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Analysis of the Tilapia Value Chain in the Philippines

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Abstract

The tilapia value chain of the Philippines is an important contributor to food security now and will be into the future. A study of the chain is essential in order to strengthen the chain, mitigate risks and vulnerabilities and overcome constraints. The value chain consists of six main functional areas, from inputs through to retailers who interact with consumers of the fish and each functional area has its own set of risks and efficiencies. Value addition for the most common marketing channel shows that farmers add the most value as they raise the fish from fingerling to market size over a period of several months. Examination of the total variable costs required to raise each tilapia shows that feed is the biggest single cost and that almost one third of the retail price is profit for the chain actors. Location of physical facilities is one of the most critical value chain drivers in order to reduce transport costs and minimise loss of quality as the tilapia is physically moved between value chain actors. Analysis shows that the tilapia value chain has high efficiency and low responsiveness, broadly achieving strategic fit with its competitive strategy. By benchmarking against the tilapia industry in China, the performance of the tilapia value chain in the Philippines is shown to be lacking in the areas of production efficiency, certification, and processing capacity. Two main conclusions drawn from this study are that the tilapia value chain needs to better prepare for the effects of climate change by breeding heat-tolerant and salt-tolerant strains of tilapia, and secondly, a marketing campaign to improve consumer perception of tilapia could drive further demand and willingness to pay.

Key words: tilapia, value chain, Philippines, climate change, aquaculture

Introduction

The Philippines has experienced solid GDP growth - averaging 4.5 per cent over the last 20 years - and increased its population size by more than 31 million people over the same period (World Bank, 2022). These factors have greatly increased the demand for food in the country and, as described by Bennett's Law, as per capita incomes increase, so does demand for protein. Similar to other archipelagic countries, seafood is a particularly important source of protein and micronutrients in the Philippines. Aquaculture has seen rapid expansion to meet that demand, with aquaculture production more than doubling between 2000 and 2017, reaching 2.24 million tonnes in that year (FAO, 2020). Despite this impressive growth, the FAO (2020, p.8) predicts that "(current) aquaculture growth in the Philippines would be insufficient to meet the fish demand of its growing population…with a demand-supply gap of around half a million tonnes…or more than one million tonnes if the Philippines would like to increase its per capita fish consumption to the South-eastern average", underlining the importance of accelerating the growth of aquaculture to meet the demands of the populace.

Tilapia (Oreochromis niloticus) is the second-most consumed fish in the country (after milkfish), and accounts for 12 per cent of overall animal protein consumption in the Philippines, representing 2.71 kg per capita per year (Philippine Statistics Authority, 2022a). Tilapia are considered a pest species in many countries, including Australia, but are a common food source in much of the developing world. Tilapia grow best in warm-water, tropical conditions and are renowned for their hardiness, fast growth rate and efficient feed conversion ratio. Mozambique Tilapia, from either Indonesia or Egypt, were first introduced to the Philippines in 1950 but commercialisation of the species did not gain traction until the 1970s when the Nile Tilapia was promoted by the government as an additional source of income for impoverished rice farmers. Since then, tilapia has become an increasingly important source of food and economic growth in the country, especially as many wild capture species have been overfished in recent years and seen declines in catch volumes (National Stock Assessment Program, 2022).

International trade of tilapia to and from the Philippines is negligible, with minimal volumes (< 1,000 tonnes) of frozen tilapia fillets being imported in some years and even smaller volumes (< 500 tonnes) being exported in some years. Interestingly, this is probably not a result of prohibitive tariffs; according to the Tariff Commission of the Philippines (2022), import tariffs on whole tilapia are 7 per cent, and the rate on imported tilapia fillets is slightly higher at 10 per cent. Additionally, if the country of origin is a member of the Association of Southeast Asian Nations, the import of tilapia and tilapia products has been tariff-free since 2017. China is by far the biggest exporter of tilapia and, considering their close proximity (geographically and economically) to the Philippines, it is surprising that they do not export sizeable volumes to their southern neighbour. The reason may be that the Department of Agriculture of the Philippines is responsible for issuing import licences for most agricultural commodities, including fish, so they act as an unofficial gatekeeper – effectively imposing quantitative import restrictions as they see fit. In 2021 the Department of Agriculture approved the importation of 60,000 tonnes of small pelagic fish and were met with much public backlash from fisherman and fish farmers (Gamboa, 2022). Due to the above reasons and the Philippines's near-100 per cent self-sufficiency of tilapia, neither imports nor exports will be considered in this analysis.

The Importance of the Tilapia Industry for Food Security

The importance of tilapia in achieving food security for the future development of the Philippines is the major reason for the analysis of this particular chain. Examples abound of food shortages leading very quickly to social unrest and political strife, which all countries want to avoid. The recent Covid-19 pandemic has exposed many vulnerabilities in supply chains, including food, and led to many countries imposing protections or industrial policies to increase their self-sufficiency in food and other critical products. In order to avoid supply chain stresses, it is important that all chain actors are economically profitable and economically sustainable, and this study will use recent financial data to evaluate the financial performance of all chain actors. Food wastage is a global problem that occurs to different degrees in different parts of the chain depending on the commodity and location. Fish such as tilapia are especially susceptible to wastage because of their perishability, and this issue is compounded in a developing country like the Philippines, where infrastructure such as cold storage is often inadequate. Reducing fish wastage can add to food security but has also been identified as a major way to reduce greenhouse gas emissions (Kruijssen et al., 2020). Analysis of the tilapia supply chain may identify where and how wastage occurs and inform policies or actions to address the issue. Finally, the tilapia value chain faces risks on many fronts: cost and availability of feeds, competition from other fish species, lack of industry-specific knowledge, climate change, harmful political policies, etc. This study aims to identify the most pertinent risks and underperformance issues and suggest ways that the value chain can be improved and strengthened to benefit all chain actors and anyone who consumes tilapia.

This paper begins by giving an overview of the tilapia supply chain in the Philippines and outlining the actors involved and their relationships with each other. Financial flows using the latest available data from 2019 are analysed to observe the profitability of chain actors and how revenues and costs are distributed across the chain. The most important aspects of both logistical and cross-functional drivers are discussed, which help to identify the main profit drivers of the chain. A strategic fit framework is applied to assess how well the overall strategy of the chain aligns with its competitive strategy. Performance of a value chain can be judged in a myriad of ways, but this report cites previous benchmarking against the Chinese tilapia industry as a very pertinent way to effectively judge the performance of the tilapia value chain in the Philippines. Finally, constraints to performance will be identified, and possible solutions suggested.

Tilapia Value Chain in the Philippines

Data from the Philippines Statistics Authority (2022a) in Table 1 show the recent trends of production, consumption and pricing of tilapia from selected years. The value chain for tilapia in the Philippines is reasonably short compared to the chains of many manufactured products and some kinds of highly processed foods. This is due partially to the perishability of the fish and partially to the consumer preference for unprocessed, whole, live fish (The Tilapia Technical Committee, 2018). Figure 1 gives an overview of the five major stages in the Philippine tilapia value chain and the major actors in each stage. The availability of knowledge and resources from extension agents is shown along the bottom of the diagram.

Table 1. Selected market data for tilapia in the Philippines

	2005	2010	2015	2020
Production from aquaculture (tonnes)	163,003	258,839	261,210	263,871
Imports (tonnes)	0	0	43	14
Exports (tonnes)	0	0	167	0
Domestic Consumption (kg/capita/year)	2.22	3.16	2.98	2.71
Wholesale Price (PhP/kg)	53.97	67.89	79.97	99.72
Retail Price (PhP/kg)	69.29	87.61	106.36	132.74

Source: Philippines Statistics Authority (2022a)

Specific inputs

Aquafeed mills

According to the Bureau of Fisheries and Aquatic Resources (BFAR) (2022), there are a total of 48 aquafeed mills in the Philippines, with 35 on the island of Luzon and 13 in other provinces. These mills produce feed for both fish nurseries and fish farms, and the composition of their feed depends on the application. Feed formulated for nurseries, to be fed to fry and fingerlings, tends to be about 50 per cent fish meal and the remainder plant-based sources. Fish feed formulated for the grow-out farms tends to have a much lower percentage of fish meal (about 10 per cent) with the remainder made up of soy meal, corn, wheat, and rice screenings. Fish meal tends to be much more expensive compared to high-protein plant sources such as soybean meal. A detailed example of fish feed composition can be found in Appendix 2.

Hatcheries

Hatcheries sometimes operate as an independent entity and sometimes incorporate a nursery function so that fish can be raised from egg through to fingerling. In the Philippines, there are 125 government run hatcheries and 498 privately run hatcheries (BFAR, 2022). The broodstock used by hatcheries are mostly derived from the Nile Tilapia but are the result of many cross-hybridisations with Red Tilapia and Mozambique Tilapia to gain desirable traits related to growth, hardiness, taste, colour (of both skin and flesh), cold tolerance and salt tolerance. Almost all of the available strains of fry are derived from the ground-breaking Genetically Improved Farmed Tilapia (GIFT) which was released by WorldFish and its research partners in the 1990s. Hatcheries offer a wide variety of fish to suit the needs of the farmer, processor, and consumer tastes, and hatcheries in different parts of the Philippines can offer fish with traits best suited to the local environment. As of 2019, the tilapia strains available in the Philippines are shown in Table 2.

Table 2. Genetically improved Nile tilapia strains that are available in the Philippines as of 2019

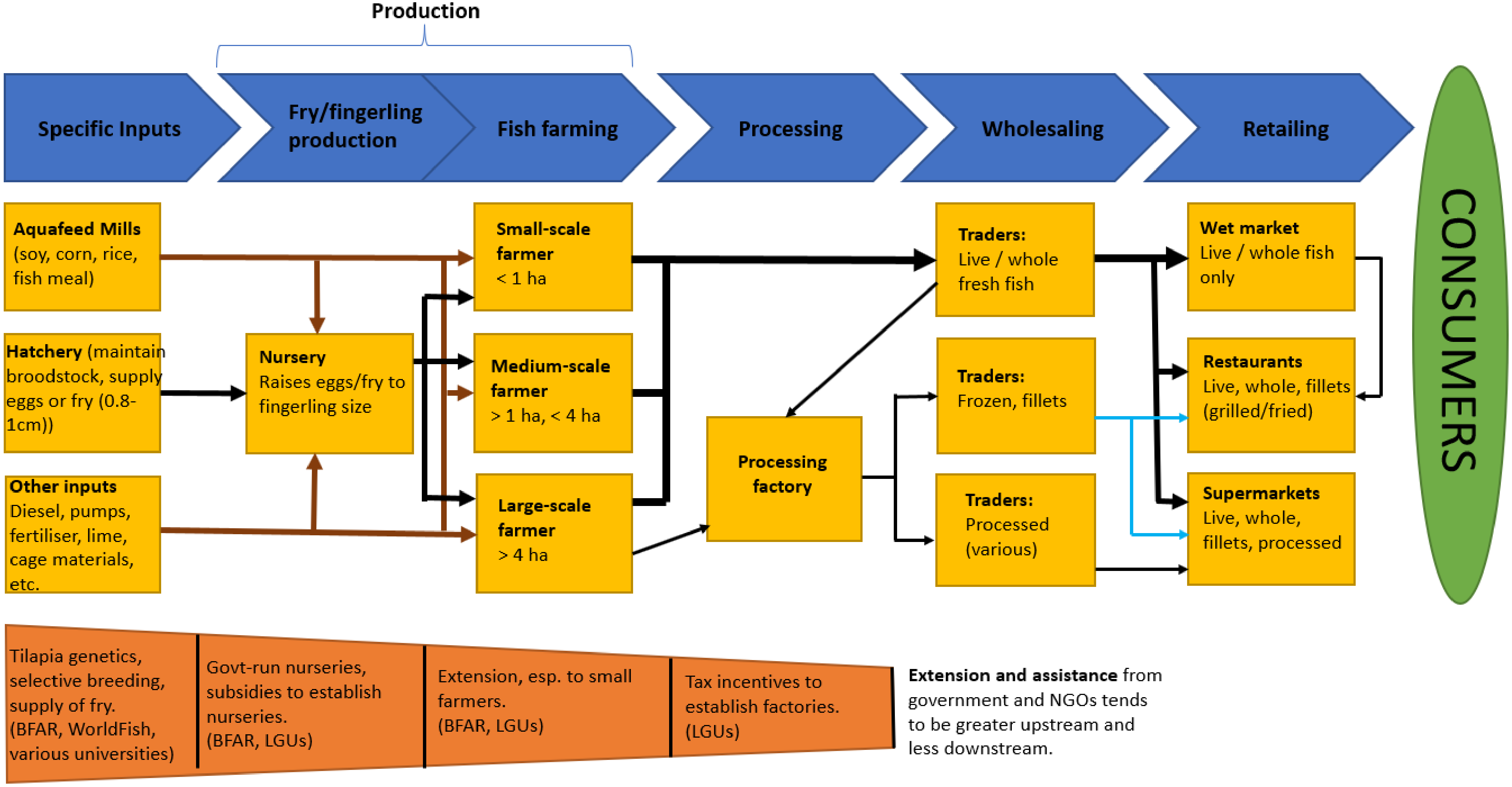
Name of Tilapia Strain	Source Agency
Freshwater Aquaculture Center Strain Tilapia (or FaST, 39th generation)	Freshwater Aquaculture Center, Central Luzon State University (FAC-CLSU), Muñoz, Nueva Ecija
Genetically Improved Farmed Tilapia-Malaysia strain (GIFT- Malaysia)	Bureau of Fisheries and Aquatic Resources (BFAR in selected regions)
Genetically Male Tilapia or YY Supermale Tilapia (GMT)	FAC-CLSU
Improved Excel strain tilapia (i-Excel)	BFAR-National Freshwater Fisheries Technology Center (BFAR-NFFTC), Muñoz, Nueva Ecija
Improved Brackishwater Enhanced Strain Tilapia (i-BEST)	BFAR-NFFTC, Muñoz, Nueva Ecija
Cold tolerant tilapia strain	BFAR-NFFTC, Muñoz, Nueva Ecija
Molobicus	BFAR National Inland Fisheries Technology Development Center (BFAR-NIFTDC), Dagupan, Pangasinan
Genomar Supreme Tilapia (GST)	Genomar Philippines (www.genomar.no)

Source: Romana-Eguia, Eguia & Pakingking (2020)

Other inputs

Fertiliser, both inorganic and organic (chicken manure), is used during pond preparation to promote plant and algal growth. Lime is spread on the bottom of ponds during preparation to regulate water pH once filled. And cages, pens, and pontoons are used for lake or estuary-based tilapia growing. These are traditionally made from bamboo but construction from HDPE is becoming more popular.

Figure 1. Tilapia value chain in the Philippines (Relative thicknesses of lines approximate relative volume of product flow)



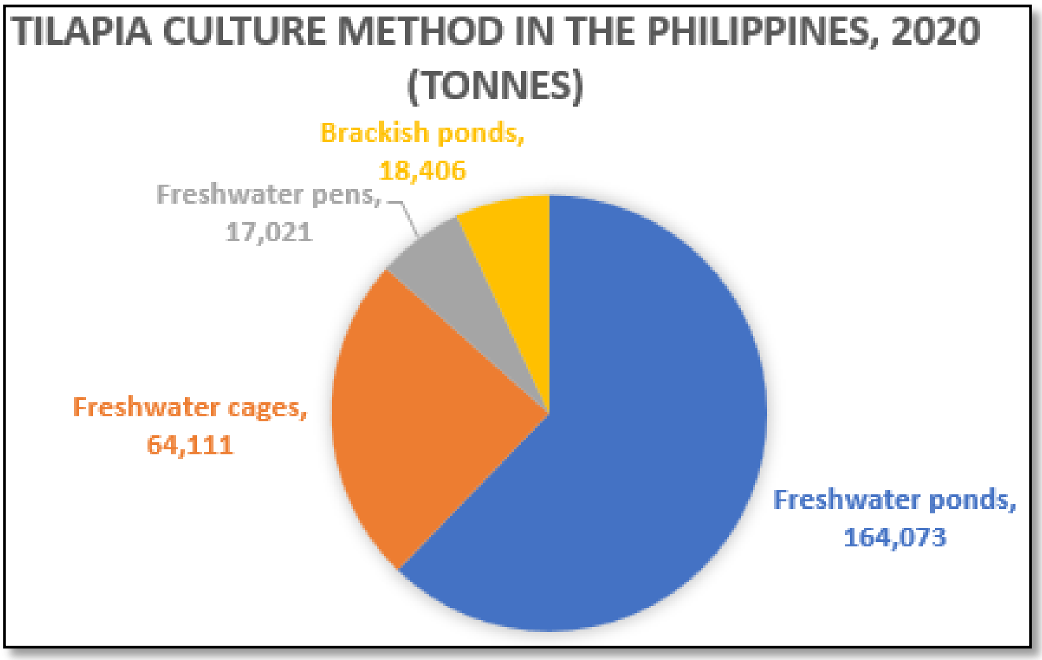
Source: Drawn by the author. Adapted from BFAR (2022), Jamandre et al. (2011a) and Ramirez et al. (2019)

Grow-out farms

In the Philippines, grow-out farms can be divided into four broad categories:
i) Freshwater ponds – earthen ponds filled with fresh water from groundwater or above-ground reservoirs.
ii) Freshwater cages – round or four-sided cages made from HDPE or polypropylene netting situated in a lake or river water.
iii) Freshwater pens – similar to cages, but typically situated in shallower water so that the netting is weighted and sits on the benthic surface.
iv) Brackish ponds – similar to freshwater ponds but situated near the coastline so that seawater or a mix of seawater and freshwater can be used as the growing medium.

Tilapia farms exist in a wide range of sizes and volumes, and each category has its own stocking rates, feeding regimes and management practices. The annual production for each type is displayed in Figure 2, which shows that freshwater ponds accounted for 62 per cent of total production in 2020 (BFAR, 2022). In Figure 1, farms are divided into three size groups, somewhat arbitrarily, to show the general situation in the Philippines.

Figure 2. The major tilapia culture methods as a proportion of total tilapia production in 2020



Source: Drawn by author using data from BFAR (2022)

Common to all farm sizes and cultures are fundamental aquaculture management practices such as feeding (six days per week), maintenance of water quality (pH, dissolved oxygen, turbidity), grading (on larger farms) and harvesting. The time period from stocking with fingerlings to harvesting is typically 4-5 months for small tilapia (200-300g) and 6-8 months for large tilapia (400-600g) (Bestari & Morales, 2003).

Small farms are defined as less than one hectare in size and are usually owner-operated, and do not employ any extra labour except during harvest time. They typically raise fish to 200-300g, which are too small to be filleted or processed, so are bought by wholesalers that trade in whole fish only.

Medium farms (more than one hectare, less than four hectares) will typically employ one labourer for every two hectares of farm (Bestari & Morales, 2003). They are likely to have more modern equipment than small producers and can achieve higher stocking rates if they invest in mechanical aerators. They may harvest fish of various sizes so that they can penetrate several consumer markets. In some cases, they may have contracts to supply processing factories or supply them on an opportunistic basis. This would involve growing fish to a larger size.

Large farms (greater than four hectares) are sometimes corporately owned and have the scale to be able to invest in efficiency-increasing technologies and achieve a degree of mechanisation to reduce labour costs. These farmers are able to target all tilapia markets (live, whole, filleted, processed) but are in the best position to have the capacity to meet the needs of the processing factories. Processing factories typically demand large size tilapia (400-600g), which large scale producers can produce by tailoring their feeding and management practices to produce different size tilapia.

Processors

Processing of tilapia takes place in small-scale "backyard" operations as well as in modern factories. Small-scale processing is limited to smoked whole tilapia and *tilanggit* (salted, sun-dried whole tilapia) and is usually done by small-scale, artisanal processors who sell within their local area only. Medium-scale processing takes place in factories and can produce product forms such as whole-gutted-frozen tilapia, fillets, cubes, surimi, *tocino* (marinated fillets) and *longganisa* (fish sausage). Typically, tilapia processors buy fish in the 350-600g range and standard processing yields are as follows (Jamandre et al., 2011a): 30-35per cent fillet; 18 per cent belly; 25 per cent innards; 21 per cent head; and 1 per cent skin.

Wholesaling

The marketing channels of tilapia are various and differ from province to province. The majority of harvested tilapia is sold whole and fresh, the second most common outcome is whole and frozen fish, and a lesser amount is sold to processors to undergo further value-adding. Time to market is crucial for such a perishable product, so harvesting is usually timed so that the fish are harvested in the morning, graded, and then transported to major metropolitan areas to arrive with the opening of the evening wet markets. If the intention is to sell fresh or live fish in a morning market, harvesting will commence under lights during the night to allow the fish to be at the market with minimal loss of quality. Small-scale and medium-scale farmers lack the volumes required to supply processing plants so will usually sell to a wholesaler (*viajero*), who in turn will sell to the market-based retailer. In some cases, the *viajero* will also be a source of finance for the small-scale farmer and so the farmer will be obligated to sell his fish exclusively to that *viajero* at a pre-determined price (Bestari & Morales, 2003). Large-scale tilapia farmers will usually have enough ponds with tilapia at varying stages of growth to be able to supply traders or directly supply processing plants. Research by Bestari and Morales (2003) noted that there was a large number of tilapia wholesalers, with entry and exit of traders a common occurrence. They also noted that this large concentration of traders can be good for producers because they have many options for selling but, on the other hand, many traders lack knowledge of the industry and are unable to match their own supply to the demands of the retailers. Financial data from BFAR (2022) (see Appendix 1) shows that wholesalers typically mark-up tilapia prices by about 5 per cent from farmgate prices, with a typical wholesale price in 2019 of PhP80/kg (AU$2.10/kg). This small profit-margin can be attributed to the competition between the large number of wholesalers and may be further diminished by the common occurrence of informal "goodwill" payments demanded by various parties during transportation and offloading.

Retailing

Consumers of tilapia in the Philippines generally purchase the fish from one of three retail channels, largely depending on their preferred form of tilapia.

Wet markets

Wet markets exist in most reasonably-sized Filipino towns and often operate seven days per week. Less than half of households in the Philippines own either a freezer or a refrigerator (Philippines Statistics Authority, 2022b), so many householders purchase and consume perishable, fresh produce on a daily basis. According to Jamandre et al. (2011a), Filipino householders prefer tilapia with firm meat and weighing approximately 200-250g per fish. Vendors in wet markets often have long-standing contracts (formal or informal) with one or more wholesalers to ensure they have sufficient supply to meet demand. According to survey data from BFAR (2022), wet market retailers markup tilapia from the wholesale price by about 7 per cent, with a typical price in 2019 being PhP109/kg (AU$2.87/kg). Apart from purchasing of the fish as stock, wet market retailers have reasonably low costs, consisting of fees to the market owner (either a fixed cost or a fraction of sales revenue), and cost of ice to keep produce fresh. Experienced wet market retailers can accurately predict daily demand and ensure they sell all of their tilapia on a particular day. If, however, they overestimate demand, they may end up having to sell at a steep discount at the end of the day or end up with wasted fish.

Supermarkets

Supermarkets in the Philippines range from small corner stores to cavernous, modern complexes selling all manner of fresh, processed and imported produce. Large supermarkets often have a live seafood section where patrons can choose a fish or crustacean from a tank and either purchase it "as is" or have it scaled and gutted/filleted by supermarket employees, and live tilapia is usually sold at a larger size (250-350g) compared to fresh, whole tilapia that predominate in wet markets (Jamandre et al., 2011a). Supermarkets are also likely to sell a selection of processed tilapia products, such as frozen fillets, tilapia surimi, *tocino* and *tilanggit*.

Restaurants

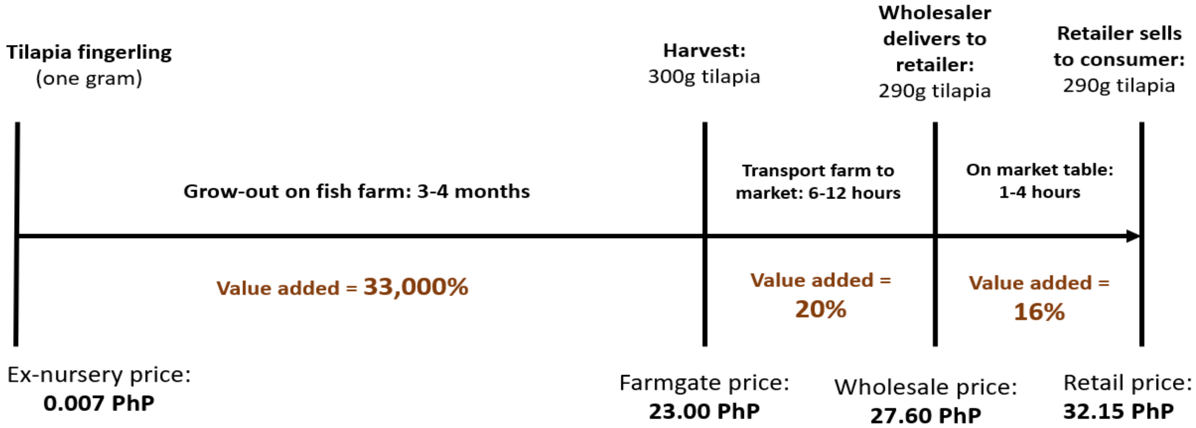
Restaurants offer tilapia cooked in several ways, either as a whole fish or in fillet form. Tilapia can be fried, grilled, or steamed, but is most commonly deep-fried in oil. Some restaurants specialise in particular tilapia-related recipes, such as fish head soup, tilapia belly or deep-fried tilapia skin, ingredients for which may be by-products of tilapia processing (Jamandre et al., 2011a). Due to its cheap price, tilapia is unlikely to be seen in high-price and fine dining restaurants but is common in the offerings of casual dining restaurants and street vendors.

Value Addition

Figure 3 shows a timeline as well as value addition for one tilapia fish which is purchased as a fingerling, grown out to a typical size, and sold in the most common consumer channel: whole and fresh from a wet market located near to the point of production.

The prices used are an average price for one fish, as provided by BFAR (2022) from their survey data, and are not necessarily the price of an individual fish. For instance, tilapia fingerlings are usually sold in 1,000 count allotments, and a farmer purchasing fingerlings will assume some fish mortality (20-30 per cent is typical) during grow-out, so he will purchase more fingerlings than he expects to harvest.

Figure 3. Timeline and value-addition of a typical sized tilapia sold whole and fresh in a wet market



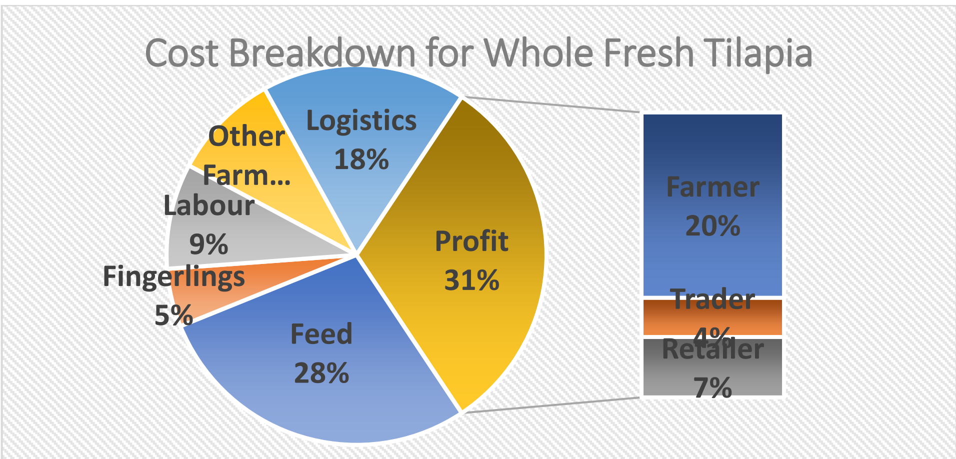
Source: Drawn by author. Pricing data from BFAR (2022). Timeline data from Bestari & Morales (2013) and Romana-Eguia, Eguia & Pakingking (2020). Timeline not to scale.

Therefore, the price of one fingerling has been increased by 30 per cent to account for this. Even with this adjustment, the value-added by the farmer is very large, as the fish increases in weight 300 times in the space of 3-4 months. The farmer must expend significant costs to achieve this value-addition – primarily feed, but also labour, fuel, and water additives. The farmer also carries significant risk during this time period, as the fish could suffer increased mortality through disease or water contamination. The wholesaler purchases the fish from the farmer either at a spot price or a pre-determined farmgate price, if they have a contract, and arranges delivery to the retailer. During this transportation phase, shrinkage of about 3 per cent is assumed and is factored into the farmgate price paid by the wholesaler. The wholesaler bears the cost of transportation and adds approximately 20 per cent of value to the fish. The retailer, in this example presumed to be a small trader at a metropolitan wet market, purchases the fish from the wholesaler at the wholesale price and holds it as stock until it is purchased by the consumer, adding 16 per cent of value.

Distribution of benefit among actors

Pricing and cost data from BFAR (2022) reveals that variable costs represent about 69 per cent of the retail price for whole, fresh tilapia and the remaining profit (ignoring fixed costs) is divided between the main actors as shown in Figure 4.

Figure 4. Cost breakdown for whole, fresh tilapia with profit margins of major actors included



Source: Drawn by author, based on data from BFAR (2022). Does not include fixed costs.

Of the three actors that receive profit, farmers would be expected to have the largest fixed costs, so the profit margin for an individual farmer is unlikely to reach 20 per cent in reality. At the same time, high fixed costs may hamper new players from entering the market, so farmers face less competition compared to wholesalers and retailers.

Logistical drivers

Due to the perishability of tilapia, all segments of the value chain tend to have facilities with close proximity to each other. The most important factor in determining the location of facilities is the location of consumer demand. Consumer demand for tilapia can depend on many factors – local tastes, price, availability and price of substitutes, knowledge about cooking methods – but these demand factors have not been studied in detail, so population is used as an indicator for quantity demanded. The largest population centre in the Philippines is Manila and the most populous island is Luzon, which is also (by a wide margin) the largest producer of tilapia. Working upstream from the consumer, tilapia retailers tend to be most concentrated in the population centres. Fish farms also benefit from close proximity to large cities and large consumer demand, but many other factors also contribute to the location of their facilities. Land costs, land suitability, water supply, proximity to feed suppliers and hatcheries/nurseries mean that fish farms tend to cluster in areas that are within a 4–8-hour drive of major population centres. Tilapia fry and fingerlings must be transported live from the hatchery/nursery to fish farms, so close proximity between the two makes transporting less costly and reduces the mortality of fish. In the case of aquafeeds, they have a low monetary value per unit weight (PhP32 to Php34/kg (AU$0.82 to AU$0.87/kg)) (Mamauag, 2022), so transport costs become increasingly important.

Cross-functional drivers

The flow of information in the tilapia value chain in the Philippines has not been well-studied, but certain observations can be made from an overview of the literature and anecdotal evidence. Information flow tends to be more transparent, and the chain is exposed to more informational assistance from external sources, in the upstream parts of the chain, but tends to become more ad-hoc further down the chain. Smaller actors, such as small-scale farmers and individual traders, often lack sufficient information to make informed decisions. For example, individual wholesalers may purchase more fish from a farmer than can be sold to retailers in the wet markets, leading to the need to discount fish steeply to sell to human consumers or discount even further and sell the fish as feed to livestock producers. Hatcheries are the beneficiaries of a large amount of extension efforts from government and non-government agencies. In the Philippines, the Bureau of Fisheries and Aquatic Resources aids and coordinates research with local universities and international organisations to improve tilapia genetics as well as providing fish health services such as monitoring efficacy of disease-prevention treatments and monitoring the environmental impacts of tilapia farming (Bestari & Morales, 2013). Many of the hatcheries are government-run so they presumably get first access to the latest research. Some international organisations such as the CGIAR-affiliated WorldFish supply hatcheries and to a lesser extent farmers and provide manufacturers with research and extension (Ordonez, Santos & Tayamen, 2014). Hatcheries and nurseries also play a significant role in extending knowledge to farmers regarding choosing the most suitable strains of tilapia and following best-practice management and feeding techniques for those particular tilapias. Hatcheries also offer advice to farmers about disease management and seek feedback so they can improve their offerings (Bestari & Morales, 2013).

There is little vertical integration in the tilapia supply chain, so sourcing decisions are undertaken by individual actors without an appreciation of what is happening in other parts of the chain. Although tilapia and aquaculture in general is a well-developed industry in the Philippines, actors are often very restrained in their sourcing opportunities. Due to the high cost of transport, farmers may be practically limited to sourcing fingerlings from only one hatchery and feed from only one mill, reducing competitive tension. Small-scale farmers in particular, may have their sourcing decisions limited by cash flow – they are unlikely to be offered credit by suppliers, unless it's at prohibitively high rates, so they are forced to source small quantities of feed and miss out on more efficient economies of scale.

Strategic Fit

Chopra & Meindl (2013, p.21) state that "strategic fit requires that both the competitive and supply chain strategies of a company have aligned goals." Tilapia is viewed as a cheap source of protein by consumers and does not have the premium appeal of more expensive fish such as tuna, so the competitive strategy of the tilapia supply chain can be broadly defined as 'supplying cheap, reasonable quality fish to as many consumers as possible'. In order for the supply chain strategy to be aligned with this competitive strategy and thus achieve strategic fit, two major aspects of the supply chain must be better understood: demand uncertainty and supply chain capabilities.

Demand uncertainty

Demand uncertainty occurs at all links in the supply chain but is anchored by the demand uncertainty of the furthest downstream actor, the consumer. Demand may be influenced by the price of tilapia substitutes, such as milkfish and scad; however, these substitutes are exposed to many of the same market forces as tilapia, such as aquafeed prices, extreme weather, and major impacts such as Covid-19, so that any change in price of substitutes would likely see a similar change in price in tilapia and not have a large effect on tilapia demand. Consumers usually purchase tilapia with frugality in front of mind, so their demands for service level and expected innovation are not high (Acuna et al., 2020). They expect a fresh, undamaged fish, of suitable size, and nothing more. This relative certainty in demand filters back through the chain – retailers can order steady quantities of fish from wholesalers, who in turn can provide steady orders for fish farmers. Farmers have reasonable certainty as to how many fish they will produce so, barring any major diseases or impediments to production, hatcheries and nurseries can have reasonable certainty as to how many fingerlings will be demanded by farmers. The Philippines is a predominantly Catholic country and the diet of those that follow this religion has some ecclesiastical influences. Traditionally, Catholics prefer to eat fish on Fridays and certain holy days, so it's possible that demand for tilapia would increase on these days; however, evidence to support this claim was unavailable.

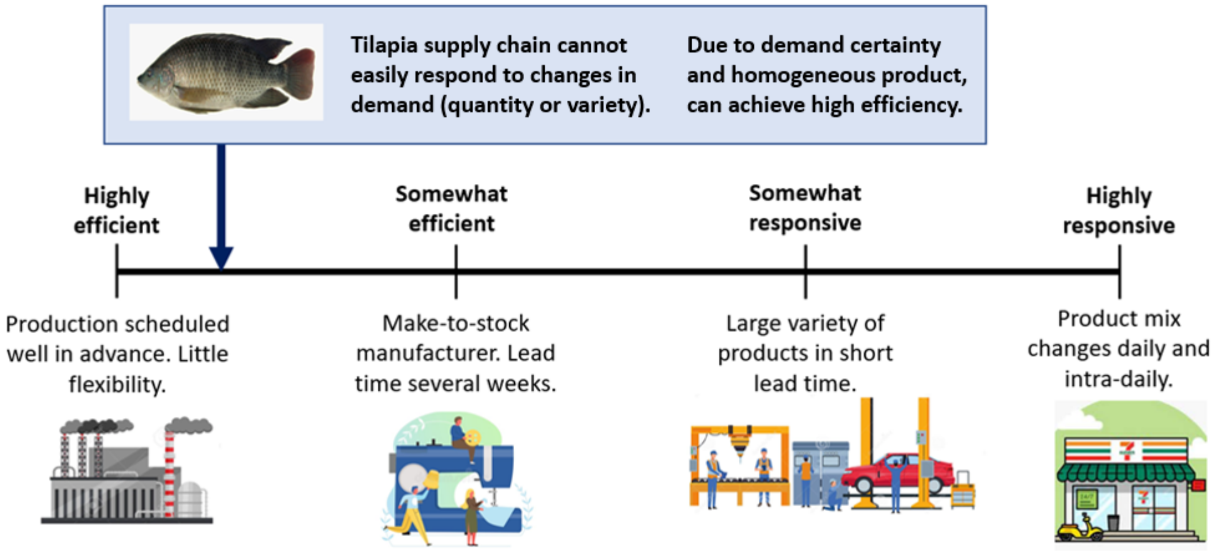
Supply chain capabilities

In terms of supply chain capability, the tilapia supply chain has very low responsiveness. Almost all chain actors would find it difficult to respond if quantities demanded suddenly changed. Farmers are limited by the growth rates of the fish, stocking rates and pond hectarage, none of which can be changed in a short period of time (or even a long period of time). If consumers were to demand a shorter lead time for delivery of fish, that could only be achieved if the customer was willing to accept smaller fish. The limits of nature also set a limit on how responsive the chain can be. There is innovation occurring in many areas along the chain, but research by Jamandre et al. (2011a) highlights that most of these innovations are aimed towards lowering cost and increasing volume of production rather than increasing the value of the end-product. They point out that tilapia has been identified by the government of the Philippines as a key commodity to address food security and poverty alleviation concerns, so most government support is targeted towards increasing production, and marketing support is very limited. Exceptions to this may be the processing of tilapia into value-added products and the development of new strains of tilapia, which may improve taste and increase consumers' willingness to pay. Figure 5 shows where the tilapia supply chain maps onto a responsiveness spectrum.

Main Profit Drivers

The OpenSTAT database of the Philippines Statistics Authority (2022a) provides detailed average costs and returns concerned with tilapia production based on survey data taken most recently in 2019. However, detailed financial data for other actors in the tilapia value chain is not easily accessible, but profit drivers summarised in Table 3 have been identified from a review of available literature.

Figure 5. Responsiveness of tilapia supply chain based on responsiveness continuum



Source: Drawn by the author, adapted from Chopra & Meindl (2013)

Performance

Performance of any value chain is difficult to quantify and performance of individual firms within the chain doesn't necessarily accurately reflect performance of the whole chain. A range of methods have been devised for measuring value chain performance; however, an agrifood-specific value chain performance measurement framework developed by Aramyan et al. (2007) groups performance indicators into four categories: efficiency, flexibility, responsiveness, and food quality. Benchmarking can also be an effective tool for comparing both whole-chain performance and individual firm performance between similar chains in different locations and, when used as a complement to formal methods such as Aramyan's, may give a superior measurement of performance.

Benchmarking against China

BFAR (2022) benchmarked several aspects of the Filipino tilapia value chain against the tilapia value chain in China, which is by far the biggest producer and exporter of tilapia in the world (FAO, 2020). The report established that tilapia production in China is much more intensive, with higher stocking rates and higher production rates per unit area (16 t/ha in China compared to about 7 t/ha in the Philippines). A much larger portion of the Chinese-produced tilapia is processed into value-added forms and, unlike the Philippines, China exports large volumes of tilapia. In order to meet processing requirements, Chinese farmers generally grow their tilapia out to a larger size and weight compared to their Filipino counterparts.

Another major difference between the value chains of the two countries, identified by the report, was the amount of regulatory oversight and certification in the Chinese system compared to the Philippines. To start a fish farming business, Chinese farmers must meet stringent guidelines regarding pond/tank construction, wastewater runoff and waste disposal. Chinese tilapia processing factories are also subject to stricter hygiene standards and HACCP standards.

Table 3. Summary of main profit drivers in the tilapia value chain in the Philippines

ACTOR	PROFIT DRIVERS
Hatchery	Offering latest genetic strains Offering extension and fingerling selection advice
Aquafeed Mill	Low cost per unit of protein Consistent quality Correct labelling
Fish farmers	Maximise feed conversion efficiency Minimise fish mortality Time feeding regime and harvest to offer maximum number of fish within buyers' specifications
Processor	Constant process-volume-flow through use of contracts with farmers
Wholesalers	Efficient transport to minimise quality loss Matching supply with daily retail demand
Retailers	Matching supply with daily consumer demand Maximise returns per unit area of physical sales space

Source: Acuna et al. (2020), BFAR (2022), Jamandre et al. (2011a), Ramirez et al. (2019)

Although the report highlights China's superior productive capacity, it does not detail the sustainability of that production or mention other advantages that China has over the Philippines. Firstly, China's grain farmers are heavily subsidised, whereby grains such as corn, soy, wheat, and rice that are used to formulate fish feed attract significant market price supports, equivalent to 33, 19, 19 and 21 per cent of gross farm receipts, respectively (OECD, 2022), allowing those commodities to be purchased by millers at very low prices. Subsequently, fish feed is cheaper in China, and farmers tend to use more of it per mass of fish compared to the Philippines.

So, while benchmarking is useful as a comparison, direct comparisons on one particular metric are not necessarily useful without holistically considering the impact on the whole chain and chain-related environment.

Major Constraints to Better Performance

Several authors have identified constraints and concerns in the tilapia value chain, and after a selective review of the literature, some of the most common concerns are summarised in Table 4.

Table 4. Selective review of common Filipino tilapia value chain constraints mentioned in the literature

AUTHORS	ACTOR(S)	CONSTRAINT
Jamandre et al. 2011	Farmers	Low quality aquafeeds Mislabelled aquafeeds Harvesting at non-ideal times due to lack of buyers/demand Extreme temperature variations
	Transporters	In-transit mortality Lack of transport vehicles with aerators
	Entire chain	Natural disasters, esp. typhoons
BFAR 2022	Hatcheries	Fry insufficiency during summer months when water temperature is high
	Aquafeed millers	Raw inputs for feed are expensive and have low availability
	Processors	Lack of equipment to process tilapia >600g/unit
	Entire chain	Lack of "Good Aquaculture Practices" Weak credit access and limited credit window Weak extension services
	Consumers	Low awareness of processed tilapia products
Acuna et al. 2020	Farmers	High incidence of natural predators (bullfrogs, snake turtles) Changing climate patterns Government restrictions of aquaculture production land use
	Consumers	Perception of tilapia as low-quality fish Competition in marketplace from other fish species Poor perception of tilapia due to use of chicken dung as feed source

Low quality and insufficient supply (and resultant high price) of aquafeeds were identified as major constraints at the production stage (Jamandre et al., 2011a; BFAR, 2022). The impacts of climate change have the potential to impact the tilapia value chain in myriad ways, but one of the most pressing concerns identified is the expected increase in water temperatures, particularly in inland ponds, which are used to raise the majority of tilapia in the Philippines (BFAR, 2022). A study of quarterly production data from the Philippines Statistics Authority (2022a) shows that tilapia production is much lower during summer months due to the effects of high water temperatures. Consumer perception of tilapia was identified as a major constraint to the value chain as consumers overwhelmingly perceive tilapia as a low-quality fish and subsequently have a low willingness-to-pay as observed in Luzon (a province where tilapia is ubiquitous) (Jamandre et al., 2011b) and also Mindanao (where tilapia is much scarcer) (Acuna et al., 2020). Recommendations to address the impacts of climate change and poor consumer perception are made in the following section.

Recommendations to Improve the Value Chain

Develop 'climate-smart' tilapia aquaculture

Many initiatives have been initiated to prepare land-based agriculture for the current and expected future impacts of climate change, often termed "climate-smart agriculture". In the realm of aquaculture, the depth of research and application of these type of initiatives is not as great, but the need and potential for improvement is perhaps greater than for land-based agriculture. In the Philippines, the greatest climate-based effect would be higher ambient air temperatures, resulting in higher water temperatures in ponds and lakes. Tilapia can survive very warm water, but their growth rates decrease sharply as they expend energy to keep their bodies cool. To adapt to warmer temperatures, two recommendations are made:

1. Develop genetic strains of tilapia that are able to maintain growth rates in warmer water: Tilapia that are especially adapted to warmer water conditions will allow current per unit area production levels to be maintained or increased, as a warming climate brings about increased water temperatures all year round, and may negate the need for other water-cooling interventions such as shaded ponds. In the shorter-term, a warm-water-optimised strain of tilapia may allow farmers to increase current production during summer months, resulting in a more consistent supply of tilapia across all seasons.

2. Develop genetic strains of tilapia that can tolerate salt water to allow sea-based mariculture of tilapia: Progress has already been made on salt-tolerant strains of tilapia with the development of the promising Molobicus strain that can withstand salinity up to 35 parts per thousand but does not yet exhibit the growth characteristics required to make it commercially successful (Guerrero, 2019). A strain of tilapia that can withstand salinity levels similar to the ocean would not only allow a vast expansion of tilapia production but would also substantially negate the effect of higher water temperatures experienced by pond-based tilapia farmers. Additionally, mariculture-raised tilapia may be perceived as "greener" by consumers and may avoid the common consumer complaint of "earthy" tastes from pond-raised tilapia noted by Acuna et al. (2020).

Development of superior genetic strains of tilapia has had past success in the Philippines but developing fish with superior growth rates for warm-water and saline conditions may involve trade-offs in other characteristics of the fish (taste, colour, texture) that negatively affect consumer uptake and ultimately reduce the overall value of the supply chain.

Consumer-targeted marketing campaign

As identified by Acuna et al. (2020), consumer perception of tilapia is as a cheap, low-quality fish. Middle-income householders perceive other species such as milkfish and scad as higher-quality fish and are willing to pay more for those species. Currently, there is effectively no marketing campaign for tilapia targeted at consumers, partly because of the high fragmentation of the value chain and a perceived likely negative cost-benefit ratio of such a campaign. This situation presents an opportunity to increase collaboration between chain actors as well as the largest group of actors in the chain – tilapia farmers. Efforts to better understand consumer preferences and what factors affect their willingness to pay for tilapia may provide guidance for implementation of an effective marketing campaign.

A potentially useful example of a tilapia marketing campaign exists in China, where a Hainanese tilapia growers' association was granted permission to re-label Hainan-grown tilapia from *luofeiyu* (tilapia) to *hainandiao* (Hainan bream) (Godfrey, 2021). The marketing campaign involved raising awareness of the locally produced fish through advertising on social media, presence at food and cooking fairs and cooking competitions involving Hainan bream (Figure 6). Such a campaign would require leadership from one or more Filipino tilapia industry groups or the government but could bring increased demand and increased prices for tilapia, benefitting the entire value chain.

Figure 6. Advertisement promoting a cooking competition using Hainan bream (tilapia) as the main ingredient. Bottom left is the logo developed to raise consumer awareness of Hainan bream

Source: 海南在线· (2022)

Conclusion

Tilapia has an important role to play in ensuring food security in the Philippines. The industry has experienced explosive growth in recent years and has the potential to increase production further to meet expected demand. The tilapia value chain is relatively simple and relatively short and broadly meets its competitive strategy of providing cheap protein for the masses. Financial analysis shows that most actors in the chain are profitable although margins for wholesalers are very thin. The value chain has many shortcomings and room for improvement and in the near future may be exposed to climate shocks and more difficult production conditions. The Chinese tilapia industry can provide some guidance for improvement although, due to structural differences and questionable sustainability practices, the Chinese metrics shouldn't necessarily be emulated. Researchers have identified many of the constraints involved in the tilapia value chain and this study presents two recommendations to improve performance of the value chain – improving genetic strains of tilapia to allow production to adapt to the impacts of climate change, and a marketing strategy similar to that used in Hainan to increase consumer demand and consumer willingness to pay for tilapia.

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Appendices

Appendix 1 – Financial Data (BFAR, 2022)

TABLE 6: FRESH TILAPIA SUPPLY VALUE CHAIN: COST STRUCTURE AND MARGIN, FOUR HECTARES FISHPOND CULTURE, TYPICAL SEMI-INTENSIVE, PAMPANGA, PHILIPPINES, 2020

CHAIN SEGMENT	AMOUNT (PHP/KG)
INPUT SUPPLY	
Feeds	30.16
Fingerlings	5.25
Fertilizer	2.28
Total cost of input	37.69
FARM PRODUCTION	
Cost of inputs	37.69
Labor, maintenance & others	9.62
Diesel	3.57
Land lease	2.91
Miscellaneous	1.00
Farmgate cost	54.79
Farmgate price	76.70
Margin (35-40% mark-up)	21.91
CHAIN SEGMENT	**AMOUNT (PHP/KG)**
LOGISTICS/DISTRIBUTION	
Handling	2.00
Ice	2.70
Transport and informal fees	6.00
Sub-total	10.70
TRADING	
Farmers' tilapia selling price	76.70
Distribution cost	10.70
Total wholesale cost	87.40
Wholesale price of fresh/chilled tilapia	92.00
Margin (5.3% mark-up) (*Consignacion/Bakulera*)	4.60
LOGISTICS/DISTRIBUTION	
Handling	1.35
Ice	2.70
Transport and informal fees	3.85
Sub-total	7.90
MARKET	
Wholesale price of tilapia	92.00
Distribution cost	7.90
Total retail cost	100.00
Retail price of fresh/chilled tilapia	107.10
Margin (7.6% mark-up)(retailer)	7.10

Appendix 2. Feed composition data

Figure 7. Typical ingredients in feed formula for Nile Tilapia intensive aquaculture

Ingredient composition (% fresh weight)	Fish size		
	Fry (0.1-1.0 g)	Fingerling (10-50 g)	Growout (>50 g)
Fishmeal	50.0	12.0	4.0
Soybean meal	17.0	46.0	34.0
Wheat middlings	4.0	30.0	30.0
Wheat meal	4.2	-	-
Corn	-	6.2	22.1
Corn gluten meal	12.0	-	-
Poultry by-product meal	2.0	-	6.0
Vegetable oil	-	3.6	0.5
Fish oil	1.0	-	-
Fish protein hydrolysate	4.0	-	-
Phosphate	-	1.4	2.6
Vitamin & mineral premix	0.5	0.5	0.5
Binder	-	-	0.01
Methionine	-	-	0.01
Proximate composition (% dry matter)			
Dry matter	91.0	90.0	88.3
Crude protein	49.5	35.0	28.5
Crude fat	13.0	12.4	11.9
Approximate cost (US$/tonne)	400	300	250

Data source: Miao and Liang (2007)

Source: Taken from Jiangnan Feed Co. Ltd., Jiangsu Province, China.