

# Competitiveness of Brazilian Tilapia Farming

Will Brazil be (and stay) a global leader?

A report for



By Mauro Tadashi Nakata

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# Executive Summary

Brazil is the fourth largest producer of tilapia in the world after China, Indonesia and Egypt. Brazilian tilapia farming is a relatively new industry. However, tilapia is already the main species for Brazilian aquaculture. The country has the main resources required for the tilapia sector to grow but achieving its potential will depend on how the industry faces its future challenges.

The objective of this Nuffield report is to have a global view of tropical aquaculture and, with this, understand why the current industry leaders are successful, what are the main threats to Brazilian aquaculture and what public policies could better support the industry's growth.

The author has visited farms and processing plants in the United States of America (USA), Colombia, Norway, China, Vietnam, Indonesia, Malaysia, Taiwan, Australia, and Japan to understand the commonalities that have made their industries successful and what are the experiences that can be valuable to Brazilian tilapia industry. Three common characteristics were consistently identified to achieve competitiveness within the tilapia industry, including:

1. Do the basics right on-farm.
2. Understand the farming environment to achieve optimal production.
3. Complete use of the fish.

Other recommendations include the need to focus on domestic and international marketing and branding as well as further research on tilapia genetic improvement and nutrition.

Water quality issues are as important to the industry longevity as financial results. Aquaculture can impact the water it utilizes and the feed ingredients it uses can be questioned if they are sustainable. Therefore, it is important to demonstrate responsibility for water used, and source only renewable sources of feed ingredients.

Increasing biosecurity regulations, investment in disease monitoring and incentivizing the use of vaccines should be a joint commitment from industry together with government.

Finally, a SWOT analysis has been produced to evaluate the competitiveness of the Brazilian tilapia industry in Chapter 3.

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# Foreword

My family's story with fish started in 1990 when my father – Mauro Yoshio Nakata – was robbed in São Paulo city and decided to move out to a safer area. Being an engineer and in partnership with my uncle in a construction company, he had to sell his part of the business for a clean break.

Our family moved to a smaller town and Dad, who loves fishing, started a fish farm where costumers would pay a fee for sports fishing. The beginning was difficult since there was almost no commercial species – only Piauçu (*Megaleporinus obtusidens*) and Pacu (*Piaractus mesopotamicus*). As there was no specific feed for the fish, we had to feed them fermented corn, horse feed, rabbit feed and whatever we could find for a good price.

The fee fishing started to work and proved to be a right choice of business. We had more than 300 anglers on a good day and all were very happy to be able to find such a good fishing spot just 50 minutes from São Paulo city. Those were my childhood years, going between the fee fishing farm and another production fish farm that we developed to grow and supply fish to the main farm.

After some good years working every weekend and holiday, and together with the increase of competition, Dad has decided he would look for a different business. He started a Tilapia cage farm with the intention to supply fee fishing farms, as well as restaurants and retailers. This was at the time I was at college and had already started to see a future for myself at the farm. My first idea was to work as an economist for a few years to get good experience in other companies and then come back to the family farm. But, after working three months at a very good cotton company I realized that what I like to do is to work with fish.

In 2008, I joined the family business and worked at the new and very small processing plant that my father had just built. In the very beginning, my father had only considered processing plant as a structure to process fish ready for sale as chilled and washed fish, the products in which we had our best margins with, but I had come back from school with the idea that processed fish would be the future of the market, and that was my thing, filleting tilapia.

The first few years were a learning curve for both of us. The conflict of generations and different approaches to the business were our main challenges, but our shared goals and mutual respect were enough to keep our relationships strong. We currently run four fish farms, we have built a newer and bigger processing plant, both of my younger brothers have joined the company, and still we love to go out fishing.

# Acknowledgments

I would like to express my gratitude to my family for providing me with education and life lessons that have allowed me to do what I am passionate about.

I would like to thank my company's team, many of them have taken more responsibility and tasks during my Nuffield Scholarship and without them, I would not have been able to take this journey.

I am grateful and inspired by Bom Futuro for providing this scholarship, I am sure this sort of investment will improve our industry in the long run and consequently benefit each and every player. I would also like to thank Nuffield Brazil for the support throughout my scholarship and travels.

Throughout the countries that I visited, I usually counted on the support of old friends from Brazil that introduced me to new and now very good friends that hosted me in their countries, businesses and homes. I would like to deeply thank them all.

# Abbreviations

ASC – Aquaculture Stewardship Council

BAP – Best Aquaculture Practices

CO – Carbon monoxide

FAO – Food and Agriculture Organization of the United Nations

FCR – Food conversion ratio

GIFT – Genetically Improved Farmed Tilapia

Ha – Hectare

HACCP - Hazard Analysis and Critical Control Point

PeixeBR – Brazilian Fish Farming Association

RAS - recirculating aquaculture system

TiLV – Tilapia Lake Virus

UN – United Nations

USA – United States of America

USD – United States Dollar

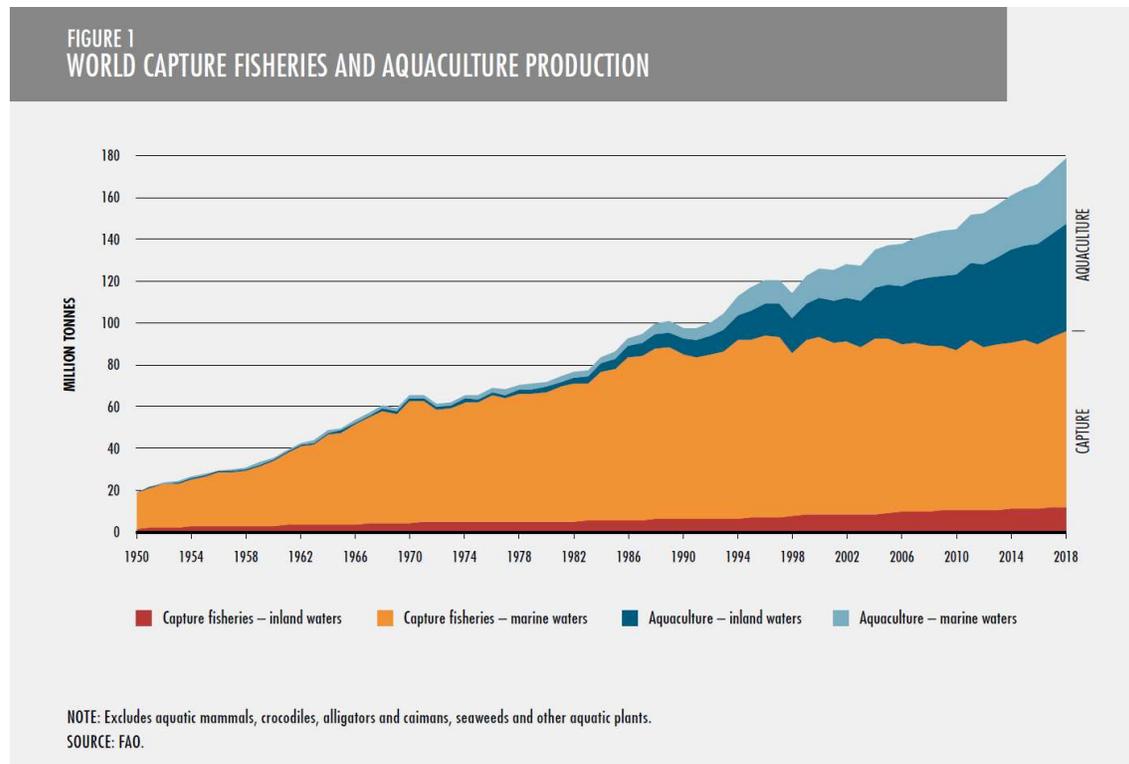
# Objectives

To have a global view of tropical aquaculture and to understand how Brazilian tilapia farming ranks among other tropical countries. This project will also generate further understanding on:

- The key factors that have made countries such as China, Norway and Vietnam become industry leaders in production.
- The main threats to the Brazilian Aquaculture industry.
- Public policies and industry actions that can support the growth of tilapia farming in Brazil.

# Introduction

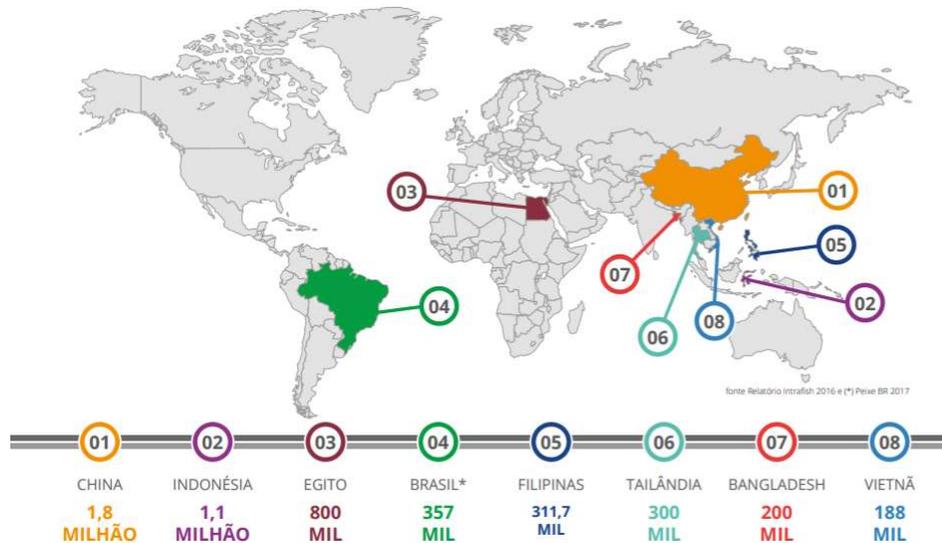
Aquaculture is the fastest growing food production sector in the world with a growth rate of 5.8% from 2010 to 2018 (FAO, 2018). Aquaculture production is projected to overtake capture fisheries in 2024 as the main source of seafood production (OECD/FAO, 2020) and this trend will continue as many fisheries are managed at its maximum capacity and as aquaculture continues to invest in new production systems, genetics and feed efficiency (Rabobank, 2017).



**Figure 1: World Capture Fisheries and Aquaculture Production, FAO, 2020**

The most consolidated export fish species in the aquaculture sector is Atlantic Salmon (*Salmo salar*) and in this industry, Norway is the leading production country and the leading investor (public and private) in new technology and machinery for salmon aquaculture and processing.

Tilapia (*Oreochromis* sp.) is a fish species that stands out since it is the second main species in production volume after carps (FAO, 2020), it has a developed international market (KUBITZA, 2011), it is the most diversified fish species sector geographically (GOAL, 2019) and it is a robust omnivore fish, that can be fed mostly by grains and renewable feed ingredients.



**Figure 2: Tilapia production globally, PEIXE BR, 2018**

Brazil is the fourth largest producer in the world after China, Indonesia and Egypt (Figure 2). Colombia and Ecuador are also important due to export volumes to the USA, which is the main importer.

This research outlines the reality faced on farms and in plants in the USA, Norway, Colombia, China, Vietnam, Indonesia, Malaysia and Taiwan and converts this information and knowledge into recommendations for the tilapia industry in Brazil to take into action at private and public levels. Some countries such as the USA, Norway, Malaysia and parts of China were visited and are described in this paper due to their technology generated for this industry. Other countries visited are described because of their relevance in tilapia/aquaculture industry (China, Indonesia and Vietnam) or because of their climate (natural conditions) similarity to Brazil's (Colombia).

## The Brazilian Tilapia industry

Aquaculture is a relatively new industry in Brazil (Valenti et al, 2021). To illustrate this statement, the first commercial aquafeed, which is the basis of fish farming, was developed and released in 1992. Furthermore, it was mainly designed for omnivore native species from Pantanal river basin. During these early stages of fish farming the main business was fee fishing farms located near big cities where interested people can go sports fishing for the day or weekend (Nakata, 2007). This fee fishing trend was the main aquaculture venture for about a decade and only in the late 1990's the pioneer tilapia processing plants got going.

In the early 2000's, tilapia farming in Brazil was focused in the Sao Paulo and Parana states of Brazil (Kubitza, 2003). The sector experienced its first major growth due exports to the USA, although this growth spike did not last long as it also aligned with Brazilian companies seizing favorable currency's exchange rates. By the late 2000's, the American Dollar and the Brazilian Real exchange rate dropped, and other competitor countries increased production, forcing Brazil to develop a domestic market for their tilapia fillets. The success in achieving consumer interest was the result of a combined effort from processing plants, retailers and restaurants to ensure a quality tilapia product (white fillets, mild taste, no off flavors and offered year-round), while capitalizing on diminishing supplies of wild caught species in the market.

By 2010, tilapia had established as one of the major fish species being produced and consumed in the south-east and north-east regions of Brazil (Kubitza, 2011). New entrants to the market were appearing, consolidation had started to take place at farm level, and business being done at the processing level.

Nowadays, two private genetic improvement programs for tilapia exist in Brazil, with one of these having the biggest investment in the world. A few large poultry and swine producers/exporters are also moving into the tilapia industry. This growth of the domestic market and the spread of tilapia farming and processing around the country has made Brazil the fourth largest tilapia producer (PeixeBR, 2019), and the only country in the top five with its main market being the domestic market.

With this history in mind and taking into account that Brazil is the largest cattle producer and exporter in the world (ABIEC, 2018), the third largest poultry producer and the largest poultry exporter (ABPA, 2018), the largest soybeans producer and exporter and the third largest corn producer and exporter (USDA, 2019), it is possible to infer that there is both a vocation and a paved road for Brazilian fish farming to develop its already strong domestic market and its export markets and become a world leader.

There is already expertise in animal farming and processing for export markets in Brazil. The country is a leading producer of soybeans and corn and has plenty of other grains that are used as basis for animal feed. Therefore, for the tilapia farming industry to develop to its potential, it is important that it has a clear understanding of where it sits compared to other tropical countries such as China, Vietnam and Colombia and the main trends that will influence the aquaculture industry in the long run.

## Chapter 2: Countries Visited

The author has visited countries that are leading global tilapia production, that are relevant exporters to the USA (main tilapia importer) and that are leaders in technology development and innovation for aquaculture. These visits were made to compare Brazilian tilapia industry with other leading countries in terms of farming systems, processing efficiency and technological development at every part of the sector. For each visited country there is a small description of the relevance of the country for this paper and a description of the visits and meeting held and the consequent information gathered is used to benchmark Brazilian tilapia industry and to make recommendations for the development of the sector in Brazil.

### United States of America (USA)

The USA is the largest tilapia importer in the world, with a total import of 172,500 ton in 2019 (FAO, 2020). The author visited the Seafood Expo in Boston to learn more about the market. In addition, the largest RAS (Recirculating Aquaculture System) tilapia farm in the world is located in the state of Virginia. In a RAS, all the water must be recirculated, treated and reused, therefore every water quality parameter has to be monitored and controlled by the farmer. This is a production system that requires technology and managerial skills to be run and can be located very close to where the market is.



***Figure 3: Tilapia in RAS, United States of America. Source: Author***

## **2018 Alltech One Seminar**

The 2018 Alltech One Seminar calls itself an 'Idea's Seminar', drawing together participants across the food producing sectors with the promise to open their minds to new concepts, different industries and create a new critical mass with this "out of the box" set of influences. The message promoted is that "ideas change everything" or "logic will take you from A to B, but imagination can take you anywhere." Dr. Mark Lyons stated that change and innovation consists in three steps:

- 1) Give yourself permission to innovate/change.
- 2) Make room for discovery.
- 3) Embed learning and failure into your mindset.

It was a great starting point for the research, and the space it created to explore and consider new concepts opened the eyes, ears and mind for all the information henceforth.

## **Blue Ridge Aquaculture**

Blue Ridge Aquaculture has great technical and market value. Established in 1989 in Southern Virginia, tilapia are grown in an (RAS) as the region is not conducive to growing tilapia in natural ponds. They also experimented with raising Channel Catfish, but the high cost compared to the pond-raised Mississippi catfish led to them swapping over to raising tilapia. Blue Ridge now has its own breeding program with 15 generations of tilapia – which is a hybrid between *Oreochromis niloticus* and *Oreochromis mossambicus* – a fish with white skin and very docile behavior, which makes possible to stock at very high densities (190kg/m<sup>3</sup>) completely adapted for a RAS. Blue Ridge only uses water from deep wells, produces all its own feed, and has strict biosecurity controls, resulting in having no disease issues over the last ten years.

These strict controls come with a cost. The price Blue Ridge sells its tilapia is around USD 7.00/kg which is five and a half times higher than Brazilian farmgate prices. To keep their products viable, the farm sells only live fish for ethnic markets such as Asians (Chinese, Phillipino, Thai) and Latins. It has found a niche market where cheaper imported tilapia will not compete.

Blue Ridge was a great example of how being innovative can make a company survive in an environment where its competitors have a fifth of its costs. It is true that it is a niche market

but the example could be extrapolated to other situations. The RAS farm model also challenges the Brazilian status quo as to what is a rational and economically viable business proposition, given that the Brazilian norm is compartmentalized fish farms, with water and temperature not being limiting factors. Blue Ridge has proved this high-cost model can work and should not be ignored when we consider the future of tilapia farming.

## **Norway**

Norway is the largest salmon producer with a total production of 1.2 million tones (FAO, 2020) and Norwegian aquaculture is largely industrial, modern and highly competitive (FAO, 2013). The industry started in late 1960's and their technology and equipment are also used for farming different species of fish, other than salmon. Single machinery can be used for farming different fish, and complete production systems can also be adapted and applied for other fishes such as tilapia.

The author visited the Nor-Fis Trade Fair, SalMar processing plant and LeRoy's Smolt plant and has held meetings with Norwegian companies organised by Innovation Norway.

### **Salmar processing plant**

The author visited the Salmar processing plant (Figure 4), built in 2013 in a small village on an island. Despite ongoing investment to improve machines and automation, the company's main challenges appeared to be how to attract and retain employees and how to add-value to the fish that are processed. The company must pay higher wages and provide community infrastructure such as gyms, parks and recreation centers in order to give an incentive for young people to stay on the island. Since it is company with 600 employees located on an island that has 2,000 inhabitants, is mandatory for its success to automate as many processes as it can, such as gutting, grading, picking robots and pallet-making robot. Salmar currently sells 70% of their production as "head on, gutted" salmon, and want to increase value-adding by producing fillets, loins and other cuts.



**Figure 4: Salmon processing plant in Norway. Source: Author**

### **Leroy Smolt Aquaculture**

LeRoy smolt aquaculture plant started operations in 2016. It also faces a challenge of lacking people, since it is located in a remote small village and the RAS must be monitored continually by at least three people. It was impressive to see a large-scale operation of a system that is modelled in labs and university hallways. An important lesson learned was that the salmon industry treats its alevins and smolts with as much care as it can. The understanding that the fish is very sensitive to the smoltification process makes the main objective of this stage to try to emulate the water quality conditions to those the fish would find in the wild as they grow and return to the ocean.

### **Reflections**

Meetings with Norwegian companies to discuss Brazilian aquaculture and what technology is lacking, as well as how Norwegian companies might enter the Brazilian market, raised some interesting points. Of note was a giant change in disease management in the salmon industry between 2005 and 2010, driven by consumer demands to decrease antibiotic use. At smolt age, most salmon now receive vaccines to protect against up to seven diseases. This replaces

antibiotic use, which has dropped by 90% from 2005 to 2010 across the Norwegian industry. The tilapia industry will also need to make this change in the near future.

## **Colombia**

Tilapia is the main species in Colombian aquaculture followed by trout, and aquaculture is has overtaken capture fisheries in production volume since 2008 (OECD, 2016). Colombia is the largest export of fresh tilapia fillets to the USA (FAO, 2020). Tilapia farming in Colombia is mainly held in cages at Betania lake and in earthen ponds situated around the lake.

### **Betania Lake**

Tilapia farming in Colombia started in cages on the Betania Lake, Magdalena River, producing mainly red tilapia with an average market size of 500gm for the domestic market. Farmers then started exporting 1.2kg average weight Nile tilapia to the USA. Host Hernan Vela explained that the industry sees its current main challenge is to deal with diseases and address the resultant low survival rates. It was not clear for the author if most of the farmers understand that poor water quality may have more impact on their farm health than the diseases themselves.

Along with being close to the Equator, the low altitude of the Betania Lake means that the water maintains a temperature between 25° C and 30° C, and the delicate state of the water quality is noticeable. 40,000 tons of fish are produced per year in the lake and given the river flows and the size of the lake, one can infer that production has long passed the lake's carrying capacity. Water transparency is low, dissolved oxygen levels are low and it likely that ammonia levels are high. Therefore, the fish lives with a lot of environmental stress where diseases such as Tilapia Lake Virus (TiLV), streptococcus sp. and others can be easily triggered. Because of these limitations, many farmers have started pond farms downriver using water from the Magdalena River (which flows from Betania Lake) and are also farming with very high densities.

### **Italcol Ration factory and hatchery**

The Italcol ration factory produces tilapia ration and pet food using the main ingredients of corn, soymeal, poultry meal and blood meal, and many of these coming from Brazil. Despite the age of the factory and its extruders, the feed being produced looked to be of a good quality.

A visit to the Italcol Hatchery showed the importance that the company gives to biosecurity. It was a simple structure, collecting alevins from a pond where three females were stocked per

male. Staff did not count or estimate the number of alevins they collected per day. Instead, an estimate was made based on the volumes harvested as the alevins were transferred between ponds. Many leech and odonata seen in the ponds indicated that survival rates of the alevins could be improved. The company had recently employed an aquaculture engineer to try and establish a culture of best production practices such as keeping pediluvium before entering the pond areas, good maintenance of the protective netting, cleaning the banks around the ponds, good feed storage conditions, and cleaning and disinfecting the ponds after harvesting, but this task was still in its early stages.

### **Piscicola Botero pond farm and processing plant**

This business had 13 ponds with a total of 22 hectares (ha) and was still expanding. The farm stocks around ten juvenile tilapia per ha and has an average final density of 40-60 tons/ ha. There was not much control of the stock numbers, with some ponds having more fish than seeds and others with high mortality, seemingly the result of not knowing how many juvenile fish are being received.

At the processing plant, the company was filleting 1.2kg fish sourced mainly from their own farms. It processes 22 tons of tilapia per day, using a sequence of heading, gutting, filleting, trimming, grading and packing – there was no numbness process. The fillets are exported to the USA, travelling five hours by truck to Bogotá and then a four-hour flight to Miami. It was a very well-organized plant, with speedy workers and not much different from a Brazilian plant. The average wage for the workers of USD\$381.00 per month, is similar to Brazil.

### **Alfapez processing plant**

Another visit was to the Alfapez processing plant, which only guts red tilapia and can therefore process big tonnages of up to 60 tonnes per day. The owner is a former fisherman with a strong lean towards practicality and functionality over formal processes and has built many innovative parts and equipment that have made the plant very efficient. Plans are in place to increase the filleting lone, but the company should focus on improving quality control, best production practices, as well as achieving HACCP certification to protect itself in this market. The trade-off is that the cheap processing cost of USD\$0.74/kg will rise somewhat, but the changes would improve product quality and safety.

In a meeting with a Mr. Henry, owner of Fish Factory where 200/tonnes are produced a month from four ponds and one cage farm, the author learnt some of the market prices for live Tilapia and Red Tilapia:

- Red Tilapia fillet export price: USD\$ 6.82 /kg
- Red Tilapia farmgate price (400g whole fish for local market): USD\$ 1.21 /kg
- Nile Tilapia farmgate price (400g whole for local market): USD\$1.15/kg
- Guttred Red Tilapia price (400g whole for local market): USD\$ 1.57/kg

### **Piscicola New York**

Piscicola New York is an integrated production and processing plant and currently processes 45 tonnes of tilapia per day. They use a simple but very effective harvesting method where the transporting truck sits on top of a ferry boat that drives up to each cage and the fish are harvested with a big bag held and operated by an hydraulic arm. One challenge the company and is facing is low fish survival rates; cages measuring 20m wide x 20m long x 5m deep are stocked with 200,000 fish weighing 1gm of which 120,000 fish survive to 30g weight and 72,000 survive to harvesting size.

### **Reflections**

Colombia is an important and significant tilapia producer as it exports large volumes to the USA, and they use relatively low amounts of technology and technical management. There are different specifications for fish destined for the domestic market versus the export market, and farmers appear to specialize in producing for one of these markets. Farmers that sell into the domestic market have the advantage of selling whole fish, which means that they have lower processing costs and can utilize every part of the fish except the viscera. Farmers that sell to export markets need better technical management of ponds or cages as they must grow larger fish that are more suitable to be affected by many different diseases and other production challenges.

They have the advantage of a very stable warm temperature, which enables high feeding and growth rates. However, quality is unstable as hatcheries collect fries that are not graded nor precisely counted. Furthermore, there are different genetic programs and little comparison seems to be done to determine which is better and why.

The tilapia farming industry will have to be proactive both at public policy and commercial levels to address the high mortality rates and water quality issues at Betania Lake. Vaccination, lower densities, feed management, pond water treatment and better management of alevins and juveniles at the hatcheries will have to be targeted. This is an illustrative example for the Brazilian tilapia industry of how over-stocking and inefficient regulation could damage industry resources, quality and production.



**Figure 5: Tilapia farming in Columbia. Source: Author**

## **China**

China is the largest fish importer and exporter in the world (Rabobank, 2017) and regarding tilapia farming, China is also the largest producer with a production of 1.7 million tones (FAO, 2020) and the main market for Chinese Tilapia is the USA. Main areas for production are the provinces of Hainan, Guangdong and Guangxi and the main production system is the use of earthen ponds with aeration.

Economy of scale and diversity of species are key strengths of the Chinese aquaculture industry. Large-scale feed production is being achieved using latest technology in milling, mixing and extruding combined with big teams researching fish nutrition. This has allowed Chinese feed companies to grow and, in turn, drive the industry's development. For example, one feed company in China can produce a fifth or even a fourth of the entire Brazilian feed production. This scale and cashflow enables the companies to invest in automation, bigger and newer mills, extruders, and other equipment that may bottleneck smaller factories.

Tilapia in China is a curious case, since the country is the largest producer in the world, but it is not a big consumer. The majority of Chinese Tilapia is ASC or BAP certified and is exported

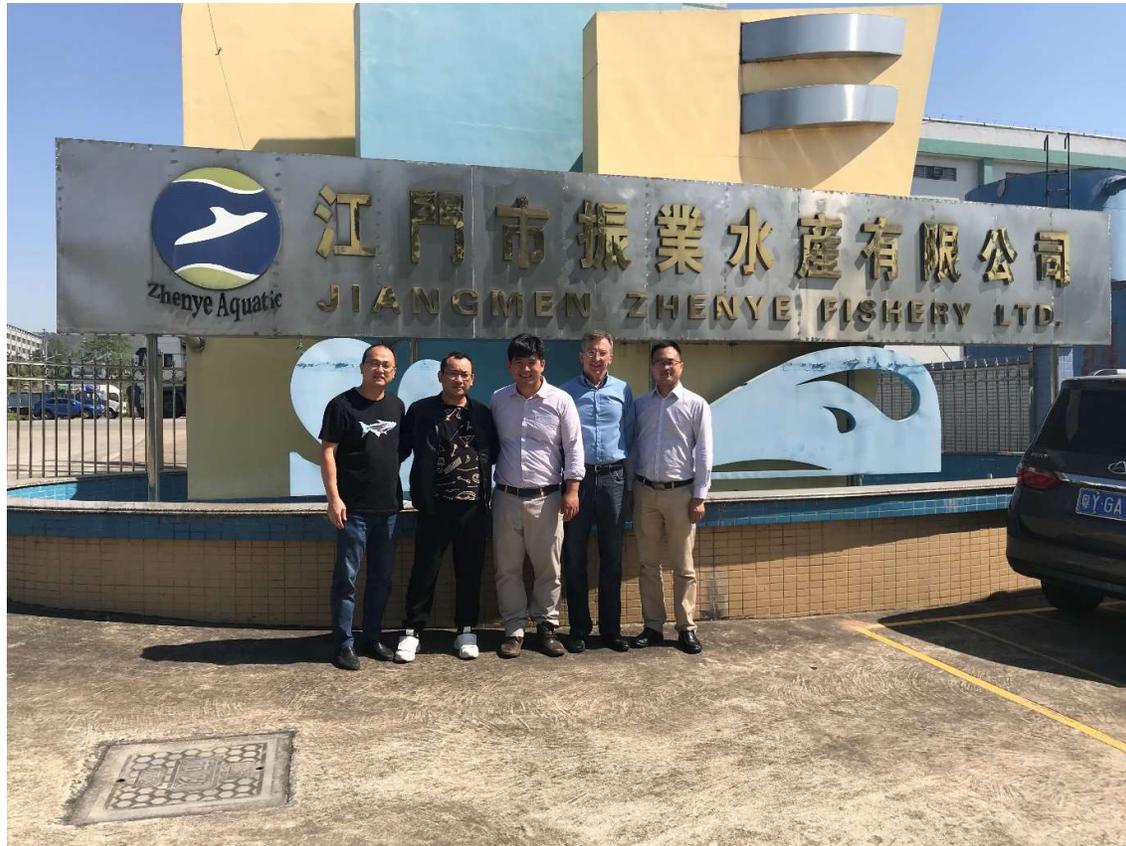
to the USA. The domestic market on the other hand, has a strong presence of local carps – each province has its own strain of carp – and has also a great diversification of species such as Largemouth Bass, Snakehead, Sturgeon, Pangasius, Yellow Catfish, Channel Catfish, Grouper, Seabass, Turbot and many others. Local markets only consume tilapia in a few provinces such as Fujian and Guangzhou. Usually, the companies selling to the domestic market have no sustainability certification such as ASC or BAP. At a production level, the diverse range of species for the domestic market lends itself to small-scale and larger-scale production farms, while the export market is naturally dominated by larger, consolidated players.

### **Nutriera**

Nutriera, a feed premix company in Guangzhou, was established by a group of researchers who had previously worked at Hayda, a leading aqua-feed company in Asia. Their view was that Tilapia in Brazil was a comparatively low-margin business and that diversification of species would be an interesting direction to take. Nutriera themselves were diversifying their business; the company has started to import raw feed materials, sell water treatment products and trade seafood in the wholesale market.

When speaking to Nutriera staff, they estimated that the total volume of tilapia feed produced in China is about 1,470,000 tonnes per year, being 920,000 tons of extruded feed plus 450,000 tons of pelleted feed. Using the average feed conversion ratio (FCR) of 1.2 gives a total Chinese tilapia production of 1,140,000 tonnes, which is less than FAO estimates. Nutriera staff believe tilapia volumes are decreasing due to both high mortality rates and low market prices. Of note, Pangasius species has been swapped into many areas previously producing tilapia and is going well from both production and marketing viewpoints. The general summary from the Nutriera staff is that tilapia will soon be outcompeted in production terms and will soon disappear from market altogether.

Jiangmen Zhenye Fishery Company in Guangzhou, Guangdong (Figure 6), is an audited BAP company with a four-star ranking that processes about 50 tonnes of fish per shift. It currently processes Pangasius and Channel Catfish for domestic markets, after stopping their processing and exporting of tilapia due to low margins and uncertainties regarding Chinese government subsidy programs.



**Figure 6: At Jiangmen Zhenye Fishery, China, with factory directors Ruben Buhler and Richard Buhler and the author in the centre. Source: Author**

A few interesting facts about this factory and fish processing plants in China include:

- Processing shifts start at 12:00pm since they harvest fish in the morning and process it afterwards.
- Carbon monoxide (CO) treatment is used before killing the fish in order to keep the bloodline on the fillets red for longer periods (not allowed in Brazil).
- Bleeding and gutting is done in the same operation.
- China uses tumblers to bleach fillets in order for them to be whiter in colour as well as adding water for extra weight (also not allowed in Brazil).

### **Buhler Liyang fabrication company**

Bühler Factory in Liyang, Jiangsu province, is a Swiss factory located in China that works to Swiss standards for quality control, safety regulations and environmental regulations. They have a 20-year history in Liyang and produce millers, mixers, extruders, pelletizers, coaters and transporting equipment in their state-of-the-art facilities. The equivalent of one feed factory worth of equipment is fabricated every four days. It currently uses 20ha of land and has the

area available to expand to 30ha. There is a common comment in the industry that Bühler Liyang is not a Chinese factory because of its efficiency and scale, the factory.

### **Huai'an fish feed factory**

Huai'an Fish Feed in Jiangsu province currently produces 200,000 tonnes per year of aqua feed, with a total company capacity to produce 400,000 tonnes per year across their plants. This equates to 25% of the Brazilian aqua feed market. The plant visited was a very spacious factory with room for expanding and was using Bühler and Andritz extruders. Many processes such as packing and palleting were automated to achieve economy of scale, an important factor in China's competitiveness. As the plant is located in an urban area, it also had an efficient air filtering system installed.

### **Tongwei feed**

Tongwei in Sichuan province owns 10,000ha of ponds to produce crabs, crayfish, shrimp and carps. They also have an experimental eco-aquaculture farm, a concept of concentrating the fish in raceways where waterflow is forced by air bubbles made from a compressor. The raceways were inside a bigger pond, which also contained fish that filter water (big head carps). Despite being an interesting concept, and similar to a project in the USA, the author notes that to "complete" the cycle, there should be an additional process where water circulates through a wetland or biofilter to be filtrated.

### **Reflections**

The trend in export markets to replace tilapia with pangasius or other seafood presents an interesting case for global tilapia players because it can both begin a new market in China for other seafood and can leave room for other suppliers to fill the gap that can be left from Chinese fish in the USA. Furthermore, Chinese expansion into pangasius and other seafood also presents an interesting global supply and demand scenario due the volume of production that is applied to every product that is produced in China and also because Chinese feed companies can make it more efficient the production of any aquatic species.

### **Vietnam**

Vietnam aquaculture is focused in the Mekong Delta. The Upper Mekong Delta, more than 40 kilometers from the sea, is dominated with pangasius being farmed in ponds and tilapia being farmed in cages. The lower reaches are dominated by shrimp production. There is also tilapia, carps and snakehead being raised in central Vietnam. The farmed fish species are generally

raised with very few technical management skills and almost no use of machinery. There were no pumps for moving water nor harvesting, no aeration, and no machinery for grading and counting fish. As a rule of thumb, Pangasius is farmed for export markets and tilapia is farmed for domestic markets. In November 2018, Pangasius's prices were good – 40,000 dong/kg or USD 1.7/kg – and Tilapia's prices were low – 31,000 dong/kg or USD 1.3/kg. Some processing plants had tried to export tilapia fillets, but they had stopped due to low prices.



**Figure 7: Panga Farm. Neovia Team in Vietnam, with the Author second from left.**  
**Source: Author**

### **Can Tho, Mekong Delta region**

The author visited three tilapia cage farms in the region of Can Tho, Mekong Delta. All had rigid stainless-steel nets, with an iron structure to hold them steady in the waters of the Mekong River. The shape of the cages was always rectangular due to water flow – five to seven meters wide by ten to 14 meters long by three to four meters deep. They were raising Red Tilapia for local markets and one of them was also raising Nile Tilapia for live export to Cambodia (Figure 8). All the three farms stocked 30g juveniles and then divided the fish when they were about 150g of average weight and then grew them to 600g of final weight. Final density varied from 140 kg/m<sup>3</sup> to 200 kg/m<sup>3</sup> and survival rates were 60% to 70%. These high mortality rates were explained by all the three farmers as being mainly caused during adaptation to flowing water, and that once the juveniles would stop dying once they were adapted. Juvenile prices were around 1,050,000 dong per thousand fish or USD 45.00 per thousand fish. Tilapia grow-out feed prices were 13,500 dong/kg or USD 0.58/kg. FCR was varying around 1.6 to 1.8. At those

farms, one worker would take care of 200,000 to 400,000 fish per cycle, with two cycles per year.



**Figure 8: Feeding red tilapia in Vietnam. Source: Author**

The two pangasius farms visited were connected to the Mekong River through a couple of pipes with one meter diameter, to allow for quick and enormous water exchange. The Vietnamese use the tide to change pond water. When the tide is high, they let new water from the river come in, and when the tide is low, they flush out a lot of water, carrying sediments and faeces to the river. The ponds were 5000 m<sup>2</sup> in area and five to seven meters deep. There was no additional aeration since Pangasius fish have lungs for aerial breathing. Both farms were stocking 100 kg/m<sup>2</sup>, had survival rates around 75% and a FCR of 1.4 - 1.5 while feeding a 26% protein diet. 30 gram juveniles cost 1,815,000 dong per thousand fish or USD \$80.00 per thousand fish. Feed was 10,500 dong/kg or USD 0.45/kg.

Despite one farmer complaining about feed value and the high FCR, he did not know his fish density per cage, nor the amount of dead fish removed from the cage. He also advised he recently had suffered significant losses due to monsoon rains creating very fast flowing waters, to the extent that he had to transfer cages to the other side of the river.

## **Reflections**

The Mekong River is the heart of Vietnamese fish farming, and it appears that the locals have understood their environment and developed farming systems appropriate to the local conditions. The flows of the water are capitalized on by both tilapia and pangasius farms. Regarding tilapia, cages are located in areas of slow flowing water so they can stock very high densities of 140 – 200kg juveniles per cubic meter. This is three or four times more than Brazilian stocking rates. These high stocking rates can cause significant mortality of juveniles. However, it is cheaper to stock high rates of juveniles and hope for upside as they grow out, rather than stocking at lower rates and losing production potential. For pangasius, using the tides to exchange water is a simple and effective idea. Maintaining downstream water quality using this natural flushing action is a cost-effective measure that provides a big water exchange with zero pumping costs.

Fish food commonly used in Vietnam is milled and premixed grain. One curiosity about the Vietnamese fish feed market is that almost all sales are done by distributors, usually community leaders that often are farmers who grow and sell an annual requirement to nearby fish farms. The feed is stored at the distributor house/warehouse and they use their local influence to build trust and make the feed sales.

Finally, every visit in Vietnam ends up with lunch or dinner at the farm. Vietnamese hospitality is remarkable, with lots of food and drinks, and the language barrier being very real, there is a very good feeling and match when visiting farms in Vietnam.

## **Indonesia**

Indonesia is a key global producer of tilapia, which is grown mainly in cages, and in around the island of Java. Actual production estimates vary, and the author heard that the Indonesian aquaculture production amount is overestimated due to the amount of fish feed consumed in the country.

All the production is in Java, except for one company called Regal Springs, is produced in cages on lakes and destined for local markets. Most farmers are producing minimal amounts and use low inputs and no machinery. A big challenge farmers face is that overstocked lakes get hit by algae blooms at least twice a year in the monsoon season, causing oxygen levels go to zero, and most fish die (Artadi, personal communication). Tilapia farming is therefore considered a high-risk activity in Indonesia.

## **Tulungagung region**

Tulungagung City region in East Java is a densely populated area, leaving only small spaces in peri-urban areas for aquaculture production. Standard ponds here are 40 - 150m<sup>2</sup> with almost no exchange of water nor aeration, which probably explains why two of the country's main farmed species (clarias and pangasius) have lungs.

Clarias have a domestic market size of 300g, which is interesting since the fish can grow up to 10kg. The Indonesian eating habit is to eat clarias in the form of the whole fish (head-on and gutted) either deep fried or barbecued, whereby one fish is an exact portion for one person. Pangasius has been farmed in Indonesia for the domestic market, with a final weight of 1.2kg for clean whole fish. Even though panga is a fish with aerial breathing, it is sensitive to water quality changes. Given Indonesia does not have a big river such as the Mekong to exchange water and discharge effluents, the stocking density in Indonesia is one fifth of what is used in Vietnam.

## **Malaysia**

### **World Fish Center**

The World Fish Center on Penang Island is responsible for the development the GIFT Tilapia strain and financed mostly by UN and by Rockefeller Foundation. GIFT Tilapia is the most popular and successful strain for farming since it has combined fast growth, good FCR and high fillet yields. This strain was spread throughout the world and since then, many research centers have continued to improve the strain. World Fish Center has started its activities in the Philippines and later moved to Malaysia. The main challenge to tilapia farming globally is disease management and prevention, and the World Fish Center is working on a strain that is resistant to TiLV, which should be available on the market by 2022 or 2023 (Twong, pers com). Investment for breeding of Red Tilapia is not occurring at the World Fish Center as there is already a project in Vietnam, and furthermore red tilapia is a hybrid there was seen to be little opportunity for genetic gain (Twong, pers comm).

## **Taiwan**

Taiwan has developed novel markets and processing for many parts of the fish, such as bellies and the mouths. The bellies, a boneless cut from the fish's ribs, are used to substitute eels for Kabayaki, a Japanese dish sold in large restaurant chains throughout Asia. The mouths have bones and fins, therefore have lower prices than the bellies, and they are usually sold at supermarkets in Taiwan and used for traditional Chinese dishes.

Gelatin and collagen are also extracted from frozen tilapia skin, and the Jellice factory is currently processing 6,000 tonnes per year. The primary ingredient required is a stable quality skin that has no presence of meat, no residual scales and a low percentage of water. The current price being paid is USD\$ 0.80/kg and the company is facing a shortage of supply due to lower tilapia production in China. This is due to factors including colder winters decreasing production potential, higher mortality rates due to TiLV, and because many farmers and processing plants are moving to other fish species that have higher margins.

# Chapter 3: Comparing Brazil to other Tropical Leading Tilapia Producers

To better understand how Brazilian tilapia farming performs against the major current tropical competitors (Indonesia, Mexico, Malaysia, Philippines), a SWOT (strengths-weaknesses-opportunities-threats) analysis was designed by the author. Strengths and weaknesses refer to the internal environment, identifying factors that already exist in Brazil. Opportunities and threats refer to the external environment, identifying factors that may happen at a general industry level.

Strengths	Weaknesses
<ul style="list-style-type: none"> <li>• Water availability</li> <li>• Feed ingredients availability</li> <li>• Large domestic market</li> <li>• Established machinery industry that can support the sector</li> <li>• Established veterinary services that can support the development of new vaccines</li> </ul>	<ul style="list-style-type: none"> <li>• Juridical insecurity</li> <li>• Incomplete use of the fish</li> <li>• High labor costs compared to other countries</li> </ul>
Opportunities	Threats
<ul style="list-style-type: none"> <li>• Trade war between USA and China</li> <li>• Two genetic improvement projects for Tilapia based in Brazil</li> <li>• Expertise from other industries such as swine and poultry can be transferred to aquaculture</li> <li>• Research centers, both private and public, that can help develop better nutrition for tilapia</li> <li>• A domestic market that can still grow</li> </ul>	<ul style="list-style-type: none"> <li>• New diseases that are not found in Brazil</li> <li>• Marketing campaign against Brazilian tilapia, similar to what happened to Vietnamese Panga</li> <li>• Inappropriate use of water bodies that could compromise the sustainability of the industry</li> </ul>

## Strengths of Brazilian tilapia industry

- **Water availability:** Brazil has the largest freshwater resource in the world and the majority is located in tropical areas that are suited to tilapia and where tilapia is already an introduced species (BNDES, 2012).
- **Feed ingredients availability:** Brazil is the largest soybean producer and the third largest corn producer in the world. It is also the largest poultry exporter in the world and therefore has a large production of poultry meal, a common ingredient for tilapia feed.

- **Large domestic market:** From the top five countries that produce tilapia, Brazil is the only one with a large domestic market. China has a large domestic fish market, but the Chinese do not eat tilapia. Other top producers have a small population and therefore a small domestic market, therefore the majority of their tilapia exported.
- **Established machinery industry supporting the sector:** Vietnam, Colombia and Indonesia need to import most machinery needed for aquaculture production or fish processing. Brazil has a strong construction industry that is already building equipment for production and processing, with an obvious interest in responding to industry needs and producing innovative equipment as solutions are developed.
- **Established veterinary services supporting the development of new vaccines:** The worldwide salmon industry has reduced antibiotic use, a trend that tilapia industry will follow for two key reasons. Firstly, the consumer and the regulator will demand such shift, and secondly, vaccinations create a more stable farming system, in turn creating a more predictable production cost for the farmer.

## Weaknesses

- **Juridical insecurity:** Many farmers in Brazil operate without environmental licences. Until 2011, Brazilian aquaculture was nationally legislated, but this was changed in December 2011 so that each state now determines its regulations and policies (Sampaio, 2019). Many states still have not developed licensing requirements, meaning that the industry is basically unregulated, and farmers have no environmental license available to apply for.
- **Incomplete use of fish:** Brazilians generally eat only the fillets of a fish. There is no use for minced fish meat and the other parts of the fish such as head, ribs, bellies and bones are used to make fish meal. For the industry to be competitive, there is a need to use as much as possible from the fish as a source of food.
- **Labor costs:** When summarizing all costs, including wages, social security, and other benefits, labor costs are higher in Brazil than other Latin American and Southeast Asian countries.

## Opportunities

- **Trade war between USA and China:** The resultant rise in trade tariffs for grains such as soy and corn can shift prices of these commodities, affecting Chinese cost of fish production. Furthermore, the USA can raise tariffs against Chinese products such as Tilapia Fillets (SCMP, 2018), potentially opening a window for Brazilian frozen fillets enter the USA market as a substitute for Chinese fillets.
- **Two genetic improvement projects based in Brazil:** There are two private companies with genetic improvement projects for tilapia in Brazil, which can speed up the fish quality and develop a better strain for the Brazilian environment.
- **Expertise from other industries such as swine and poultry can be transferred:** Brazil is a leader in poultry and swine production, processing and exports. These industries are already mature, with solid knowledge in technical matters, development of business models, opening of new markets and institutional relations that can be transferred from those industries to the aquaculture industry.
- **Research centers (private and public) can help develop better nutrition:** There are universities such as UNESP, public research centers such as EMBRAPA and private companies such as NEOVIA working on tilapia nutrition. Those are at the top of the pyramid, but combined with many other universities and institutes, can be a valuable asset for the industry.
- **A domestic market that can grow:** Although the majority of the tilapia produced in Brazil is consumed inside the country, Brazilian people still eat only 9kg of fish/inhabitant/year (PeixeBR, 2019). When compared to the consumption of poultry, 42kg/inhabitant/year (ABPA, 2018), or beef, 42kg/inhabitant/year (ABIEC, 2018), the potential to increase Brazilian domestic market is significant.

## Threats

- **New diseases not found in Brazil:** Diseases such as TiLV and new types of Streptococcus sp. have caused large losses in other countries. There is a need for Brazil to build an efficient biosecurity plan that can avoid and isolate losses. This is further challenged by the industry regulations being shifted from federal to state responsibility.

- **Marketing campaign against Brazilian tilapia, similar to Vietnamese Panga:** As Vietnamese Panga became an internationally-traded commodity fish, competitors producing other species started a scare campaign to turn the consumer off this fish species. Although the campaign was mostly based on fake news, it was very effective in reaching its target audience. The Tilapia industry in Brazil must understand this story and work proactively to be the one telling its own story.
- **Inappropriate use of water bodies that could compromise industry sustainability:** In many rivers or lakes where aquaculture has been established, farmers often surpass their licenses and produce more than the carrying capacity of the water body. This ends up with lower water quality, high mortality rates and compromises the longevity of the industry.

# Conclusion

After spending 16 weeks undertaking this Nuffield Scholarship, visiting farms and processing plants in countries outlined throughout this report, the author identified three common characteristics to achieve competitiveness within the tilapia industry:

- 1) Do the basics right on-farm.
- 2) Understand the farming environment to achieve optimal production.
- 3) Complete use of the fish.

## Do the basics right

Basics are the essentials, but they are not always easy. For this reason, it is important to emphasize that successful farms understand and prioritize doing the basics right. Maintaining water quality and flow, understanding fish behavior and their basic feeding habits tend to fix most problems found at farm level, or at a minimum will play an important role in identifying the solution. There is no value in adopting a new technology or acquiring a modern equipment if farm staff are not paying attention to the basics of fish farming.

## Understand the environment

In very unique environments like the Mekong Delta in Vietnam or peri-urban areas in Indonesia, it was clear that the farmers understood their environment very well and, as a result, had developed compatible farming systems and fish species. In the Mekong Delta, cages are designed to withstand the flowing waters and ponds are always located by the river to have better water exchange. The fish species being farmed are those that produce well under these conditions. In Indonesia where there are very limited water sources and not much area to build ponds, farmers build small ponds and selected species that have aerial breathing.

## Complete use of fish

In China, Vietnam and even in Colombia, the companies that were achieving solid growth had more than one product coming from the tilapia. Fillets were always the main product, but the skin, bellies, and minced were valuable by-products. When the fish was sold whole (gutted), even better margin by weight was achieved.

In summary, Brazil's availability of natural resources such as good quality and volumes of water and adequate climate, along with the production of the main ingredients for fish feed means the country has great potential to be a global leader in tilapia production. Brazil also

has industry support in terms of research centers, universities and other chain links in the industry that can act as a basis for the development of the tilapia industry.

Different to its competitors, Brazil has a large domestic market – 200 million inhabitants – that mainly consumes tilapia, even though each Brazilian consumes only nine kilograms of fish per year. Therefore, there is a great opportunity to raise fish consumption levels. Brazilian aquaculture can also benefit from the expertise of other agricultural production sectors that are already global leaders, either by adopting and adapting their business models and technology or by taking advantage of their distribution channels.

The threat of new diseases, bad marketing and water quality issues can seriously damage Brazil's tilapia and aquaculture sector. However, if the industry and government work together to set clear regulations, establish and enforce technical parameters and to be the teller of its own story, these threats are not likely to eventuate.

# Recommendations

1. **Utilize complete use of the tilapia.** Industry associations should incentivize companies to develop new products from the fish and help spreading those products to market.
2. **Focus research on genetic improvement and nutrition.** Feed is 70% of tilapia's cost, therefore nutrition and genetic improvement that will stress better growth rates are key factors to industry development.
3. **National biosecurity program.** Increasing biosecurity regulations, investment in disease monitoring and incentivizing the use of vaccines should be a joint commitment from industry together with government. Public policies need to be developed that are both feasible for farmers and effective in terms of disease risk management.
4. **Create juridical security.** Industry development and growth depend on predictability of the present and future regulations. Therefore, it is important to start a process of standardization of environmental legislations (since each state have a different law).
5. **Domestic and international marketing and branding.** The Brazilian tilapia industry already has a strong market development effort made through its industry body PeixeBR. They should be aware of efforts by competitors domestically (other animal proteins) and internationally (fish producers) to disrupt the confidence in Brazilian tilapia and other aquaculture products. If the industry does not tell its customers that companies produce a product responsibly, that is high-quality and has health-benefits, the industry will open itself up to letting competitors tell their side of the story instead.
6. **Sustainability.** Water quality issues are as important to the industry longevity as financial results. Aquaculture can impact the water it utilizes and the feed ingredients it uses can be questioned if they are sustainable. Therefore, it is important to demonstrate it is responsible for the water it uses and to source only renewable sources of feed ingredients.
7. **Employee welfare.** It is important not only to apply all the local labor regulations but go forward and assure that the consumers can have their demands met.

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# Plain English Compendium Summary

<b>Project Title:</b>	<b>Competitiveness of Brazilian Tilapia Farming. Will Brazil be (and stay) a global leader?</b>
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<b>Objectives</b>	To have a global view of tropical aquaculture and to understand how Brazilian tilapia farming ranks among other tropical countries. This project will also generate further understanding on: <ul style="list-style-type: none"><li>• The key factors that have made countries such as China, Norway and Vietnam become industry leaders in production.</li><li>• The main threats to the Brazilian Aquaculture industry.</li><li>• Public policies and industry actions that can support the growth of tilapia farming in Brazil.</li></ul>
<b>Background</b>	Tilapia ( <i>Oreochromis sp.</i> ) is a fish species that stands out since it is the second main species in production volume after carps (FAO, 2020), it has a developed international market (KUBITZA, 2011), it is the most diversified fish species sector geographically (GOAL, 2019) and it is a robust omnivore fish, that can be fed mostly by grains and renewable feed ingredients
<b>Research</b>	The author has visited farms and processing plants in the USA, Colombia, Norway, China, Vietnam, Indonesia, Malaysia, Taiwan, Australia and Japan in order to understand the commonalities that have made their industries successful and what are the experiences that can be valuable to Brazilian tilapia industry. A SWOT analysis has been produced by the author to evaluate the competitiveness of the Brazilian tilapia industry.
<b>Outcomes</b>	Three common characteristics were identified to achieve competitiveness in the tilapia industry: 1) Do the basics right on-farm. 2) Understand the farm environment to achieve optimal production. 3) Complete use of the fish.
<b>Implications</b>	Brazil's availability of natural resources such as good quality and volumes of water and adequate climate, along with the production of the main ingredients for fish feed means the country has great potential to be a global leader in tilapia production. The threat of new diseases, bad marketing and water quality issues can seriously damage Brazil's tilapia and aquaculture sector
<b>Publications</b>	1) Aquaonline – Seminário online da Rvista Aquacultura. 2) Aquishow – Santa Fé do Sul, SP. 3) Rondonia Rural Show – Ji Paraná, RO. 4) Aqua Pará – Castanhal, PA 5) International Fish Congress – Foz do Iguaçu, PR