

An aerial photograph of a tilapia aquaculture system. Several large, circular, blue-lined tanks are connected by green plastic pipes. A central platform with a yellow roof and a small structure is situated in the middle of the tanks. A yellow buoy is visible in the water. The background is a dark blue body of water.

Aqua Insights

*An Introduction to Tilapia
in Sub-Saharan Africa*

›Powered by Aqua Spark



AquaSpark

> Investing in the Future of Aquaculture

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September 2021

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Cover Photo Chicoa Fish Farm's tilapia cages in Lake Cahorra Bassa in Mozambique
(photo credit: Chicoa Fish Farm)

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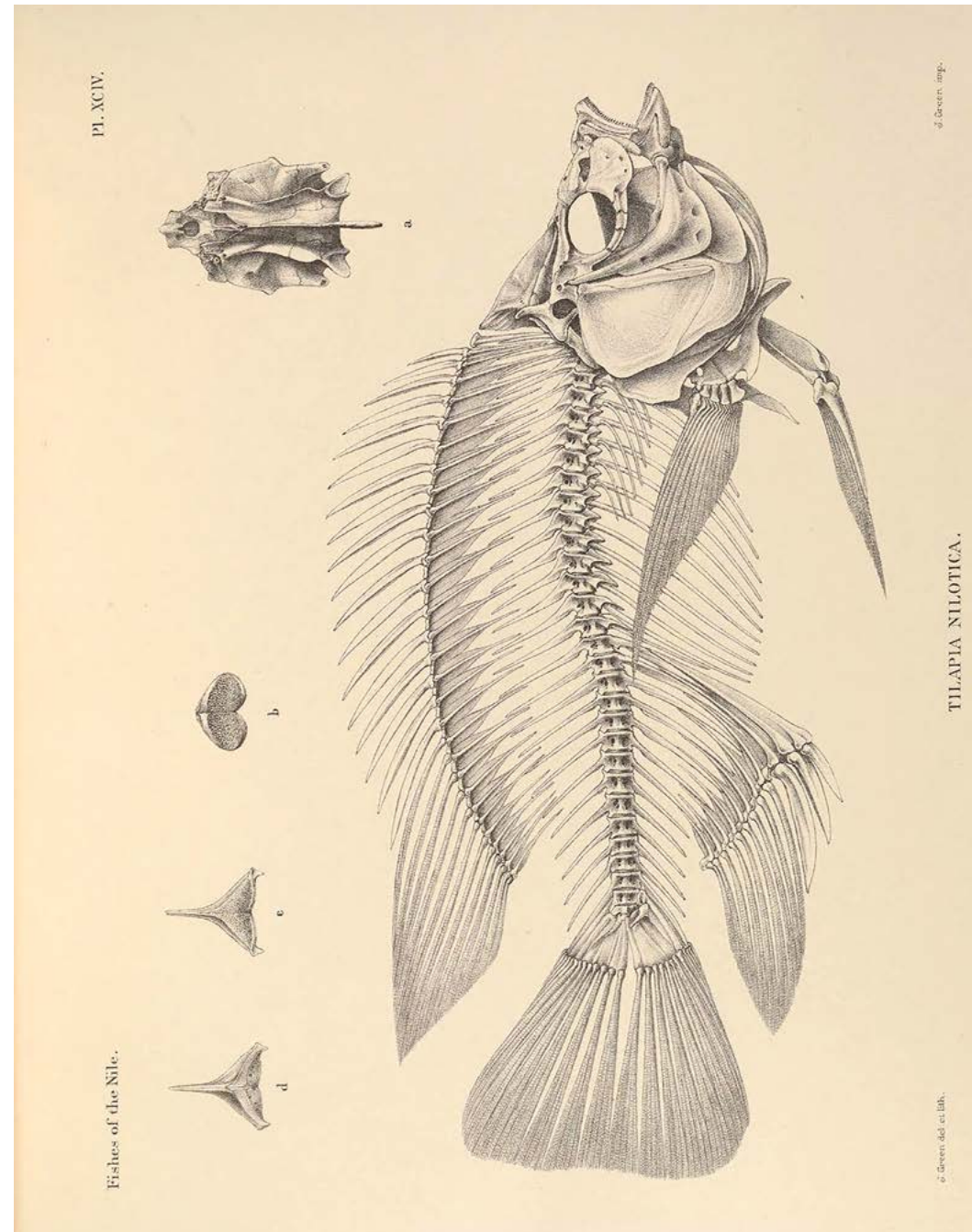
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Preface

We're very excited to present the first edition of Aqua-Spark's Aqua Insights Report Series: "An Introduction to Tilapia in Sub-Saharan Africa." With the Aqua Insights Report Series we aim to provide investors and others alike with an introduction to different segments and geographies of the aquaculture industry. Our aim is to give you enough insight to convince you that sustainable aquaculture should become an even bigger part of the solution to the protein challenge that we're confronted with, and impel you to support and engage in efforts to ensure sustainable aquaculture's success. We believe that reliably meeting the world's growing demand for protein while simultaneously sustaining our environment will require a radical transformation of global aquaculture, which needs to be a large-scale collaborative effort between diverse stakeholders and investors committed to supporting innovation and long-term growth. With the Aqua Insights Report Series we wish to ignite discussions and create this momentum. We hope that after reading these reports you're—even more—excited about joining us in our bid to invest in the future of sustainable aquaculture.

This first report addresses why and how farmed tilapia can and should play an important role in solving sub-Saharan Africa's challenge to produce sufficient food for its growing population. We provide you with an overview of the current geography of tilapia production, the producers involved, and the various segments of the supply chain (including feed and feed ingredients, genetics and hatcheries, health, aquatech, and marketing and distribution), as well as insights into the challenges that the sector is confronted with, and an overview of the investment opportunities and the existing investment landscape. After reading this report, you'll have a good overview of the status of the sector and understand what's needed to take tilapia in sub-Saharan Africa to the next level.

This report wouldn't have been possible without the support of all the people that have contributed to its content. First of all, a big thank you to all the people at the companies and organizations involved in tilapia in sub-Saharan Africa who've been willing to share their insights with us: your views have been of tremendous value for developing this report and will enlighten others as much as they did us. Also, the support of William Leschen—who manages the Sarnissa network and knows tilapia in sub-Saharan Africa better than anyone else, and who has reviewed almost every section of this report—has been invaluable in capturing the whole story that needs to be told. Lastly, to the whole team at Aqua-Spark; Annette Farshchi, Josanne Blokker, and Jo Hamilton-Biljam at Editors Collective Amsterdam who edited the report; and Marnix de Klerk and Nina Mathijssen at Detour who took care of designing and illustrating the report: a big thank you for all your energy and hard work.

Willem van der Pijl, Editor-in-Chief
Amy Novogratz and Mike Velings, Managing Partners

Key Observations

- In the last quarter of 2021, we will launch the “Aqua-Spark Africa Fund,” a fund dedicated to aquaculture in sub-Saharan Africa. It will initially close at \$50m and will grow to \$300 million over the next 6-8 years. This will kickstart the first phase of development: the most fundamental investments will be made so as to further develop the framework for growth of sub-Saharan Africa’s aquaculture sector. The Aqua-Spark Africa Fund focuses on the entire aquaculture sector. This Aqua Insights report, however, will concentrate on one species—tilapia—and here we explain why.

- We don’t doubt that farmed tilapia production in sub-Saharan Africa will grow. The region’s population will increase from 1 billion presently to 2 billion by 2050. This population growth will lead to a demand for fish that far exceeds that of today, which currently stands at 10 million MT per year: by 2050, demand for fish is likely to reach between 16-29 million MT per year. Due to overexploitation, wild catch can’t be increased, and thus won’t be able to meet the additional demand. Even if alternative proteins start playing a larger role, we at Aqua-Spark believe that aquaculture production will have to accelerate. We’ve identified tilapia to be the fish to do so: it’s scalable *and* it’s healthy, sustainable, and affordable.

- Tilapia is currently the second-most farmed fish in the world and the most farmed fish in sub-Saharan Africa. Although many tilapia species are native to sub-Saharan Africa, the region’s farmed tilapia production is negligible compared to major producers such as Brazil, China, and Egypt. For 2019, the FAO reported a farmed tilapia production volume of 263,000 MT in sub-Saharan Africa. Our own estimate is that actual production was around 125,000-150,000 MT. Nevertheless, tilapia production is growing.

- Since the early 2000s, the expansion of tilapia farming has primarily been driven by commercial cage farms. Some of the largest farms have reached scale and dozens of small- and medium-sized commercial farms are ready to step up, too. To reach a yearly production capacity of 10,000 MT, a greenfield cage farming project requires an investment of around \$9-10m and about 7-10 years to reach scale. This includes investments in basic infrastructure, hatchery capacity, and nursery and growout cages. Once at scale, the large farms become platforms for growth and contribute to creating vibrant local tilapia industries. Scaling up production through direct investment in tilapia farms is of the highest priority to accelerate further industry growth. Although we acknowledge the potential of other production systems such as “green water” pond farming and RAS, we believe the number of these types of farms will only grow in the longer term.

- Even though in some markets in sub-Saharan Africa tilapia prices may, at present, still be around \$3-3.5/kg, a future retail price of \$2-2.5/kg is realistic. These prices require tilapia farmers in sub-Saharan Africa to reduce their production costs to at least \$1.5-2/kg. This calls not only for investments to scale up farms, but also investments along the value chain to improve genetics, hatcheries, feed ingredients, feed availability, and the application of farming technology.

- For every farmer, the performance of fingerlings is essential: healthy and fast-growing tilapia that thrive under local conditions result in a lot of fish in a short period of time. The quality of the fingerlings depends on both genetics and the way the production process is managed. Before investing in genetics, the infrastructure and management of the hatchery and farm must be optimized. Once everything is in place, acquiring broodstock from advanced breeding programs abroad or investing in a vertically integrated breeding program would be a logical next step, and could significantly contribute to a farm’s productivity and profitability.

- Commercial cage farmers, intensive pond farmers, and RAS farmers depend entirely on the availability of extruded pelleted feed. Accounting for 60-70% of a farm’s production costs, feed performance and prices have a large impact on a farm’s profitability. Although feed has become more readily available in countries like Ghana, Kenya, Nigeria, and Zambia, in many other countries farmers still depend on imported feed. Investments in feed production and feed-ingredient supply chains play a crucial role in local tilapia industries reaching scale and maturity. Feed is also crucial in terms of sustainability; replacing unsustainable ingredients (such as fishmeal from wild-caught origin) with sustainable alternatives (such as black soldier fly) is a must.

- Since disease outbreaks on Lake Volta in Ghana in 2018 caused mass mortalities on several farms, it’s clear that governments and farmers need to work together to prevent diseases from putting production and investments at risk. This involves a strong regulatory framework for importing broodstock as well as the collective management of waterbodies to ensure that the carrying capacity is not exceeded. For individual farms, genetics and vaccination play an increasingly important role, but good farm management and the use of technology to monitor fish health are of equal importance. As far as technology is concerned, we at Aqua-Spark believe that we’re only at the beginning of the tech revolution in the tilapia sector. This is the moment to get the industry right: a digitalized, data-driven industry is part of that vision.

- One of the major bottlenecks preventing the growth of the commercial tilapia sector is the lack of local talent and expertise, both in terms of vocational positions and higher management. This results in expats filling part of the void that currently exists. Expats may well be part of the solution, but long-term local capacity is needed, and investments in capacity development must therefore be scaled.

- Even though there is already a market for tilapia, it doesn’t just fall into the farm’s lap; to sustain a surge in production, tilapia farms and their distribution partners must ensure that locally farmed tilapia becomes available in every corner of sub-Saharan Africa, on any day of the week, and at any time of day. While this currently involves traditional marketing channels and a network of dedicated fish shops, in the future this will take the form of more innovative delivery models including online B2B and B2C platforms. But what’s really important is that even if consumers have *access* to farmed tilapia, they must also be sufficiently convinced of its health, taste, and sustainability to actually *buy* it. Marketing—both online and offline—is therefore a must.

- Whether we’re talking about investors such as Rabobank, EXEO Capital, or Norfund, most don’t question the potential of tilapia in sub-Saharan Africa. But what is a sticking point is their investment requirements: these often don’t match the current status of (most) tilapia farms and companies along the value chain in sub-Saharan Africa. So far, only a handful of medium- and large-sized farms and feed mills have managed to attract significant investment, with most coming from development finance institutions (DFIs) and impact investors. The relatively long time frames, small ticket sizes, and high levels of risk prevent other investors from getting involved. That’s why Aqua-Spark is launching a fund dedicated to sustainable aquaculture in sub-Saharan Africa. Aqua-Spark’s Africa Fund exists to kickstart the next iteration of the sector while catalyzing further and more diverse investment into this space. In time, we hope this means that farms will also start to meet the criteria of these larger investors. Want to know more? Then turn to p. 88 or get in touch at info@aqua-spark.nl.

THE FOOD CHALLENGE OF SUB-SAHARAN AFRICA

The population of sub-Saharan Africa is booming and projections of the UN are impressive: it predicts that the region's population is set to increase from 1 billion in 2018 to 2 billion by 2050, and to 4 billion by 2100. In this article we take a closer look at these estimates and try to answer the following question: How can fish and seafood help feed this growing population?

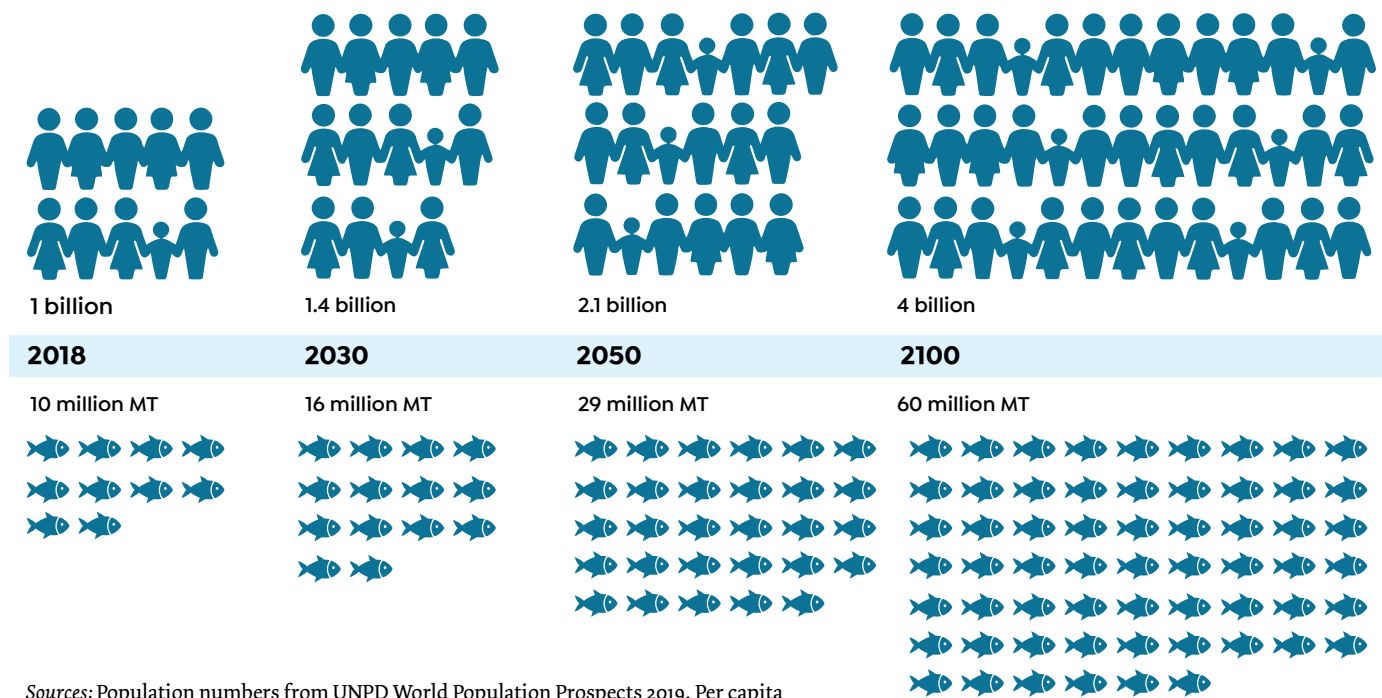
¹“World Population Prospects 2019,” UNPD (2019): <https://population.un.org/wpp/>.

²“World Population Prospects 2018,” UNPD (2018): <https://population.un.org/wpp/>.

According to its 2019 World Population Prospects, by 2050, the population of sub-Saharan Africa will reach anywhere between 1.9–2.2 billion, growing further to 2.7–5.2 billion by 2100.¹ By 2100, the world's 10 most populated countries are projected to include Nigeria (733 million), the Democratic Republic of the Congo (362 million), Ethiopia (294 million), and Tanzania (286 million). **The most significant part of the new population will live in the cities of sub-Saharan Africa.** The United Nations Population Division (UNPD) expects the urbanization rate to increase from 43% in 2018 to 59% in 2050.² Today, Kinshasa and Lagos are already among the world's top 20 largest cities, and by 2035 Dar es Salaam in Tanzania and Luanda in Angola will be regarded as megacities as well. Though these types of projections come with high uncertainty levels, **the population of sub-Saharan Africa will clearly grow tremendously.**

Demand for Fish Might Increase from 10 million MT to 29 million MT by 2050, and to a Possible 58 million MT by 2100

FIGURE 1: ESTIMATION OF DEMAND FOR FISH BASED ON UNPD WORLD POPULATION PROSPECT MEDIUM VARIANT AND WORLD FISH'S HIGH AQUACULTURE GROWTH HIGH GDP SCENARIOS



Sources: Population numbers from UNPD World Population Prospects 2019. Per capita consumption numbers for 2018, 2030, and 2050 are taken from WorldFish.³ Note: For comparison, per capita consumption in 2100 is assumed to remain flat.

³ Chin Yee Chan et al., "Prospects and challenges of fish for food security in Africa," Global Food Security 20 (2019), 17-25.
⁴ Idem.

In a 2019 study, WorldFish found that if the aquaculture sector in Africa continues on its current path, the per capita consumption of fish would gradually decline from 10 kg to 7.7 kg by 2050 because population growth would exceed food production and income levels.⁴ However, a more aggressive scenario simulated by WorldFish—where it modeled an acceleration of investments in the sector alongside more rapid population growth and increased GDP—found that, in such a scenario, the per capita consumption would increase to 11.7 kg in 2030 and 13.5 kg in 2050. Even though this last scenario might be optimistic, population growth and at least moderate GDP growth are likely to substantially increase the demand for fish.

The growing population of sub-Saharan Africa will need food. A lot of it. With more than 1 billion people and a per capita consumption of around 10 kg/year, the region consumes more than 10 million MT of fish and seafood yearly. With a projected population of 2 billion by 2050 and 4 billion by 2100, what will future demand for fish and seafood look like?

Fish Farmers Need to Step Up to Meet Future Demand

Sub-Saharan Africa produces more than 10 million MT of fish and seafood annually. Freshwater fish account for around 35% and marine fish for about 65% of total production. While freshwater fish is entirely consumed within sub-Saharan Africa, a portion of marine fish production, around 1 million MT, is exported. Local production is complemented by 1-2 million MT of imported fish. Of total production in sub-Saharan Africa, fishermen catch 10 million MT annually, while fish farmers still account for just a fraction of production (see Figure 2).

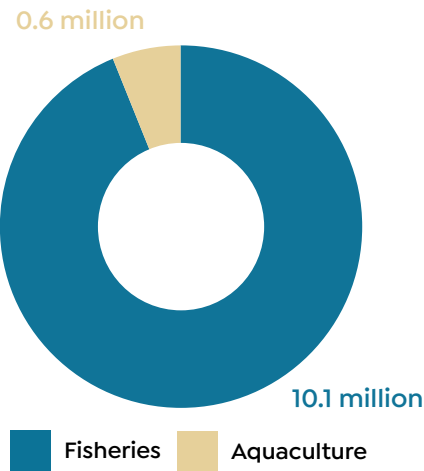
⁵ "Aquaculture and Fisheries Statistics," FAO (2020): <http://www.fao.org/fishery/statistics/en>.

With fishermen reportedly being confronted with declining catches due to depleting wild stock, the production of wild-caught fisheries may flatten or even drop soon. Fishermen are therefore not in the position to meet the foreseen surge in demand. If we want to satisfy the demand for fish of sub-Saharan Africa's growing population with local supplies and not with even larger volumes of imported fish, aquaculture production needs to accelerate.

At present, aquaculture plays a more critical role for freshwater fish than for marine fish. While aquaculture's contribution to marine fish production is insignificant, freshwater fish farmers account for 17% of freshwater fish output, and their share is steadily increasing. Freshwater aquaculture, specifically tilapia cultivation, can and should play an important role in accelerating aquaculture production to meet the growing demand for animal

proteins. With the first commercial tilapia farmers reaching significant levels of scale, the momentum for tilapia to start playing its role has come. Tilapia is one of the most sustainable, healthy, and economically beneficial freshwater fish species out there.

FIGURE 2: FISHERIES AND AQUACULTURE PRODUCTION IN SUB-SAHARAN AFRICA FROM 1950-2018⁵

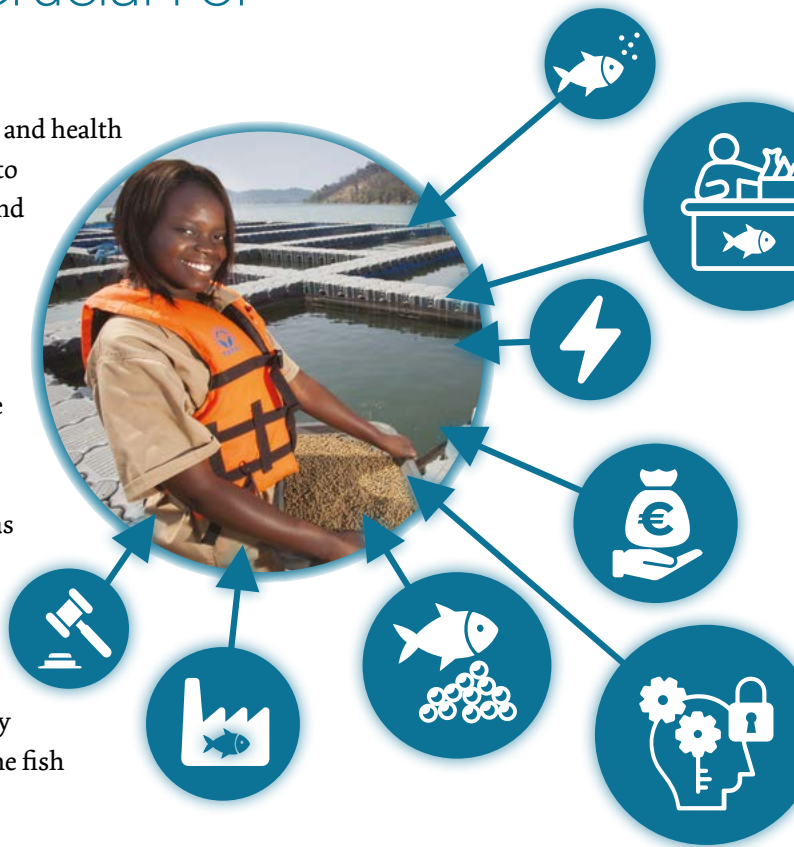


Enabling Environment Crucial For Success of Fish Farmers

While farmers produce the fish, the farmers and their fish can only flourish under the right conditions. Strengthening the enabling environment will be crucial for the expansion of aquaculture in sub-Saharan Africa. The enabling environment includes a regulatory and governance framework that supports sustainable aquaculture; capacity building in the public and private sector to create an educated workforce; investments in infrastructure such as roads, electricity, and transportation; the production of high-quality inputs (such as

feed mills, hatcheries, and health products); and access to technology, finance, and investment.

With the food challenge of sub-Saharan Africa becoming more apparent daily, a tipping point may have already been reached as aquaculture is on the rise in the region. Governments and the private sector alike may now be ready to step up and allow the fish farmers to flourish.



WHY FARMED TILAPIA?

Niacin

Helps to lower blood cholesterol

B12

Vital for brain functions and nervous system

Phosphorus

For strong, healthy bones

Selenium

Plays a critical role in metabolism and thyroid function

Potassium

Regulates fluid balance, muscle contractions and nerve signals



Farmed tilapia is generally accepted to be a healthy, sustainable, and affordable source of nutrients. Being the world's second most farmed fish, it's part of many people's diet. Nevertheless, some question its health benefits and claim tilapia is unhealthy, unsustainable, expensive, or difficult to produce. Let's debunk some of those myths!

Tilapia is Less Healthy than Bacon



In articles on various popular food websites, such as eatthis.com back in 2015,¹ it has been suggested that research found the inflammatory potential of farmed tilapia to be greater than that of a burger or even bacon. These claims can be traced back to a scientific article by Kelly L. Weaver et al. from 2008.² Since then, many have disagreed with its findings, including Harvard Medical School.³ The editors of eatthis.com argue that, compared to other fish, farmed tilapia contains relatively small amounts of the beneficial omega-3 fatty acids to which much of the health benefits of fish are attributed. Grown on a diet of corn, soy, and vegetable oils instead of lake plants, farmed tilapia is claimed to be proportionally high in omega-6 fats, some of which are associated with inflammatory risks.

Even though eatthis.com might be right about the low amount of omega-3 and the high ratio of omega-6 in farmed tilapia, their conclusion that farmed tilapia has greater inflammatory potential or is even less healthy than burgers and bacon is wrong. An article published on ScienceFriday.com summarizes the criticism on the way Weaver's findings were used to frame farmed tilapia as an unhealthy choice,⁴ and explains that the lack of omega-3 and omega-6 fatty acids in farmed tilapia is because it's not a fatty fish. The levels of fatty acids in fish correspond to the quantity of fat in a fish, and in farmed tilapia this quantity would never be enough to harm humans. Kevin Fitzsimmons, cited in the same article, argues that "single slices of bacon and burgers would have way more omega-6 fatty acids than ten tilapia fillets."

To function optimally, our body needs six crucial nutrients: protein, carbohydrates, fats, vitamins, minerals, and water. Fish, including tilapia, contains many of these nutrients. Tilapia is high in protein and contains considerable amounts of vitamins and minerals. It's rich in niacin, vitamin

B12, phosphorus, selenium, and potassium.⁵ Since tilapia contains little fat, it's indeed not a good source of fatty acids, but is still a good source of protein and other nutrients. The high amount of fat contained in bacon and burgers certainly make them less healthy choices than tilapia.



Tilapia is Bad for the Environment

Tilapia Farming Could Reduce Pressure on Wild Fish Stocks

Some articles report that farmed tilapia is detrimental to the environment. One argument that these articles often use, is that introducing farmed tilapia to waterbodies that it's not native to will likely threaten the local ecosystem's balance.

Although this risk indeed exists, it doesn't make tilapia farming unsustainable. Nile tilapia, the most important species for aquaculture, has been introduced to waterbodies around the world to complement declining wild stocks and to keep waterbodies clean. As a result, it is now found in most of the world's freshwater bodies with the right temperature for tilapia to grow.

Certain countries in sub-Saharan Africa protect their waterbodies from the introduction of Nile tilapia: they don't allow the import of Nile tilapia broodstock but demand that farmers use local strains. WorldFish found that if local species selectively bred by farmers were to escape into waterbodies, they would also outcompete wild tilapia and threaten the wild stocks in the waterbody. Nevertheless, from an environmental perspective, using local strains is mostly preferred. Using proper equipment and farm management is crucial to mitigate the risk of escapees.

¹ "How Tilapia is a More Unhealthy Food Than Bacon," Eat This, Not That!, June 1, 2015, <https://www.eatthis.com/tilapia-is-worse-than-bacon>.

² Kelly L. Weaver et al., "The Content of Favorable and Unfavorable Polyunsaturated Fatty Acids Found in Commonly Eaten Fish," Journal of the American Dietetic Association 108, 7 (2008): 1178-1185, <https://doi.org/10.1016/j.jada.2008.04.023>.

³ "Flap over tilapia sends the wrong message," Harvard Medical School, November, 2008, https://www.health.harvard.edu/newsletter_article/Flap_over_tilapia_sends_the_wrong_message.

⁴ Vanessa Schipani, "Is Bacon Really Better For You Than Tilapia?," Science Friday, August 1, 2017, <https://www.sciencefriday.com/articles/is-bacon-really-better-for-you-than-tilapia>.

⁵ According to the Dutch Food Composition Database (NEVO), available at <https://nevo-online.rivm.nl>.

While we shouldn't overlook the risk of escapees, tilapia farming can actually reduce pressure on overfished wild tilapia in sub-Saharan Africa if done the right way. Tilapia fisheries in sub-Saharan African major lakes and rivers are reportedly under pressure. Catches in Lake Victoria, Lake Volta, and the Zambezi River basin are said to be stagnating or even declining. Replacing wild-caught tilapia by farmed tilapia could reduce the pressure on these wild fish stocks.

Tilapia Easily Converts Animal Feed into Bodyweight and Is a Flexitarian

Just like humans, tilapia can feed on almost anything. When grown in a pond, tilapia will eat algae and other naturally present foods. Farmers can complement natural feeding with raw ingredients or commercial feeds. Farmers that don't use commercial feeds will generally use lower stocking densities. The higher the stocking density, the more likely the farmer will use commercial feed. Here we mainly discuss farmers that use commercial feed.

A feed conversion ratio (FCR) refers to the amount of feed needed to produce a kg of fish or meat. According to industry experts, under optimal conditions, the average FCR of a plate-size tilapia farmed in sub-Saharan Africa is around 1.6 in intensive ponds, 1.4 in cages, and even closer to

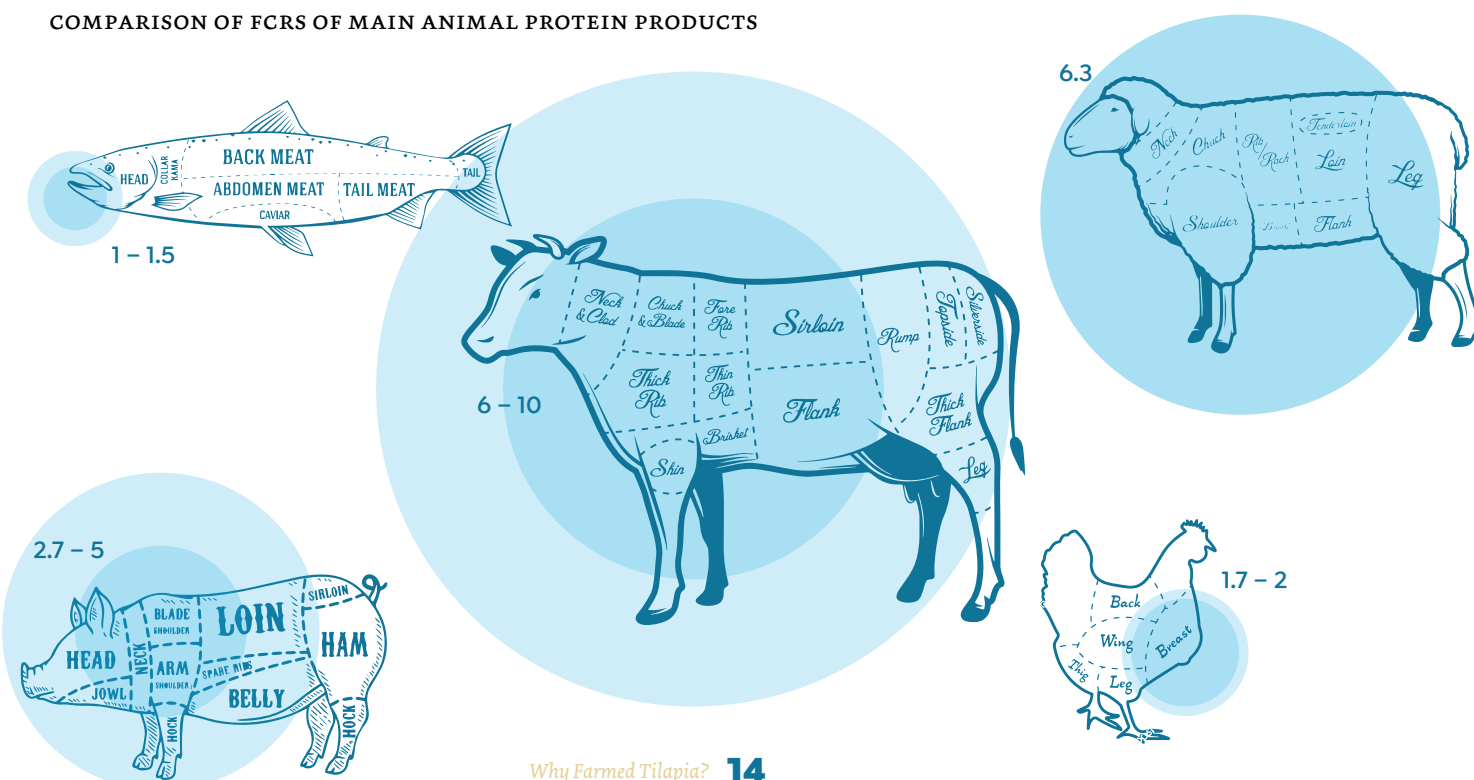
1 when farmed in extensive "green water" ponds. Compared to land-based animals, tilapia's FCR is much lower, while it's in the same range as that of various other farmed fish.

Rather than only looking at *how much* fish need to eat, we should also consider *what* they eat. One of the concerns in aquaculture is the amount of fish-meal and fish oil that fish need to grow. Species like salmon and shrimp traditionally need more significant amounts of fish protein to grow. Tilapia can be considered a flexitarian; it can easily convert a vegetarian diet into protein and energy, and only needs minimal fish protein to grow. The amount of fish protein required to produce a kg of fish is often expressed by the fish-in fish-out (FIFO) ratio. Together with carp, tilapia has the lowest FIFO ratio (0.06) of all significant aquaculture species fed with commercial feed, such as salmon (0.98), shrimp (0.52), milkfish (0.18), and catfish (0.08).⁶

Although tilapia's predominantly corn and soy-based diet benefits tilapia farmers due to its relatively low production cost, it also runs the risk of being deficient in nutrients. The nutrient profile of farmed fish ultimately depends on the quality of feed it gets. Therefore, to further build the case for tilapia as a healthy and sustainable protein source, tilapia producers should try to enrich tilapia's diet with ingredients that improve its nutrient profile.

⁶ Björn Kok et al., "Fish as feed: Using economic allocation to quantify the Fish In: Fish Out ratio of major fed aquaculture species," *Aquaculture* 528 (2020), <https://doi.org/10.1016/j.aquaculture.2020.735474>.

COMPARISON OF FCRs OF MAIN ANIMAL PROTEIN PRODUCTS

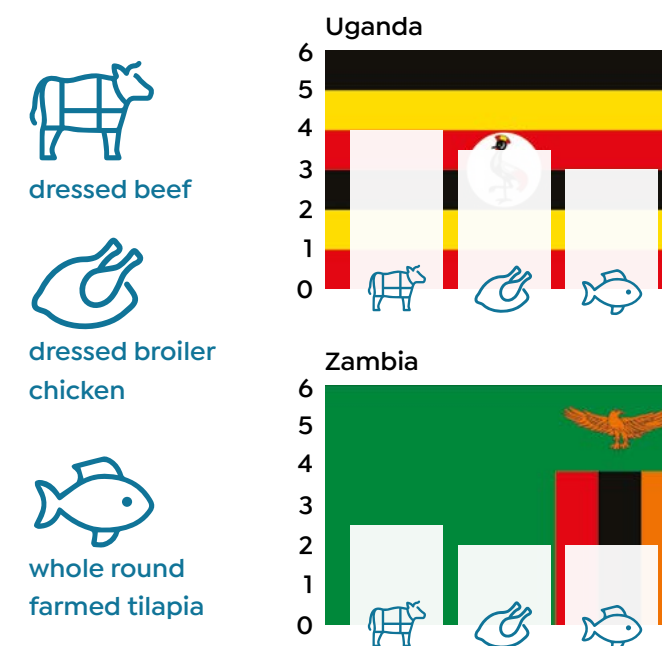


Locally Farmed Tilapia Is Not Affordable in Sub-Saharan Africa

After carp, tilapia is the second-most-farmed fish. Consumers often regard this nutrient-rich food as an affordable option compared to other animal protein.

However, whether farmed tilapia is cheap mainly depends on where it is produced. Production costs in Asia and South America are considerably lower than those in sub-Saharan Africa, where consumers primarily buy whole round, or gutted and scaled, tilapia. Depending on their budget, consumers can buy a specific size of locally farmed, wild-caught, or cheaper imported tilapia. The price of tilapia varies widely within sub-Saharan Africa and depends on the balance between local supply and demand but also on production costs. In general, the price can vary from \$2.25/kg in places where supply tends to outgrow demand, such as Zambia, and \$3.5/kg in places where demand outgrows supply, such as e.g. in the Democratic Republic of the Congo (DRC). Even within a country, prices will vary significantly from one place to another.

PRICES PER KG OF TILAPIA COMPARED TO OTHER PROTEINS IN UGANDA AND ZAMBIA



In Zambia, farmers can produce at around \$2/kg for a plate-sized farmed tilapia but in Uganda and Ghana these costs are higher. In most cases, local production costs in sub-Saharan Africa are still well above those in Asian and South American countries. While the production costs of farmed tilapia are at around the same level as those of broiler chicken, they are often slightly lower than those of beef. To be more competitive in the marketplace, tilapia producers in sub-Saharan Africa need to become more efficient and reduce their costs.



Tilapia Is Hard to Produce

Though we can acknowledge that it's not easy to produce in a cost-efficient and effective manner, the tilapia species is a hardy fish. It can grow in lakes, rivers, ponds, and closed systems alike. Depending on the species, tilapia can grow in almost every salinity level, making it suitable to farm in landlocked as well as coastal countries.

The fact that tilapia grows in all of these production systems and environments, and that it feeds on a largely vegetarian diet, allows it to be produced by small-scale farmers

in ponds with minimal input as well as by commercial farmers using floating pellets in cages and ponds. These factors make tilapia a farmer-friendly choice that contributes to food security, employment rates, and economic development.

Are You Convinced?

Are you convinced that tilapia can be a healthy, sustainable, and affordable fish that should play a role in meeting the future demand for fish of Africa's booming population? We hope you are by now. However, it all depends on farmers being able to work under the right conditions and to produce in an efficient and sustainable way. In the end, when sold to the consumer, farmed tilapia will only be as healthy, sustainable, and affordable as it has been produced.

The Fish that Powered the Ancient Egyptians' Transition to the After-life is Feeding the Modern World



Africa and tilapia go a long way back: tilapia is part of ancient Egyptian mythology as long ago as 3000 BC—it was believed to have strong regenerative powers and provide protection, a belief that stemmed from the female tilapia carrying her hatchlings in her mouth.¹ The ancient Egyptians called the fish “in.t,” and it was of such great importance that they created a special hieroglyph for it. Tilapia was associated with Hathor,² the mother of sky god Horus and sun god Ra. Hathor and her sons helped deceased souls transition to the afterlife—Tilapia accompanied Ra on his journey and protected his sun boat from his enemy Apophis, the serpent, warning the sun god in case of the serpent’s approach.

¹ Patrick Hunt, “Ancient Egyptian Tilapia Fish Story,” *Electrum Magazine*, September 29, 2012, <http://www.electrummagazine.com/2012/09/ancient-egyptian-tilapia-fish-story/>.

² “Hathor,” Wikipedia, last modified April 29, 2021. https://en.wikipedia.org/wiki/Hathor#Sky_goddess; “Tilapia,” Wikipedia, last modified April 23, 2021. <https://en.wikipedia.org/wiki/Tilapia>.

Tilapia was not only known in ancient Egypt but in ancient Greece, too: Aristotle is believed to have named it “fish of the Nile” in 300 BC. In Christianity, the biblical story of the “Feeding of the 5,000” speaks of Jesus feeding 5,000 people with only five loaves and two fish, which scholars think were tilapia. Tilapia is also known as “St Peter’s Fish”—in the Gospel of Matthew, the apostle Peter catches a fish, thought to be a tilapia, with a coin in its mouth in the Sea of Galilee. And in Jewish Talmudic times, tilapia was one of three main types of fish caught in the Sea of Galilee and was called “Amnoon” or “Motherfish.” The name “tilapia” that we use nowadays most likely has its origins in the Bantu languages of sub-Saharan Africa, in which the word for fish is “tlhapi.” Scottish zoologist Andrew Smith named the genus “tilapia” in 1840 based on this etymology.

SUB-SAHARAN AFRICA’S FISHERMEN CATCH ALMOST 300,000 MT TILAPIA ANNUALLY BUT CATCHES DECLINE

Many tilapia species are native to rivers and lakes in sub-Saharan Africa. And if not native, tilapia was often introduced to rivers and lakes where fish catches were declining. As such, tilapia has been an important target species for fishermen, and is a common species found on fish markets across sub-Saharan Africa.

According to the Food and Agriculture Organization of the United Nations (FAO), in 2019, fishermen across 19 sub-Saharan African countries jointly caught 286,000 MT of tilapia. Western and Eastern Africa’s fishermen are the largest producers, accounting for 144,000 and 141,000 MT each. Although fishermen continue to fish tilapia, their catches are reportedly often in decline. If stocks are well-managed, these fishermen can continue to supply a similar volume of tilapia, but are unlikely to increase their catches to meet the growing population’s demand for fish.

Tilapia has undoubtedly been a part of sub-Saharan Africa’s fish supply for such a long time that it’s already an integral part of many people’s diets. This creates an opportunity for farmed tilapia producers to step up and meet growing demand for protein in general, but also to capitalize on the expected shortfall of the wild-caught stocks. The key for farmed tilapia in doing this will be how it’s promoted: the ultimate goal is that people begin to accept farmed tilapia as a replacement for both the wild-caught variety and other (animal) proteins, and that we see it become increasingly part of people’s food habits. This is a challenge for the industry, but ultimately the move from wild-caught to farmed tilapia should not be that big for consumers. And if the farmed tilapia is positioned in the right way, it will offer some welcome relief to the wild tilapia stocks which are—in many cases—under pressure.

Young boys waiting to buy fish from fishermen at the shores of Lake Victoria, Kisumu, Kenya, Eastern Africa



³ André G. Coche, Boyd A. Haight and Michael M.J. Vincke, “Aquaculture development and research in sub-Saharan Africa. Synthesis of national reviews and indicative action plan for research,” CIFA Technical Paper No. 23 (FAO, 1994), <http://www.fao.org/3/T3340E/T3340E00.htm>.

⁴ Idem.

FARMED TILAPIA PRODUCTION IN SUB-SAHARAN AFRICA HAS BEEN ACCELERATING BUT NOT AT THE SPEED HOPED FOR

While Egypt is still Africa’s largest farmed tilapia producer, its share in Africa’s total production declined from 90% in the early 2000s to its present level of 80%. Farmed tilapia production in sub-Saharan Africa has been accelerating in recent years—although probably a bit inflated, according to the FAO, it’s currently at 267,000 MT per year, and expansion is underway in several sub-Saharan countries.

Colonial Regimes Introduce Tilapia Farming in the 1940s-1950s, and Donors Drive Slow Expansion Through Institutional Capacity Development and Smallholder Pond Production in the 1970s-1990s

Although trout farming was already introduced to sub-Saharan Africa in the 1920s, tilapia farming was first introduced in the late 1940s when colonial regimes—mainly the French and the British—brought the practice to the Democratic Republic of Congo first of all (in 1946), and then to Cameroon and Rwanda. Not long after that (sometime in the 1950s), tilapia farming was introduced to the Central African Republic, Côte d’Ivoire, Kenya, Malawi, Madagascar, Tanzania, Zambia, and Zimbabwe.³ Although production increased quite rapidly during this initial period, in the early 1960s, when many colonial regimes were coming to an end and resources became scarce, aquaculture development slowed down or even came to a halt entirely.

Catalyzed by multilateral and bilateral donor-driven programs, since the late 1960s various structural attempts have been made to revitalize aquaculture in the region. Most of these projects have—at least partly—focused on introducing tilapia farming. According to the FAO, in the 1970s and 1980s, more than \$500m, divided over more than 65 grants and loans, was invested to stimulate the sector.⁴ The main multilateral donor was the United Nations Development Program. Bilateral donors included European countries and the US, and loans were provided by the World Bank, the African Development Bank, and the French Development

⁵ Cecil Machena and John Moehl, “African Aquaculture: A Regional Summary with Emphasis on Sub-Saharan Africa,” in *Aquaculture in the Third Millennium*. Technical Proceedings of the Conference on Aquaculture in the Third Millennium, Bangkok, Thailand, 20-25 February 2000, ed. Subasinghe et al. (NACA and FAO, 2001), <http://www.fao.org/3/AB412E/ab412e21.htm>.

Agency (at that time called the CCCE). Technical assistance for these programs was provided mainly by the FAO, the US Peace Corps, and a range of NGOs and donors that implemented projects themselves. All of these projects focused on developing basic infrastructure, extension services, and the yield of small-scale producers—many of these farmers practiced fish farming as a side activity alongside growing other crops. Most of the projects that aimed to promote and introduce tilapia farming focused on pond production only; cage farming was not yet a common practice.

An increase in production only becomes more visible in the statistics from the mid-1980s onwards. Before that time, it was mainly Nigeria that produced some tilapia (at that time reporting between 2,000-5,000 MT of tilapia production annually), and Ghana and the Central African Republic (which reported a few hundred MT each). By the year 2000, 6 countries were reporting a production

above 1,000 MT, and 9 countries reported between 100-1,000 MT. All in all, the impact of the development aid invested in promoting tilapia farming in the region was disappointing for many of the governments, donors, and farmers involved.

In 2001, the FAO summed up several constraints that the sector was still facing. A lack of government support, research, and extension services were mentioned as general constraints. Overdependence on donor aid, a lack of access to affordable credit and to quality seed and feed, as well as being geographically dispersed were also mentioned as specific obstacles for small-scale farmers. For medium- and large-scale commercial producers, the FAO noted that, although they had better access to quality seed and feed, they also lacked access to credit and, more importantly, they were largely neglected by donor aid and extension services.⁵

From the Late 1990s, Donors Turn to Private Sector Development, Accelerating Tilapia Production

Tilapia production took off again in the early 2000s when, instead of only being driven by small-scale farmers, production shifted to large-scale commercial producers. Even though there were already some private companies involved in the early stages of development such as Kafue Fisheries in Zambia and Baobab Farm in Kenya, their number was limited. But over the last 20 years or so, more private companies and large-scale producers have started operations in the tilapia sector. These large-scale producers with their upstream and downstream supply chains are expected to be the catalyst for future growth.

According to the FAO, since 2003 Eastern Africa consistently produces more tilapia than Western Africa, and is accountable for a major part of this more recent growth. By 2019, FAO data showed that 8 of the top 10 producers in sub-Saharan Africa were Eastern African countries, and the region as a whole was producing 67% (177,000 MT)

of the total production of sub-Saharan Africa. But these figures are contested. Some estimate actual production to be around 125,000-150,000 MT instead of the volume reported by FAO—see p. 26. It's also reported that commercial tilapia production has only started to take off in countries like Kenya, Uganda, Zambia, and Zimbabwe since around 2012.

Some of the large-scale producers organized themselves as the Commercial Aquaculture Producers of Africa (CAPA) through which they applied for funding for cross-cutting pre-competitive work. With more donors having turned their strategies towards encouraging private sector development, more public money has become available to support the private sector directly as well as its enabling environment. Examples of private sector development programs are provided on p. 22.

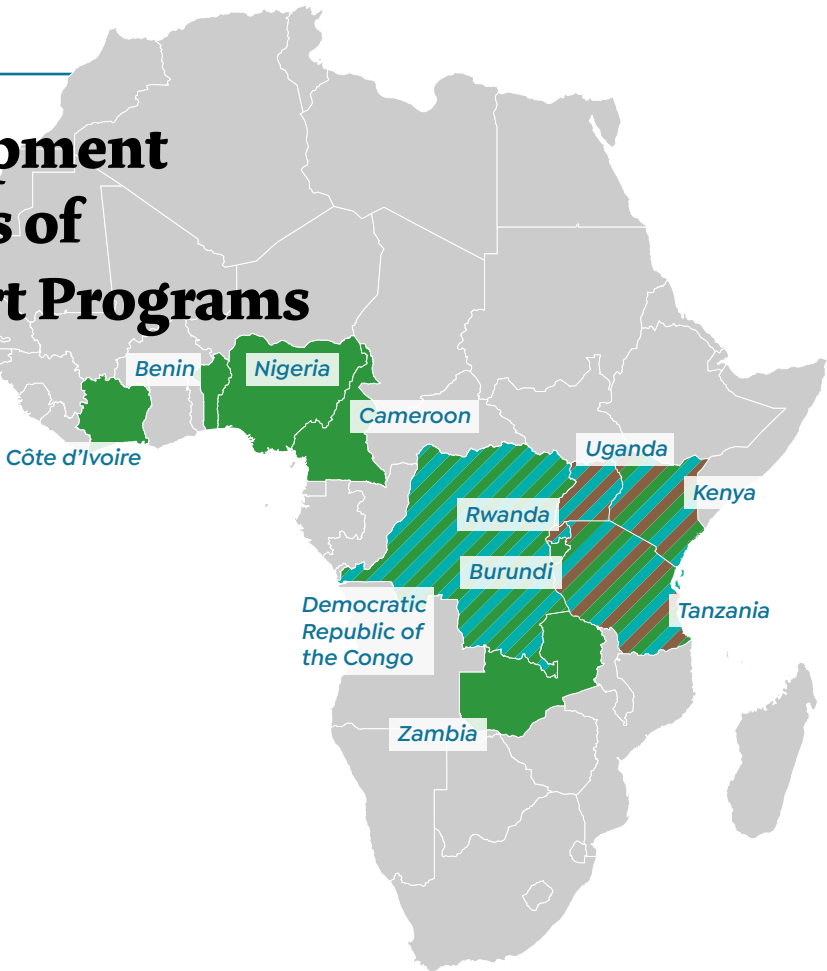
INVESTMENTS ARE NEEDED TO ACCELERATE GROWTH AND PUSH FARMING TO THE NEXT PHASE

While earlier most tilapia farming happened in ponds, most of the newly established companies are cage farmers who have obtained permits to start exploiting lakes and man-made reservoirs. All of sub-Saharan Africa's current top 4 tilapia producers farm in cages on Lake Kariba, Lake Victoria, and Lake Volta: in Western Africa, Tropo Farms, Ghana's largest cage farmer, was established in 1997 and operates on Lake Volta; in Eastern Africa, Lake Harvest started its operations on Lake Kariba in Zimbabwe in 1997 and in Zambia in 2011, and on Lake Victoria in Uganda in 2017. FirstWave, another major farmer on the same lakes in Zambia and Uganda, began operations in these countries in 2011 and 2019, respectively. Finally, Victory Farms, operating out of Kenya on Lake Victoria, started in 2015.

Many of the large-scale producers have managed to attract investment through equity or debt financing from development finance institutions (DFIs) and (impact) investors. Attracted by the promise of tilapia's huge potential to contribute to food security and economic development in sub-Saharan Africa, DFIs have started financing the expansion of major producers. Examples of DFIs engaged in tilapia in sub-Saharan Africa include the African Development Bank and Norfund (the Norwegian government)—both of which own part of the Lake Harvest Group—and Finnfund (the Finnish government) and the Entrepreneurial Development Bank (FMO)—both of which have invested in FirstWave. Some impact investors, also driven by the potential of tilapia to impact food security and development, one of which is Aqua-Spark, have also entered the space. If you want to read more on who's investing in tilapia in Africa, turn to p. 88.

Private Sector Development Increasingly the Focus of Donor-Driven Support Programs

Recently, aid programs have started to focus more on private sector development. They support the development of small and medium-sized enterprises (SMEs) and often consist of public-private partnerships (PPPs). Some of the donors and/or NGOs (e.g. many instruments of the Dutch government as well as NGOs, such as the IDH Sustainable Trade Initiative) have a co-funding requirement, which means that a grant needs to be matched with a private sector investment. The overview below lists some recent examples of private sector-focused aid programs.



MSINGI

BUILDING EAST AFRICA'S INDUSTRIES OF THE FUTURE

Donor Gatsby Foundation and UK Government
Type of financing Grant
Implementer Msingi East Africa
Timeframe 2016 – open-ended

Msingi was established by the Gatsby Foundation. Over 2016/17, Msingi developed a strategy for engagement in aquaculture and built an effective industry platform for around 30 of the region's biggest aquaculture businesses, and provided technical and business support to a group of 16 leading aquaculture producers. Among other things, Msingi is currently investing in a program that supports hatcheries with their breeding programs to improve the quality of fingerlings in the region. The company also supports investments in feed mills, cage farming operations, and fish marketing.

msingi.com/aquaculture-2/aquaculture

FoodTechAfrica

Donor Government of the Netherlands
Type of financing Co-funding (50% grant, 50% private sector)
Implementer Larive International (consultancy)
Timeframe 2012 – open-ended

FoodTechAfrica is a PPP of 21 Dutch and Eastern African companies and universities improving food security in Eastern Africa through the establishment of a fully integrated aquaculture value chain. The consortium partners use modern technology to create a profitable fish farming industry. Co-funded by the Dutch government, consortium members have established several hatcheries, farms, and a feed mill in Eastern Africa using modern, state-of-the-art technologies that could serve as examples for the region. The project finances capacity-building as well as investing in infrastructure.

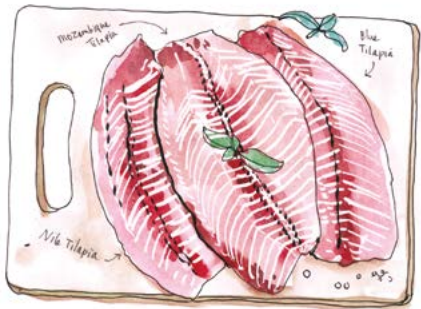
foodtechafrica.com

Technologies for African Agricultural Transformation (TAAT)

Donor African Development Bank
Type of financing Grant
Implementer WorldFish
Timeframe 2018 – 2021

A PPP consisting of companies, farmers' associations, research institutions, government institutions, and NGOs. The project aims to disseminate aquaculture technologies deployed by WorldFish, such as those required to (1) produce fast-growing mono-sex tilapia fingerlings; (2) produce quality low-cost fish feed; and (3) improve the overall productivity of fish farms. The private sector is engaged as the buyer of the technologies and to disseminate the tech to other fish farmers. The program finances training and exchange programs, but does not finance investments in hardware that companies need to make.

taat-africa.org/aquaculture



1 Tilapia originates from Africa and the Middle East, and has been part of these regions' diets for many ages. Over the past century, tilapia has been introduced to almost every other continent: it's become the coffee of aquaculture.



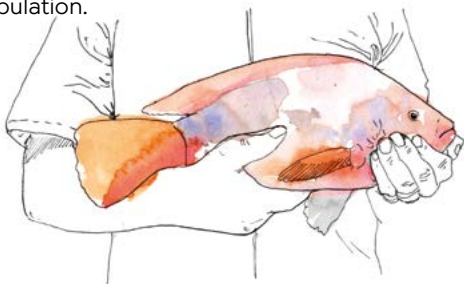
4 Red tilapia, black tilapia, and even zebra tilapia: just a few examples of the colors tilapia can have. Only a few species are commercially farmed, with the Nile tilapia and the Mozambique tilapia being the most important ones.



6 Tilapia efficiently converts feed into fish as long as it doesn't start reproducing—one of the reasons why a tilapia farmer often prefers an all-male population.



8 Tilapia can be grown in freshwater and seawater, and everything in between. There's a tilapia species for every salinity level!



9 In 2019, fishermen in sub-Saharan Africa caught 283,000 MT of tilapia (according to the FAO). Farmers produced another 125,000-150,000 MT (our own estimate). Tilapia accounts for 3% of wild-caught and 40% of farmed fish in sub-Saharan Africa.



3 An omnivorous fish, tilapia can digest both animal and vegetable proteins. It feeds mainly on corn and soy, but can also grow on algae and insects. Talk about being flexible!



5 Full of collagens, tilapia skin is used in Brazil to treat burns—with encouraging results! Don't worry, the tilapia skin is treated before use to remove its fishy smell.



7 A caring fish, tilapia protects its eggs and larvae by holding them in its mouth. For this reason, tilapia has always been associated with fertility and protection.



10 Manolo Blahnik, whose designs were featured in the popular television series *Sex and the City*, has produced a range of sustainable shoes made of tilapia skin which used to be for sale for \$895.

10 Things You Didn't Know About Tilapia

A Closer Look at Sub-Saharan Africa

LEGENDA

Population (1 = 10,000,000)

Population growth

Total GDP at current prices
\$ = \$1,000,000,000

Average GDP growth rates

Average per capita fish consumption in kg (1 = 1kg)

% of fish in total animal protein consumption

DEFINING SUB-SAHARAN REGIONS

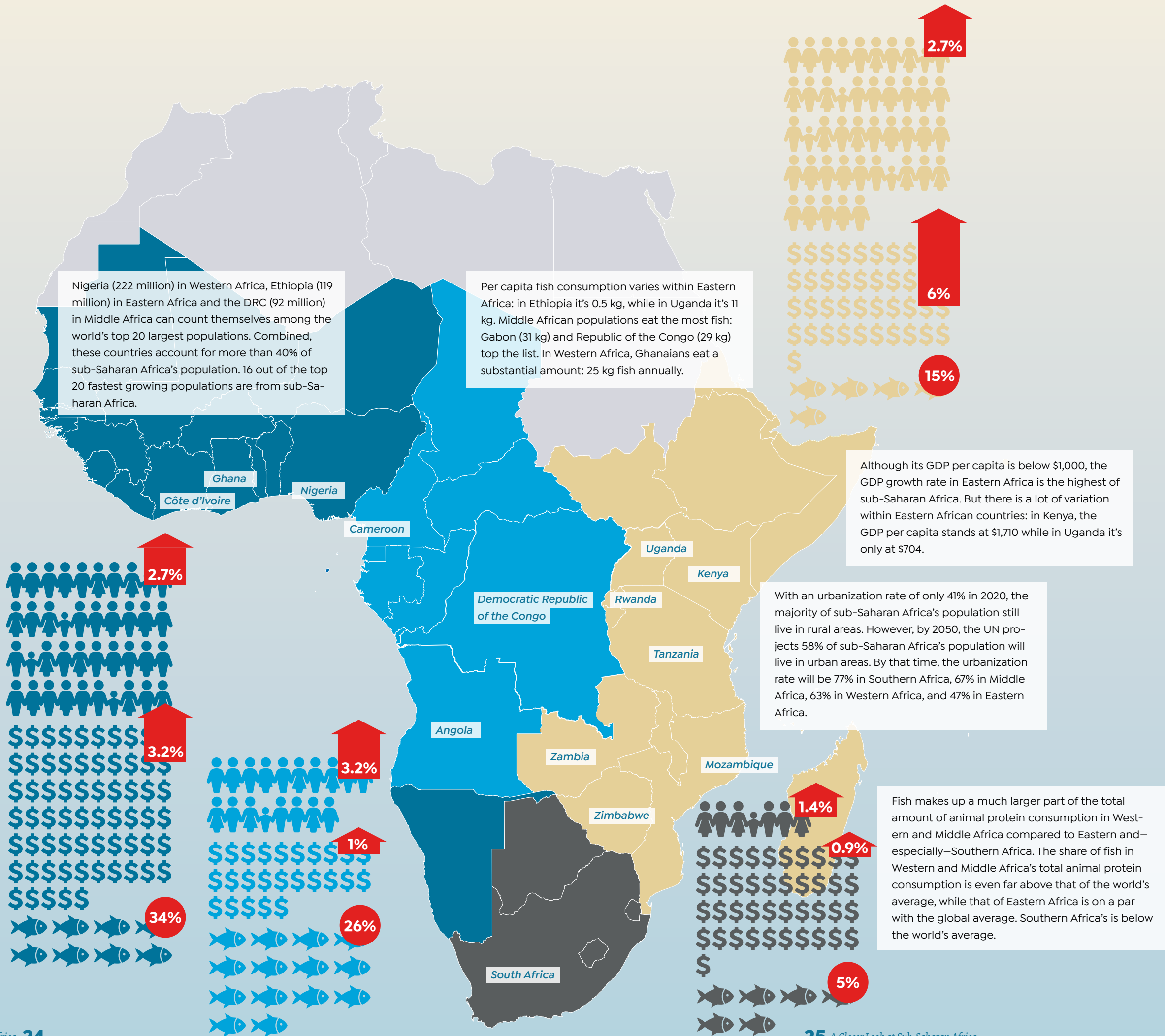
This report covers tilapia farming across all of sub-Saharan Africa. When relevant, we look separately at Middle, Eastern, Southern, and Western Africa. When speaking about these regions we use the definition of these regions as used by UN stats.

Western Africa

Middle Africa

Eastern Africa

Southern Africa



Tilapia Production in Sub-Saharan Africa

Western Africa

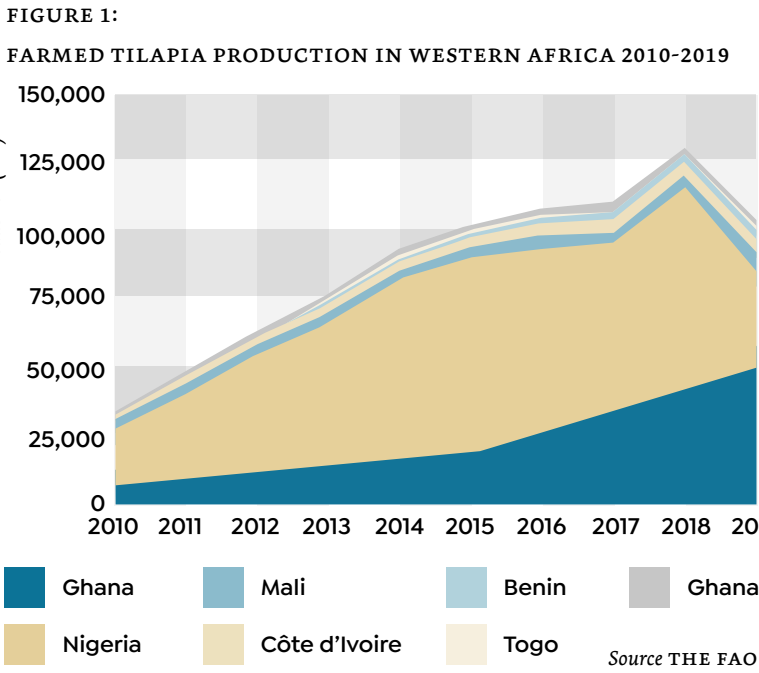
Figure 1 shows farmed tilapia production in all Western African countries from 2010–2019. According to the FAO, in 2019, Western Africa produced 83,000 MT of farmed tilapia. On top of that, Western Africa produced 143,000 MT of wild-caught tilapia. But let’s take a look at the production of farmed tilapia.

Ghana

Ghana is the largest farmed tilapia producer of Western Africa. Production is concentrated around Lake Volta and its lower river basin. Twenty or so large and medium-scale cage farmers combined, such as Tropo Farms, West African Fish, Flossell, and Triton, produce the majority of farmed tilapia. A couple of large-scale land-based farms and around 2,000 small-scale farms complement production. According to the FAO, Ghana’s output dropped from 71,000 MT in 2018 to 46,000 MT in 2019. However, insiders in Ghana’s aquaculture industry suggest that these numbers have always been slightly inflated and might never have exceeded 50,000 MT. They estimate current production to be more likely at around 25,000 MT.

Ghana’s recent decline in production can be attributed to disease challenges at several farms on Lake Volta and the Volta River. The disease outbreaks, the largest in sub-Saharan Africa’s tilapia sector so far, were allegedly caused by farms that imported broodstock that carried pathogens and were infected (more about diseases on p. 68).¹ While some believe that Ghana’s production will improve once these disease issues are mitigated, others feel that other structural challenges, such

DISCREPANCIES BETWEEN FAO DATA AND INDUSTRY ESTIMATES
The FAO is the only comprehensive source for global wild-caught and farmed tilapia production data. Some believe that this data, reported to the FAO by national governments, is inflated. Others believe that those questioning FAO data are mainly large-scale producers and feed manufacturers who underestimate the production of small-scale farmers. Keeping these different perspectives in mind, actual production will likely be somewhere in the middle. Where applicable, this section mentions discrepancies between FAO numbers and industry estimates.



as the current restriction on importing advanced genetics, need to be solved first. Ghana’s government regulations obligate farmers to use the local Akosombo tilapia strain.² The Genetically Improved Farmed Tilapia (GIFT) strain, commonly used in other countries, grows twice as fast as the Akosombo strain.³ Ghana’s producers argue that while their government intends to protect the local industry, improved genetics will allow farmers to reach their production targets. They claim that controlled imports can prevent broodstock that possibly carry diseases from being smuggled into the country—more about the importance of genetics on p. 64.

¹ José Gustavo Ramírez-Paredes et al., “First detection of Infectious Spleen and kidney Necrosis Virus (ISKNV) associated with massive mortalities in farmed tilapia in Africa”, *Transboundary and Emerging Diseases* (2020): <https://www.biorxiv.org/content/biorxiv/early/2020/04/28/680538.full.pdf>.
² Efua Konyim Okai, “No strains, no gains: are Ghana’s bio-restrictions harming its aquaculture?”, *The Fish Site* (2018): <https://thefishsite.com/articles/no-strains-no-gains-are-ghanas-bio-restrictions-harming-its-aquaculture>.



Check out this video about recent challenges in tilapia farming in Ghana

³ Robert Fletcher, “GIFT versus Akosombo strain tilapia – which fare better in Ghana?”, *The Fish Site* (2020): <https://thefishsite.com/articles/gift-versus-akosombo-strain-tilapia-which-fare-better-in-ghana>.

Nigeria

While farmed tilapia production in Nigeria, according to the FAO, reached a peak of 28,000 MT in 2015, it dropped to 21,000 MT in 2019. With this amount, Nigeria only comes second after Ghana in terms of farmed tilapia production. However, if we would add the 66,000 MT of wild-caught tilapia as reported by the FAO to this figure, Nigeria would currently be Western Africa’s largest tilapia producer. In terms of aquaculture, tilapia is Nigeria’s second-most important species. At 157,000 MT, North African catfish (*C. gariepinus*) is farmed much more extensively.

As the Niger Delta is very suitable for production and there’s a huge domestic demand for fish, Nigeria is believed to have the potential to become a significant tilapia producer. However, only a few larger producers—such as Stallion (Premium

Aquaculture) and Triton—produce substantial volumes of tilapia. Another major farming project is reportedly being developed as we speak. So far, there aren’t many other large producers. However, with the establishment of the Tilapia Aquaculture Developers Association Nigeria (TADAN) and its drive to promote commercial tilapia production, the desire to increase production over the next couple of years may be gaining momentum.

Just like their colleagues in Ghana, one of the significant challenges Nigeria’s producers face, as identified by the TADAN, is their access to improved genetic strains. Recent genetics shipments from the Dutch Til-Aqua and plans from the Nigerian government to introduce WorldFish’s GIFT strain into the country may well change this soon.

Other Producers

While production in Ghana and Nigeria recently tumbled, other producers in Western Africa are stepping up. Mali (5,800 MT), Côte d’Ivoire (3,700 MT), and Benin (2,800 MT) each have surpassed 1,000 MT, and smaller producers like Togo, Burkina Faso, Senegal, Niger, and Sierra Leone now produce several 100 MT each. While there are often a cou-

ple of commercial producers that drive production in these countries, a considerable part is accounted for by small-scale producers supported by government and development aid funding. With imports of cheap Chinese tilapia into Western Africa rising (see p. 45), there’s clearly sufficient demand that could be met by production expansion.

THE NORTH OF EASTERN AFRICA



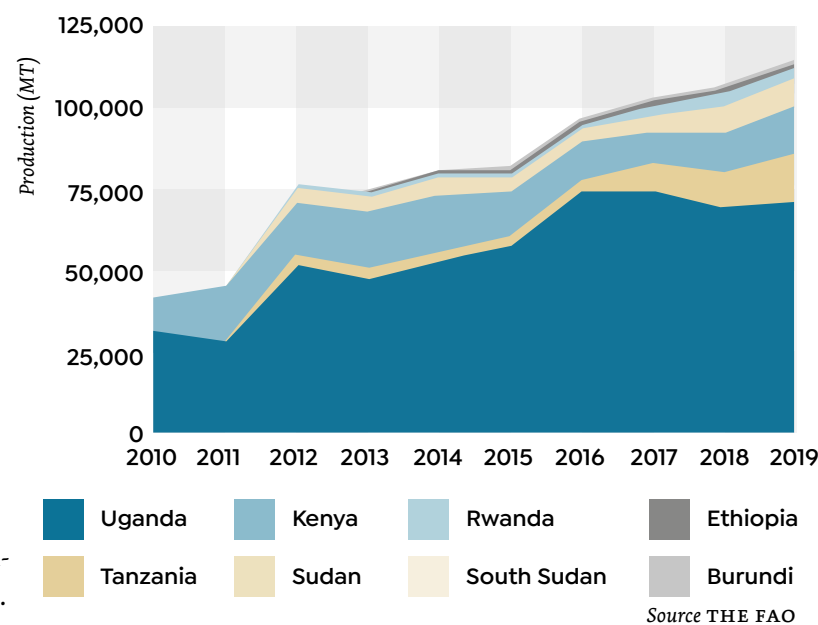
Eastern Africa

According to the FAO, in 2019, Eastern Africa produced 142,000 MT of wild-caught tilapia and 176,000 MT of farmed tilapia, making it the largest tilapia producer in sub-Saharan Africa. The UN definition of Eastern Africa, used in this report, is very broad (pp. 24–25). Because the tilapia sectors in the north and south of Eastern Africa operate independently, we'll look at these regions separately.

The North of Eastern Africa

According to FAO data, the north of Eastern Africa produced 115,000 MT of farmed tilapia in 2019. Its production of 71,000 MT would make Uganda the largest producer, though some insiders in the aquaculture industry estimate the country's production to be at best around 20,000–30,000 MT. Even if this were the case, if we add Uganda's 30,000 MT of North African catfish production (after Nigeria, the largest in sub-Saharan Africa), it's apparent that Uganda is the region's aquaculture leader. The country produces possibly twice as much tilapia as Kenya and Tanzania, which each produced 10,000–15,000 MT. Production in Tanzania has expanded faster than in Kenya.

FIGURE 2:
TILAPIA PRODUCTION IN THE NORTH OF EASTERN AFRICA
2010–2019



Sudan (8,100 MT), Rwanda (3,500 MT), Burundi (1,460 MT), and Ethiopia (290 MT) are also upcoming producers, though still operating on a smaller scale.

Cage farmers, especially those on Lake Victoria, the waters of which are shared by Kenya, Tanzania, and Uganda, have contributed most to production expansion. While producers in Uganda—such as Lake Harvest, Yalelo Uganda, and IG

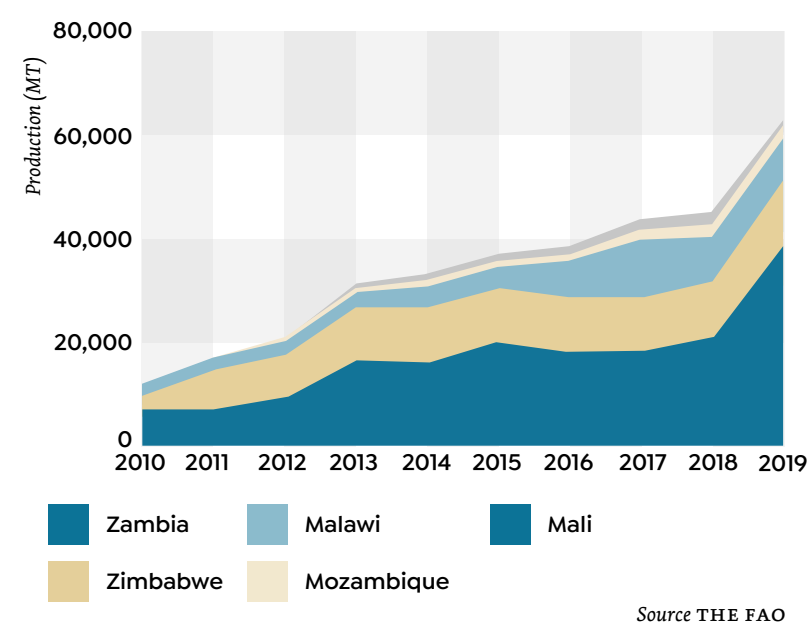


Check out this video from 2020 about the challenges and opportunities of aquaculture development in Uganda.

THE SOUTH OF EASTERN AFRICA



FIGURE 3:
TILAPIA PRODUCTION IN THE SOUTH OF EASTERN AFRICA
2010–2019



Check out this video from 2020 about the challenges and opportunities of aquaculture development in Zambia.

Invest—and Victory Farms in Kenya dominate output, the number of small and medium-scale cage farmers—such as Perch of the Nile—has been on the rise as well. With expansion plans of all significant farmers on Lake Victoria underway and others aiming to start operations, production from Lake Victoria is likely to increase further over the next couple of years. Much of the development in other countries in the region is also driven by cage farming, such as production on

Lake Kivu and Lake Muhazi in Rwanda. While cage farming plays a dominant role, land-based farming by small and medium-scale producers continues to expand as well, often with the help of donor and government-driven programs. Almost all tilapia produced in Eastern Africa consists of Nile tilapia, both imported and from local strains.

With the governments of several countries in the region having aquaculture prioritized in national policies, expansion in the region is likely to continue. Donors might play an important role both for small-scale and large-scale producers. For example, the EU is supporting the Ugandan government in establishing two aquaparks with a capacity to produce around 2,000 MT of tilapia each that will be managed by the Ugandan government as public-private partnerships where the private sector can operate the farms under lease agreements. Other national governments, such as the government of the Netherlands, and non-profit organizations, such as Msingi East Africa, actively support aquaculture development in the region.

The South of Eastern Africa

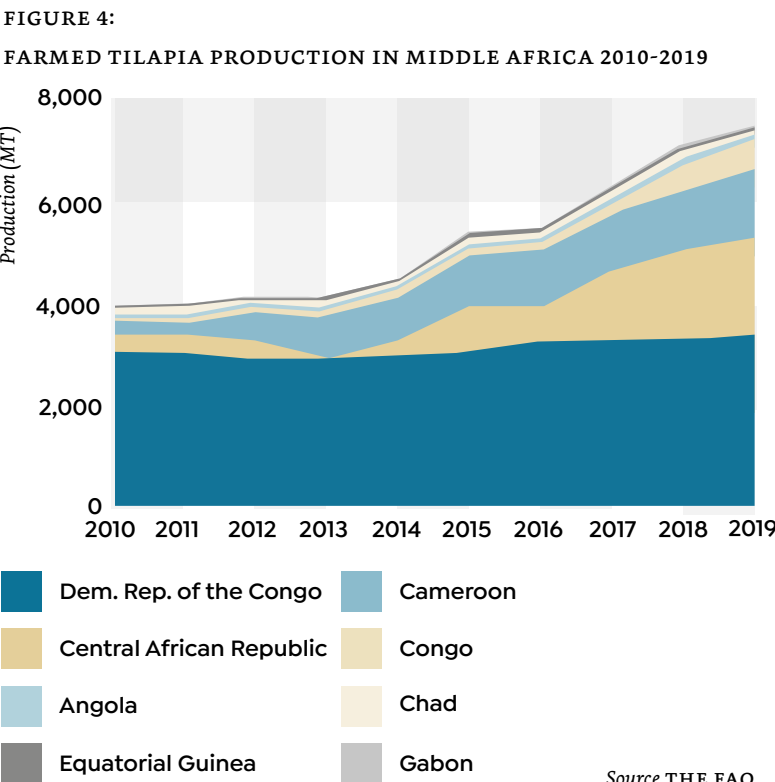
Contrary to the north of Eastern Africa, in the south, sometimes forced by government regulations, farmers do not only produce Nile tilapia but sometimes also produce other species such as Mozambique tilapia (*O. mossambicus*), redbreast

tilapia (*C. rendalli*), and Shire tilapia (*O. shiranus*), which are native to the area. According to the FAO, the region produced 62,000 MT of tilapia in 2019, of which Zambia contributed 38,000 MT. Zimbabwe (12,000 MT) and Malawi (8,000 MT) are the two other major producers in the region. Production in Mozambique (2,500 MT) and, to a lesser extent, in Madagascar, is increasing. Although these numbers are a good indication of what’s happening in terms of production, many people also warn of inflation of FAO numbers in the case of Zambia and other countries in the region.

Just like in other parts of sub-Saharan Africa, commercial producers dominate production in the south of Eastern Africa. A significant amount of production comes from Lake Kariba, located in the south of Zambia at the border with Zimbabwe. Tilapia harvested from Lake Kariba is marketed as “Kariba Bream.” It’s the only region in Zambia where the cultivation of Nile tilapia is allowed. Production on Lake Kariba is dominated by Yalelo Zambia and Lake Harvest (Zambia and Zimbabwe), but some smaller cage farms have started operations on Lake Kariba more recently. Commercial farmers are also producing increasing volumes of tilapia on other lakes in the region. Examples include Mpende Fisheries on Lake Tanganyika (Zambia), Maldeco Fisheries on Lake Malawi (Malawi), and Chicoo on Cahora Bassa Lake (Mozambique).

Middle Africa

Figure 4 shows farmed tilapia production in all Middle African countries from 2010–2019. Middle Africa produced 500 MT of wild-caught and 7,300 MT of farmed tilapia in 2019, according to the FAO. While fish consumption in Middle Africa is much higher, it’s a much smaller producer than other regions in sub-Saharan Africa. To meet local demand, the area imports tilapia from neighboring countries and China. Though on a small scale, production continues and is increasing in several countries.



Besides cage farmers, there are also some larger land-based farms in this region, of which the most well-known are Kafue Fisheries in Zambia and Chambo Fisheries in Malawi. According to Zambia’s Department of Fisheries, in 2019, cage farming accounted for 70% of total tilapia production, large-scale pond production for 10% and the remainder was accounted for by small-scale producers. Although figures for other countries are not available, the Zambian situation is most likely representative for the region.

Also in the south, governments are very supportive of aquaculture development. Donors once again play an important role in the national strategies. The International Fund for Agricultural Development (IFAD), for example, has just launched a new program with the government of Mozambique where it will provide a \$33.4m grant and an \$8.6m loan to the government to support 88,000 fish farmers to transition from subsistence farming to becoming commercial entrepreneurs. The aim is to connect them to the commercial aquaculture value chain, linking them to markets and business partners.

⁴ Andrew Parker et al., “Short-term research support: Rapid Assessment of the Aquaculture Sector in the DRC”, UKAID (2018): <https://www.opml.co.uk/files/Publications/a1281-managing-decision-support-unit-verification-evaluation-private-sector-development-programme/full-research-paper-rapid-assessment-of-the-aquaculture-sector-in-the-drc.pdf?noredirect=1>.

Aquaculture in the region is mainly concentrated around the Congo River Basin and Lake Kivu. The Democratic Republic of the Congo (DRC) is the largest producer, but output has somewhat stagnated at around 3,000 MT, and the country has yet to prove its potential.⁴ Current production in the DRC consists of a mix of small-scale and large-scale pond culture around Kinshasa, and small-scale pond and cage culture closer to Lake Kivu. Angola has become the region’s second-largest producer but still produced only 1,900 MT in 2019. Even Cameroon, believed to have tremendous potential for aquaculture de-

velopment, produced only 1,300 MT in 2019. Yet with Cameroon’s government prioritizing aquaculture development and having set a production target of 100,000 MT yearly, output in the country is predicted to surge.

While many feel that the region has great potential and several donors and governments support the development of aquaculture, the sector in Middle Africa has yet to deliver on its promise to supply Africa’s booming population with an affordable protein.

Southern Africa

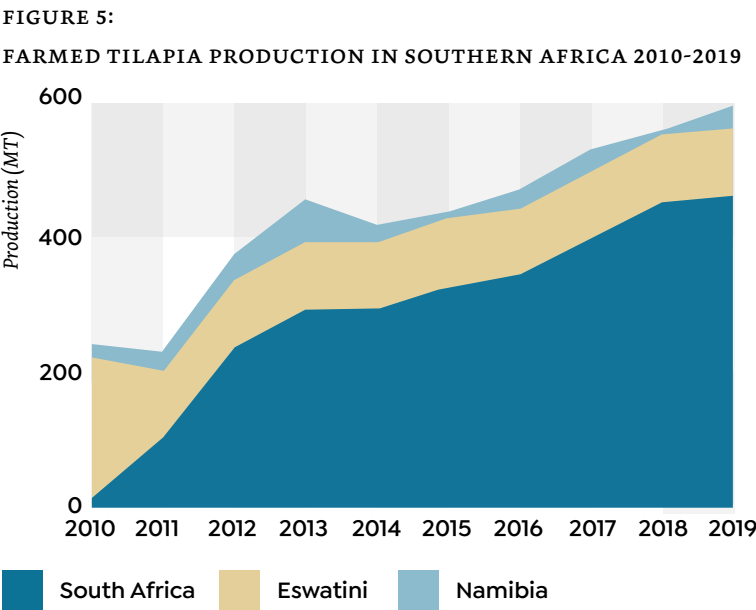
Figure 5 shows farmed tilapia production in all Southern African countries from 2010–2019. Southern Africa produced less than 600 MT of farmed tilapia and less than 100 MT of wild-caught tilapia in 2019. However, the area imported 12,000 MT of tilapia as well, which is sold in the region and in the south of Eastern Africa.

⁵ Guy Rogers, “Wild Coast fish farm gets a fillip”, *DispatchLIVE* (2020): <https://www.dispatchlive.co.za/news/2020-07-29-wild-coast-fish-farm-gets-a-fillip/>.

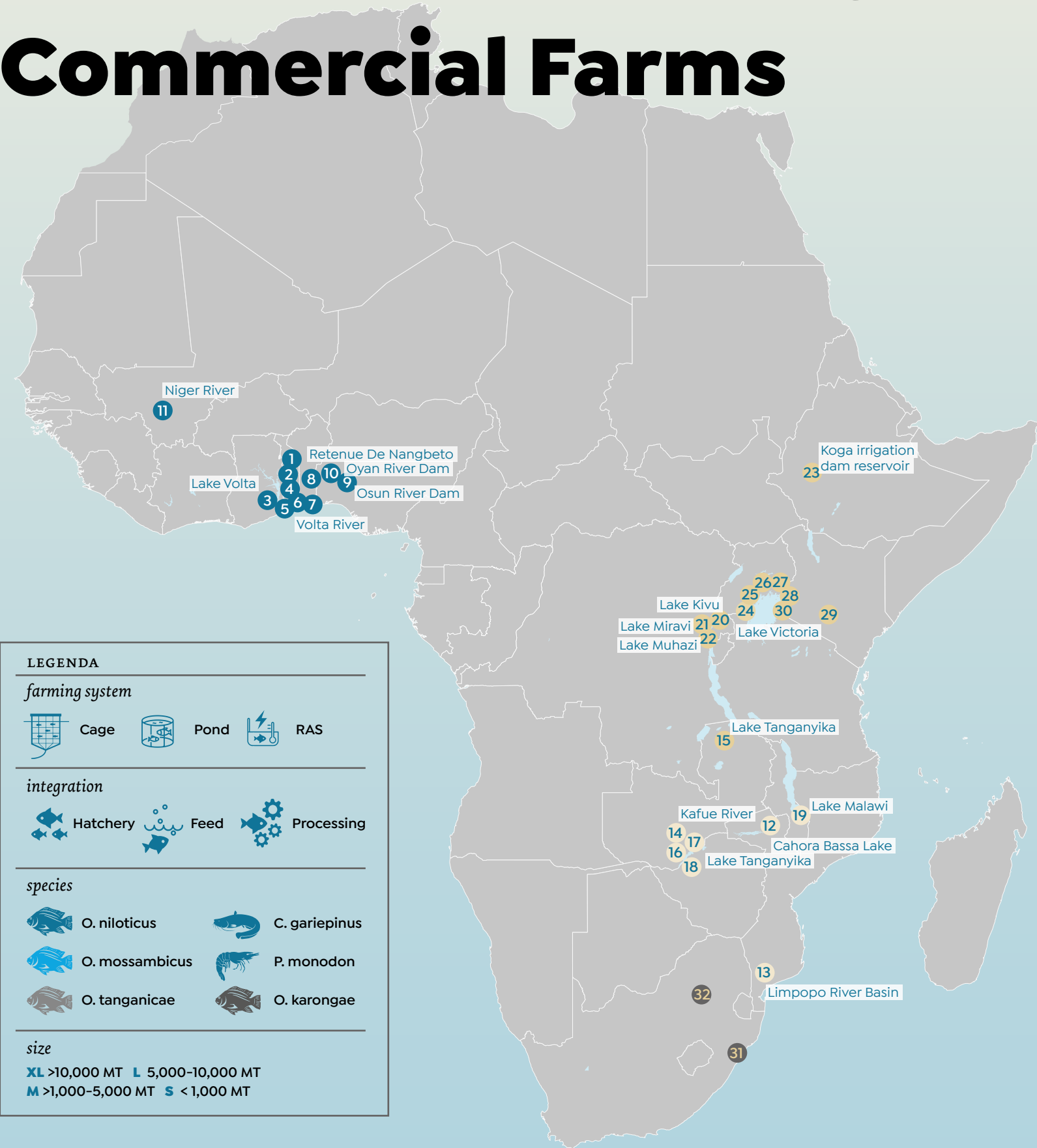
While South Africa’s tilapia farming represents the lion’s share of tilapia production in the region, the country only produces a very small volume. The main reason is the climate: Nile tilapia doesn’t grow properly below 24 degrees Celsius, and winters in South Africa can get much colder. As a result, inland tilapia farming has mainly developed in closed recirculating aquaculture systems. These farms are relatively small and operate at high costs, but are often located in or close to cities, which allows them to sell their fish to nearby premium markets.

Coastal tilapia farming is somewhat on the rise. An Eastern Cape Rural Development Agency (ECRDA) initiative aims to develop farms using biofloc systems.⁵ The incubator of the project, a farm with a capacity of producing 2,000 MT, is being established. This farm will serve as a model for other farms, and the plan is to eventually develop five clusters of farms with a capacity of 20,000 MT each, which should be operational by 2030. Even though regional and national authorities prioritize this project, we’ll have to wait and see whether required partners and investors will come aboard.

Tilapia farming in closed recirculating aquaculture systems might not reach a significant scale, and the new initiatives for coastal tilapia farming still have to prove themselves. We should therefore not expect Southern Africa to become a significant player any time soon.



Overview of Well-Known and Upcoming Commercial Farms



	Farm Name	Part of Group	Size	Farming System	Species	Integration
1	Delta Fisheries		S			
2	Triton Ghana	Triton Aquaculture Africa	M			
3	West African Fish	Royal Danish Fish	M			
4	Tropo Farms		L			
5	Fish n Feeds Ghana	DanMarin (Kangamut Group)	S			
6	Florell		M			
7	Maleka Farms		S			
8	Lofty Farm		M			
9	Triton	Triton Aquaculture Africa	M			
10	Premium Aquaculture	Stallion	M			
11	Complex Baragnouma		M			
12	Chicoa Fish Farm		M			
13	Papa Pesca		S			
14	Kafue Fisheries		M			
15	Mpende Fisheries		S			
16	Kariba Harvest	Lake Harvest Group	M			
17	Yalelo Zambia	FirstWave Group	XL			
18	Lake Harvest Aquaculture	Lake Harvest Group	M			
19	Maldeco Fisheries	Press Corporation Limited	M			
20	Lake Kivu Tilapia		M			
21	Lakeside Fish Farm		S			
22	Frefish		S			
23	Africa Sustainable Aquaculture		S			
24	Yalelo Uganda	FirstWave Group	M			
25	Perch of the Nile		S			
26	IG Invest		M			
27	Source of the Nile (SON)	Lake Harvest Group	M			
28	Victory Farms		L			
29	Kamuthanga Farm		S			
30	Dominion Farms	Dominion Group	M			
31	Zini Fish Farms		S			
32	David Fyncham Aquaculture		S			



Cage Farming Dominates Commercial Tilapia Production but Ponds and RAS Have Potential As Well

Cage farming site of Yalelo Uganda

As we have seen in the previous sections of the report, commercial cage farming has driven most of the recent growth also in tilapia production. However, land-based ponds and recirculation aquaculture systems (RAS) play a role. Let's take a look at the three production systems.

Cage Farming Will Drive Short- and Mid-Term Growth but Has Its Limits in the Long Run

Over the past two decades, commercial cage farming has driven tilapia production in sub-Saharan Africa, and may continue to do so for the foreseeable future.

As it stands, 1 company produces above 15,000 MT; 3 companies produce 5,000-15,000 MT; about a dozen companies produce 1,000-5,000 MT; and roughly a hundred companies produce 50-1,000 MT.

Commercial cage farms may account for 60-75% of total farmed tilapia production in sub-Saharan Africa.

To start a cage farm first of all requires obtaining a government permit. Governments have a crucial role in regulating the expansion of cage farming and everything related to it. If not done properly, the carrying capacity of a waterbody may be exceeded and/or diseases or invasive species may be introduced. This would put production of all tilapia farmers, and others such as local fishermen, at risk. Therefore, it's also in the farmers' interest that expansion is correctly managed. Recent events in Ghana have shown the potential devastating impact where disease spreads from one cage farm to another. This occurred as one farm allegedly introduced

imported tilapia carrying pathogens to Lake Volta. Enforcing good aquaculture practices and public-private cooperation are, thus, crucial for all stakeholders.

Cages

CAPEX	High
OPEX	High
Type of feed	Extruded pellets
Stocking densities	Medium
Environmental risk	Medium
Disease risk	Medium
Technical risk	Low
Production \$/kg	Medium

An important investment is, of course, the cages. They can come in different shapes (rectangular, circular) and sizes. Farmers use smaller nursery cages positioned in protected areas of the lake and larger cages for growout, which are sometimes positioned in deeper waters. The larger cages require large boats to place and anchor them. Farmers need to continuously inspect and maintain the nets of the cages to ensure that damage doesn't result in escapees. This is in the interest of the farmer, but also in the interest of others: one of the major concerns of cage farming is that farmed tilapia, being highly invasive, will threaten local fish populations if they escape from the cages.

How to Build a Vertically Integrated Cage Farm

So what does it take to build a cage farm of the size that has the potential to become a sizeable tilapia operation? Aqua-Spark’s assessment is that the total capital expenditure (CAPEX) for 10,000 MT farms is around \$9-10m. This investment can be staged over multiple years and, potentially, be partly debt financed. The growout cages account for around \$5m, including all equipment and contingency-related costs. An investment in a hatchery for such a farm is a must if access to high-quality fingerlings needs to be assured. Aqua-Spark estimates that a total of \$2m needs to be invested to reach the hatchery capacity to provide year-round, high-quality juveniles for the growout.

A farm also needs to invest in other areas, such as buildings and roads, and although it depends a lot on the situation, Aqua-Spark estimates that this size of farm will need to invest \$2.25m of its CAPEX in infrastructure. These figures exclude investments in feed production and distribution channels, which is additional to the initial \$9-10m.

From a financing perspective, there are a couple of main takeaways. Underfunding is one of the biggest risks. Expansion has its ups and downs, and a lack of

cash for CAPEX or working capital could potentially lead to delays and higher costs. At the first stage of development of a farm, the majority of the CAPEX and working capital needs to be financed through equity. In the later stages, with more steady cash flows, the company might be able to partly finance the scale-up from its own cash flows and debt. Another takeaway is that the period between ordering the cages and actually having the cages “in the water” can take up to 6 months, requiring detailed financial planning.

Aqua-Spark believes that 7-10 years is the minimum amount of time needed to establish a 10,000 MT tilapia farm: 1-3 years are required to develop site infrastructure and the hatchery, and the first 1,000 MT/year of growout production can be expected. Years 3-5 are when growout production grows rapidly to 5,000 MT/year. Years 5-7 are when investments in feed production and processing are made, which enable additional growth to 7,000 MT/year. Years 7-10 are when the optimization of farming practices and sales channels occur, tech is implemented at all stages of the supply chain, and a new farming site is established. Production increases to 10,000 MT/year.



Countries | **Uganda, Zambia, and Zimbabwe**
Top Management | **James de la Fargue, CEO**

Lake Harvest Group was the first vertically integrated tilapia producer in Eastern Africa and is partly owned by Norfund, the African Development Bank, and African Century Limited. Lake Harvest started with a hatchery and farm in Zimbabwe at Lake Kariba in 1997 and ventured into the Zambian waters of the lake in 2010. In 2012, the company opened up the Source of the Nile (SON) fish farm at Lake Victoria in Uganda. Early on, it invested in processing facilities and a distribution network to serve markets across Southern and Eastern Africa. Partnerships include: Skretting to produce feed in Zambia (2017); Ictyopharma/Virbac on fish health (2018); and Benchmark Spring Genetics (2020) to obtain advanced genetic broodstock. In 2020, the company produced 7,000 MT of tilapia.



Country | **Ghana**
Top Management | **Mark Amechi, Founder, and Glisson Wilson, CEO**

Tropo Farms, just like Lake Harvest Group, was established in 1997. It was the first large cage farm in Ghana and is still today the largest farm in the country. The company runs two hatcheries and two farming sites, and has invested in a distribution network. In Ghana, the company is also known as Volta Catch, the name of its brand. So far, contrary to most of the other large farms, Tropo Farms has not asked for equity investment and the company is still entirely owned by its founder, Mark Amechi. Although in recent years production declined due to the situation at Lake Volta, output is estimated to reach around 8,000 MT again in 2021.



Country | **Mozambique**
Top Management | **Damien Legros, Co-Owner, and Gerry McCollum, Co-Owner**

Chicoa Fish Farm was founded in 2015 by a management team that previously set up the Lake Harvest in Zimbabwe. Chicoa is the first and only farm producing tilapia at a previously desolate location at Cahora Bassa Lake in Mozambique. Its cages are situated in deep waters close to the shore, making it cost-effective to operate, but a lack of infrastructure has been a major challenge for the company. Aqua-Spark has made several rounds of investment, and Goodwell Investments and IDH Farmfit Fund have joined as co-investors. Production reached 900 MT in 2020 and is expected to reach 1,500 MT in 2021. Chicoa aims to become one of the largest tilapia producers of the south of Eastern Africa and should reach 20,000 MT over the next couple of years—10,000 MT of which from the company’s own farm and 10,000 MT through outgrowers.



FirstWave Group

Countries | **Uganda and Zambia**
Top Management | **Adam Taylor, Co-Founder and Chairman; Bryan McCoy, Co-Founder and Co-CEO; and Tembwe Mutungu, Co-Founder and CEO**

FirstWave Group has grown from a start-up into a regional aquaculture leader within just 5 years. The company was founded in 2011 and since then has managed to attract a range of impact investors and development banks to support its growth. It started with a hatchery and farming operation at Lake Kariba in Zambia and expanded to Lake Victoria in Uganda in 2018. In 2017, the company invested in an aquafeed mill in Zambia in a joint venture with Aller Aqua Zambia. Recently, the company announced a partnership with Xelect to establish a family-based genomics selection program. Both Yalelo Uganda and Yalelo Zambia have considerable investments in distribution including 60 retail outlets, 30 supermarket concessions, and sales operations across the region.



Country | **Kenya**
Top Management | **Joseph Rehmann, Founder and CEO**

Victory Farms was founded in 2015 and is now one of the four largest tilapia producers in sub-Saharan Africa. The company harvested 6,000 MT in 2019 and expects to harvest around 9,000 MT in 2021. Besides its hatchery and farm, Victory Farms has invested heavily in a distribution network involving more than 10,000 traditional female traders that distribute and sell fish to hotels, restaurants, and the many roadside stalls in Kenya’s urban areas. Victory Farms received a mix of equity and debt from early private investors Hans den Bieman (among others former board member of Nutreco and former CEO of Marine Harvest) and Ed Brakeman (former Senior Managing Director of Bain Capital) and, more recently, from organizations like Msingi East Africa, DOB Equity, and Conservation International Ventures. As we speak, the company is going through a Series B funding round.

Pond Farming Can Result in a Competitive and Sustainable Product for the Market

While some of the current commercial pond-based tilapia farms were already established long before the first cage farms existed, their number and scale are now staying behind. Nevertheless, there are at least two or three medium-scale commercial pond farms producing anywhere between 1,000 and 5,000 MT/year, and a couple of dozen small-scale commercial pond farms producing several hundred MT/year each across the region. Their contribution to total tilapia production is likely not to exceed 10%. Small-scale farmers often use similar systems to commercial pond farms to produce tilapia, but an in-depth look at small-scale production systems is not within the scope of this report. Further expansion of commercial pond farming may be limited due to the scarce availability of affordable land close to the freshwater resources required for freshwater fish farming. However, in the future, small-scale pond farming by farmers who own land in these areas may become more prominent when the expansion of cage farming has reached its limits. Commercial farmers may play a crucial role in supporting small-scale farmers to become successful through outgrower programs (see p. 41).

Potentially, pond farming can be a relatively low-cost method to produce tilapia and result in

a competitive product for the market. In sub-Saharan Africa, tilapia pond farming mainly consists of production in fertilized “green water” ponds where tilapia can feed on plankton that grows in the pond. Pond farmers don’t use high protein diets. They supplement the naturally occurring sources of nutrition in the pond—which are normally high in protein—with raw feed ingredients or low-protein formulated feeds. This reduces the production costs significantly. In some cases, tilapia farming is combined with black tiger shrimp (*P. monodon*) or other marine fish species in a polyculture set-up. Contrary to more intensive, higher density tilapia pond farming, these extensive farming methods don’t require significant aeration and therefore electricity is less important, although water pumps may sometimes be needed to maintain the water level and quality for the fish to thrive.

Ponds

CAPEX	Medium
OPEX	Low to medium
Type of feed	Natural, raw feed ingredients and extruded pellets
Stocking densities	Low to medium
Environmental risk	Low
Disease risk	Low to medium
Technical risk	Low
Production \$/kg	Low



Makindi Farm in Kenya

Papa Pesca

Country	Mozambique
Top Management	Pieter de Klerk, Owner

Papa Pesca is a pond-based tilapia farm on the Limpopo river flood plain in Chokwé, Mozambique. It uses saline land which otherwise is wasted. It’s located close to Maputo and Johannesburg and as such has access to market. Currently the company manages its own breeding program and consists of a hatchery and a farm. The latter is also used as a training facility for youth and is supported by Norges Vel—a Norwegian NGO. Due to its low input production system where even green water exchange is managed through gravity, the farm can produce tilapia relatively cheaply. As and when fully developed the farm has a total capacity to produce 3,000–4,000 MT annually.

Fish and Feed Ltd.

Country	Ghana
Top Management	Rajiv Banerjee, CEO

Fish and Feed Ltd. was founded in 2018 and may well be the newest pond farm in sub-Saharan Africa. The farm is owned by Dan Marin (part of one of Denmark’s largest fishing companies) and Kewalram Chanrai Group. Today, the company operates 20 ha of extensive tilapia and black tiger shrimp ponds along the Volta River, has its own distribution channels, and also has an app through which it sells its fish. It can produce around 600 MT of tilapia and 120 MT of black tiger shrimp per year. Although starting small, the company has the ambition to grow into the largest pond-based farm in Western Africa with 400 ha of ponds producing 5,000 MT of tilapia and 500 MT of shrimp per year.



Kafue Fisheries

Country	Zambia
Top Management	Speedy Holden, Co-Founder and Managing Director

Kafue Fisheries is located along the Kafue River in Zambia, and only 60 km from Zambia’s capital Lusaka. It was founded back in 1981. In 2017, it produced around 1,200 MT on 110 ha of land. That same year, the farm announced plans to double its output, but it’s not clear to what extent this ambition has been realized. The farm combines the production of pork, fish, and beef. Waste from the pigsty is released into the ponds as a fertilizer which supports the growth of plankton for the fish. The water from the ponds is recycled onto the pastures where cattle graze. Most of the time, its tilapia is sold into the market in Lusaka at a price below that of cage-farmed tilapia from Lake Kariba.

The Potential of RAS

RAS—buzzword in aquaculture—are applied by hatcheries for a variety of species. In growout, however, the use of RAS has so far been limited mostly to salmon and other marine fish. Salmon RAS farms are established close to markets where cage farming is not suitable, such as in China, Japan, and South Africa. Although lots of investments have been made, the profitability and technical viability of RAS for salmon still has to prove itself at a large scale. To raise investment, just to illustrate the capital intensity of high-end RAS, several RAS farmers recently went public. The best known company involved is Atlantic Sapphire.

For tilapia, a much less sought-after species, the feasibility of RAS is still doubtful. Even though there are low-cost alternatives to the expensive systems used by salmon farmers, the CAPEX and operating expense (OPEX) requirements for a tilapia RAS farm are considerable.

RAS

CAPEX	Very High
OPEX	Very High
Type of feed	Extruded pellets
Stocking densities	High
Environmental risk	Low
Disease risk	Low
Technical risk	High
Production \$/kg	High

Tilapia RAS consist of four key components: 1) a tank (PVC or concrete); 2) a filter to clean the water; 3) a pump to circulate the water; and 4) an aeration system. An electricity supply is therefore essential. In the case of a power cut, the fish can die within minutes due to a lack of oxygen. An RAS farm therefore needs to have a back-up system. Although the productivity per ha is high compared to other systems, the level of expertise required and the level of risk involved are very high too. Moreover, due to the elevated production costs, RAS farmers need to look for niche markets that pay a premium price allowing them to make a profit.

So far, the adoption of RAS is limited to a number of farms around Johannesburg and Pretoria in South Africa and a few farms in Eastern and Western Africa. Despite the fact that RAS are currently very costly, their potential is tremendous if the cost comes down. RAS can be deployed everywhere: they require little space and can be built close to cities or in areas where temperatures are normally unfavorable for tilapia production. With much of sub-Saharan Africa's future population growth predicted to be in the cities, producing fresh tilapia close to these markets will help to alleviate the short-



Victor Biersboom from Dutch company Viquon B.V., a RAS consultant, at work in Kenya

age of animal proteins available in these areas. Use of RAS being a more tech-based method, it should attract a new generation of talent to develop small- and medium-sized companies and kickstart new livelihoods. Although unlikely to be a major factor for growth in the short run, in the long run RAS is certainly something to keep an eye on.



Countries | Kenya, Rwanda, and Tanzania
Top Management | Wouter van Vliet, Partner at Larive International, and Winnie Ouko, CEO at Lattice Aquaculture

FoodTechAfrica is a consortium of Dutch and Kenyan aquaculture companies and stakeholders which has developed RAS technology specifically designed for tilapia farms in Eastern Africa. The first deployment was at Kamuthanga Farm in Kenya in 2015, presently Eastern Africa's largest RAS farm. More recently, FoodTechAfrica developed the technology into a modular aquakit which has a capacity of 7.5 MT per unit. The investment cost amounts to \$4-5 per kg of capacity. With the support of the Dutch government, the system has been successfully deployed at Lakeside Fish Farm in Rwanda, BigFish in Tanzania, and The Roost in Kenya.



David Fincham
Aquaculture and
Rydawi Fish Farm

Country | South Africa
Top Management | David Fincham, Owner

David Fincham Aquaculture and Rydawi Fish Farm operate their own RAS farms but also supply other companies with RAS. They offer a modular system which is relatively low-cost and can be easily deployed in small indoor facilities. The system is called the "Farm in a Box", and its aim is to provide small-scale farmers with the opportunity to farm 500 fish (around 250 kg) per month with a limited investment. Customers are trained to manage the systems correctly.

Private Sector-Driven Outgrower Programs May Increase Production Potential of Small-Scale Farmers

Donor-driven aquaculture programs have not delivered on their promise to accelerate aquaculture development through small-scale farmer production in sub-Saharan Africa. Often, once the donor funding comes to an end, farmers lose access to inputs, finance, and expertise, and gradually see their production drop. As a result, many of the farmers involved have been disappointed and have ceased operations. Presently, small-scale farmers only account for a small portion of tilapia production.

The Benefits of Outgrower Programs

Some of the large farms are looking at establishing outgrower programs. These farms would support small farmers by providing them with feed, fingerlings, and expertise, and train them on the job. Having an outgrower program allows a company to sell surplus production from its hatchery and feed mill, while simultaneously increasing the local fish supply. The large farm can buy back the tilapia from the small farms to meet market demand and ensure that the small farm can pay for the fingerlings and feed. By having certain a degree of control over the farming practices of neighboring small farms, the large farms also limit their own production risks. By actively supporting local communities to venture into farming, these large farms become platforms for growth and develop vibrant local industries.

Overcoming Financial Challenges

Although the theoretical potential of outgrower programs is clear, a lot needs to be done before they can actually work. One of the major challenges to be overcome is the financial aspect. Small farmers often lack the financial capacity to buy inputs in cash and large farms would have to provide inputs on credit or support the small farmers to obtain access to finance elsewhere. However, due to the perceived risks of financing these small farmers, and with large farms experiencing working

capital challenges themselves, even if interested, many farmers—small or large—lack the financial capacity to engage.

Disruptive technology providers, which supply technology to small farms and remotely monitor farm performance, can de-risk financing small farms for large farms, input providers and banks, and could become an essential part of the solution.

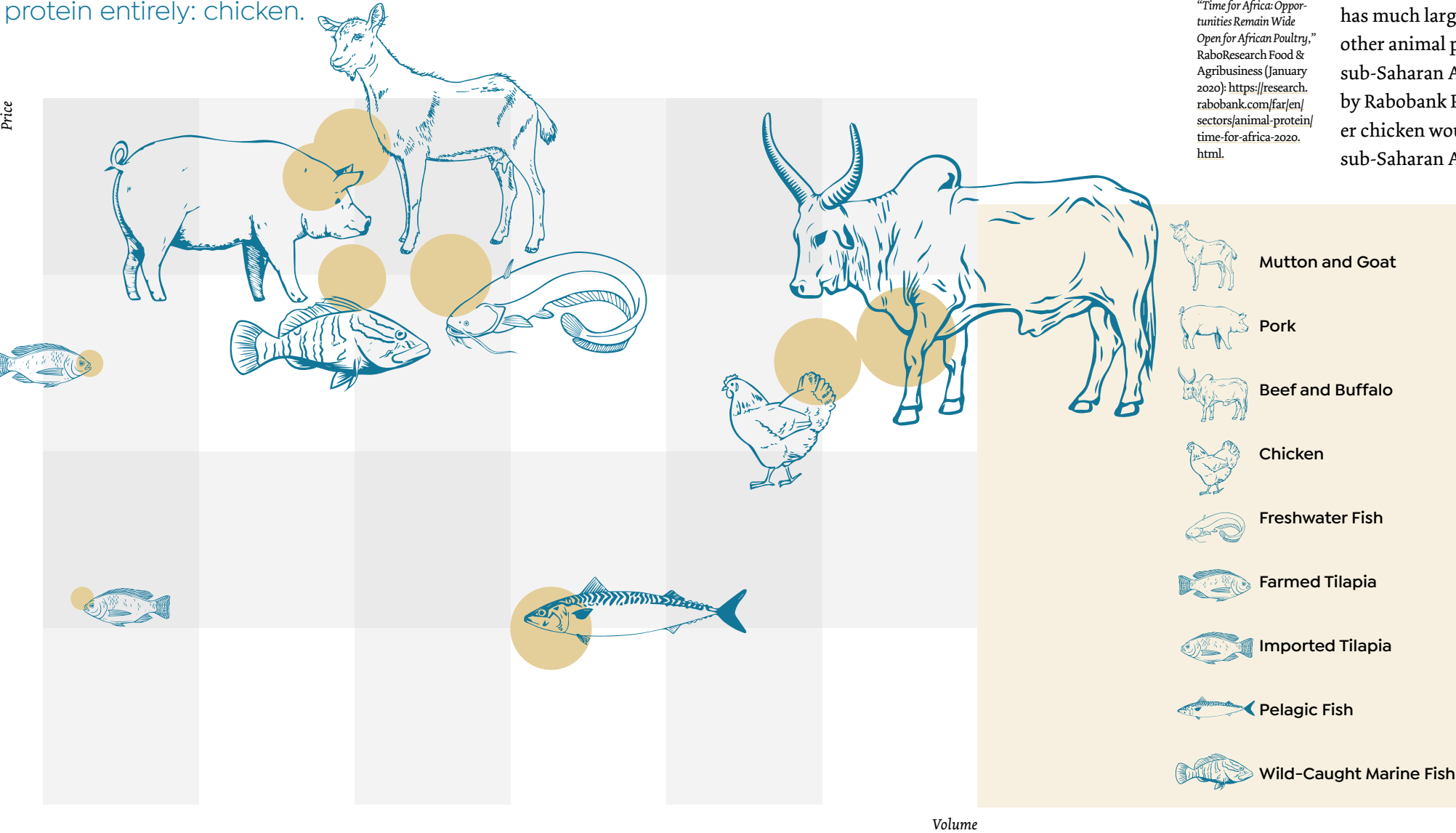
Chicoa Fish Farm: Providing Livelihoods

In April 2021, the IDH Farmfit Fund signed a €1.4m investment deal with Chicoa, an Aqua-Spark portfolio farm in Mozambique. This investment enables Chicoa to strengthen its supply chain and grow further into a regional leader. One of its key performance indicators is providing livelihoods for at least 350 small-scale farmers who will be trained to raise tilapia in cages and ponds. Chicoa will supply fingerlings and feed and will support the farmers in marketing their fish at the time of harvest.

If done correctly and with the right partners, outgrower programs could well become a key driver of future production growth, with small-scale farmers becoming significant players in meeting sub-Saharan Africa's future demand for animal protein.

The Middle Ground: Tilapia or Chicken?

Commercial tilapia producers in sub-Saharan Africa are still struggling to compete with the cheaper Chinese small-sized tilapia. To expand their market reach, commercial producers could look down the chain in a bid to enter the space occupied by those providing the cheaper small-sized fish to the urban poorest. Or they could look up the chain and attempt to supply the more exclusive, large-sized fish to the wealthy few. But perhaps where commercial tilapia producers in sub-Saharan Africa really need to focus their attention is on the middle ground occupied by the urban middle class and compete with another protein entirely: chicken.



Chicken Is on the Rise and Set to Be The Protein that Will Meet Growing Demand for Meat

Demand for animal protein will grow tremendously in Africa over the next few years due to both population growth and rising incomes. In 2018, total meat supply in sub-Saharan Africa accounted for almost 14.5 million MT, and comprised cattle, chicken, sheep, and goat. A considerable amount—1.7 million MT—was imported.

Chicken's share in the supply of meat to sub-Saharan Africa is growing. The reason for this? Commercial broiler chicken producers expanding the sector combined with the inability—currently—of other animal proteins to meet increasing (and projected) demand.

And this is no coincidence: broiler chicken has much larger potential for growth than any other animal protein currently consumed in sub-Saharan Africa. In a report released in 2020 by Rabobank Research,¹ it was stated that broiler chicken would be best positioned to meet sub-Saharan Africa's growing demand for animal protein: the report pointed to a new segment in the broiler chicken sector currently under development consisting of small- and medium-sized integrators using modern facilities and improved stocks that will consequently produce larger volumes.

But What about Tilapia?

The tilapia farming sector is in a similar phase to that of chicken (albeit a couple of years behind), and offers similar potential for investment and, importantly, expansion. If done correctly, as some of the recently established larger producers are now doing, this healthy

source of affordable protein can be produced in a very competitive way. Investments in genetics, feed, technology, and scale can support commercial farmers to bring their production cost per kg down. Investments in processing, distribution, and market promotion will enable commercial farmers to improve the accessibility of tilapia as a regular menu item. As with broiler chicken, there are relatively low entry barriers for commercial producers, production cycles are relatively short, and production can be industrialized. The possibility to create a steady supply of affordable tilapia exists, thus making it a real contender against chicken in the race to find a new supply of animal protein to feed a growing population.

So What Does All of This Mean for Chicken and Tilapia?

Well, modern broiler chicken and farmed tilapia have much larger potential for growth than any other animal protein. These sources of protein are not yet the largest animal proteins consumed in sub-Saharan Africa, but they are the ones that producers will be able to scale-up production of and meet the growing demand. Beef, other meats, and local wild-caught fish are unlikely to be able to do so for several reasons.

In the case of beef, growth of the sector is limited due to its reliance on production by the informal and tribal sectors. Whilst there are several notable and successful efforts to develop commercial beef production, the growth of these producers is limited by long rearing cycles and disruptions from drought. The same is true of mutton and goat, while there is little demand for pork. As for fish, supply in 2018 accounted for 8.5 million MT. Most of the fish supplied is from wild-caught inland and marine fisheries. But wild-caught fish stocks are under pressure and are, therefore, unlikely to increase. The overfishing of freshwater and marine fish has resulted in stagnating—and sometimes even declining—catches. While the majority is produced within the region, large volumes of cheap pelagic fish (particularly mackerel) are also imported. Similarly to chicken, large-scale commercial producers have contributed to a recent increase in local farmed tilapia production: if sub-Saharan Africa's tilapia

farmers don't want to become more dependent on fish imports, or lose market share to broiler chicken, commercial fish farmers will have to step up their game.

With the production of beef, mutton, goat, pork, and wild-caught fish not appearing to keep up with sub-Saharan Africa's population growth, per capita consumption of animal protein will decline unless other sources fill the void. And that's where broiler chicken and farmed tilapia come in. But while they may have similar potential to solve this looming problem, it also puts these two proteins in direct competition with one another in the short term.

Targeting Chicken and the Urban Middle Class

When buying meat and fish, the poorest urban consumers of sub-Saharan Africa are extremely price sensitive; they look for the cheapest options. For fish, this means that they tend to choose small fish such as imported tilapia or mackerel, or local wild-caught freshwater fish. Even if governments would better regulate the imports of cheap fish, the current production costs for small-sized farmed tilapia mean that expanding the market among the poorest urban income groups might prove to be hard in the short term. While the urban upper class has a bigger wallet and can spend more on food, they are still small in number and, thus, the volumes being sold to this group will remain limited. What's more, they have more expensive taste and tend to go for "exclusive" products, such as larger pieces of farmed fish, tuna, shrimp, or lobster. Competing for a share in the urban rich market would require commercial tilapia producers to offer larger sizes that are filleted, and also wage a considerable marketing campaign to raise the status of the fish.

With a sales price anywhere between \$2-3.5 for a plate-sized tilapia of 250-500 g, commercial tilapia producers are very much targeting sub-Saharan Africa's middle class... just as chicken producers are. The game changer for tilapia is that commercial tilapia producers are now in a position to guarantee a steady and stable supply of it, and this has put imported Chinese plate-sized tilapia much lower down the pecking order for wholesalers and retailers alike.

Facing a population growth challenge means that any protein produced will ultimately find its way to the market under the right conditions: if the price is right and the distribution channels are established, the product will make

it. But at what cost? This is where tilapia becomes not only a viable option, but also a good and sustainable one.

Tilapia: The Sustainable Option

The challenge for tilapia is, in a similar way to chicken, getting the product to every corner of the continent, at every time of day, on every day of the week, and at every time of the year. Broiler chicken has managed to do this—it's become widely available and at a low price—so people have started to eat more chicken, even in countries where it's never really been on the menu before. Tilapia is heading in this direction and is making good progress, as we see in Uganda where a network of fish shops has been established where people can buy fresh fish every day of the week (see p. 49). But we at Aqua-Spark want tilapia to go even further. Why? Because tilapia has a couple of big advantages over chicken: it's an altogether healthier option—high in protein and low in fat (for more about the health benefits of tilapia, see p. 12)—and is certainly a more sustainable option. The benefits of exploiting tilapia as a source of protein thus go beyond only meeting the demand for protein. Still, if we want tilapia to feed a growing population at a large scale, then effort is needed to gain momentum and catch up with the chicken industry. All of this will be theory if the tilapia sector doesn't start to put practical structures in place to achieve it: the sector needs to make headway by investing in infrastructure; by scaling-up feed mills, hatcheries, farms, and processing and distribution networks; and by working with governments to implement the right policies. We shouldn't see chicken only as a rival; rather, we should see it as an example, gain insights from it, learn from it, and then the tilapia sector should do the same but even better.

If done in the right way, farmed tilapia will be in a position to start conquering consumers—particularly city-dwellers belonging to the urban middle class—who don't traditionally eat this fish. This will maneuver tilapia into a position of desirability and affordability through a combination of price, marketing, availability, and education. The ultimate goal for the humble tilapia fish, then, is that it gradually but firmly finds its place on the plate of the average urban middle class sub-Saharan African household as part of a regular, balanced diet *alongside* chicken and other proteins. It's a fish worthy of investment: it's healthy, sustainable, and—when scaled up correctly—a truly affordable protein. And, moreover, it can provide a good return on investment.

Do Chinese Exporters Still Outcompete Sub-Saharan Africa's Tilapia?

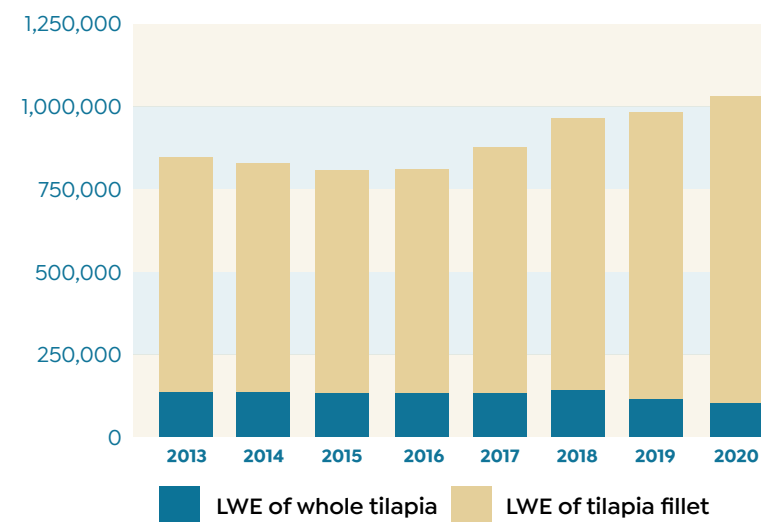


Check out a more comprehensive analysis of China's tilapia exports to sub-Saharan Africa on our website!

One of the concerns many in sub-Saharan Africa express is the competition local producers face from cheap tilapia imported from China. However, for a couple of years now, China's tilapia exports to sub-Saharan Africa have been declining. While China has been a significant source of competition in the past, this is no longer entirely true.

China's Tilapia Production Volume Used for Exports Exceeded 1 million MT in 2020

FIGURE 1: CHINA'S TILAPIA EXPORTS IN LWE ESTIMATION OF ACTUAL EXPORT VOLUME



Source TRADEMAP.ORG

Note: Export volumes converted to a LWE with a ratio of 0.37 for fillets and an average ratio of 0.9 for whole round, and gutted and scaled tilapia.

Though tilapia production in China is believed to be stable at around 1.8 million MT, its exports increased from a live weight equivalent (LWE) of 858,000 MT in 2013 to just over 1 million MT in 2020. The increase is entirely increased by fillets, the LWE of which rose from 724,000 MT to 941,000 MT. The rise in exports of fillets is a clear indication of China's farmers' focus on producing larger tilapia sizes suited for filleting. While exports of fillets to the US have declined over the years, exports to other markets—such as Mexico—have soared. The LWE of the export volume of whole fish dropped from 134,000 MT to 90,000 MT. This decline comes largely at the account of sub-Saharan Africa which over the past two years significantly reduced imports of Chinese tilapia.

Sub-Saharan Africa Today Accounts for 65% of China's Total Exports of Whole Tilapia

According to Chinese customs, after climbing from 81,000 MT in 2015 to 92,000 MT in 2020,

sub-Saharan Africa’s imports of Chinese tilapia dropped to 65,000 MT in 2019 and 61,000 MT in 2020. In 2020, sub-Saharan Africa accounts for 65% of China’s total official whole tilapia exports. In terms of direct imports from China, Western Africa is clearly the largest importer within the region, followed by Southern Africa, Eastern Africa and Middle Africa (Figure 2). According to Chinese customs, direct imports into Western Africa are on the rise, while direct imports into other regions are declining. Some trade between regions, especially Middle, Eastern, and Southern Africa, may occur.

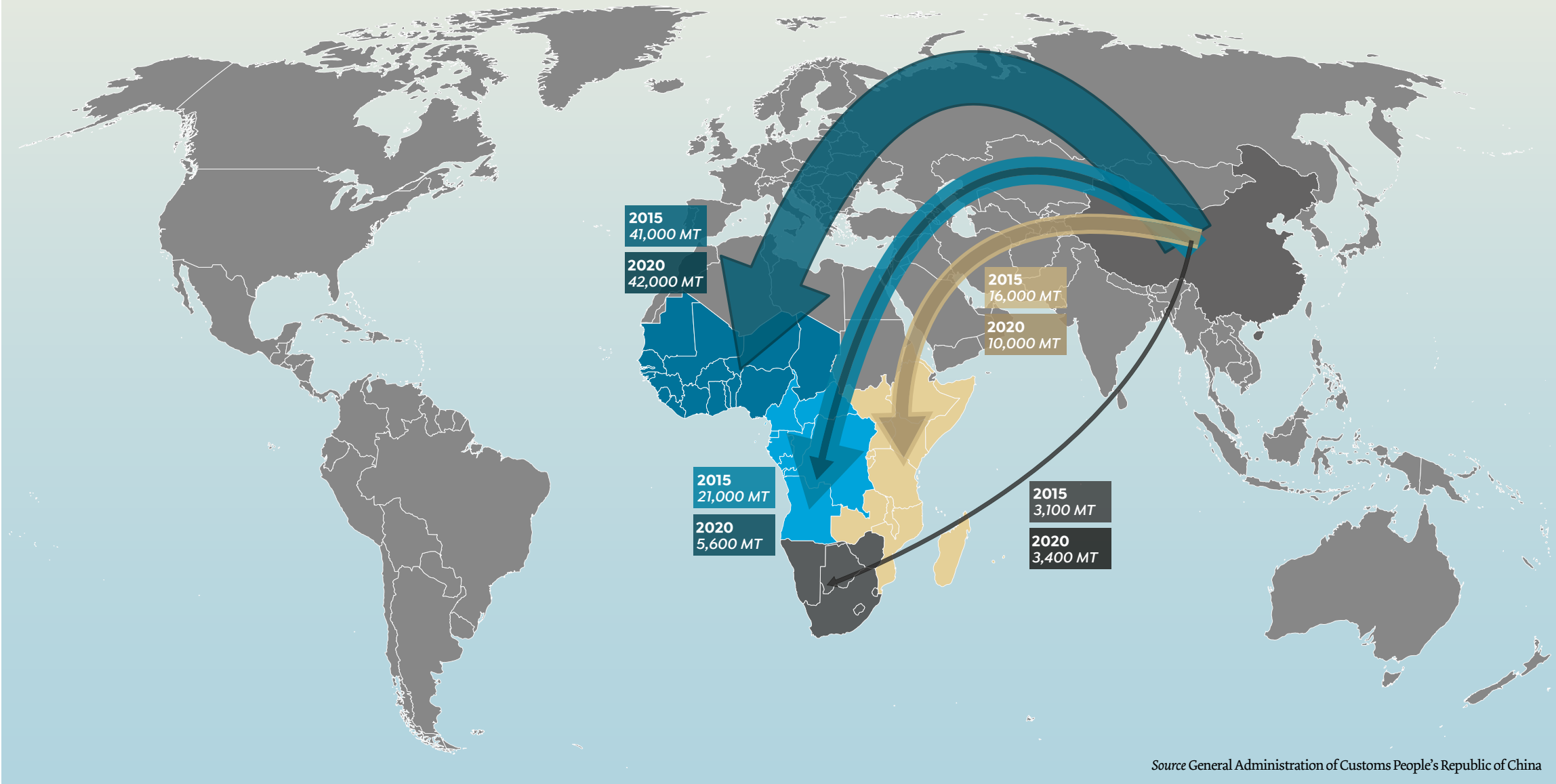
Many insiders in the aquaculture industry in sub-Saharan Africa believe that the actual volume of tilapia imported from China might be larger than the volume declared to customs: local governments may report higher import numbers and, on top of that, it is thought that importers and exporters may agree to declare the product as, say, mackerel or as “other fish” to circumvent import duties on tilapia or bans that prohibit the import of Chinese tilapia. This discrepancy is believed to be the biggest in Southern Africa (where local sources estimate Chinese tilapia imports at 12,000 MT) and in Eastern Africa.

Chinese Exporters Offer Tilapia in Sub-Saharan Africa at \$0.85–\$1.50, Depending on Size

Chinese exporters sell whole tilapia in various sizes, ranging from 100/200 g to over 800 g. The most common size tilapia imported into sub-Saharan Africa is 100/200 and 200/300 g, but regional differences exist: Eastern, Middle, and Southern Africa tend to import small and medium-sized tilapia, while Western Africa tends to import medium-sized tilapia as well as some larger sizes. In early 2021, Chinese sellers offered tilapia at prices (CIF) ranging from \$0.85/kg for 100/200 g to \$1.53/kg for over 800 g. These prices may drop during the year when the peak harvest season in China starts in June, and when the—currently extremely high—container prices tumble.

Among other reasons, Chinese exporters can sell at these prices because they receive a subsidy of 10% for exporting tilapia to sub-Saharan Africa. In some cases, the smaller tilapia is believed to primarily be a by-product of farms which mainly target larger sizes. As there is no domestic market for this product, Chinese farmers are willing to sell it to processors at around—or even below—the actual production cost.

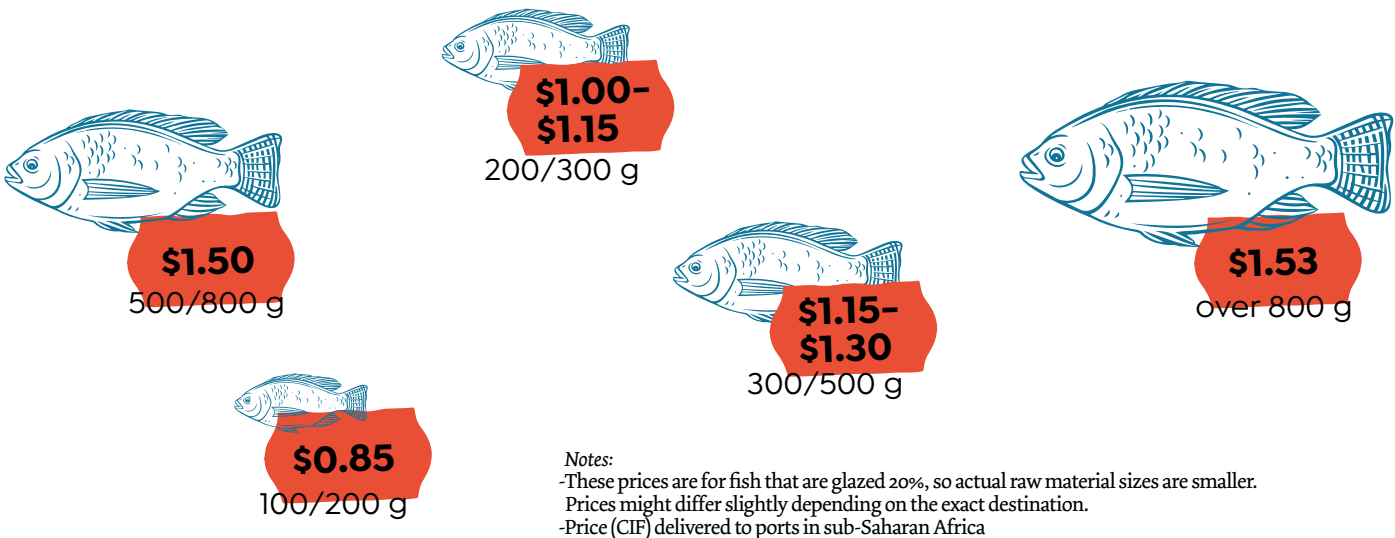
FIGURE 2: CHINA’S OFFICIALLY REPORTED TILAPIA EXPORTS TO SUB-SAHARAN AFRICA IN 2015 AND 2020



Local Producers Have Started Outcompeting Chinese Medium-Sized and Large Tilapia

While the low prices for the smaller Chinese tilapia are hard to compete with, commercial producers in sub-Saharan Africa have started competing with Chinese prices for medium-sized and large tilapia. Though a considerable volume of small Chinese tilapia is still sold to the lowest-income urban consumers of sub-Saharan Africa, medium-sized tilapia—more expensive than the poorest can afford—is sold mostly to the urban middle class. With Chinese tilapia being less of a threat, competition might come from other animal proteins instead.

FIGURE 3: CIF PRICES DELIVERED TO PORTS IN SUB-SAHARAN AFRICA QUOTED BY CHINESE EXPORTERS IN MARCH 2021



Tilapia—As Healthy

Deep-Frying Is the Preferred Way to Cook as the Final Dish



Mamma Betty



Nanaaba's Kitchen



Ndudu



Lucilia's Kitchen

Grilled, Cooked, Dried, and Smoked

In Western Africa, other preparations of tilapia are more common. Ghanaians like to grill tilapia on the barbeque or cook it in a traditional soup. In Nigeria, just like with catfish, they like to dry and smoke tilapia. All of these options are healthy ways to cook the fish: they ensure a healthy fish ends up as a healthy dish. Luckily, for these dishes, consumers prefer to use medium- and large-sized fish, which is also the preferred size for most of the tilapia producers.

Consumer Education Is Important

Even though tilapia is a healthy fish, it's only as healthy as the way it's prepared. And choosing how to prepare tilapia is not only a matter of budget—it's also about understanding how to cook it. Larger tilapia producers, governments, and

donors alike, whose aim is to produce a healthy food for Africa's growing population, have a role to play in this: they need to work towards educating consumers about how to cook tilapia in a healthy way.

Catherine Twesigye Wants to Make Farmed Tilapia Part of Uganda's Daily Dish



If we want farmed tilapia to deliver on its promise of being a healthy, sustainable, and affordable protein, it's not enough to only reduce production costs. Consumers should also be tempted to buy and eat it! Having tilapia available everywhere year-round is a good start, but we should also convince consumers that locally farmed tilapia is a healthy and tasty fish to put on their plates. Catherine Twesigye, previously brand manager for Guinness at Diageo Uganda, joined Yalelo Uganda as the Marketing Manager in October 2020 with exactly this mission.

From Promoting Premium Beer to Making Tilapia a Popular Food

My name is Catherine Twesigye. I'm naturally a problem solver; I don't settle until I find a solution to whatever I set out to do. My friends call me a go-getter. In my previous role, I was privileged to be the custodian of brands like Guinness that have a global footprint. Under my stewardship, Diageo Uganda won accolades for the best global marketing executions for 2 years running. Uganda also became the fastest growing market for Guinness. After 8 years of transforming Diageo brands, I felt the need to take on new challenges.

It's exciting to be part of the team at Yalelo Uganda laying the foundations for a multinational to expand into Eastern Africa right from my homeland, Uganda. I've also found it very fulfilling to play a role in improving food security in the region, particularly in Uganda where fish plays such an important role in our diet. That feeling you get at the end of the day knowing you're contributing to putting healthy and affordable food on thousands of tables that night is unmatched.

I Realized that Tilapia is Much More Sustainable than Chicken

Before I joined Yalelo Uganda, I wasn't aware that aquaculture—if done well—is much less harmful to the environment than wild-caught fish and other animal production systems. I thought farmed tilapia was comparable to chicken and other meat in terms of environmental footprint. Guess what? I was wrong! Tilapia farming has a much lower carbon footprint, and a much lower water usage and land-use footprint than cattle or poultry.

Sustainability touches every area of the business; from the coolant we use in the fridges to the source of the maize in our feed. To give a few examples, we monitor dozens of water quality parameters on a daily basis to ensure our impact on the water is not more than the lake can handle, we have proper animal welfare protocols, and we know our feed supply chain is sustainable because all feed comes from our own group's feed factory Aller Aqua Zambia. Our guiding principles are the Aquaculture Stewardship Council standards and IFC Performance Standards, and we work with several local and international experts to ensure those are met.

In Uganda, Tilapia is Accessible Daily at Any Moment

I also didn't know that it was possible to have access to fresh fish whenever you want. Fish often used to be sold through roadside and makeshift stalls that are difficult to find, not very clean and can often have no stock. Because of the hassle of finding good fish at a fair price, most families would consume fish only at the weekend, on special occasions, or when they were at the beach. The Yalelo shops we've established throughout the country have completely turned that model on its head: consumers can now find really fresh fish near their homes for a fair price every day. And if going to the shop isn't possible, we offer a paid motorbike delivery service and very soon we'll onboard experienced e-commerce partners with a larger reach. We've solved the problem of fish availability! This benefits consumers but it also benefits us, because rather than competing for market share with other fish sellers, the improved quality and availability of fish means consumers now eat more fish and less chicken and beef.

Yes, We Can!

My team and I are now supercharged with making Yalelo a household name. We're up for the challenge: we've a well-developed marketing strategy that centers on increasing awareness of the freshness, availability, and affordability of Yalelo. We're finding that our brand message is resonating, both through digital marketing channels and the in-store touchpoints. Having achieved our first goal of making Yalelo Uganda's #1 fish, we think it's only a matter of time before we'll see

the "fish everyday" trend catch on like wildfire!

#Kisoboka, it is possible, like we say at Yalelo Uganda!



Feed and Feed Ingredients Access, Quality and Affordability

Access to high-quality and affordable feed plays a crucial role in making tilapia deliver on its promise of being a healthy, sustainable, and affordable protein. When growing tilapia in intensive ponds, cages, or recirculation aquaculture systems (RAS), farmers depend on formulated, often extruded, floating feeds. Feed makes up around 60-75% of the production cost and growth cycle, and many farmers stress the importance of bringing down the cost of feed to reduce the final price of the fish. While doing so, the balance between price and performance is essential. A cheap feed with a low nutrient profile may result in a higher feed conversion ratio (FCR) and an increased production cost. *Rubbish in means rubbish out.* A more expensive feed with a better nutrient profile may result in a lower FCR and a lower production cost. The job of the formulator at the feed manufacturer is to ensure the best performance for the lowest feed cost per kg of harvested fish. Some major famers have suggested that if the cost comes down to below \$1.00/kg of fish, this will ensure competitiveness in the overall cost of production. However, it's also important to factor in that high-quality feeds can only deliver on their promise when the farmer knows how to use them in the right way.

Following the expansion of large-scale farming operations, there's been rapid growth of aquafeed production capacity as well. Across sub-Saharan Africa, there are currently at least 20 feed plants with extrusion lines able to produce floating pellets for fish farmers. The facilities have an estimated joint capacity of 400,000-500,000 MT per year, and the largest 8 facilities contribute more than 90% of feed. Currently, most of the aquafeed manufacturing capacity is concentrated in Nigeria (160,000 MT), Zambia (90,000 MT), and Ghana (60,000 MT), with smaller capacities installed in Kenya, Rwanda, Tanzania, Uganda, and Zimbabwe, among other countries. Togeth-

er, if running at full capacity, these manufacturers could sustain around 250,000-330,000 MT of catfish and tilapia production yearly. Capacity is expected to grow significantly with new factories expected to be established within 1-3 years in Ghana, Kenya, Nigeria, and Uganda.

While most of the feed mills primarily supply local markets, some also export to neighboring countries. For example, Aller Aqua Zambia exports on a weekly basis to Botswana, Kenya, Malawi, and Uganda, and occasionally to 5 other countries. Raanan Fish Feed West Africa supplies farmers in Benin, Burkina Faso, Côte d'Ivoire, Mali, and

Togo from its facilities in Ghana. Once demand in these markets surges, the companies with established brand presence are likely to look into local production capacity. Growout feeds and, even more commonly, hatchery and starter feeds are also imported from outside sub-Saharan Africa. Suppliers of growout feeds include Growel Feeds (India) and Archer Daniel Midland (ADM) (Brazil). Suppliers of imported hatchery and starter feeds include LFL (Mauritius), Alltech Coppens (the Netherlands), Skretting (Europe or Egypt), and Raanan Fish Feed (Israel).

Two Types of Feed Manufacturers

Specialized Aquafeed and Diversified Animal Feed Producers





There are two main types of feed manufacturers: 1) multinational aquafeed producers such as Skretting in Nigeria, Aller Aqua Zambia, and Koudijs and Raanan Fish Feed West Africa in Ghana; and 2) diversified animal feed producers such as Novatek in Zambia, Unga Group PLC in Kenya, Ugachick in Uganda, Pro-feeds in Zimbabwe, and Premier Feed Mill Company and Grand Cereals in Nigeria. While the first have the advantage of often having superior aquafeed expertise, the second frequently have the advantage of established brand presence in the target market and of having scale. While the first type of manufacturer often starts as a joint venture with a locally established aquaculture producer, the second type typically engages in technical partnerships with specialized aquafeed producers who offer production and formulation assistance.

Some of the diversified animal feed producers also have investments in raw material production and operate large soy, wheat, and maize plantations, or are partly owned by—or work in close collaboration with—large commodity traders. Through these investments and partnerships, animal feed producers secure access to local as well as international feed ingredients. An example of a large commodity trader with investments in companies in sub-Saharan Africa that produce animal feed (including aquafeed) is Seaboard Overseas and Trading Group. The company is a shareholder in Premier Feed Mill Company in Nigeria, Unga Farm Care (EA) Limited in Kenya, and National Milling Company in Zambia.

2010

A Timeline of Aquafeed Manufacturing Capacity Development in Sub-Saharan Africa ^

Other types of feed produced

-  Aquafeed
-  Pig
-  Cattle
-  Poultry

Note The feed production capacity is based on publicly disclosed information or information disclosed by the company to Aqua-Spark and approved for publication in this report.



Ugachick

Country Uganda
Feed production capacity (MT)
Total 60,000 | Aqua Feed Unknown

Ugachick is a vertically integrated poultry producer operating broiler farms, slaughterhouses, and feed mills. Ugachick started producing aquafeed as early as 1994 and expanded its aquafeed capacity with modern equipment in 2010 when investing \$1.2m in an extrusion line.



2011

Company Name

Owned by



Country Ghana
Feed production capacity (MT)
Total 48,000 | Aqua Feed 48,000

Raanan Fish Feed is an Israeli-based aquafeed producer with a fully owned subsidiary in Ghana. The company has an 80% market share. Raanan was the first and, until recently, the only dedicated fish-feed producer in Ghana and works closely together with most of the farms on Lake Volta.



2012

Company Name

Owned by



Country Zimbabwe
Feed production capacity (MT)
Total 135,000 | Aqua Feed 12,000

Profeeds produces around 135,000 MT of animal feed yearly. In 2017, the company formed a joint venture with an existing aquafeed producer that had been producing aquafeed since 2013. Aquafeeds has a technical partnership with Trouw Nutrition (like Skretting is part of Nutreco).



2013

Company Name

Owned by



Country Nigeria
Feed production capacity (MT)
Total 85,000 | Aqua Feed 85,000

In 2014, Skretting acquired 60% of Nigerian aquafeed company Durante, which had been producing aquafeed since 1999. In 2018, Skretting acquired the remaining shares from Durante. Skretting will replace its current 10,000 MT capacity with a new 85,000 MT aquafeed plant soon.



While most of the feed mills focus on producing extruded high-protein tilapia feed for cage farmers, depending on the country, they will also produce feed for catfish. Some feed mills have a separate product for extensive pond farmers. This feed normally contains only 50-70% protein compared to feed for the cage farmers, and is packed in smaller bags to make it more affordable for small-scale farmers. Examples of feed mills with a low-cost feed are Aller Aqua Zambia and Novatek in Zambia and Raanan Fish Feed West Africa.

Running a Dedicated Aquafeed Plant Requires Demand of at Least 10,000 MT

Industry experts believe that the minimum output for installing a profitable extrusion line is 10,000 MT yearly. Others argue that to become really efficient and competitive, demand needs to be at least 30,000 MT. While a diversified feed producer who manufactures aquafeed on the side might be able to run an extrusion line at low capacity, for a dedicated aquafeed mill, the minimal

saleable volume is more important. Without continuous 24/7 production and only producing a marginal volume, investments in expertise and maintenance become unreasonably high, but also raw material management becomes an issue. At a small scale, it will be difficult to compete with the quality and price of feed from larger producers, or with imported feed, unless you have an undisputed advantage in raw material procurement and delivery to the feed mill.

For a dedicated aquafeed mill, it's therefore crucial to have guaranteed offtake of around 10,000 MT. Large farmers that reach scale tend to start looking to team up with a feed manufacturer and engage in a joint venture partnership. In 2017, FirstWave/Aller Aqua and Lake Harvest/Skretting established joint-venture aquafeed mills in Zambia. Some of the other larger producers may take similar steps soon. While these manufacturers produce first and foremost for the farms associated with the joint-venture partners, the aim is always to sell surplus capacity to other farmers, small and large, as well.


Bearing in mind that demand in most countries in sub-Saharan Africa is still far below 10,000 MT and only

a few producers are reaching production volumes above that level, it might take a while before locally produced extruded feed becomes available in countries with nascent tilapia industries as well. Until that time, logistical costs, import tariffs, and currency fluctuations might contribute to relatively high feed costs in those countries. The 10,000 MT tipping point is nicely illustrated by the situation in Kenya where, with the increase in production of Victory Farms and other producers, local aquafeed production capacity is also expanding rapidly.


The Challenge of Sourcing Local Raw Materials

Tilapia feed contains a combination of raw materials that serve as sources of protein, fat, carbohydrates, vitamins, and minerals, and contribute to the energy of the diet. Commonly used protein sources are: soybean meal, fishmeal, poultry meal, meat and bone meal, and—more recently—black soldier fly (BSF) meal (30-40% of the feed). Maize, wheat, rice, cassava, and sorghum, for example, are commonly used carbohydrate sources (45-55% of the feed) that mainly contribute energy to the diets. The fat content in the diets originates from all ingredients, and

Company Name




Owned by



Country Zambia

Feed production capacity (MT)
Total 300,000 | Aqua Feed 11,000

Zambef Plc. is involved in the production, processing, distribution, and retail of various land-based animal proteins, animal feed, and flour, and has upstream investments in maize, soy, and wheat farms. Novatek started producing aquafeed in one of its two factories in 2015.




2014

Huye Feeds


Country Rwanda

Feed production capacity (MT)
Total 15,000 | Aqua Feed unknown

With \$5m of support from the Korean government, the Rwandan government established Huye Feeds. The company produces a range of animal feeds and has a 40 MT/day capacity.



2016



Country Nigeria

Feed production capacity (MT)
Total 75,000 | Aqua Feed 75,000

Olam has vast investments in the Nigerian agriculture sector ranging from farming to flour milling as well as animal feed production. The company opened a dedicated fish feed mill in 2017 and has established itself as a dominant player since then.



2017

Company Name



Owned by



Country Kenya

Feed production capacity (MT)
Total Unknown | Aqua Feed 10,000

Unga has investments in flour milling and produces food for consumption and animal feed. In 2017, Unga installed dedicated aquafeed capacity. The company has a technical cooperation agreement with Skretting. Unga is partly owned by Seaboard Overseas and Trading Group, a commodity trader with investments in companies across Africa and South America.



2017

Company Name



Owned by



Country Zambia

Feed production capacity (MT)
Total 50,000 | Aqua Feed 50,000

Aller Aqua Zambia is the largest feed mill in South-Eastern Africa and produces primarily for FirstWave's cage farm in Zambia but also sells to other farmers. The company claims to be one of the few, if not the only, feed producers that can produce the smallest 2 mm pellet sizes.



2017

Company Name



Owned by



Country Zambia

Feed production capacity (MT)
Total 15,000 | Aqua Feed 15,000

Nutreco and African Century Limited (shareholder of Lake Harvest Group) established a feed mill at Lake Kariba close to the feed plant of Aller Aqua Zambia. In 2021, Skretting decided to close down the factory, but it remains present and active in Zambia and the region through its sales office in Lusaka.



sometimes fish-, palm-, or soybean oil are added. Minerals are added (salt, calcium, and phosphates, 1-3% of the feed), as are feed additives (premixes, less than 1% of the feed). Feed formulation software helps a feed manufacturer to decide on the optimal combination of ingredients to produce the cheapest feed that meets the nutritional requirements.

Ideally, most of the ingredients are locally sourced, but in many countries in sub-Saharan Africa the ingredients required are not always available: oilcakes (proteins), minerals, and feed additives are often imported, while wheats, maize, and (sometimes) soy are sourced locally. There is also competition for local ingredients that are also needed to feed the local population. This should be avoided; using the ingredients for human consumption should take precedence over using them for animal feed in the majority of cases. A major challenge for locally sourced materials is that these are often produced by small-scale farmers. This is very positive from a livelihood perspective, but it also poses logistical challenges and often results in quality issues when the materials arrive at the factory. To deal with the many farmers, feed manufacturers often purchase raw materials through

middlemen. Although these middlemen also do some of the pre-processing of the raw materials and as such add value, they're believed to often take considerable margins and (possibly) sometimes adulterate the product to make more money. Working with middlemen requires the feed companies to have strict quality control measures in place to ensure that the quality of the end product—the fish feed—can be guaranteed.

Local diversified animal feed producers often have much broader collection networks for feed ingredients as they are dealing with larger volumes. Multinational feed companies, while at a global level are possibly also dealing with large volumes, might be relatively small players in the local animal feed context. But investing in the upstream part of the supply chain—organizing farmers into cooperatives, establishing collection centers in production regions, and educating farmers about the quality of ingredients—is of equal importance for both local and multinational feed manufacturers, and is crucial to overcoming the above-mentioned challenges and ensuring a quality and affordable feed.

Producing a Sustainable but Affordable Feed













Theoretically, if soy were readily available, a tilapia feed could contain up to 50% soy, accounting for most of the protein requirement of the feed. Tilapia can live on a vegetarian diet that, besides soy, contains other ingredients such as maize, wheat, and rice to provide energy, and added minerals and premixes to meet other nutrient requirements. However, to achieve optimal FCRs, tilapia-feed producers in sub-Saharan Africa often include some animal protein (5-10%), traditionally fishmeal. Including fishmeal, in addition to improving the FCR, also reduces the need to include other protein sources.

When using fishmeal, a feed producer can reduce the amount of soy in the formulation, which is often scarce and relatively expensive, and can use cheaper ingredients such as wheat, maize, and rice instead. If done in the right way, using fishmeal in tilapia feed brings down the FCR and the cost per kg of the feed. But from a sustainability point of view, fishmeal is not desirable, and, although digestible, should be eliminated. Therefore, feed manufacturers have started to look for other ingredients that are high in protein and amino acids but have lower environmental footprints.



Feed and Feed Ingredients 54

55 Feed and Feed Ingredients

<p>Company Name Owned by</p> <p> Hill Group Hill Animal Feeds & Agri-ventures Co., Ltd. "The trusted name with a New Focus"</p> <p>Country Tanzania Feed production capacity (MT) Total 30,000 Aqua Feed 5,000</p> <p>Hill Group started in 2000 and opened its first animal feed mill in 2006. The company's main business is poultry feed but a dedicated extrusion line for aquafeed was installed in 2017.</p> <p></p>	<p>Company Name Owned by</p> <p> FMN Food and Agro-Allied Group</p> <p>Country Nigeria Feed production capacity (MT) Total 730,000 Aqua Feed 60,000</p> <p>FMN is one of Nigeria's largest agricultural conglomerates. The company operates three feed mills. In 2018, 60,000 MT of extrusion capacity dedicated to catfish and tilapia feed was installed. Premier Feed Mill Company is partly owned by Seaboard Overseas and Trading Group.</p> <p></p>	<p>Company Name Owned by</p> <p> UAC Nigeria</p> <p>Country Nigeria Feed production capacity (MT) Total 360,000 Aqua Feed 30,000</p> <p>Grand Cereals is part of UAC Nigeria and produces a wide range of food products for (domestic) animals, and human consumption. Grand Cereals started to produce aquafeed in 1997, but as of 2019 operates a \$3.3m dedicated facility for extruded feeds for tilapia and catfish.</p> <p></p>	<p>Company Name Owned by</p> <p> de heus</p> <p>Country Ghana Feed production capacity (MT) Total 90,000 Aqua Feed unknown</p> <p>In 2019, Koudijs started the construction of its first multi-purpose animal feed mill in Ghana which started operations in 2021. The company produces both catfish and tilapia feed. It operates aquafeed mills in Vietnam and Indonesia (De Heus), and in Egypt (Koudijs).</p> <p></p>	<p>Company Name Owned by</p> <p> Cycle Farms (France) Wisdom Abodakpi</p> <p>Country Ghana Feed production capacity (MT) Total 3,500 Aqua Feed 3,500</p> <p>Cycle Farms, a French-based BSF producer, opened a dedicated fish feed mill in Ghana in 2019. The company has started production with a capacity of 3,500 MT annually but can easily expand its capacity according to demand. Cycle Farms started producing catfish feed but recently also launched a tilapia product, both including BSF.</p> <p></p>	<p>Company Name Owned by</p> <p> Maxim</p> <p>Country Kenya Feed production capacity (MT) Total 108,000 Aqua Feed 36,000</p> <p>Maxim Holding BV is a Dutch company but started its first venture in 2009 in Pakistan. In 2018, the company started a trading business in Kenya. Samakro Limited will have an initial capacity of 36,000 MT that it can double when demand requires it to do so. At the same location, Maxim Agri Kenya will produce cattle feed as well.</p> <p></p>
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¹ To be launched in 2021.

Including Chicken and Other Animal By-Products in Animal Feeds

Hans Boon, an experienced aquafeed formula-tor who was recently involved in a study about circular feed ingredients in Egypt, believes in the potential of using by-products (slaughter waste) rendered from poultry. He predicts that such by-products could become a major aquafeed ingredient. Although less rich in proteins and less digestible for fish than fishmeal, chicken and other animal by-products are richer in protein and easier for the fish to digest than soy. What's more, they don't have the same negative environmental impacts that are associated with producing fishmeal and soy. Instead of including fishmeal, by including chicken by-products in fish feed, a feed manufacturer can reduce the need to use soy and increase the use of cheaper ingredients such as maize, rice, and wheat. At present, in most of sub-Saharan Africa, chicken is mainly slaughtered on wet markets where slaughter waste is not well managed. It's therefore unsuitable for being turned into a high-quality feed ingredient. However, with commercial poultry production rapidly

expanding and central slaughtering becoming more common, using poultry by-products as an ingredient in fish feed is likely to become more important and is a circular alternative to fishmeal.

Black Soldier Fly

Although chicken by-products might be a better option than fishmeal, there are other alternatives on the horizon that are more sustainable and possibly better-suited as a tilapia feed ingredient. The most promising alternative at this moment is black soldier fly (BSF). BSF is appraised as a sustainable feed ingredient as it can be produced on both pre- and post-consumer organic waste streams such as agriculture waste streams, by-products of breweries or on organic waste streams from supermarkets and fast-food chains, to name a few.

In a recent study, Rabobank concluded that although already applied to feed for carnivorous aquatic species,² the production cost of BSF as an ingredient for aquafeed for herbivore aquatic species was still too high. However, this scenario

² Gorjan Nikolic and Beyhan de Jong, "No Longer Crawling: Insect Protein to Come of Age in the 2020s", RaboResearch Food & Agribusiness (February 2021): <https://research.rabobank.com/far/en/sectors/animal-protein/insect-protein-to-come-of-age-in-the-2020s.html>.

may be different in sub-Saharan Africa, where aquafeed producers presently import high-value protein ingredients from overseas because local supply is scarce. If local BSF producers can scale up production, and bring their price to the same level or even below the price of the scarce local high-protein ingredients and imported ingredients, then adoption of BSF in tilapia feed production may possibly happen sooner than expected.

In sub-Saharan Africa, there are a couple of upcoming producers such as Chanzi, Cycle Farms, Inseco, Insectipro, and Sanergy. Chanzi and Cycle Farms have already started to supply to aquafeed producers. Primarily, they so far target replacing fishmeal in catfish diets, a carnivorous species. While Chanzi aims

to sell its BSF products to external feed manufacturers, Cycle Farms has invested in its own aquafeed production in Ghana where it can currently produce 3,500 MT of fish feed annually. After starting with a catfish feed line in 2018, in 2020 the company also added a line for tilapia feed containing its BSF ingredients. Chanzi also promotes BSF as a tilapia-feed ingredient. Although the large-scale inclusion of BSF in tilapia feed might still be quite a long way off, the first signs of adoption are already there. To increase adoption in the future, R&D on the optimal use and benefits of BSF in tilapia feed is needed. If additional benefits—such as positive effects on the immune system—are found, BSF's replacement value might improve, making it an even more competitive alternative feed ingredient.





Tilapia Hatcheries in Sub-Saharan Africa

Tilapia hatcheries use broodstock to produce fingerlings which are then sold to farmers in their vicinity. Hatcheries come in many sizes and set-ups. Almost every country in sub-Saharan Africa has some breeding operations and hatcheries run by the government that produce broodstock and fingerlings for private hatcheries and small-scale farmers. In most cases, commercial farmers have their own integrated hatcheries and some independent commercial hatcheries operate across sub-Saharan Africa as well. Throughout the region, there are maybe around 50 that produce significant numbers of fingerlings for commercial sales and probably only around five to ten of these hatcheries manage some kind of monitored mass selection or family-based breeding programs. Although using broodstock from advanced selective breeding programs is a crucial step for hatcheries aiming to take the performance of their fingerlings to the next level, it's only one piece of the puzzle: before obtaining broodstock from an advanced breeding program, a hatchery needs to have well-designed infrastructure and good hatchery management practices in place. Without that, broodstock from advanced breeding programs cannot deliver on their promise. It's only when both elements are combined—hatchery management and broodstock from advanced selective breeding programs—that the best-performing fingerlings can be produced. So what does it take for hatcheries to produce good fingerlings and how do they do it?

While Infrastructure May Differ, General Steps in Producing Monosex Tilapia Fingerlings Are Mostly the Same

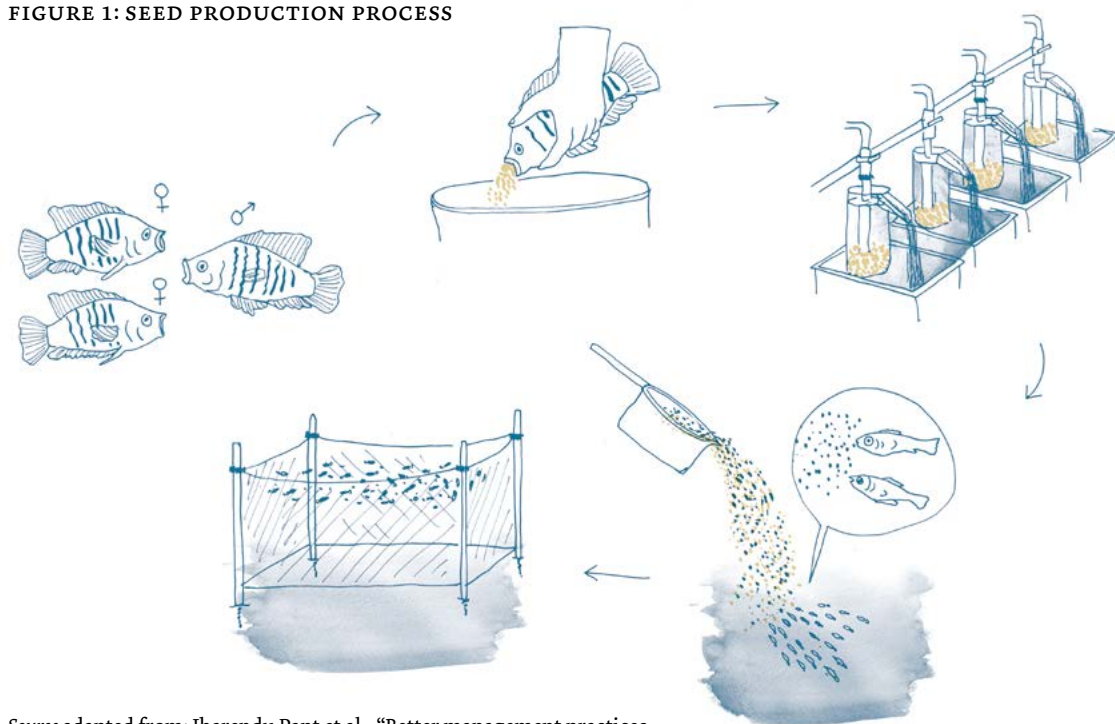
¹ Jharendu Pant et al., "Better management practices for monosex tilapia seed production: An illustrated guide", WorldFish (2020):

The most common hatchery system used for tilapia fingerling production worldwide is referred to as the hapa-in-pond system.¹ This system normally involves a number of earthen outdoor ponds with hapas (a kind of net enclosure) and an indoor facility where tilapia eggs are hatched and reared. But it really depends on the climate and other local conditions as to where the hatchery is located: if a hatchery is located where it is too cold for fingerling production, more of the facilities may be located indoors. And the opposite is true for hatcheries located where there is no electricity, for example, or if the company doesn't have the capital to invest in the land-based or indoor facilities needed. In these cases,

a hatchery system might be set up in small cages in a lake. But while the infrastructure may differ, the general steps in producing monosex tilapia fingerlings are almost always the same.

Upon arrival at the hatchery, male and female broodstock are ideally kept in separate ponds, tanks, or cages where they are acclimatized before being moved to breeding ponds or tanks. Tilapia should be stocked at a ratio of 2/3 females to 1 male, and the fish then breed naturally. A female fish starts to produce eggs after 1 week. These are fertilized by the male and then collected by the female in the mouth. If the farm has a separate incubation facility, the eggs are

FIGURE 1: SEED PRODUCTION PROCESS



Source adapted from: Jharendu Pant et al., “Better management practices for monosex tilapia seed production: An illustrated guide”, WorldFish (2020)

then collected by the hatchery staff from the fish’s mouth, and are separated according to their maturity stage. Once removed, the female fish can be released back into the pond and the eggs are then moved indoors to the incubation facility where they are transferred to trays or jars that are supplied with a constant flow of filtered water. Where there is no incubation facility, the eggs can be retained by the mother, spawn into fry, and be collected as swim-up fry within 2-3 weeks of hatching.

Once hatched, the fry (at this stage referred to as swim-up fry) can be stocked in small hapas, tanks, or cages again. At this moment, sex rever-

sal should take place. But how does this happen? The hatchery mixes fishmeal or another larvae feed with 17-alpha methyltestosterone hormone and feeds it for 21 days to the swim-up fry. Sex reversal then takes place around 10-15 days after hatching, and if done correctly, will result in a 98% or more all-male fingerling population. To prevent contamination of the ecosystem, this process would ideally not take place in open water unless there is no other option. Afterwards, the fingerlings can be moved into a pond, tank, or small cage where they are fed frequently to grow to at least 1 g before being transferred to larger growout ponds, tanks, or cages.

Optimizing Hatchery Infrastructure and Management

If hatcheries follow the basic steps as described above and in the illustration, and use high-quality broodstock, they should be able to produce high-quality post-larvae with high survival rates. However, at present for hatcheries in sub-Saharan Africa, mortality rates of 40% or more are acceptable. This is often compensated for by producing more swim-up fry. But what is really needed is for other factors—infrastructure, management, feed, and proper

broodstock—to be in place. If all of this is done properly, a mortality rate of only a few percent could become the new norm. This would significantly improve the efficiency of the hatchery.

Much of the mortality occurs due to poor management of water quality and fish husbandry in the first weeks of rearing. One possible solution could be to install small re-



Inside the incubation section of one of Lake Harvest's hatcheries

circulating aquaculture systems (RAS) where water quality, feeding, parasite control, and biosecurity can be much better managed than in outdoor ponds, and certainly than in open water cages.

Although advanced genetics in the form of marker-assisted (MAS) and genomic selection (GS) has the most impact (see p. 64), for many smaller hatcheries and farms this is too expensive and too difficult to manage. The costs would outweigh the benefits. But if the hatchery can implement better infrastructure and management practices and optimize these, a selection program could well be the next best way to improve the performance of broodstock and fry. In this way, most hatcheries could still make significant improvements: if done properly, a gain of 10% faster growth per generation is not uncommon. Good hatchery staff is a prerequisite for any program, and there are lots of consultants that offer support to hatcheries to set up programs and train staff in the right way.

Step-by-Step Approach

What is really crucial is that before investing in a selective breeding program, a hatchery, and also the farms that are using its fingerlings, should have all of the other elements in place. This is even more the case if the hatchery belongs to an integrated player. In this case, all of the other parts of the operation, such as the growout system and feeds, should also be optimized to get the most out of these investments. Only if everything is in place in terms of the best possible infrastructure and conditions will the fry—with improved genetics or resulting from selective breeding programs—have an environment in which they can really flourish and reach their full potential. While some of the front-running hatcheries may be in a position to take their operations to the next level by upping their genetics or manual selection game, many others will first of all need to get the basics right.

Sex-Reversal? Hormones? What's That All About?

Tilapia become sexually mature very early on. This means that a mixed population would lead to uncontrolled reproduction which would, in turn, result in inefficiency in the production system. Males also grow faster than their female counterparts. These factors combined make an all-male population the obvious choice for virtually every commercial tilapia producer in the world. Instead of manually selecting males and disposing of the females, which is sometimes done but is less effective and can't be done for the larger numbers, the most conventional way to produce an all-male population is to reverse the sex of the female tilapia. The most common way to do this is to feed tilapia fingerlings a feed containing 17-alpha methyltestosterone. Within 3 weeks, female tilapia become male tilapia. But the use of hormones raises several concerns relating to human health, animal welfare, and the environment.² Most hatcheries argue that they use hormones for a very short period of time only and in a controlled environment, and that such concerns are therefore unnecessary and unfounded: the hormones are no longer present in the animal after a couple of weeks, and spillage of hormone-contaminated water into the ecosystem would rarely happen in a controlled environment.

To avoid these ethical and environmental problems, an alternative method of YY-technology can offer a solution. Temperature is used to give male tilapia a thermal shock. This makes them change sex. Males and females are cross-bred for several generations until both males and females only have Y chromosomes, the result being that when they mate they will produce only male offspring.

Til-Aqua is the only significant supplier of YY-offspring in sub-Saharan Africa and markets its products as "Natural Male Tilapia." It's promoted as a sustainable alternative to hormone-treated tilapia. While Til-Aqua has been selling YY-offspring to hatcheries across sub-Saharan Africa for many years, it recently decided to change its business model. Previously, it only supplied the offspring of its breeding program in the Netherlands. In sub-Saharan Africa, it supplied to 10 countries including Côte d'Ivoire, Kenya, Mali, Mozambique, and Togo. But in 2020 and 2021, due to several problems related to COVID-19, the company decided to wrap up its breeding program in the Netherlands, and sold the parent broodstock of its pure lines to a number of hatcheries around the world. Six of these hatcheries are located in sub-Saharan Africa, including in Cameroon, Nigeria, Rwanda, and Tanzania. Til-Aqua now supports these hatcheries to develop their own YY-breeding programs, facilitating more independent breeding programs that produce fingerlings without using hormones. Til-Aqua emphasizes that using YY-technology allows hatcheries to drastically reduce their mortality rates as the use of hormones for sex reversal suppresses the development of the tilapia's immune system.³

Although some hatcheries might be able to adopt this technology and set up family-based breeding programs with it, other hatcheries consider it too complex and unfit for their operations. With hormone-based sex reversal still seen as the easiest and most efficient method, the adoption of YY-technology is likely to remain limited to niches where the hatchery operator recognizes the value of hormone-free tilapia, or where government regulations limit the use of hormones in aquaculture as is already the case in the EU and the US.

² Iwalewa Megbowon and T.O. Mojekwu, "Tilapia Sex Reversal Using Methyl Testosterone (MT) and its Effect on Fish, Man and Environment," *Biotechnology* 13, no. 5 (October 2014): 213-216, <https://scialert.net/fulltext/?doi=biotech.2014.213.216>.

³ Haitham G. Abo-Al-Ela, "Hormones and Fish Monosex Farming: A Spotlight on Immunity," *Fish & Shellfish Immunology* 72 (January 2018): 23-30, <https://www.sciencedirect.com/science/article/abs/pii/S1504644817306459>.

Training Sub-Saharan Africa's Next Generation of Aquapreneurs

Investors and CEOs of sub-Saharan Africa's vertically integrated tilapia producers alike highlight the lack of talent and practical skills as two of the main bottlenecks that prevent the sector from growing. Although expats fill some of the gaps, there's strong competition among companies to recruit those with managerial and practical knowledge. With staff hopping from one job to the other, companies find it difficult to build strong teams. To increase the available talent pool at all levels of seniority and across the supply chain, people need to be trained to catalyze the next phase of growth of the tilapia sector in sub-Saharan Africa. Some initiatives are already in place, such as the recently launched Aquaculture Academy in Kenya.



Take a Tour of the Homa Bay Campus

To contribute to developing the Eastern African talent pool of "aquapreneurs," Larive International and Lattice Consulting recently launched the Aquaculture Academy: the first vocational training center for aquaculture. It consists of two campuses: one in Machakos at Kamuthanga Farm, Eastern Africa's largest recirculation aquaculture system (RAS) farm, and one in Homa Bay, at the premises of local hatchery and cage farmer Jewlet Enterprises. The Aquaculture Academy offers the next generation of aquapreneurs a vocational training across all farming systems, including hatcheries, ponds, cages, and RAS. The goal is to inspire talented individuals to become fish farmers, develop practical skills applicable across the value chain, and eventually operate sustainable and profitable businesses.



Could Genetics Be the Silver Bullet for Commercial Tilapia Producers in Sub-Saharan Africa?

Selective breeding and genetics play a crucial role in animal husbandry. Among other things, they contribute to faster growth and tolerance to diseases, while also reducing production costs and the environmental footprint of animal husbandry. New technologies allow us to not only select animals based on their physical appearance (phenotypic selection) but also on information hidden in their genes (genotypic selection). Can advanced genetics help commercial tilapia producers in sub-Saharan Africa to produce an even more affordable and sustainable protein?

Selective Breeding and Advanced Genetics

While many tilapia hatcheries aren't doing any serious selection at all, those that do mainly apply mass selection and only a few have set up family-based selection. Though mass selection means that strong performers are selected from mixed populations based on their own phenotype, family-based selection implies that this strong performance is selected from within or between families. Depending on the number of target traits, a family-based breeding program would require between 50 and 100 separate families and calls for infrastructure to be in place. This usually includes a nucleus where individual families are reproduced and tracked and a multiplication facility where broodstock is multiplied before supplying it to hatcheries for fry production.

Newer technologies, such as marker-assisted selection (MAS), genomic selection (GS), have started making their way into tilapia breeding only more recently. Applying

these technologies to a mass-based or family-based selection program enables selection on a broader range of traits. This, in turn, allows for more complex selective breeding programs and increased potential gains to be achieved per breeding program generation. The application of these technologies demands significant investment in DNA sequencing technology and managing it requires a lot of expertise. Therefore, only some of the larger producers in the world have this kind of program in place.

With simple selection already substantially increasing growth rates, the investment in MAS and GS may not always weigh up against the additional gains that a traditional breeding program can achieve, especially during the first few generations. However, with DNA sequencing technology becoming rapidly more affordable, more industry players may step up their genetics game soon.

The Establishment of GIFT, Its Public and Commercial Distribution

WorldFish Has Played a Major Role in the Advancement of Tilapia Genetics and Its Integration in National Breeding Programs

In 1988, WorldFish (when it was still called ICLARM) and its partners founded the Genetically Improved Farmed Tilapia (GIFT) project. In a facility in the Philippines, Nile tilapia (*O. niloticus*) sourced from Asia and Africa was used to start a family-based selection program focused on growth. Already after a few generations, researchers observed significant improvements. GIFT was supplied to stakeholders in among others the Philippines, Bangladesh, China, Thailand, and Vietnam, where GIFT was integrated into breeding programs operated by research organizations and governments. In some cases, private companies acquired broodstock from these national breeding programs and integrated them into their own breeding programs. This made GIFT part of many of the world's current tilapia breeding programs.

In 2001, WorldFish brought GIFT to its own facilities in Malaysia which it operates in partnership with the Malay-

sian government. Here, WorldFish still runs its own family-based selection program today. Considering GIFT to be a public good, WorldFish continued to make it available to governments that could justify their necessity to access GIFT. Their strain is now known as WorldFish GIFT. At present, WorldFish is producing the 14th generation since its transition to Malaysia and has supplied 16 countries worldwide, among which Costa Rica and Brazil, but no countries from sub-Saharan Africa are included in this list. Although not much information is available, WorldFish is believed to have started applying MAS and GS to further improve its strain.

Until 2007, WorldFish restrained distribution of the original and WorldFish GIFT strain to sub-Saharan Africa as introducing genetically improved tilapia to Africa was considered a threat to wild tilapia populations native to the continent. Instead, WorldFish offered to develop national breeding programs with local strains using GIFT methodology. This resulted in the development of the Akosombo strain in Ghana and the Abbassa strain in Egypt, while

other countries such as Malawi and Côte d'Ivoire received WorldFish support to improve their breeding programs. WorldFish changed its position in 2007 and can at present supply to sub-Saharan Africa. The original WorldFish GIFT was supplied to Ghana in 2012 for research purposes only and wasn't introduced to sub-Saharan Africa for commercial purposes. This may change soon since Nigeria's government has made the official request to do so.

Commercialization of the GIFT Strain Started Late 1990s

Besides supplying governments in Asia and South America with the GIFT strain, in 1997, the consortium partners established the GIFT Foundation International Inc. (GFII), which was granted the rights to commercialize the GIFT strain. The GFII soon entered into a partnership with GenoMar from Norway, which took control of the facilities in the Philippines. GenoMar used GIFT to develop its own strain: GenoMar Supreme Tilapia (GST). Likewise, Benchmark Spring Genetics has developed its Spring Genet-

ics® stock of Nile tilapia of GIFT origin, developed at its breeding operations in the US. Today the GST and Spring Genetics® stocks are considered two of the best strains available worldwide. Other companies, such as Nam Sai Farm and Mani Farm in Thailand, and ProGift in China, have used GIFT strains to develop their own breeding programs.

GenoMar and Benchmark Spring Genetics are leading the implementation of advanced genetics technologies in tilapia breeding. GenoMar already started applying MAS back in 2004 and in 2019 it fully integrated GS into its selection program. Benchmark Spring Genetics previously used traditional family-based selection methods to select for growth, survival, temperature tolerance, fillet yield, and disease resistance, but implemented MAS and GS in 2019. Benchmark Spring Genetics' work on genomics is based on its proprietary high-density SNP array which it has been developing since 2017.

Restraints on Imports Limit Movement of Improved Genetics in Sub-Saharan Africa

Nile tilapia is the main tilapia species cultivated commercially in sub-Saharan Africa. Most countries with Nile tilapia as a native species allow hatcheries and farmers to import Nile tilapia for breeding purposes. However, in some countries where Nile tilapia is not native, its cultivation is controlled by government regulations requiring local farmers to use native species only. This is the case in parts of Zambia and Malawi. Even in some of the countries where Nile tilapia was already introduced many years ago, like in Ghana and Uganda, government regulations today restrain imports of broodstock.

There are various reasons for these policies. Just like WorldFish has a policy not to supply to sub-Saharan Africa, some governments ban imports or the use of Nile tilapia because of concerns that introduced strains will outcompete local strains in the wild, threatening diversity. There's also a fear of introducing disease through the transboundary movement of broodstock. Although the first concern may be valid in some cases, the second

reason possibly less so, and it may even be counterproductive; prohibiting imports may encourage the illegal trade of broodstock within sub-Saharan Africa. Contrary to regulated imports, smuggled broodstock might not be tested for disease and could therefore pose an actual threat to local production. Therefore, a strong regulatory framework for importing broodstock and capacity to enforce this framework are necessary for countries that wish to benefit from the gains that overseas broodstock suppliers have already made.

Some commercial farmers mention import bans on tilapia broodstock as a reason for not reaching their production targets. Although they acknowledge that breeding with local strains is possible, strains such as those from Benchmark Spring Genetics, GenoMar and WorldFish are believed to significantly outperform local strains. Many commercial farmers perceive obtaining these strains as an essential step to reach their production goals.

With Two of the Largest Producers Taking the Leap, a Turning Point May Have Been Reached

Two of the leading tilapia farmers in sub-Saharan Africa, FirstWave Group (FirstWave) and Lake Harvest Group (Lake Harvest), recently announced partnerships to improve their access to advanced genetics for their vertically integrated tilapia operations in sub-Saharan Africa. They consider genetics to be a next step in becoming more efficient and reducing production costs. Interestingly, both companies take opposite strategies.

Thanks to its deal with Benchmark Spring Genetics, Lake Harvest has secured access to broodstock for at least 5 years for its operations in Zambia and Zimbabwe. Lake Harvest has also obtained the right to sell fingerlings to other farmers, functioning as a regional multiplication center. For Benchmark Spring Genetics, this partnership is a breakthrough. So far, selling to sub-Saharan Africa was perceived as a risk. It was challenging to find partners that could be trusted to respect the intellectual property of the genetics and that wouldn't use it to obtain quick gains in their breeding programs instead of engaging in a long-term mutually beneficial partnership. James de la Fargue, CEO of Lake Harvest, says he can't wait to soon benefit from the progress made over the many generations of Benchmark Spring Genetics' breeding program. He sees it as quick win and a significant step towards improving

survival rates, significantly reducing Lake Harvest's production costs, and accelerating his biomass turnover.

In Zambia and Uganda, FirstWave will continue to develop its own high-performance local tilapia breeds using local strains only. FirstWave's breeding program is currently in its 11th generation. The company recently announced a partnership with Xelect, a genetics service provider with DNA-sequencing capabilities located in Scotland, moving from a mass selection program to a family-based GS-assisted program. Xelect will use samples sent by FirstWave to continuously improve the selection based on traits that FirstWave finds important, and that ensure the fish thrive under local farming conditions. Adam Taylor, Chairman of FirstWave Group, believes it's better to invest in a breeding program that doesn't depend on the transboundary movement of broodstock and that allows his company to keep complete control over the quality and costs of its broodstock and fingerling production. Having partnered with Xelect, he is confident that the local breeding programs can achieve significant progress in terms of improved efficiency and health—allowing FirstWave to reduce production costs significantly over time while remaining fully independent.

The Future of Advanced Genetics

There is no silver bullet, but genetics could become an essential piece of the tilapia puzzle for producers in sub-Saharan Africa. However, before genetics can deliver on its promise, other things need to be in place—including optimal infrastructure, management of hatcheries, and optimization of growout production systems, such as use of high-quality feed. Moreover, proper management of shared waterbodies and enforcement of laws need to be in place as well. One can have a fish that's tolerant or resistant to a certain disease, but what if due to poor enforcement of regulations broodstock infected with other diseases is imported into the country?

Few producers are at the point where they can and should invest in genetics to reap its benefits. For them, with costs of sequencing hardware having come down considerably, genomics programs have become more affordable. Besides, by applying well-developed family-based selection and advanced genetics it might take tilapia only 10 years to achieve the kind of progress that took other species 50 years.

Diseases Pose a Threat to Production and Profitability of Farmed Tilapia

Diseases are a risk to animal husbandry and it's no different for tilapia. Several bacteria, parasites, viruses, and fungi pose risks to the fish's health, performance, and survival.

¹ José Gustavo Ramírez-Paredes et al., "First detection of infectious spleen and kidney necrosis virus (ISKNV) associated with massive mortalities in farmed tilapia in Africa," Wiley Online Library (2020): <https://onlinelibrary.wiley.com/doi/full/10.1111/tbed.13825>.

² Win Surachetpong, Sri Rajiv Kumar Roy and Pamela Nicholson, "Tilapia lake virus: The story so far," Wiley Online Library (2020): <https://onlinelibrary.wiley.com/doi/10.1111/jfd.13237>.

Between 2017 and 2019, Ghana's production almost reduced by half due to various diseases, such as the infectious spleen and kidney necrosis virus (ISKNV) and multiple strains of Streptococcus. And then there's the tilapia lake virus (TiLV), which scared the tilapia industry worldwide. First reported in 2014 in Israel, by 2020 it was reported in 16 countries, including Tanzania and Uganda.²

If not properly managed, diseases not only threaten farmed tilapia but can also spread to wild populations or vice versa. Strong regulatory frameworks, good biosecurity, adequate management practices, improved genetics, and possibly vaccinations need to be in place to prevent disease outbreaks in the first place, and deal with them swiftly if they occur despite all the measures in place. Keeping in mind the challenge of antimicrobial resistance, the irresponsible use of antibiotics should be avoided.

Government Regulations Have an Important Role to Play

The government has an important role to play in designing and enforcing a regulatory framework for animal health. Regulations concerning biosecurity, monitoring, and reporting at each level of the supply chain—from the import of broodstock, to breeding and hatchery facilities, and growout farms—need to be in place. Stakeholder participation and expert consultation in developing these regulations are essential to ensure that the framework

contributes to an enabling environment for the aquaculture industry while safeguarding its sustainability.

An essential part of government regulation is related to the import of live animals for breeding. Internationally, trade in live animals is regulated by the World Organisation for Animal Health (OIE), which develops standards for the transboundary movement of live animals. It's

often through these transboundary movements that diseases spread. In the case of ISKNV and TiLV, it is suspected that these viruses were introduced into sub-Saharan Africa by importing infected broodstock. If governments apply and enforce OIE standards, the risks that transboundary movements pose will be reduced to an acceptable level. Preventing unregulated broodstock imports is in everybody's interest, as the damage of introducing new diseases can be catastrophic.

As to the use of antibiotics, governments also have an important role to play, for example by ensuring that the use of antibiotics in all animal husbandry is limited as much as possible. Use of antibiotics as a preventive measure needs to be prohibited and antibiotics should not be for sale without a prescription from a competent professional. For setting up a residue monitoring plan, governments may look at EU regulations for aquaculture products which third countries need to comply with when exporting aquaculture products to the EU. These regulations are regarded as the most stringent worldwide.

Genetics Help to Select Fish Free of and Resistant to Pathogens

Breeding programs play a crucial role in selecting a fish that is free of pathogens and that is tolerant or resistant to pathogens when exposed to them. Fish that are free of particular pathogens are referred to as specific pathogen-free (SPF), with the emphasis on "specific," as the fish are often not free of all pathogens. Obtaining the "SPF" status is different from testing negative for a specific pathogen as it implies regular monitoring of the pathogen-free status over time. SPF fish are allegedly free of a particular pathogen as long as they are kept in a biosecure environment.

Robustness, tolerance, and resistance—buzzwords in aquaculture genetics—refer to the way the fish responds to pathogens upon exposure, for which there are two main approaches. In the first one, animals that survive and perform well when exposed to pathogens are selected from a pond or cage. Upon reintroduction to the breeding program, each successive generation may be more tolerant than the previous one to the pathogens it was exposed to. The other approach consists of applying advanced genetics to select the genes that make the fish more tolerant or resistant to specific diseases. This is described in detail on p. 64.

Using these methods allows for the identification and selection of those genes that make the fish more robust, tolerant, or resistant. Benchmark Spring Genetics and GenoMar are companies that are currently developing tilapia strains that are tolerant or resistant to various strains of Streptococcus and other diseases.



Biosecurity and Farm Management Can Prevent Diseases from Spreading

If a fish that's free of pathogens is introduced to a farm, it's a matter of biosecurity to ensure that the production unit itself is, and remains, free of pathogens as well. While this is relatively easy in a closed system, in open systems—where different farms use the same waterbody—the risk of pathogen introduction can only be reduced, not eliminated. In those cases, area-based management—the collective management of a shared waterbody—is crucial to prevent diseases from spreading from one farm to another. Though this might be viewed as a role for governments, carrying out this task is in the industry's interest

as well. Therefore, farmers need to be proactive for this approach to be effective. Each farm has to implement better management practices in terms of stocking densities, fish handling, feeding, disinfection protocols, and fish health monitoring and reporting. When farms and waterbodies are managed correctly and stress for the fish is reduced to a minimum, diseases are less likely to put production at risk. Technology, especially in terms of data collection and monitoring, is expected to play an increasingly important role in preventing disease outbreaks.

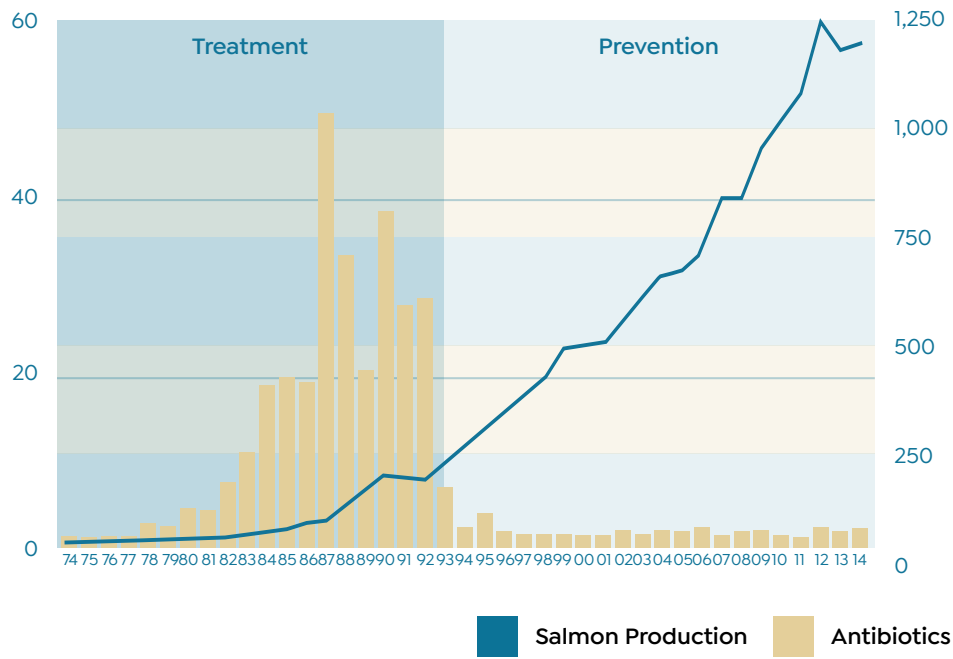
Vaccination as a Potential Solution

So far, most farmers in sub-Saharan Africa don't have access to selectively bred tilapia that is tolerant or resistant to the pathogens that cause disease. As an alternative, farmers can choose to vaccinate their fish if a vaccine for that pathogen is available. Once a vaccine obtains registration, it becomes possible for hatcheries and farmers to invest in vaccination and reduce risks of mortalities, especially during growout. This has proven to be effective in the salmon industry; ever since salmon farmers have started using vaccines against the most common diseases, use of antibiotics has reduced drastically. When the right vaccines become more readily available, and farmers become convinced of the business case, the same might happen in tilapia farming in sub-Saharan Africa.

Recently, larger animal health companies have started to invest in tilapia vaccines. Virbac acquired Ictyopharma, which registered the first vaccine for *Streptococcus* in Ghana. PHARMAQ and MSD Animal Health also launched tilapia vaccines

but these aren't yet available in sub-Saharan Africa. While these vaccines are gradually becoming available in sub-Saharan Africa, the cost of a vaccination program might be too high for individual farms. As long as farmers aren't convinced of the business case for using vaccines, governments can play a role and support collective vaccination programs.

FIGURE 1:
THE EFFECT OF PREVENTIVE VACCINATION ON THE USE OF ANTIBIOTICS IN SALMON FARMING (ADOPTED FROM PROF. OYSTEIN EVENSEN)



Tilapia Farming and the Aquatech Revolution

So far, using technology in aquaculture has mainly been seen with the higher-value species such as salmon and shrimp. However, in the tilapia value chain, tech is increasingly being adopted as well, and Aqua-Spark believes that we're only at the beginning of the tech revolution. This is the moment to get the industry right. And a digitalized, data-driven industry is part of that vision. Companies should be encouraged to adopt technologies that support the profitability and sustainability of the sector to make a giant leap into the future. For tilapia farms, technology adoption can be divided into three blocks: farm hardware, farm software/digitalization, and tech-enabled disruptive business models.

Farm Hardware Enhances Economic and Environmental Performance of Farms Worldwide

A lot of innovation relevant for tilapia and which is already used in large tilapia producing countries such as Brazil, China, and Egypt is also suited to pond farming in sub-Saharan Africa. Such innovations include technologies like automated feeding, the use of sensors to manage water quality, new solar energy-based aeration technologies, and farm management platforms that allow farmers to control these technologies on their smartphones. For Aqua-Spark, one of the best examples comes from its investment in eFishery which has developed automated feeding for tilapia pond farmers. eFishery started providing sensor-based, intelligent, automated feeding solutions to tilapia farmers in Indonesia back in 2013 and has now developed into a disruptive service provider with a significant positive impact on the profitability and livelihoods of small-scale farmers.

Salmon farmers have driven technology adoption in cage farming in countries like Canada, Chile, Norway, and Scotland. Most of the innovations are facilitated by obtaining live, farm-level and

environmental data—collected through technologies such as acoustic sensors and cameras—and satellite data. Improved farm-level data enables smart feeding and health control, and contributes to the overall efficiency of a farm. This is known as precision aquaculture. Tech is, thus, already playing a significant role in enhancing the economic and environmental performance of salmon farmers worldwide, but we expect further efficiency gains once mass adoption takes place.

Even though salmon is a much higher-value species than tilapia, with the cost of many technologies gradually coming down, some of the innovations used in salmon farming may soon also become available in the tilapia sector. This includes the push towards lower-impact production systems such as recirculating aquaculture systems (RAS).

One example of tech innovation in tilapia farming is Aqua-Spark's investment in Brazilian tilapia farmer Fisher Piscicultura: while most commercial tilapia farmers in Brazil use imported cages, Fisher Piscicultura has designed its own cages to



hold larger volumes of fish and has integrated auto-feeding and fish-handling technology. This innovation improves animal welfare and reduces operational costs. Another example is the eFishery technology which is already being used by pond tilapia farmers in Indonesia.

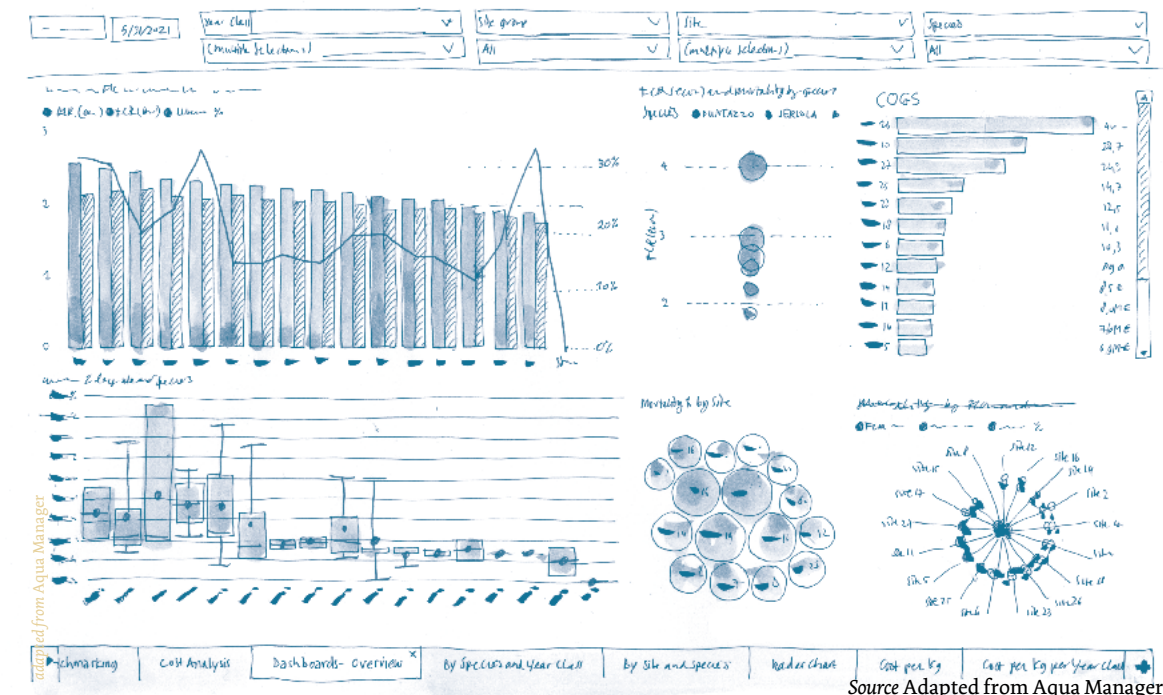
Digitalization: Farm Software Playing a Disruptive Role

Farm software could well play an equal—or maybe even a more prominent—disruptive role in tilapia farming in sub-Saharan Africa. Tech start-ups and established industry players are developing apps that provide digitalized book-keeping and farm management. When farmers enter parameters into these apps, such as the amount of fish stocked, the feeding moments and quantities, and the average weight of the fish, the farm software provides insights into the economics of the crop and the performance of the fish. The next step would naturally be to fully automate data collection and reporting, and to provide the next level of actionable insights.

AquaManager, an aquaculture-management platform developed in Greece, recently generated attention when the company announced a partnership with FirstWave Group. Bryan McCoy, Co-CEO of FirstWave Group, explained that “[w]ith the current deployment of aquaManager, we are running core operational processes and managing 123 cages in two locations, with data accessible by all staff. [...] The platform allows us daily visibility into operational performance in both geographies, and enables us to plan production in a detailed way to support customer demand.”¹ FirstWave Group has also worked with Sensaway, a Hatch Blue portfolio company, and is currently using its OxyCast product to measure dissolved oxygen levels in cages and ponds. This information is vital for optimizing fish feeding and for aeration control. Victory Farms is another example of a company using tech, this time to monitor the fish in their cages.

Large farms can more easily afford to adopt farm hardware and software. The advantage of soft-

¹ Tembwe Mutungu, “AquaManager Aquaculture Management Software Goes Live at Leading African Tilapia Producer”, Cision PRWeb, October 21, 2020, <https://www.prweb.com/releases/2020/10/prweb17480496.htm>.



ware solutions is that they're often relatively low-cost, making them accessible to small- and medium-scale commercial farmers too. Standardized apps enable farmers to digitalize the traditional farm diary. If used correctly, this provides farmers with the opportunity to make operations more efficient. With a new generation of farm manager emerging, and with more and more farms adopting tech solutions in general,

it's only a matter of time before using apps and other tech will be common practice in tilapia farms in sub-Saharan Africa.

Tech-Enabled Disruptive Business Models and the Aquatech Revolution

Tech is already being used in other parts of the world, and we firmly believe that the aquatech revolution will soon enable disruptive business models in the tilapia sector in sub-Saharan Africa. The Aqua-Spark-backed company eFishery goes far beyond optimizing feeding: it uses the data collected through the automated feeding hardware to provide farmers with financing services and market access. This contributes to more efficient and sustainable production while increasing profitability. Such data-driven solutions aim to put smallholders on an equal footing with the large-scale farmers through access to financing and the ability to sell their fish at prices that value their practices. And all of this is done while also helping farmers to do the right thing from an environmental perspective. This means that in sub-Saharan Africa, innovative companies just like eFishery in Indonesia, could contribute to making small-scale tilapia pond farming much more profitable in the future.



The “Aquatech Revolution” deserves much more attention, so we’re dedicating our next AquaInsights report to it!



Marketing and Distribution



Farmers Investing in their Own Distribution Networks

Most farmers, especially the smaller ones, sell at least part of their fish at the farm gate to local traders or fish mongers who sell it onwards to local and regional traditional markets. In these established supply chains, traders and fish mongers take considerable margins at the cost of the farmer. Moreover, demand from these local and regional markets may saturate once nearby production surges. Therefore, as soon as their volumes grow, farmers tend to invest in their own distribution channels. This allows them to cut out intermediaries, develop their own market presence,

and promote their product and brand as a healthier, more sustainable and affordable alternative to wild-caught and imported tilapia and other animal proteins.

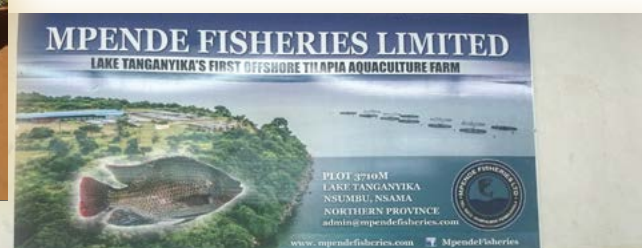
Some tilapia farmers are already involved in marketing and distribution because they came from a fishing background which often means they have their own shops. This is the case, for example, for companies like Mpende Fisheries in Zambia and Maldeco Fisheries in Malawi. However, for most of the farmers, marketing and distribution is a new venture that requires significant investment and expertise to develop and manage these activities. Expansion of distribution channels has been a priority for all major farmers such as FirstWave Group and Lake Harvest Group in Zambia and Uganda, Victory Farms in Kenya, as well as Tropo

Farms in Ghana. Although venturing into marketing and distribution is—as a first step—often done by developing partnerships with existing wholesalers or retailers, most of the companies soon invest in their own network of wholesale and/or retail shops to take control into their own hands.

It's having a network comprising their own shops that allows farmers to guarantee their customers a consistent supply of tilapia and also ensure the freshness of their products. This also allows them to build brand presence in the market. As most tilapia in sub-Saharan Africa is sold fresh, investments in distribution are not limited to the shops alone but also include equipment such as ice machines, insulated boxes, and refrigerated trucks that keep the products fresh from farm to plate. Farmers also invest in brand development and promotion to expand their market and customer base. What's more, having their own distribution networks allows the farmers to enter more formal market segments such as institutional food service, fast-food chains, and the fast-growing supermarket chains.

Processing and the Advantage of Freezing Capacity

As already mentioned, most locally farmed tilapia in sub-Saharan Africa is sold by the farmer as a fresh fish. It's harvested, (sometimes) put on ice, and sold onwards to the market where it's mostly then deep-fried or grilled before being sold to the consumer. In some cases, especially in Western Africa, local processors dry, salt, and smoke the fish, and supply traditional markets with these products. But in most markets, the processing of fresh tilapia—if any—is limited



to descaling and gutting the fish. The required investments for processing the fish in terms of facilities and equipment are, thus, minimal. Although some producers offer tilapia fillets as well (which requires a bit more investment in equipment and expertise), presently much of the fish they farm is too small for fillets and, more importantly, the market for fillets is rather small too.

Some of the largest producers have, however, chosen to invest in freezing equipment. This includes plate freezers and/or blast freezers, and cold storage facilities along the supply chain from the farm, to the trucks, all the way to the wholesale and retail shops where the frozen fish will be sold. Although one might think that frozen fish is of lesser quality than fresh fish, this is not necessarily the case. If the fish is frozen right after harvest and if the cold chain is maintained properly, once defrosted, a frozen fish may even be fresher than a fish that was chilled on ice after harvest and sold to the customer several hours later. If customers are aware of this, and if they are already convinced of the fact that locally farmed tilapia is a good choice, having freezing capacity brings many other advantages. Most importantly, it allows a farmer to keep a stock of fish in the cold store instead of in the pond where the fish still need to be fed and kept healthy. This means that farmers can produce more fish when conditions are optimal and freeze the fish that can't be sold immediately. This fish can then be sold once market demand outgrows the fresh fish supply available at that moment. Of course, freezing brings a cost as well, and it can only be done if reliable supply of energy is secured.

Frozen products can also be sold to markets even further away. First of all within sub-Saharan Africa, but possibly in the future also to export markets in the US, Europe, and, if the world turns upside down, also to China—in a scenario that it becomes a net importer instead of an exporter of tilapia. However, producers have to be aware of the fact that to export fish to overseas markets requires a strong regulatory and compliance framework, and that government involvement is also necessary for certifying establishments and monitoring the quality of products according to the standards and requirements of each individual market.



Downstream Digitalization and the Rise of Home-Delivery Models

An interesting development worth mentioning is downstream digitalization, often enabled through farm-level technology and enhanced product traceability. These are data-driven digital marketplaces linking producers to buyers domestically and internationally. Such platforms typically provide services to producers to help them increase productivity and optimize product specifications to obtain higher prices for their products, whilst at the same time linking them with buyers. In doing so, this often leads to data-driven finance solutions for farmers. These platforms are, at present, still typically B2B, but are increasingly also developed for the B2C market, enabled by the fast growth of home-delivery models: in such a case, fish is delivered straight from the farm to the consumer's doorstep. Whilst for terrestrial animal and plant-based foods many of these marketplaces already exist across Africa, for fish and seafood it's still an emerging trend, but there are some pioneers. Because of the fast growth of these kinds of platforms in other parts of the world, there's a great opportunity for Africa to follow.



Twiga Foods in Kenya



Agrocenta in Ghana

Lake Harvest's CEO Reveals His Processing and Distribution Business Story

Lake Harvest Group (Lake Harvest) was the first tilapia producer to make significant investments in processing and distribution. Today, it operates processing and freezing facilities, and a network of distribution companies and shops across Southern and Eastern Africa. Interestingly, Lake Harvest has partnered with Surrey Group to provide customers with a broad range of animal proteins. James de la Fargue, CEO of Lake Harvest, tells us why.

We Started Exporting Fresh Fillets to Europe but Later Turned to Regional Markets

The genesis of Lake Harvest was exporting fresh tilapia fillets to Europe—this prompted our investment in the processing factory 20 years ago. Ten years later, regular freight flights between Zimbabwe and Europe declined with the reduction in flower, and fruit and vegetable exports. Combined with volume growth in the business, Lake Harvest reoriented its sales to regional markets and needed to develop a broader product range for those markets covering fresh and frozen, whole round, gutted, and filleted fish. Freezing capacity was introduced to allow us to keep up a daily harvest of 25-30 MT, part of which is directed to weekly fresh orders. The balance is frozen and packed for the supermarket route to market; supermarkets need guaranteed supply all year round, and we can provide this for our full product range.

We Established our Distribution Network to Protect Fish Sales but Broadened Our Protein Product Offering to Generate Sufficient Throughput

When we started to turn to regional markets, there were few third-party distributors willing and able to add fresh fish to their logistics routes due to drip loss and smell, among other things. We found that it was more effective to do the distribution ourselves, and it also meant we could ensure that our brand name was promoted and safeguarded. Today, we have our own depots and retail outlets in each distribution country. The investment in cold-chain logistics and a distribution network is significant, and this needs to be recovered with a high volume of product. We focus on our own tilapia to break even, but through our partnership with Surrey Group we also sell other animal proteins, such as *kapenta* (a traditional Zambian fish), mackerel, and poultry to provide a more interesting distribution bottom line.



We tested selling fish and chicken in the same depot or shop and concluded that there was no cannibalization of sales—in fact, shoppers preferred to pick up both products and so it actually became an attractive customer proposition. We were focused on tilapia and so we needed to find a partner of a similar size and with a similar approach to provide the other products: Surrey Group was a perfect match. It was strong in the provinces and on wholesale sales, and we were stronger in the capital and had better contacts in the major supermarket chains. When both partners provide a cost-effective service of excellence, and protect and enhance each other's brands, this approach of combining expertise and network can work well.

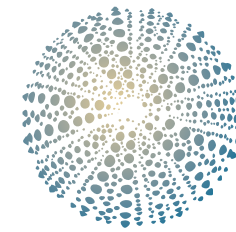
The Devaluation of Local Currencies Requires Us to Continue Widening Our Export Reach

In countries like Zambia and Zimbabwe, the local currency has devalued significantly compared to the US dollar. If we only sell domestically and don't increase the price of our fish for the local consumer, the inputs we purchase abroad will become increasingly expensive. In summary, it's necessary to have a good working knowledge of the dynamics of the local currency, how quickly one needs to review prices yet appreciate local spending power. More importantly, we need to have markets that exceed our supply at viable prices by 20% so we can reorientate product to better markets quickly. At one stage, we exported 60% of our product from Zimbabwe to Zambia. Now it's less than 10% due to the market dynamics at play.



TALKING TO THE INVESTORS

To give you an idea of how investors view the opportunity of investing in tilapia in sub-Saharan Africa, we talked to a few of them. Something that all of our interviewees have in common is that they can all see the potential of tilapia, despite approaching the subject from different perspectives. Three out of the five investors we've spoken to are involved in upstream and downstream aspects but have yet to invest in tilapia production as most farms have not yet reached the scale required to meet their investment criteria. The others are actively investing in tilapia production in Africa.



AquaSpark

Investing in the Future of Aquaculture

Relevant Investments
Chicoa Fish Farm
Mozambique (tilapia)
Fisher Piscicultura Brazil (tilapia)
Indian Ocean Trepang
Madagascar (sea cucumber)

Who
Joel Mugwisa Ssemukaaya *Investment Manager*
Jan Slootweg *Investment Manager*

The Fundamentals Are There, As Is Demand, and This Is Set to Grow Further with Better Infrastructure in Place

We believe there are strong fundamentals for tilapia in sub-Saharan Africa. First of all, because many consumers are familiar with the fish, while there's also still room for growth. Secondly, sub-Saharan Africa provides ample opportunities to farm tilapia. While various countries have been farming it for many years, there aren't that many sizeable farms yet, unlike in other parts of Africa such as Egypt. Demand has thus consistently exceeded supply and led to an increase in tilapia imports, mainly from China. This trend can be reversed through significant investment in the production of tilapia in sub-Saharan Africa.

Developing sustainable aquaculture as a self-sufficient food system to replace fisheries in sub-Saharan Africa requires good and sizeable farms, but also feed suppliers and other value-chain parties. This industry will provide ample opportunities for entrepreneurs, like farmers, suppliers, and off-takers, and will create new jobs.

Aqua-Spark Looks for Founder-Led Teams with a Vision of Innovation and Sustainability

We're looking for companies to help realize the potential of sustainable aquaculture through showcasing what's possible. We have a specific strategy for portfolio construction regarding size, sustainability mindset, and social and environmental impact goals. For those companies that meet these criteria, we then look at management—strong, founder-led teams with an entrepreneurial spirit and a clear vision are a must for us; we assess the potential (including socio-economic impact) of a company, and what we can contribute in addition to capital, for instance through our ecosystem of (innovative) portfolio companies and partnerships.

There Are a lot of Challenges for Investing in Tilapia in Sub-Saharan Africa that We Aim to Overcome with Our Africa Fund

The Aqua-Spark Africa Fund (see p. 88) will be dedicated to aquaculture in Africa, and tilapia is obviously a prominent species. We see quite a number of interesting opportunities, especially since we've become more explicit about our ambitions in sub-Saharan Africa and more companies have started to approach us. The investment opportunities in sub-Saharan Africa are relatively small in terms of ticket size, compared to the pipeline of the main fund, but this will change as the industry develops. This isn't only true for farming operations, but also for alternative feed ingredients and cold-chain distribution. Likewise, we also expect that digitalization and (new) technologies will become more relevant.

In addition to kickstarting this next phase of necessary sector development, the fund serves to encourage other investors to engage in this space. We do notice the lack of sizeable opportunities. We also notice (concentration) risks that can be another factor holding them back. By investing in a portfolio of companies in several countries and along different parts of the value chain, we aim to mitigate these risks for our investors and create an investment model that works for scaling sustainable aquaculture in Africa.

Relevant Investments
Rabobank hasn't yet financed sub-Saharan African tilapia farmers, largely because the farms aren't yet large enough to fit the strict corporate mandate for the continent. The involvement at present limits itself to the financing of multinational feed companies with operations in sub-Saharan Africa.

Who
Kees Verbeek
Chief Representative Officer at Rabobank Kenya and Investment Committee Member of Veris Investments



Tilapia Can Become an Affordable Protein that Meets Growing Demand in Sub-Saharan Africa

Coming to this conclusion isn't that difficult: it's easy to farm, wild-caught fish catches are declining, and, for several reasons, pork and beef just won't make it. As the potential of chicken might be limited due to a shortage of soybean, tilapia's potential could be even bigger. I believe that farmed fish will become very large in sub-Saharan Africa.

With a Growing Pool of Know-How and Expertise, the Momentum for Investment Is Present

The momentum for more investment has absolutely arrived, mainly because the pool of know-how and expertise is growing, which drives the expansion of the sector. The staff of the big farms are moving from one company to the other. They apply what they've learned and help others to become successful as well. Entrepreneurs, once having seen others succeed, try their luck and start their own businesses with the help of these experts. This is actually what's happened in Nigeria's booming catfish sector. After a lot of people observed that a pond with catfish actually makes money, many others jumped in and tried to do the same. This accelerated the practice and contributed to a surge in production. The same is happening with tilapia cage farming. In countries like Kenya and Uganda, new cage farmers are emerging who aim to copy the success of others who've started to make money already.

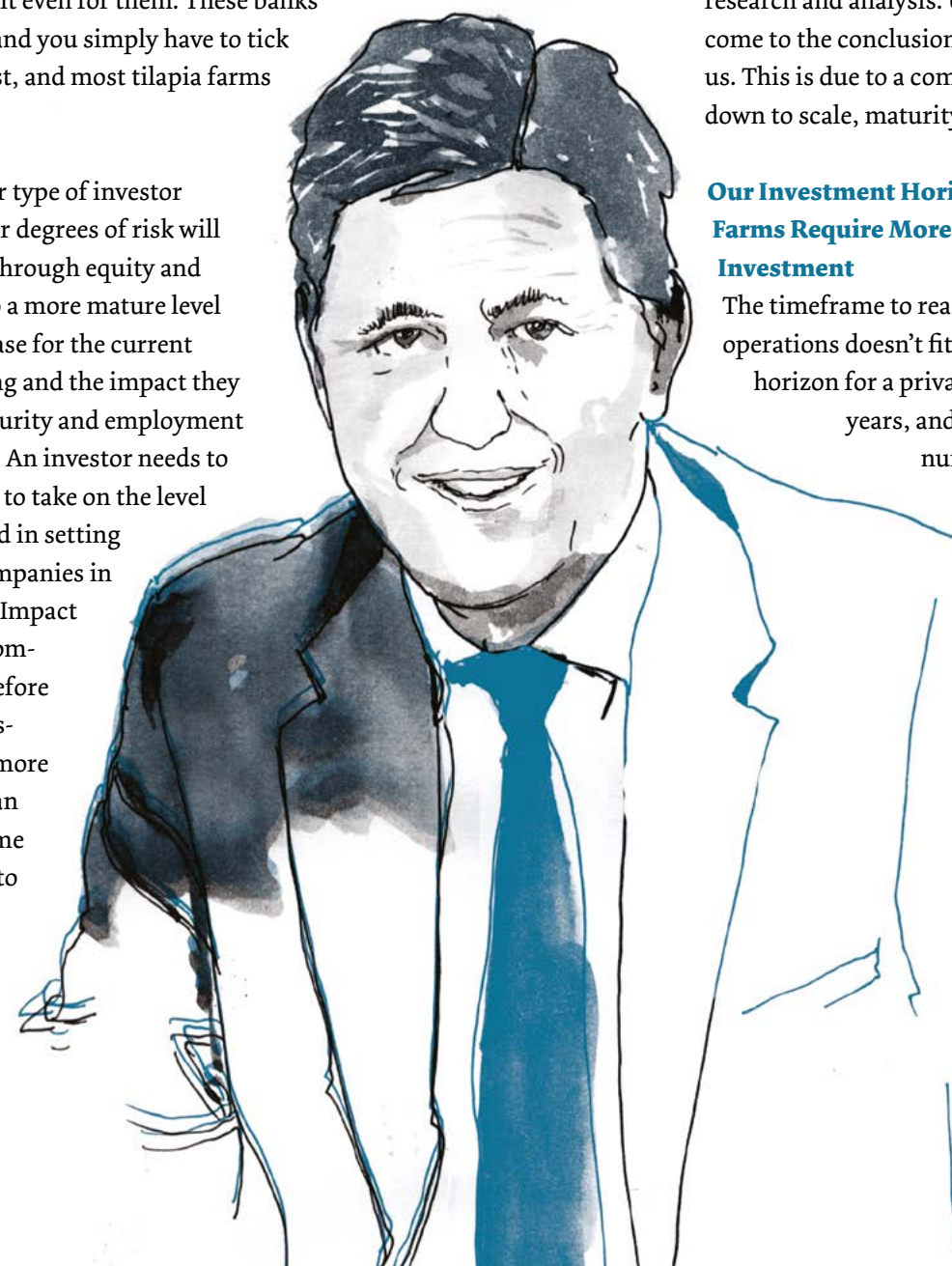
I believe that tilapia pond farming also has potential. Cage farming requires a larger investment and although farmers may eventually become profitable, several of the major cage farmers have needed at least 5 years—but often even more—to get there. Not many investors can or want to take that level of risk. Pond farming can be done on a smaller scale and with less investment. Many people in sub-Saharan Africa already own a bit of land that they can easily convert into fish ponds. I believe in franchise models where larger fish farmers support smaller, entre-

preneurial farms in terms of technical know-how, inputs, and possibly also small loans to venture into fish farming.

For a Commercial Bank Like Rabobank, Most Tilapia Farms Are Still Too Risky to Finance

For a commercial bank, it's not easy to finance the companies currently involved in tilapia in sub-Saharan Africa. Most of them are in an early growth stage and the risks are simply too high. Maybe big African retail banks would be better positioned to serve this size of customer, but this might be difficult even for them. These banks are very risk-averse and you simply have to tick every box on their list, and most tilapia farms don't.

I believe that another type of investor willing to take higher degrees of risk will be needed to invest through equity and develop the sector to a more mature level first. The business case for the current tilapia farms is strong and the impact they can have on food security and employment justifies investment. An investor needs to have the willingness to take on the level of risk that's involved in setting up these types of companies in sub-Saharan Africa. Impact investors can help companies get to scale before another type of investor—one with even more capital available—can come in and take some of the large farmers to the next level.



Business investment with purpose.

Relevant Investments
HIK Abalon South Africa (abalone)
TerraSan South Africa
(abalone, mussels, canning, fishmeal and oil, and aquafeed)

Who
Avril Stassen Senior Partner

We're Looking for Companies with a Minimum Revenue of \$20M Annually

EXEO Capital is an alternative investment firm in Africa, managing the Agri-Vie Funds I (\$100m) and II (\$146m), and a proprietary investor in a number of selected sectors. We're looking for companies with a minimum revenue of \$20m annually. They should ideally be fully integrated, from inputs to marketing and distribution. And our minimum ticket size is \$8m. We've looked at several deals over the past couple of years and have done quite a lot of research and analysis. Unfortunately, so far we've had to come to the conclusion that the time isn't yet right for us. This is due to a combination of factors which all boil down to scale, maturity, and price.

Our Investment Horizon is 5-7 Years—Most Tilapia Farms Require More Time to Deliver a Return on Investment

The timeframe to reach economies of scale in terms of operations doesn't fit with our funds. The investment horizon for a private equity fund is limited to 5-7 years, and our insight when evaluating a number of investment opportunities is that it takes much longer to build a scalable tilapia business in sub-Saharan Africa. Also, the valuations put on the table were too high. The multiples that the companies we looked at expected were very high and don't reflect the risk and expected returns associated with such investments.

Dependency on Imported Feeds, the Risk of Disease, and a Lack of Talent Are Also Holding Us Back

The deals we looked at depended on imported feed. This introduces foreign currency risks in the countries where domestic currencies are weakening, which is a threat to the profitability of many producers. We also became increasingly aware of the risk of disease as evidenced by events in Lake Volta in Ghana, one of the countries that we looked to invest in. Fish farming in sub-Saharan Africa is a relatively nascent industry and the lack of depth and breadth of skills and knowledge is a challenge. Expats fill some of the gaps, but there is not yet a sustainable pool of local technical and management talent that is needed for the sector to grow; the industry needs to invest in training and development in a much bigger way.



Relevant Investments
Various, for example:
Victory Farms Kenya
Various small- and medium-sized fish farms across Uganda, Kenya, and Rwanda

Who
Ben Gimson
Industry Director Aquaculture



Promising Entrepreneurs See the Opportunity and a Number of Farms Have Proven the Business Case

Africa urgently needs sustainable and affordable sources of protein; tilapia and catfish have the potential to play a vital role in meeting this demand. Wild-catch fisheries have stagnated in some places and dropped off a cliff in others. Increasingly, promising entrepreneurs see this opportunity, and in recent years a number have demonstrated that fish farming in Africa can be highly commercially attractive and scalable. Moreover, critical investments are being made in the supporting value chain, such as in feed and genetics, which are making the industry more competitive. Although the sector in sub-Saharan Africa is just starting to take off, the opportunities and momentum are clear.

Msingi East Africa Uses Investment as Just One Tool among Several Approaches

The Gatsby Foundation founded Msingi East Africa to support the development of Eastern Africa's future industries, thus helping to create employment for its growing population. Msingi East Africa invests in aquaculture through various mechanisms, from returnable instruments (such as debt, guarantee facilities, and grants) to technical assistance and research. Msingi East Africa has already invested in commercial tilapia operators from larger through to smaller ones, and at different value-chain segments.

In terms of Msingi East Africa's ideal investment, we have an additional lens: Msingi East Africa is non-profit, and our primary objective is to help support the healthy growth and development of the industry in Eastern Africa. To contribute to this, we use investment as only one tool among several approaches. So our ideal investment or project can have a catalytic impact on the development of the wider industry—whether the project is testing and commercializing an innovation, supplying a new or better product or service that increases the industry's competitiveness, or something entirely different.

Improvements in the Competitiveness of Feed and Genetics and Better Regulations Are Needed to Solve Challenges as the Sector Continues to Grow

As with any young sector, the industry needs to solve challenges as it continues to grow. To name just a few examples, some improvements can be made in the competitiveness of feed and genetics, and capabilities such as vet services and better regulation to help mitigate the biosecurity risks that all livestock industries face. Many of these areas are also likely to generate investment opportunities. For our part, Msingi East Africa will be working to contribute to improvements in all of these areas in Eastern Africa, and in many areas (such as feed), we already see encouraging progress.



Relevant Investments
Source of the Nile (SON) fish farm
Uganda (tilapia farming)
GenoMar
Norway (tilapia genetics): exited
Lake Harvest Group

Who
Andreas Davidsen
Vice-President—Agribusiness and Manufacturing

Norfund Strongly Believes in the Future of Fish Farming in Sub-Saharan Africa and Hopes to Close at Least One Transaction over the Next 12 Months

The industry is professionalizing and the cost of production is coming down. Demand has tailwind from several megatrends, and we expect it to rapidly increase for decades to come. The environment with regards to access to water and climate is particularly suited to growing tilapia. Norfund is therefore actively evaluating several aquaculture opportunities and hopes to close at least one transaction within the next 12 months.

We Invested in Lake Harvest Group Early On—After Overcoming a Few Obstacles,

It's Now Set to Grow

Lake Harvest Group is ideally situated at Lake Kariba with abundance of water resources and a good climate.

The industry has access to locally produced raw material for fish feed. The population is culturally used to eating tilapia and consumption is growing rapidly.

We've encountered some difficulties, especially related to rapidly expanding the production volume. Building local competence also takes a lot of time. But we're confident that we've got a strong local team both at management level and within the rest of the organization.

Although Aquaculture is One of Norfund's Priorities, a Lack of Scale, Local Management Competence, and Disease Risks Have Held us Back

Norfund is the Norwegian government's investment fund for developing countries. Our mission is to create jobs and improve lives by investing in businesses that drive sustainable development. The fund has about \$4bn in assets under management. With Norway's legacy as one of the world's leading aquaculture producers, investing in aquaculture is one of Norfund's key priorities, something that is ingrained in our founding statutes.

Apart from our investments in Lake Harvest Group and SON, we haven't yet made any other investments in tilapia in sub-Saharan Africa. We have a minimum ticket size requirement of \$5m and can only take up to a 35% equity stake. As such, the businesses we can look at have to be relatively large. We've visited most of the sizeable tilapia farms in sub-Saharan Africa, but only a couple have reached that scale.

Another challenge relates to competence. Many aquaculture companies in Africa are very dependent on just one or two people in terms of management, leaving the company vulnerable to key-person risk. A third element holding us back has been biological risks: most waterbodies are not optimally regulated for aquaculture, creating a risk of disease outbreaks.

Publicly disclosed investments in tilapia farms in sub-Saharan Africa

2009 Investment Fund for Developing Countries (IFU) [DFI] Denmark <div>USD 5,000,000 investment in</div> West African Fish Ghana	2011 African Development Bank [DFI] Multilateral <div>USD 8,000,000 investment in</div> Lake Harvest Group Zimbabwe and Zambia	2014 Oikocredit [NON-PROFIT] Netherlands <div>USD 3,500,000 investment in</div> Yalelo Zambia Zambia
2011 Oakfield Holdings [VENTURE FUND] UK <div>USD 2,000,000 investment in</div> Yalelo Zambia Zambia	2013 Zambian Development Bank [DFI] Zambia <div>USD 2,000,000 investment in</div> Yalelo Zambia Zambia	2015 Aqua-Spark [IMPACT INVESTOR] Netherlands <div>USD 570,000 investment in</div> Chicoa Fish Farm Mozambique
2011 African Century Limited [VENTURE FUND] UK <div>Undisclosed investment in</div> Lake Harvest Group Zimbabwe	2013 Norfund [DFI] Norway <div>USD 14,000,000 investment in</div> Lake Harvest Group Zimbabwe and Zambia	2016 Investment Fund for Developing Countries (IFU) [DFI] Denmark <div>USD 7,700,000 investment in</div> Aller Aqua Zambia Zambia

2016 Aqua-Spark [IMPACT INVESTOR] Netherlands <div>USD 1,200,000 investment in</div> Chicoa Fish Farm Mozambique	2019 Finnfund [DFI] Finland <div>USD 6,000,000 investment in</div> Yalelo Zambia Zambia	2020 DOB Equity [IMPACT INVESTOR] Netherlands <div>Undisclosed investment in</div> Victory Farms Kenya
2018 Msingi East Africa [NON-PROFIT] UK <div>USD 2,500,000 investment in</div> Victory Farms Kenya	2019 Entrepreneurial Development Bank (FMO) [DFI] Netherlands <div>USD 10,500,000 investment in</div> Yalelo Zambia Zambia	2020 Conservation International Ventures [IMPACT INVESTOR] US <div>USD 500,000 investment in</div> Victory Farms Kenya
2018 Veris Investments [IMPACT INVESTOR] Netherlands <div>Undisclosed investment in</div> Yalelo Zambia Zambia	2020 Dutch Good Growth Fund [DFI] Netherlands <div>Undisclosed investment in</div> Yalelo Uganda Uganda	2021 IDH Farmfit Fund [NON-PROFIT] Netherlands <div>USD 1,400,000 investment in</div> Chicoa Fish Farm Mozambique
2018 Aqua-Spark [IMPACT INVESTOR] Netherlands <div>USD 900,000 investment in</div> Chicoa Fish Farm Mozambique	2020 Goodwell Investments [IMPACT INVESTOR] Netherlands <div>USD 1,500,000 investment in</div> Chicoa Fish Farm Mozambique	

Type of Investment

Debt

Equity

Aqua-Spark Launches Africa Fund to Ignite the Next Iteration of Sustainable Aquaculture in Sub-Saharan Africa

Substantial investment is required in tilapia farming to both realize its potential and, at the same time, ensure it plays a role in meeting the foreseen surge in demand for protein in sub-Saharan Africa. At Aqua-Spark, we believe that in the short term around \$300m needs to be invested through equity, which will only cover the current capital requirements of the top 25 most-needed investments in our pipeline for aquaculture in sub-Saharan Africa. A significant amount of this total involves tilapia production and its upstream and downstream value chain. These initial investments will be the basis from which to develop and scale a regional industry.

The figure of \$300m is enough to fund the cornerstone investments required to build this framework—but it's just the tip of the iceberg. We have more than 300 companies in our pipeline and their combined investment requirement is a multitude of \$300m. Moreover, these companies don't only look to raise investment through equity, but also through debt. If we were to include that amount, we'd reach much higher figures. Therefore, it's time for us, and other investors, to step up.

A Significant Amount of Our Pipeline Consists of Tilapia-Related Opportunities, but Salmon, Seaweed, Catfish, Sea Cucumber, and Shrimp Farmers Are Also Raising Investment

In our pipeline for sub-Saharan Africa, currently around 40% of the total investment need and 50% of the opportunities are directly related to existing and greenfield tilapia farms and hatcheries. But there are also opportunities in salmon, seaweed, catfish, sea cucumber, and shrimp production. Further, across species, a number of other opportunities can be found, such as black soldier fly (BSF) producers, cold-chain and distribution companies, as well as online B2B and B2C platforms for marketing farm inputs and outputs.

The highest priority opportunities in tilapia in our pipeline lie mainly in Western Africa (Ghana and Nigeria), the north of Eastern Africa (Kenya, Rwanda, Tanzania, and Uganda), and the south of Eastern Africa (Malawi, Mozambique, Zambia, and Zimbabwe) but there are also plenty of opportunities in other countries.

We at Aqua-Spark are planning to play our part by launching our Africa Fund in the last quarter of 2021—a dedicated fund that will close at \$50m and will grow to \$300m over the next 6 to 8 years.

So Far, Investments Have Been Driven by Impact Investors and Development Finance Institutions (DFIs): Perceived Risks and Ticket Sizes Have Held Back Other Investors

Not all investors involved in tilapia in sub-Saharan Africa publicly disclose the deals that they've made. However, some do. The timeline on pp. 86-87 provides an overview of those deals. Many investors perceive investing in Africa, specifically in live animals, and even more so in such a nascent industry as aquaculture, as very high risk. Even if investors are willing to take that risk, for many, the ticket sizes are too small to manage. Therefore, many investors still hold back and companies that do raise investment are limited to the few large farms that have reached scale and several small- and medium-sized farms which the investors believe have the potential to grow. The investors that have become involved so far are mainly DFIs and impact investors. But to attract a more diverse group of investors, the challenges of perceived risk and ticket sizes have to be overcome.

Aqua-Spark to Launch a Dedicated \$50m Fund in Q4 2021 Aiming to Overcome Some of the Challenges Related to Investing in Aquaculture in Sub-Saharan Africa

At Aqua-Spark, we aim to be part of the solution: we're launching a separate fund for aquaculture in Africa. The Africa Fund focuses on building aquaculture infrastructure across the continent to enable a thriving aquaculture industry that focuses on regional food security. The fund's core investments will be 6-8 vertically integrated farming hubs (over 20,000 MT per hub) where we envisage that about 50% of production will be through outgrower programs. The Africa Fund will also invest in small- and medium-sized farming operations and the broader aquaculture value chain (including feed ingredients, technology, cold chain, marketing and distribution, genetics, and animal health).

The current lack of aquaculture infrastructure makes the sector in sub-Saharan Africa a different (risk) profile to that which the investors in our main fund signed up for. The Africa Fund will therefore raise funds from investors with specific investment objectives or with a different risk appetite. It will also allow investors who struggle with the typically small ticket sizes of individual deals to get involved. The Africa Fund gives investors the chance to build a portfolio of investments, which will avoid the concentration risks associated with investing in only a couple of companies. The minimum investment amount to get involved will be \$1m for individuals and \$2.5m for institutions. The fund will provide equity—and convertible debt in specific cases—and the initial ticket size will range from \$0.25-\$5.0m. Aqua-Spark will have a minority position of 20% to 49% and a board seat in the companies we invest in. Aqua-Spark portfolio companies

benefit from being part of a global ecosystem of committed industry stakeholders. All of Aqua-Spark's portfolio companies commit to working together, offering each other favorable terms, and to making the industry more sustainable. This means that all the companies invested in through the Africa Fund will have access to global partners within the Aqua-Spark ecosystem, as well as access to key inputs at favorable conditions and pricing, allowing them to reduce costs and improve sustainability.

The first round of the fund will close at \$50m. We aim to raise an additional \$250m within the next 6-8 years and to grow the fund further after that depending on the capacity to deploy. The initial \$50m allows us to finance a significant part of the immediate funding requirement of some of the top 25 companies in our pipeline, and with \$300m we'll be well positioned to finance the longer-term future of aquaculture in sub-Saharan Africa.



Do you want to get involved as an investor? Please leave your details.



Looking for investors? Then please leave your details.



Aqua Spark's Investment Managers responsible for sub-Saharan Africa: Joel Mugwisa Ssemukaaya (L) and Jan Slootweg (R)

aqua-spark.nl/aqua-insights

