its remarkably high rate of production in aquaculture and capture fisheries, consumer demand exceeds supply. Efforts to meet demand through imports have made Nigeria one of the world's largest importers of fish, yet a significant supply shortfall still exists. Clearly a market opportunity for aquaculture producers exists in Nigeria, but the sector faces challenges. While coastal areas have great potential to make use of mariculture, pressures from industry—particularly oil and gas—have impeded growth. Inland production is primarily responsible for aquaculture production, but challenges due to land availability and a lack of incentives make producing at scale difficult. Additional investments by the federal government, including aquaculture-specific legislation and a national strategy aimed at boosting production, could increase production, reduce reliance on imports and improve food security. Of particular interest could be boosting research and technology and improving support to nurture private sector investments in the sector.

4.1 Aquaculture production trends

Aquaculture production in Nigeria has seen remarkable growth. In 2006, overall aquaculture production amounted to less than 100,000 MT (FAO, 2023a) (Figure 11). The sector experienced a period of strong growth in the following decade, peaking at 317,000 MT in 2015. Since then, production has levelled out somewhat, reaching 295,000 MT in 2021. The value of production follows a similar trend. The growth period is also reflected in the share of aquaculture in total fisheries production which rose from 13% in 2006 to 31% in 2015, before dropping again to 26% in 2021 (FAO, 2023a) (Figure 12).

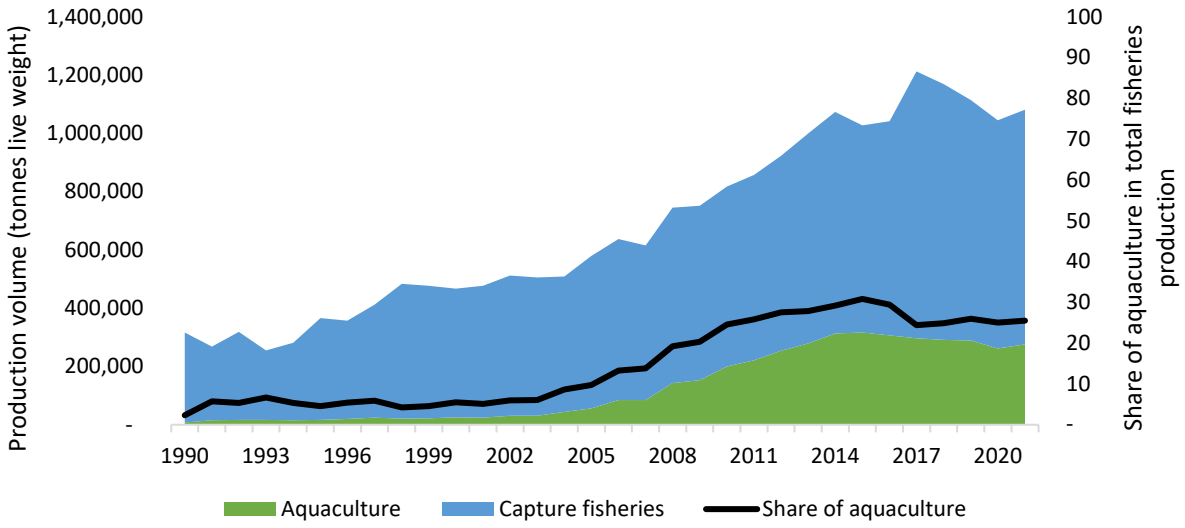
The most commonly farmed fish species in Nigeria is African catfish, accounting for 64% of production volume and 71% of value in 2021 (FAO, 2023a). Four types of catfish are cultivated, among which African sharptooth catfish is by far the dominant species. Other species include tilapia (8%), Nile perch (7%) and aba (5%) (FAO, 2023a). The production levels for the major species have remained relatively stable in recent years, with minor changes in preference for other species.

Figure 11: Aquaculture production volume and value in Nigeria (1990-2021)



Data source: FAO (2023a)

Figure 12: Fisheries production from aquaculture and capture fisheries in Nigeria (1990-2021)



Data source: FAO (2023a)

4.2 Policy frameworks and national strategies

Nigerian aquaculture is dominated by the private sector with little government support nurturing the sector as seen in Egypt. Nigeria has no specific legislation on aquaculture at the national level. In fact, the country's two key policy instruments related to fisheries—the Sea Fisheries Decree (1992) and its Sea Fisheries Regulations (1971)—make no mention of aquaculture. However, the Federal Department of Fisheries, which is responsible for developing Nigeria's fisheries sector, worked in concert with the FAO to develop and approve Nigeria's National Aquaculture Strategy (NAS) in 2008. The NAS aims to boost sustainable and renewable fish stocks to meet domestic demand and achieve a level of self-sufficiency in the medium to long term.

In 2011, a National Aquaculture Task Force was established to develop Nigeria's National Aquaculture Development Plan (NADP). Composed of experts and policymakers from the Department of Fisheries and National Programs for Food Security of the Ministry of Agriculture and Rural Development, the Task Force included a number of aquaculture-specific policy statements in the NADP. For example, it articulates Nigeria's goal of increasing sustainable and renewable domestic fish production from all sources to achieve self-sufficiency and, even, developing a surplus for export. The growth of small- and medium-sized enterprises (SMEs) in the sector is expected to contribute significantly towards achieving these objectives.

The NADP is aligned with several SDGs, the Malabo Declaration, and the CAADP. The Plan aims to harness the potential of aquaculture to contribute to the country's economic development through food security improvement, job creation, income generation, poverty reduction, and inclusive growth. It also aligns with the African Blue economy strategy, focusing on poverty alleviation, livelihood enhancement, and wealth generation within the blue economy sector.

The NADP emphasizes responsible aquaculture development, incorporating measures for effective farm and fish health management to ensure the production of safe aquaculture products. It is supported by legal instruments such as the Inland Fisheries (Aquaculture) Regulation (2016), which governs aquaculture practices, and other acts and regulations that ensure compliance with national and international standards for animal health, food security, and environmental impact assessment.

The plan seeks to create employment opportunities throughout the aquaculture value chain, promoting private sector investment, and transforming Nigeria into a net exporter of fish and fishery products. It encourages sustainable land and water use practices, ecosystem protection, and biodiversity conservation. Additionally, the NADP promotes innovative approaches such as cage culture, mariculture, and integration of fish culture with crops or poultry to optimize resource utilization and enhance community livelihoods in the face of climate change.

4.3 Governance structure

Nigeria's Federal Department of Fishery and Aquaculture (FDF) under the Federal Ministry of Agriculture and Rural Development (FMARD) is the dedicated organ of Government vested with the responsibility of developing and regulating Nigeria's fisheries resources, including the aquaculture sector. The vision of the Department is to ensure the production of a sufficient quantity of good-quality fish and fish products locally, to meet the nutritional needs of the population at an affordable cost, and to produce enough for export in order to earn foreign exchange, create wealth, generate employment, and enhance the socio-economic status of our rural fisher folks. With regard to aquaculture, the FDF is, among others, responsible for registration, approval and monitoring of fish farms and hatcheries, certification of fish products and feed, and setting and monitoring of standards related to food safety, quality and environmental impacts.

Nigeria has no specific legislation on aquaculture at the national level. In fact, one of the country's key legal instruments related to fisheries, i.e. the Sea Fisheries Act (1992) and its Sea Fisheries Regulations (1992), make no mention of aquaculture. The Inland Fisheries (Aquaculture) Regulations 2016 under the Inland Fisheries Act (1992) regulate certain aspects of inland aquaculture, such as registration, approval and monitoring of fish farms and hatcheries, certification of fish products and feed, and standards related to food safety, quality and environmental impacts. However, the Regulations are not encompassing and do not cover all emerging issues in the sector.

In 2022-2023, the FDF undertook a comprehensive assessment of all existing legal frameworks pertaining to fisheries and aquaculture. One of the objectives of this endeavour was to effectively encompass a spectrum of emerging concerns within the sector and to establish rigorous sanctions for instances of non-compliance. Since November 2022, the FMARD – with support from CGIAR Initiative on National Policies and Strategies, the International Food Policy Research Institute (IFPRI), WorldFish and the Agriculture Policy Research Network (APRNet) – has been reviewing, drafting and updating the Fisheries and Aquaculture Policy of Nigeria (2024-2028). The resultant revised legal framework is presently undergoing evaluation by the legal team of the Ministry (as of August 2023).

4.4 Natural resources

Nigeria has a favourable natural environment for aquaculture, but it is not being utilized optimally. The country has a coastline of approximately 853 km along the Gulf of Guinea and the Sea Fisheries Decree has a non-trawling zone provision that reserves five nautical miles off the coast for exclusive use of artisanal fishing and cage/pen fish farming. However, water pollution due to industrial development—particularly in the oil and gas sector—has severely impacted coastal mariculture opportunities (Adeleke et al., 2021). As a result, the vast majority of aquaculture in the country focusses on freshwater species—primarily catfish—produced via a fish hatcheries that supply to pond and tank culture systems (Adeleke et al., 2021).

Nigeria's climate is favourable to inland aquaculture, with total inland water surface areas made up of seasonal and perennial rivers, lakes, reservoirs, and dams amounting to some 14 million hectares (Finlayson and D'Cruz, 2005). The climate is tropical, with variable rainy and dry seasons. It is hot and wet most of the year in the southeast but dryer in the southwest and farther inland. A savannah

climate, with marked wet and dry seasons, prevails in the north and west, while a steppe climate with little precipitation is found in the far north. However, while much of the country has a climate that could be used for aquaculture, availability of land is a challenge.

4.5 Technologies and innovations

Technological innovation and research into fisheries in Nigeria takes place at three government-operated fisheries research institutes and a number of polytechnics and colleges. The three institutes include the Nigerian Institute for Oceanography and Marine Research (NIOMR), the Institute for Fresh Water Fisheries Research (NIFFR), and the African Regional Aquaculture Centre (ARAC). While these institutions are responsible for leading fisheries research and driving innovation in the country, much research needs to be done to drive the aquaculture development in the country. The disaggregated data on gender representation at these institutes suggest that male researchers, technologists and students generally outnumber females.

Nigeria's aquaculture sector appears to be open to adopting low-cost and effective technologies to enhance production. These technologies include using fingerlings from certified hatcheries rather than those caught in the wild, introducing pelleted floating feed rather than other feed sources, and employing mobile tanks for their flexibility in location. Additionally, more advanced and costly technologies, such as automated feeders, water recirculatory systems, aeration, and cage culture have also been readily adopted. Fish processors have also embraced improved smoking kilns to enhance product quality and safety, and to improve access to international markets.

Different types of enclosures and farm designs are used for fish farming in Nigeria. These include earthen ponds, plastic-lined earthen tanks, wooden tanks with plastic lining, net cages in dams, rivers, or lagoons, rectangular raceway tanks, circular or rectangular fiberglass tanks, and concrete tanks. Production mainly follows an extensive land-based system that is practiced at subsistence levels. It takes place in reservoirs and non-drainable ponds. In this system, once the fish are stocked, they are left to grow under natural pond conditions. This method is characterized by low inputs, low-density stocking, no artificial feeding, no fertilization, and a very low yield per unit area. However, the yield can be improved with better pond management practices. Brackish water aquaculture is also practiced mainly in fishponds located in coastal areas, while marine culture and integrated fish farming are carried out on a limited scale.

4.6 Feed and seed

Access to quality and reasonably priced ingredients is a significant constraint for the Nigerian aquafeeds manufacturing sector (Yakuba et al., 2022) while poorly developed infrastructure and long distances hamper the distribution of feed (Simus et al., 2022). Local feed producers are unable to meet demand and a sizeable share of feed needs to be imported. As a result, feed prices remain high, hampering the expansion of the sector (Kaleem and Bio Singou Sabi, 2021). Two types of aquafeeds are used to culture fish in Nigeria: on-farm feed and commercial feed. On-farm feeds are usually made up of native foodstuffs blended as dough or compressed into pellets. They are cheaper than commercial aquafeeds hence their preference by local/semi-intensive farmers in Nigeria.

Currently, Nigeria is building-up local manufacturing capacity and consequently, many local feed millers are producing some aquafeeds commercially that are formulated to meet the nutritional requirements of the cultured fish species and their different life stage. Some of the major feed millers include CHI, Grand Cereals for Vital Feeds and Aquamax, Tempo Feed Mill for Fresh Line Feeds, Durante, MOSAB, Ideal Fish Feeds, Aqua Vista Feeds, Megatimex, UNIFACO, Aqua Plus, High Yield, Jib Feeds, Darrell Feeds, and Premier Feed Mills. These companies also offer compounding services (tolling) to farmers willing to self-formulate their feeds.

Similarly, the domestic supply of fingerlings is not able to meet the growing demand. An estimated 1.5 billion fry/fingerlings will be required to enable aquaculture production to double in order to meet current and predicted demand (Simus et al., 2022). Most seed is sourced from hatcheries, but a lack of sufficient quality control negatively impacts seed quality, sizes and price and consequently productivity and profitability (Adewumi, 2015). Similar to feed, centralization of seed providers is making access to fingerlings difficult for the widely distributed farmers (Simus et al., 2022).

Genetic improvement programs are underway, but still in an infancy stage. WorldFish, for instance, is working with Nigerian producers to introduce its Genetically Improved Farmed Tilapia (GIFT) strain and efforts to genetically improve African catfish are underway. WorldFish estimates that within ten years, 150,000 smallholders could produce an additional 720,000 MT of GIFT worth USD 1.4 billion (Simus et al., 2022).

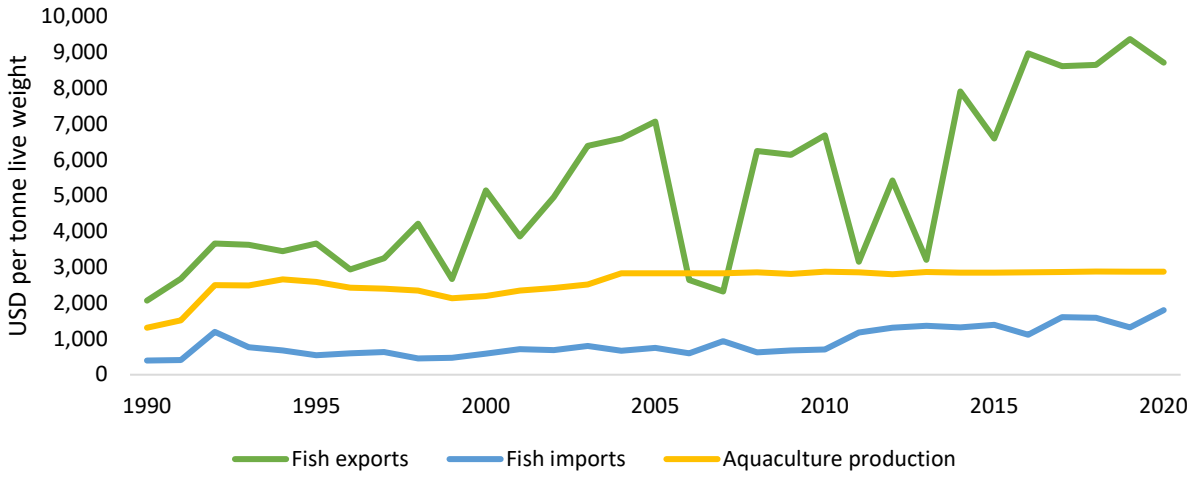
4.7 Markets

Fish is a staple food for many Nigerians and domestic demand far outstrips supply—both domestic production and imports (Adeleke et al., 2021). Of the total fish supply in 2020, only 63% came from domestic sources while the rest had to be imported (FAO, 2023a). Actual demand is thought to be much higher than what is available in the market. As a result, Nigeria has become one of the largest importers of fish in the world. Similar to Egypt, the main imports are low-value mackerels and herrings. While import volumes fluctuated over the years (Figure 13), value per tonne has remained relatively stable and low (Figure 14). In 2020, the majority of fisheries imports were supplied by Europe (60%) and the Americas (26%) while only 5% of imports originated from African countries (FAO, 2023a).

Figure 13: Fisheries exports and imports in Nigeria (1990-2020)

Data source: FAO (2023a)

Figure 14: Value (per tonne) of aquaculture production and fisheries trade in Nigeria (1990-2020)



Data source: FAO (2023a)

4.8 Private sector role and public-private partnerships

The Nigerian aquaculture sector is dominated by a high number of SMEs, but large-scale intensive farming operations have also started to emerge (Bradley et al., 2020). The private sector has been driving investments with limited support from government (Adeleke et al., 2021). Farms are often organised in clusters of 25 to 2000 farmers located in the fish producing states (Simus et al., 2022). These clusters hold significant potential for scaling if they can be turned into robust commercial enterprises which could facilitate access to inputs, improve marketing and attract outside investors (Simus et al., 2022). To realize the full potential of the aquaculture sector to generate wealth, social benefit and contribution to the national economy, the government is increasingly facilitating the effective application of public-private partnerships in aquaculture by encouraging market led sustainable and profitable aquabusinesses with a focus on SMEs.

4.9 Food security and employment

Fish and seafood play an important role in the Nigerian diet, but consumption levels differ between geographical regions and income groups (Bradley et al., 2020). Thus, levels tend to be higher in the southern than in the northern region, in urban areas and among higher income groups. With an average per capita consumption of fish and seafood of 6.8 kg in 2020 (FAO, 2023b), Nigeria falls well below the African average of 9.6 kg. The slow growth in fisheries production in recent years cannot keep up with the rapidly expanding demand of Nigeria's large and fast growing population. In 2020, an additional 396,000 MT of fish would have been required to reach the African average.[4] Nigeria therefore offers a substantial market opportunity for domestic and other African producers to replace imports and close the supply gap. Fish and seafood also play an important role in per capita protein intake from animal sources, accounting for 37% on average ahead of eggs (12%), mutton (11%) and beef (9%) (FAO, 2023b).

The aquaculture sector creates important job opportunities along the value chain. It is estimated that over 10 million Nigerians are actively engaged in primary and secondary fisheries operations (Nnodim, 2023). However, reliable data on employment specifically in the aquaculture sector are not available.

[4] Calculated using data from FAO (2023a).

5 Conclusions and recommendations

Drawing on insights from Egypt, Kenya and Nigeria, this study aimed at identifying investment and policy priorities to sustainably develop the aquaculture sector in Africa. As the fastest growing food sector globally, aquaculture holds tremendous potential to bolster food security in low- and middle-income countries. Not only does the sector produce protein-rich food, but it can also create a wide range of jobs along the entire value chain.

Aquaculture is still in its infancy in many African countries. However, a closer look at major players Egypt and Nigeria as well as the complex environment a smaller player like Kenya is facing, has provided valuable insights into how the sector can grow at scale. The analysis focused on nine themes to ensure a comprehensive overview of the sector and to better understand the relative strengths and weaknesses in each country: sector trends, national policy frameworks, government institutions, natural resources to support aquaculture, sector-specific innovation, feed and seed, market access, public-private partnerships, and sectoral impacts.

Each country offers unique lessons in these themes. For example, Egypt has created a strong enabling environment by implementing solid national strategies along with the governance structures needed to see them through. By also ensuring that the private sector can participate fully, Egypt has enabled the country to become a major global player in the sector. Nigeria offers helpful insights into shortcomings in government support, which could help ensure that the natural environment could be used more effectively to develop the sector and increase food security. Demand currently far exceeds domestic supply plus imports, creating enormous potential for future sectoral growth.

Kenya is another important case study that demonstrates the importance of government support to not only establish, but also maintain the industry. Major growth was spurred by national investments in the form of its Economic Stimulus Program between 2008 and 2014, resulting in a five-fold increase in production. This growth tapered off with the removal of the Program and, more recently, competition from less expensive frozen fish imports—especially from China. Efficient logistical networks are a challenge for remote domestic producers, particularly for perishables, such as fish.

Unpacking the nine themes in relation to the three case study countries has been a useful exercise in understanding the broad tapestry of factors that come together to support a sustainable aquaculture industry. Drawing on the detailed analysis in the report, some general lessons can be identified:

Production trends: In all three countries, demand for fish and seafood products (at times substantially) outstrips supply and shortfalls need to be met through imports. In particular in Nigeria, the large and fast growing population offers a promising market not only for domestic, but also regional aquaculture producers. While Kenya's population is considerably smaller, raising the low per capita consumption rates also offers opportunities for expansion. Taking advantage of these opportunities not only requires boosting production levels, but also improving linkages to consumers.

Recommendation #1: Beyond increasing production capacities, promote investments in transportation and cooling infrastructure, quality control and trade integration to close fish supply gaps.

Policies and governance frameworks: With regard to policies, Egypt demonstrates how sector-specific national frameworks and strategies that are aligned with international and regional policies create a robust foundation for sustainable aquaculture growth. Additionally, these frameworks and strategies must be supported by government organs and institutions to ensure intentions are sufficiently equipped to be actioned. An equivalent policy and institutional focus is currently lacking in Nigeria and Kenya.

Recommendation #2: Develop and implement dedicated policies and related institutions to promote the aquaculture sector, based on a sound understanding of supply and demand structures.

Natural resources: All three countries are well endowed with natural resources (including marine and freshwater resources) that can support a productive aquaculture sector, but the full potential remains underutilized. Marine aquaculture is underdeveloped in all three countries despite long shorelines. While Egypt has been successful in establishing facilities in harsh and dry environments, sustainability of production related, for instance, to water use and pollution remains a concern. Both Nigeria and Kenya rely on freshwater aquaculture, but do not take full advantage of their water bodies. Government support will be required to strategically develop the underused areas. Future development will also have to take into account freshwater resources in countries facing harsher environments due to climate change. Strategic planning for future sustainable use will be crucial to supporting aquaculture, agriculture and other freshwater needs.

Recommendation #3: Map high potential areas for aquaculture development at the national level and develop strategies for expansion in these areas, based on an assessment of current challenges, market opportunities, competition with other sectors and environmental considerations in the short- and long-term.

Technologies and innovation: Adequate technical capacity and research and development are critical to successfully scaling aquaculture sectors. Technologies aimed at boosting efficiencies and maximizing outputs in the sector are growing at a rapid pace. While all three countries have been making progress in the adoption of innovative solutions in the aquaculture sector, the potential of technological progress both at the production level and along the value chain remain underutilized. Modernization of the sector will depend on local expertise at research facilities and ease of access to beneficiaries.

Recommendation #4: Increase local research capacities to develop new or adapt existing technologies to improve productivity and commercialization of the aquaculture sector, supported by measures to facilitate uptake, such as capacity building, extension services and access to finance.

Feed and seed: Access to feed and seed remains a significant constraint in all three countries, but more so in Nigeria and Kenya. Local production of feed is generally insufficient and shortfalls need to be met with expensive imports, especially in Nigeria, exposing fish farmers to the risk of price increases due to global inflation and exchange rate changes. The quality of inputs is also a concern for fish farmers, as is access to ingredients for feed manufacturers and hatcheries. Access is further hampered by poorly developed infrastructure and long distances to feed producers and hatcheries. Genetic improvement programmes for local fish varieties are at an infancy stage in the three countries.

Recommendation #5: Invest in decentralized feed and seed production to ensure easy access and lower input prices while also generating income and employment in rural areas, supported by quality control mechanisms and capacity building initiatives.

Recommendation #6: Promote breeding programmes for locally farmed fish species and foster related knowledge exchanges between countries where these species are or could be suitable for the local aquaculture sector.

Markets: In all three countries, the aquaculture sector is primarily focussed on domestic markets and heavily concentrate on species of local preference and ease of production. Quality requirements in

higher-income markets prevent producers from taking advantage of market opportunities, as exemplified by Egypt's inability to export farmed fish to the EU. At the same time, local producers cannot capitalize on regional market opportunities, such as the significant supply gap in Nigeria. For the most part, these gaps are closed by imports from non-African countries, for instance cheap imports from China to Kenya, which undermine the development of the local industry. Poorly developed infrastructure and cold chains also hinder trading from local to global levels.

Recommendation #7: Foster national, sub-regional and continental market integration to benefit from market opportunities, including facilitation of fisheries trade through the African Continental Free Trade Area (AfCFTA)

Private sector role: Government support to foster private sector participation in the aquaculture sector is crucial to overall success. The example of Egypt, where national strategies are explicitly geared towards supporting the private sector, shows the potential benefits of promoting strong PPPs. In Nigeria and Kenya, the private sector has mostly been left to operate on its own.

Recommendation #8: Provide an enabling environment for private sector engagement in the aquaculture sector, e.g. by supporting PPPs, access to finance, infrastructure investments, quality control mechanisms and capacity building.

Food security and employment: In all three countries, fish and seafood play an important role in national diets (albeit with variations within countries and income groups). By regional and global comparison, however, per capita consumption rates are still low, especially in Kenya but also in Nigeria. Sustainably increasing supply of and access to fisheries products could therefore increase protein intake and improve food and nutrition security. Fish can be an important source of affordable animal-sourced protein, in particular among lower income groups, as shown in Kenya. At the same time, the sector has high potential to boost employment at the production level and along the value chain. The actual extent of job creation (potential) is difficult to determine given a lack of disaggregated data.

Recommendation #9: Promote sustainably farmed fish and seafood as a high-quality, affordable and locally produced source of protein (e.g., through awareness raising campaigns or school meals).

Recommendation #10: Collect disaggregated data on employment in the aquaculture value chain, including spill-over effects on other sectors, to better understand employment potentials and guide investments in skill development to take advantage of job opportunities, especially among women and youth.

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Annex: Case study indicators and means of measurement

This working paper is based on in-depth case studies on the aquaculture sectors in Egypt, Kenya, and Nigeria. Case study authors based their findings on qualitative data (gathered from interviews and focus group discussions with key players and service providers in the fisheries sector and related value chains) and a thorough analysis of existing literature on sustainable aquaculture development as well as technological and innovation systems. The following aquaculture-related criteria were evaluated in each case study country: aquaculture policy frameworks and national strategies; governance structure; natural resources that can support aquaculture; technologies and innovations, including participatory research and development; production and aquaculture trends; feed and seed; diversification of aquaculture; markets; private sector role and public-private partnerships; and food security, employment, and household income. The indicators and means of measurement for evaluating these criteria are outlined below.

Aquaculture policy frameworks and national strategies

National policies and strategies for the selected countries were collected and reviewed in terms of the following aspects:

- Does the country have an aquaculture specific policy, which has been actioned by a strategy and sector-specific legislation?
- Is the policy aligned to UN's Sustainable Development Goals?
- Is the policy aligned to the Malabo Declaration?
- Is the policy aligned to the Comprehensive Africa Agriculture Development Programme?
- Is the policy aligned to the African Blue Economy Strategy?
- Has the strategy been informed by Article 9 of the FAO Code of Conduct for Responsible Fisheries?
- Does the policy and the strategy take cognisance of the African Union's Policy Framework and Reform Strategy for Fisheries and Aquaculture in Africa?
- Is the policy and strategy gender responsive and sensitive to opportunities for the youth?
- Does the policy and strategy create a framework for the creation of jobs and opportunities in aquaculture?
- Is the policy and strategy geared to trade – locally and internationally – and have the legal instruments and procedures been created to allow for systems and standards insofar as international trade is concerned?
- Does the policy and strategy support public-private partnerships and allow for the private sector to play a leading role under government support and a conducive governance framework?
- Does the policy, strategy, and legislation support the sustainable use of natural resources, the ecosystem approach, and biodiversity protection?
- Is the policy sensitive to the impacts of climate change?

Governance structure

Government organs in the selected countries were assessed in terms of:

- Whether there is a dedicated government organ that deals with aquaculture development, extension, and regulations and whether the powers of regulation have been separated between sector promotion and sector governance.
- A general understanding of the capacity in terms of manpower (numbers, qualifications, experience, and gender division) compared to aquaculture sector size.

Natural resources that can support aquaculture

As a general overview, information was collected on:

- Coastal length
- Inland water bodies
- Climate and rainfall
- Tenure systems that allow access to natural resources for aquaculture development.

The case studies determined whether legal frameworks are in place for protection of natural resources and biodiversity, while the extent of use of alien aquaculture species provided insight.

Technologies and innovations, including participatory research and development

An assessment was made around the level of training, research, and the adoption of technologies in the respective countries in terms of the following aspects:

- How many aquaculture training and research institutions are there in the country?
- How gender representative is training and research, both in terms of trainers and trainees?
- How actively is aquaculture information disseminated (e.g. via journals, social media etc.)?
- How receptive is the aquaculture sector to new methods and technologies, which will be measured by level of new production and related technologies that have been adopted by the sector?

Production and aquaculture trends

For this criterion, the FAO Global Aquaculture Production database was consulted, as well as production volumes depicted by volume, value, and species for a period of ten years. These data were corroborated insofar as this was possible through discussion with national authorities and aquaculture associations / societies.

Feed and seed

Aquaculture growth is often limited by the availability of high quality and affordable feed and seed. In using this as a criterion to characterize the success of a country's aquaculture sector, the following matters were investigated and documented:

- To what extent is aquaculture feed produced in the country and what is the estimated ratio between local feed production and imported feeds?
- Based on available data of total feed use, what is the sector-wide feed conversion ratio when using total production volume in the calculation? This will allow for some degree of further corroboration of production volumes.

- How many local hatcheries provide seed (by volume and species), and how much seed is imported?
- How active are genetic improvement programmes in the country?

Diversification of aquaculture

Diversification of aquaculture in a country was measured by:

- The number of species that are actively farmed in each target country.
- The number of primary production methods that are use (i.e., ponds, tanks, cages, RAS etc.)

Markets

Aquaculture markets were investigated for the selected countries in terms of the following aspects:

- Quantification of aquaculture market segments (i.e., localized selling, national selling, international selling, and, specifically, whether international selling is to neighbouring countries or into global markets).
- Indicative Dollar or Euro farmgate price for common products, such as farmed tilapia and catfish.
- Whether the country has standards and a regulatory framework in place that allows for international trade of aquaculture products.

Private sector role and public-private partnerships

This was measured subjectively by commenting on the role and lead that the private sector plays in the country's aquaculture and whether this is supported by government. This included an investigation into whether public-private partnerships have been established.

Food security, employment, household income

Measuring the impact of aquaculture on food security, employment and household income was very difficult within the scope of this work. However, the following information was collected and documented:

- Aquaculture's contribution to GDP, based on data from FAO Global Aquaculture Production.
- The contribution of aquaculture to the country can also be depicted as production volume per capita, although it is understood that this will not reflect fish consumption per capita (which will be collected and shown separately). If volumetric data on national capture fisheries and import volumes are available, it will allow for a strong indication around the potential for aquaculture growth pinned to certain levels of per capita fish consumption.
- Employment levels will be determined insofar as this is possible by discussions with aquaculture associations and societies.
- Household income will be obtained from global data resources, such as those compiled by the World Bank.

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