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PRELIMINARY INVESTIGATION ON THE IMPACT OF COVID-19 ON AQUACULTURE IN CHINA:
A CASE STUDY ON FARMED TILAPIA AND CHANNEL CATFISH SECTOR

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PRELIMINARY INVESTIGATION ON IMPACT OF COVID-19 ON AQUACULTURE IN CHINA: A CASE STUDY ON FARMED TILAPIA AND CHANNEL CATFISH SECTOR

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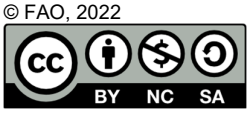


PREPARATION OF THIS DOCUMENT

This document is the final report on the preliminary investigation of the impact of the COVID-19 pandemic on aquaculture industry in China with a case study of channel catfish farming sector in Hubei Province and tilapia farming sector in Guangdong Province. The investigation was jointly implemented and funded by the Food and Agriculture Organization of the United Nations (FAO) and the Freshwater Fisheries Research Centre of the Chinese Academy of Fishery Sciences (FFRC). The FAO Fisheries and Aquaculture Division (NFI) provided technical support, while the FFRC research team was responsible for: conducting the field questionnaire survey; collecting of secondhand data and information; consulting relevant experts and institutions; analyzing data and information; and drafting the report. The Responsible Officers (ROs) adopted a flexible work method by: holding virtual meetings; supporting the desk study; assisting with the questionnaire design preparation; data analysis; and report preparation. The result of the investigation and survey was presented at the NFI-seminar in December 2020. Comments and recommendations on further improvements to be made were taken into account by the ROs and the FFRC team and were incorporated in both the draft and final report.

The investigation could not be completed without the strong support from NFI and FFRC. Great thanks are extended to Mr Xu Pao and Mr Matthias Halwart for allocating needed resources and overall guidance towards the study. Colleagues in the Fisheries and Aquaculture Resilience Team are acknowledged for sharing the “Best practices for developing surveys and questionnaires on the impacts of COVID-19 on fisheries and aquaculture”, which provided a good reference point for the design of the questionnaires. We would like to acknowledge Mr Matthias Halwart, Mr Lionel Dabbadie, Mr Rodrigo Roubach, Mr Lansley Jonathan and Ms Jennifer Gee for their comments and suggestions in refining the document. Special thanks are extended to Ms Teri Neer, Ms Lisa Falcone, Ms Nathalie Perisse and Ms Elisa Tarsi for their support in editing and formatting the document, and the publishing process.

ABSTRACT

In order to investigate the impact of COVID-19 on the entire aquaculture sectoral chain and understand what strategies and measures have been taken to mitigate the impact of the pandemic on the sector, FFRC, carried out a preliminary investigation in China with the support of FAO. The investigation focused on channel catfish (*Ictalurus punctatus*) farming in Hubei Province and tilapia farming (*Oreochromis* spp.) in Guangdong Province. It was expected that the investigation would provide information for FAO and its Members to better understand the impact of the pandemic on aquaculture thereby developing appropriate strategies to cope with the pandemic and similar risks in the future.

The investigation included questionnaire surveys and analysis of data from related sources, which emphasized the impact of COVID-19 on major links along the well-established sectoral chains. In addition, the study also tried to capture the government interventions and measures taken by different actors along the sectoral chain to minimize the disruption caused by epidemic containment measures and to support the recovery of the sector. In order to comprehensively assess the impact of the pandemic on the different links of the value chain, five questionnaires were developed for the survey: 1) grow-out farmers; 2) seed producers; 3) fish processers; 4) fish traders; and 5) feed companies along the supply chain. The questionnaires attempted to assess: the immediate impact of the pandemic during the period in which there was a strict enforcement of pandemic containment measures (January-March 2020); the lasting effect and recovery after the strict pandemic containment measures were lifted (April-July 2020); and the projection of impact on sectoral performance for all of 2020. The survey was carried out by the field staff from local aquaculture service agencies during July-August 2020 with technical support of the FFRC team.

A total of 46 questionnaires were completed and some important findings are summarized as follows:

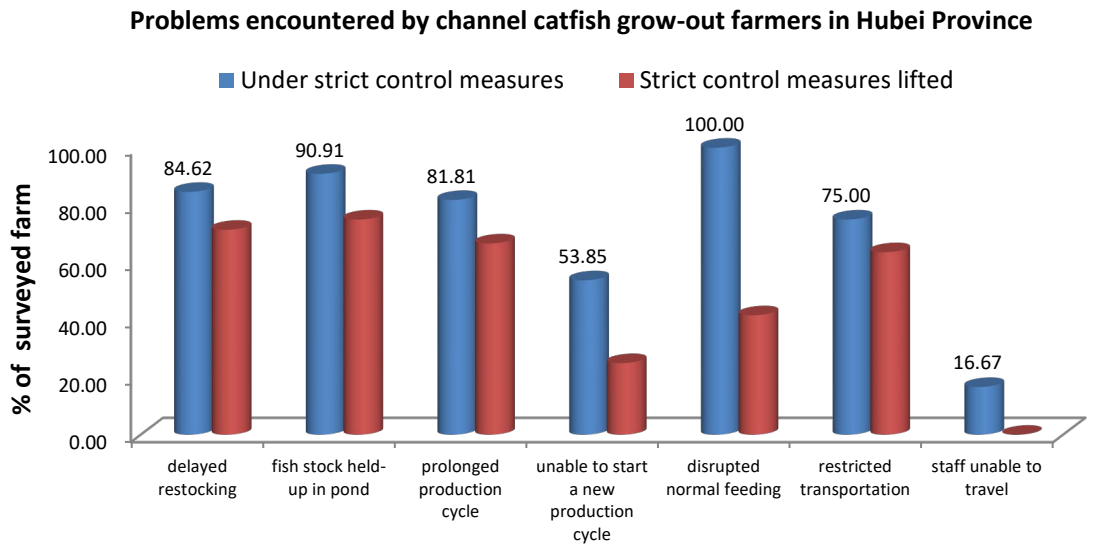
- the farmed catfish sector in Hubei Province has been more severely impacted by the pandemic than the farmed tilapia sector in Guangdong province;
- catfish farmers and fish traders are most severely impacted by the pandemic among all the surveyed stakeholders - feed companies and fish processers felt the impact less; and
- international trade of the two farmed commodities was more seriously impacted than domestic sales.

The investigation uncovered significant specific impacts of the pandemic on production and operations at different value chain links of farmed channel catfish and tilapia sectors in the two provinces. These include:

- holding of harvestable fish stock in ponds due to marketing difficulty, which caused fish weight losses and hindered the farming cycle;
- poor fish growth resulted from management interruptions (e.g. irregular feeding) caused by the implementation of certain epidemic containment measures;
- supply cut-off to fish traders and significantly reduced international orders and sales; and
- financial difficulties due to increased operational costs and reduced or delayed revenue.

The investigation also assessed the impact on the livelihood of households engaged in the value chain, which showed that family income was significantly reduced due to reduced payments and less business revenue (e.g. income of all the catfish seed producers reduced by more than 50 percent) and some families encountered financial hardships (30-40 percent of surveyed farmers). Special attention was paid to the additional impact on women associated with the sector. One of the main issues was the increased burden in caring for and educating children due to school closures and the extra pressure to maintain basic living conditions of the family.

The investigation showed that the sectoral actors adopted practical measures to mitigate the impact caused by the pandemic. Prolonging the production cycle, reduction of input use, such as feed, and marketing products through E-commerce were among the most commonly adopted measures.



The government had adopted an appropriate strategy and intervention to sustain the basic living of its people and supported the continuation of farm operations during the lockdown period. This included the provision of green passage for transportation of food commodities and key production inputs, financial incentives for processing and trade companies in order to purchase fish products, and financial assistance to households with difficulty in managing basic living.

Based on the forecast of the respondents, the yield of farmed catfish and tilapia would decrease by about 20 percent, the production costs would increase by more than 10 percent and the profit would be 20-25 percent lower in 2020. The sale of farmed channel catfish and tilapia in 2020 would be 20-30 percent lower than the previous year. However, the prediction of the sectoral performance in 2020 made by the experts leading the national programme on industrial chain for tilapia and channel fish, is more optimistic because they anticipate a significant increase in culture areas in the second half of the year to compensate the reduced production during the pandemic period.

An important output of the study is the recommended strategies and measures to support the aquaculture sector and value chain stakeholders in coping with the pandemic and other similar risks in the future. The recommendations included; strengthening the disaster early-warning system and local capability of risk mitigation; supporting development of modern trade/marketing methods for aquaculture products and needed infrastructure; and promoting innovation and transformative changes in aquaculture technology and production systems for better resilience and preparedness for disasters. The specific innovations include: changes to the cropping system to avoid production seasonality; concentrated harvesting and marketing; better organization of farmers to support collective efforts in coping with hazards; e-commerce technology and infrastructure; and remote manipulation of culture environment and management. Regarding improvements of social security and protection systems for the aquaculture sector, specific recommendations include; the full inclusion of farmers into the local social security systems; scaling up of the pilot aquaculture insurance scheme; and dedicated mechanisms and systems for disaster assistance.

Keywords: Grow-out farming, Seed production, Processing and Trade, China, Mitigation strategy and measures

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ABBREVIATIONS AND ACRONYMS

Aoni	Crossbreed of blue tilapia and Nile tilapia
AR	autonomous regions
BoF	Bureau of Fisheries, Ministry of Agriculture and Rural Affairs of China
CNY	Chinese Yuan
COVID-19	Coronavirus disease
FAO	Food and Agriculture Organization of the United Nations
FFRC	Freshwater Fisheries Research Centre of Chinese Academy of Fishery Sciences
GAP	good aquaculture practices
GIFT	Genetic Improved Farmed Tilapia
MDCG	municipalities directly under the central government
NFI	Fisheries and Aquaculture Division of FAO
NFISR	Fisheries and Aquaculture Resilience Team

1. INTRODUCTION

1.1 Background

The COVID-19 pandemic, known as the novel coronavirus (SARS-CoV-2), was first identified in December 2019 in Wuhan, China. The World Health Organization declared the outbreak of a Public Health Emergency of International Concern in January 2020 and a pandemic in March 2020.[1]

On 23 January 2020, the Wuhan Municipal Government made the decision to close all outbound paths connecting the city with other cities and provinces outside its borders,[2] to temporarily shut down different types of commercial activities and public services and enforce strict lock-down measures in the entire city of Wuhan. On 24 January, the top-class response mechanism for a major public health emergency was initiated in many provinces and cities across China[3]. The responsibility of the local governments was to manage the crisis through enforcement of relevant containment measures, including strict lockdown, banned travel, cancelation of all types of mass gathering events and activities, and shut-down of large business activities, in order to contain the spread of the epidemic with the utmost effort.

With the strictest enforcement of science-based measures by the Chinese government, the COVID-19 epidemic was well controlled by late March in China, indicated by zero cases of new infection in most provinces. On 25 March 2020, the out-bound travel control from Hubei Province was lifted except for Wuhan city, and most provinces and municipalities down-graded the level of response to the major public health emergency.[4] On 8 April 2020, the control over the outbound travel from Wuhan city was lifted, all transportation returned to normal and the social and economic activities gradually returned to normal in China.[5]

China is the largest aquaculture producer in the world, and for decades, has contributed to over 50 percent of world aquaculture production. The fast development of the aquaculture industry has contributed significantly to national food security, high quality aquatic food supply, increasing income of rural farmers and job opportunity development in China (Yang, 2012). China is the largest player in the global trade of aquatic products and has been the biggest exporter of aquatic products since 2002. It is the third largest importer of aquatic products since 2011 (FAO, 2020a). Its total volume of exported and imported aquatic products reached over 10 million tonnes in 2019.[6]

Aquaculture has become a well-developed food production sector with strong market orientation in China. China's aquaculture sector has a highly specified production chain, job specialization and a strong link between the upstream and downstream of the sector. The sectoral operation relies highly on the functioning of all links along the industrial chain. The COVID-19 pandemic and the containing measures had a significant impact on the food production systems (including aquaculture) and the logistic systems. Chinese government adopted various measures to mitigate the immediate and short-term impact on the aquaculture sector while taking firm measures to contain the epidemic and achieve good results. The long-term impact of COVID-19 on the aquaculture sector will continue for a fairly long period, particularly with the global pandemic, which has yet to be well controlled.

In order to comprehensively understand the direct impact of COVID-19 on major stakeholders in China's aquaculture industrial chain, the FFRC carried out an investigation on the impact of COVID-19 on the Chinese aquaculture industry with selected cases, namely the tilapia sector in

[1] https://www.who.int/zh/news/item/29-06-2020-covidtimeline
[2] Announcement of Wuhan Headquarters for Prevention and Control of Pneumonia Outbreak of Novel Coronavirus Infection (No. 1) [EB/OL]. 2020-01-23, http://www.wuhan.gov.cn/sy/whyw/202003/t20200316_960171.shtml
[3] Shanghai, Tianjin, Chongqing and Anhui launched first-level response mechanisms for major public health emergencies [EB/OL]. 2020-01-24, http://www.gov.cn/xinwen/2020-01/24/content_5472050.htm
[4] Notice of Hubei Province New Coronavirus Infection Pneumonia Epidemic Prevention and Control Headquarters [EB/OL]. 2020-03-24, http://www.hubei.gov.cn/zhuanti/2020/gzxxgzbd/zxtb/202003/t20200324_2189256.shtml
[5] Notice of Hubei Province New Coronavirus Infection Pneumonia Epidemic Prevention and Control Headquarters [EB/OL]. 2020-04-07, http://www.hubei.gov.cn/zhuanti/2020/gzxxgzbd/zxtb/202004/t20200407_2207131.shtml
[6] According to the data reported by China Customs, 2020.

Guangdong Province and the channel catfish sector in Hubei Province. The investigation was jointly funded by FAO and the FFRC and implemented by the research group of the FFRC from July to November 2020 with technical support provided by FAO. Tilapia and channel catfish are both important aquaculture commodities for both domestic consumption and international markets. Specifically, about half of the farmed tilapia production in China is processed for export and about 30 percent of farmed channel catfish production is processed and destined for foreign markets (Dai, 2019). Guangdong Province and Hubei Province are among the most important aquaculture areas in China, and were ranked the first and the fourth in terms of aquaculture production in China in 2019 (BoF, 2020).[7] Guangdong Province is the largest producer and exporter of farmed tilapia in China with a total farmed tilapia production of 740 000 tonnes in 2019 (BoF, 2020). Hubei Province is the largest freshwater aquaculture province and one of the most important farming areas for channel catfish in China, which is also the major breeding center for channel catfish seed supply in the enitre country. The total production of farmed channel catfish in Hubei Province reached 40 000 tonnes in 2019 (BoF, 2020). Hubei Province was the first place that reported a COVID-19 outbreak in China and Guangdong Province was among the provinces most severely hit by the epidemic. Both farmed commodities rely heavily on external markets and the normal function of a well-established industrial chain. The COVID-19 pandemic and the enforced lock-down measures are expected to have a significant impact on the tilapia and channel catfish subsectors.

In order to fully understand the impacts of COVID-19 on farmed tilapia and channel fish sectors, the investigation covered all the major stakeholders along the industrial chain, including the grow-out farmers, seed producers, product processers, fish traders and feed manufacturers. The study provided good snapshots of the impact COVID-19 had on the overall aquaculture industry in China with a particular focus on the two important farmed species in China. This investigation also collected information on strategy and policy measures taken by the government at different levels and the actions by the sectoral players to mitigate the impact of COVID-19 on the sector to speed up the recovery of the sector when the epidemic is well controlled and lock-down measures lifted across the country. The study also attempted to make a forecast on the production, market demand, export and market price of farmed tilapia and channel catfish for 2020 considering the epidemic and post-epidemic effect based on the survey findings, expert predictions, and literature references.

1.2 Objective

The overall objective of the joint FAO-FFRC study is to conduct a preliminary assessment of immediate and long-term impacts of COVID-19 on farmed tilapia and channel catfish aquaculture industrial chains in China, evaluate the strategy and measures taken by the governments and sectoral actors to mitigate the impact of the pandemic and enable the speedy post-pandemic recovery of the sector, identify further needed assistance by the different actors along the sectoral chain in recovering from the disruption and restore their normal production operations and daily life. It is expected that the result of the study can provide a good reference to FAO in developing fact-based strategy and programmes to assist its Members to effectively address the impact of COVID-19 on the global aquaculture industry. It is hoped that the findings of the investigation can assist FAO Members and development partners in formulating strategy and programme to encourage adaptation and increase the resilience of aquaculture sector to challenges like COVID-19, through transformative changes and innovation in farming systems, management practices and industrial chain structures and operations of aquaculture sector.

1.3 Methodology

1.3.1 Questionnaire survey and participatory interview

A set of survey questionnaires were designed for the study and each questionnaire targeted individual links of the farmed tilapia and channel catfish chains, i.e. grow-out producer, seed producer, processer, marketing/trader, and feed manufacturer. The design of the survey questionnaires also referred to the "Best practices for developing surveys and questionnaires on the impacts of COVID-19 on fisheries and aquaculture" prepared by the COVID-19 Task Force of the Fisheries and Aquaculture Division of

[7] According to the data reported by China Fishery Statistical Yearbook, 2020.

FAO (FAO, 2020b). While focusing on the impact of COVID-19 pandemic on operations and performance at different links along the sectoral chain, the questionnaires also covered the impact of COVID-19 epidemic on household livelihoods, daily life and more specifically, impact on women engaged in the entire industrial chain. Based on the structure of the tilapia sector in Guangdong Province and the channel catfish sector in Hubei Province, survey samples for grow-out production, seed production, processing, marketing/trade, and feed manufacture units were identified by survey coordinators in the two provinces following the general requirement determined by the FFRC-FAO working group. The questionnaire survey was carried out by the provincial survey teams in each province through face-to-face and telephone interview.

The questionnaire targeting each stakeholder group in the industrial chain covered the following aspects:

- profile of stakeholder: name, location, production scale/capacity, products species and types, production systems, staffing, etc.;
- direct impact on business operations and management of the surveyed farm/company during the epidemic (by the end of April 2020);
- impact on livelihoods and daily life of households and women engaged in or associated with the industrial chains;
- forecasted lasting impact after the lift of strict measures to contain the epidemic and prediction of operational performance in 2020 by the interviewed respondents;
- impact on external services to stakeholders of the industrial chains;
- actions taken by the government to support the sector to mitigate the impact of the epidemic and speedy recovery of the industry after the epidemic is well controlled and measures taken by the stakeholders to mitigate the impact of the pandemic; and
- anticipated further support from the government to assist the aquaculture sector in recovering during the post-pandemic stage and build preparedness and resilience strategies when facing challenges like pandemics and other hazards.

1.3.2 Literature review

In order to provide a general picture of the sector development background, the development history and status of farmed tilapia and channel catfish sector in China, the overall evolution of the COVID-19 pandemic and its nation-wide impact on the aquaculture industry in China, the research team reviewed extensive available literature, reports and statistic data released by the Government of China and FAO.

1.3.3 Expert consultation

In order to validate the results of questionnaire, literature review and to provide a sectoral level assessment, the FFRC team had consultations with the leading sectoral experts with extensive knowledge and experience in the subsectors to obtain their insight about the impact of the pandemic on the overall sector and the projection on the performance of the sector in 2020.

1.3.4 Case study on mitigation measures

Based on the survey results, the case study summarized the specific mitigation measures in relation to the pandemic on the industrial chain of channel catfish in Hubei Province and tilapia in Guangdong Province. It described the actual impact of the strict containment measures on the channel catfish and tilapia industries in Hubei province and Guangdong Province, the long-term impact on the channel catfish and tilapia industries in China, as well as the recovery after the lift of strict containment measures.

2. TILAPIA AND CHANNEL CATFISH FARMING SECTOR IN CHINA

This chapter provides an overview on farmed tilapia and channel catfish sectors in China, covering aquaculture development history, trends and distribution of production, and industrial chain development in China, as well as related policies issued and support provided by the Chinese government for the development of tilapia and channel catfish industry.

2.1 Farmed tilapia sector in China

Tilapia has many advantages for aquaculture production: fast growth, omnivorous feeding habit, strong disease resistance, good adaptation to high stocking density and variable water quality, and no intermuscular bones etc. In recent years, the domestic consumption of tilapia in China has been expanding and international demand increasingly flourishing. Tilapia has become the sixth largest freshwater aquaculture commodity in China, and China's tilapia aquaculture production has ranked the first in the world in recent years (National tilapia research system, 2016).[8] The tilapia industry in China can be divided into primary production (i.e. grow-out and seed production), secondary industries (i.e., processing and supply of aquafeed and fishery medicine) and tertiary industries (i.e., marketing, international trade, and associated services). The farmed tilapia sector has become a pillar of China's fisheries economy.

2.1.1 Development history

The Mozambique Tilapia (*Oreochromis mossambicus*) was first introduced to China from Vietnam in 1956, and later Nile tilapia *(Oreochromis niloticus)* was also introduced to China from Thailand. For better growth and color appearance, Fushou red hybrid tilapia was developed by using Nile tilapia as the male parent and Mozambique tilapia as the female parent. In 1983, Blue Tilapia *(Oreochromis aureus)* was first introduced from the United States, and later used as a female parent to crossbreed with male Nile tilapia for producing all-male hybrid named Aoni (Xia, 1999). With the fast expansion of the culture area since the 1990s, tilapia has become an important aquaculture species in China and a complete industrial chain has been established for farmed tilapia.

At present, China’s main farmed tilapia include GIFT tilapia (WorldFish strain improved in local condition), red tilapia and Aoni tilapia (blue tilapia and Nile tilapia hybrid). At present, GIFT and Aoni tilapia account for about 60 percent and 30 percent respectively of the total tilapia production in China. The other 10 percent of the production comes from red tilapia and other farmed types of tilapia (National tilapia research system, 2016). After several decades of development of tilapia farming, various tilapia farming systems have been adopted in China, which include pond, reservoir, tank, paddy-field and indoor culture system. Earthen pond monoculture is the main tilapia culture system, and can produce yields as high as 30 tonnes/ha. The average production cost is about USD 1.2/kg, generating a profit of about USD 6 500/ha (Yuan *et al*., 2016a). It was estimated that the entire tilapia industry provides 238 000 direct employments and 150 000 part-time and temporary jobs in China. There are about 149 000 workers in the seed and grow-out production sector, 34 000 workers in processing industry, approximately 18 000 workers in feed manufacturing, and about 37 000 workers in logistics and marketing (Yuan *et al*., 2016b).

[8] Data source: the book series: Research on the Sustainable Development Strategy of China's Modern Agricultural Industry-Tilapia.

2.1.2 Production and distribution

Tilapia was first included in the national fisheries statistics as an individual aquaculture commodity in 1989. From 1989 to 2015, China's tilapia production grew rapidly with an average annual growth rate of 12.2 percent. The growth of tilapia production slowed down during 2016-2019, with an average annual growth rate of 1.7 percent. The drastic drop of production in 2017 was the result of an official adjustment to aquaculture production in the national fisheries statistics in 2017. In 2019, the total production of tilapia in China reached 1.64 million tonnes (Figure 2-1), accounting for 6.0 percent of the total cultured production of freshwater fish in China (BoF, 2020).

In 2019, the total culture area of tilapia in China was approximately 73 300 hectares,[9] accounting for about 2.86 percent of the total freshwater aquaculture area in China. China's tilapia farming is widely distributed over 31 provinces/autonomous regions (AR)/municipalities directly under the Central government (MDCG). Ningxia and Qinghai Provinces are the only two administrative areas where there is no tilapia farming. The top five provinces/ARs of tilapia production are all in southern China, namely Guangdong, Guangxi, Hainan, Fujian, and Yunnan, which contribute about 95 percent of the national production. Among them, the tilapia production from Guangdong Province was 744 000 tonnes in 2019, which accounted for 45.31 percent of the total national tilapia production. Guangdong Province is also the region where tilapia farming first started in China and featured the largest farming area, the highest yield, and the largest export volume in China (Liu, 2017). This was the rationale to choose Guangdong Province for the case study of the impact on the tilapia industry during the pandemic.

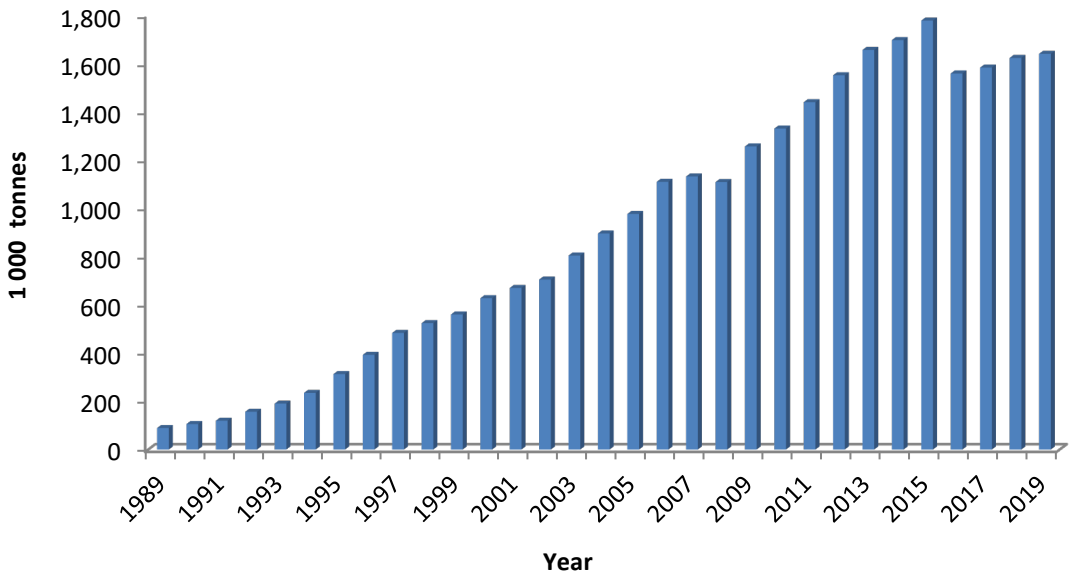

Figure 2-1 Tilapia production in China from 1989 to 2019
Data sources: China Fishery Statistical Yearbook (1990-2020)

2.1.3 Industrial structure

2.1.3.1 Seed production

Tilapia seed production is fundamental for tilapia industry development. In China, tilapia seed production is a three-level operation system: the state tilapia germplasm banks, provincial tilapia breeding centers, and commercial tilapia hatcheries. There are many research institutes devoted to genetic improvement and breeding programmes. Presently, there are seven state tilapia germplasm

[9] According to the data reported by the Demonstration station of the major cultured non-carp freshwater finfish species Industrial Research Center of China's agriculture research system.

banks in China. These well-established tilapia breeding centers and commercial hatcheries ensure China's tilapia seed quality management system and the capacity of high-quality tilapia seed production. Benefited from the innovation and adoption of new technology, the indoor tilapia hatcheries became the dominant system for tilapia seed production in China in order to satisfy the demand for high-quality tilapia seed with a high male rate, sound survival and growth performance. Some tilapia hatcheries and nurseries use indoor systems, traditional earthen ponds, cement tanks, and cages for seed production. After the first feeding, tilapia fry are usually reared for 15-30 days as an intermediate nursery period before being sold to distributors or farmers with a minimum body length of 1 cm. In 2019, the total production of tilapia seed in China was about 21.5 billion (BoF, 2020). The reliable supply of standardized tilapia seed has greatly contributed to the steady growth of tilapia production and the improved product quality for domestic and international markets.

2.1.3.2 Grow-out farming

Through several decades of development, tilapia grow-out culture has been gradually evolving from extensive and polyculture to intensive monoculture in China, such as intensive earthen pond culture, cage culture, and raceway culture. Currently, the proportion of the culture area between tilapia monoculture and polyculture is about 4:6 (Research department for economics of major cultured non-carp freshwater finfish species, 2017). Based on the market demand and climate character, different production cycles have been adopted for grow-out culture of tilapia. These include a one-crop per year, a two-crop per year scheme as well as a three-crop per two-year scheme. In recent years, there have been new emerging aquaculture models for tilapia, such as recirculating aquaculture systems, raceway culture models, and culture with cooling water from power plants. The main tilapia producers are small-scale family farms, small and medium-sized companies, and large-scale leading corporations. Tilapia farming is largely concentrated in the Southern part of China, taking advantage of favorable natural and climate conditions as well as skilled workers and a cluster of aquaculture businesses. Along with the development, tilapia farming has been expanding to northern parts of China, such as Shandong, Hebei, Beijing and other northern regions.

2.1.3.3 Processing

Before the 1990's, tilapia was mainly sold in the form of fresh and live products in China. China's tilapia processing industry grew rapidly in the late 1990s, and its tilapia production has kept growing due to the increased demand from the international market. According to the statistics, about half of the tilapia production has been processed in recent years (Zhao *et al*., 2017). There are about 200 plants that process tilapia in China, with annual processing capacity above 2 million tonnes. In 2017, the actual production of tilapia processed was about 600 000 tonnes (China Aquatic Products Circulation and Processing Association, 2017). The major tilapia processing plants and the majority processing capacity are located in Guangdong Province, accounting for 58.5 percent of the total tilapia processing capacity in China. The product types of processed tilapia in China include fillets (frozen, breaded and smoked), frozen whole tilapia, canned tilapia and marinated products. The main export product form is frozen tilapia fillets, which has a longer storage period and convenience in cooking. Frozen fillets are the most welcomed processed tilapia product in both international and domestic markets (Zeng, 2005). In recent years, the demand for prepared and preserved tilapia products has increased steadily. The main targeted international market of processed tilapia products is North America, followed by Mexico, Côte d'Ivoire, and Russia. Limited processed tilapia products are sold in the domestic market, which include frozen tilapia fillets and frozen whole tilapia. There is an emerging demand of prepared fish fillet products, which is favored by white-collars, school students and the elderly. Nevertheless, the processed products still have limited market shares, such as canned tilapia. (China Aquatic Products Circulation and Processing Association, 2017).

2.1.3.4 Export

China's tilapia export grew quickly from 2002 to 2006 with an average annual growth rate of 51 percent. The annual average growth declined to 11 percent during 2007-2012. The lowest growth in tilapia export was 4.2 percent in 2008, which was due to the heavy loss of cultured tilapia production resulting from a nation-wide extremely cold winter and snowstorms (Yuan *et al*., 2014). In recent years, the growth of China's tilapia export volume has been further slowed due to the international financial crisis. China's tilapia export reached the highest volume of 445 900 tonnes in 2018. The export volume of tilapia dropped slightly to 436 100 tonnes in 2019 (Figure 2-2). As shown in Table 2-1, the main export products are prepared and preserved tilapia (mainly breaded, smoked and marinated). The top three export destination countries are the United States, Mexico, and Côte d'Ivoire.

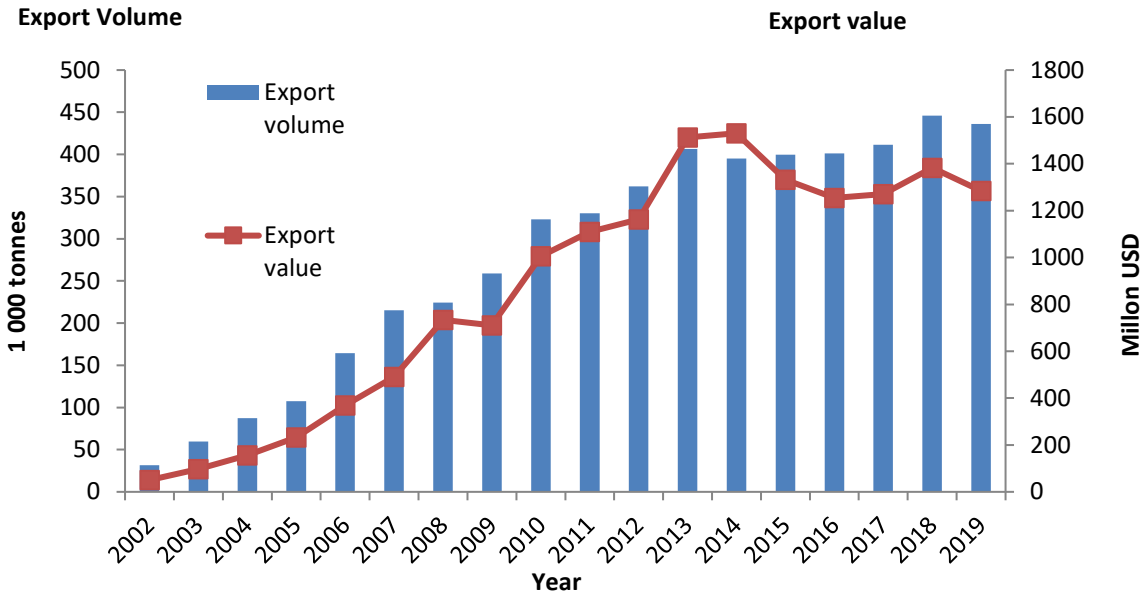

Figure 2-2 China's tilapia export volume and export value from 2002 to 2019
Data sources: Statistical Yearbook of China's Aquatic Products Import and Export 2002-2019

Table 2-1 Tilapia export volume in 2019 (unit: 1 000 tonnes)

Province	Tilapia, frozen	Tilapia fillets, frozen	Tilapia, live	Tilapia Prepared or preserved, not minced	Export quantity
Guangdong	36	9.2	1	208.9	255.1
Hainan	33.5	61.8	0.02	29.7	125
Guangxi	2.8	4.3	0	7.6	14.7
Fujian	36.9	0.07	0	2.4	39.3
Yunnan	1.6	0	0	0	1.6
Liaoning	0	0	0	0.02	0.021
TOTAL	110.8	75.3	1.02	248.6	435.8

Data sources: China Customs

China's tilapia export value and export volume during 2010-2019 followed a similar trend with greater fluctuation in the export value (Figure 2-2). There was a significant decline in the export value in 2009. After reaching the peak export value in 2014, the export value declined sharply by 12.9 percent in 2015 and the decline continued in 2016. In 2017, there was a slight rebound of the export value, which was followed by a significant increase in 2018 with the export value of 1.382 billion US dollars. The average price of exported Chinese tilapia products was USD 2.81/kg during 2002-2019. After reaching the highest price of USD 3.87/kg in 2014, the export price of tilapia from China declined gradually and dropped to USD 2.94/kg in 2019. The prices of major exported tilapia products continued a downward trend during 2015-2019 except for the export price of frozen tilapia which increased in 2018.

2.1.3.5 Domestic market and consumption

According to statistics, about 800 000 tonnes of fresh and live tilapia products are sold in the domestic market each year (Yuan et.al, 2017). The major areas of tilapia consumption are the five southern provinces/ARs (Guangdong Province, Guangxi Zhuang Autonomous Region, Hainan Province, Yunnan Province and Fujian Province). Tilapia is also consumed in northern and western provinces, such as Hebei, Shandong, Beijing, Tianjin, Xinjiang, Sichuan, and northeast China. Due to culinary tradition, fresh and live tilapia are most preferred in the domestic market. The preferred size of tilapia in domestic markets varies from place to place. For instance, tilapia larger than 600g is preferred in the southern markets while consumers prefer bigger tilapia, around 1 000g, in the northern markets. Fresh and live tilapia are popular in the wholesale markets, fresh food markets, supermarkets, chain stores, hotels, and restaurants etc. Frozen tilapia (with scales and gut removed) is mainly sold in the northern markets and often used for barbecue. Frozen tilapia fillets are convenient to deliver and sell in frozen wholesale markets, supermarkets, online e-commerce platforms and the sales volume is gradually increasing. Canned tilapia products can be found in supermarkets and e-commerce channels, and fish collagen protein are mostly sold through specified agents.

China's domestic tilapia consumption has followed a "rising-falling-rising" pattern. The domestic consumption of tilapia increased from 653 900 tonnes in 2002 to the high record of 745 400 tonnes in 2005 (Research department for Economics of major cultured non-carp freshwater finfish species, 2017). Then, it gradually declined to 536 600 tonnes in 2010, at an average annual decrease of 6.36 percent. From 2010 to 2019, tilapia consumption increased significantly and reached 718 800 tonnes.

The sales price of tilapia in the domestic markets of China varies according to the location. In general, tilapia market prices in Beijing, Tianjin, Hebei, and Yunnan are relatively higher than other provinces. Figure 2-3 showed that the domestic wholesale price of tilapia was relatively stable from 2017 to 2019. In 2019, the average tilapia farmgate price and wholesale price were CNY 11.76/kg and CNY 13.60/kg respectively.

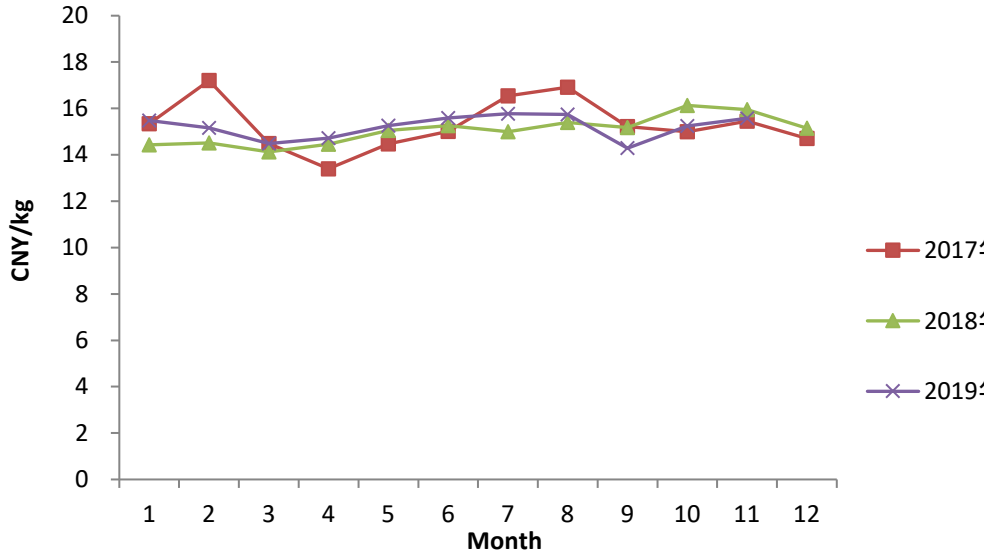

Figure 2-3 Farmgate price of live tilapia from 2017 to 2019
Data sources: Industrial economic Database of major cultured non-carp freshwater finfish species Industrial Research Center

2.1.3.6 Feed and manufacture

Tilapia is a typical omnivorous fish. It was introduced as a non-fed species in polyculture ponds in the early years of tilapia farming in China. With the adoption of intensive tilapia farming technology, tilapia culture now depends heavily on commercial pellet feed in China. It is reported that more than 85 percent of the tilapia production areas are using formulated pellet feed (National tilapia research system, 2016). The increased demand for commercial feed in tilapia farming has greatly stimulated the development of the tilapia feed industry. The annual tilapia feed production has been stabilized at about 1.5 million tonnes (National tilapia research system, 2016). Currently, the tilapia feed factories are located in four main production provinces/ARs, including Guangdong, Hainan, Guangxi and Fujian. Guangdong ranks as first, followed by Hainan, Guangxi, and Fujian. There are two major types of tilapia feed, floating pellet and sinking pellet. The production volume share of floating pellets and sinking pellets is 3:7.

2.1.4 Sectoral development policy and strategy

China's tilapia industry development has been supported and benefited from the long-term conducive policy from government at all levels. The government has provided guidance, support, protection, coordination, and services to promote tilapia industrial development. China's tilapia industrial policy could be summarized into three phases.

Before 2003: The industrial policy was to reasonably expand the aquaculture area and to increase the harvest size of tilapia. China carried out the planning of the tilapia industry, established demonstration areas, large-scale leading tilapia farms and hatcheries. In 2000, the project on high-quality tilapia production systems and demonstrations received funding support from the central government, which was a component of the Agricultural Science and Technology Leapfrog Programme (Li, 2000). In 2003, tilapia was identified as one of the seven advantaged aquatic products for export by the Ministry of Agriculture. In the meantime, Guangdong provincial government proposed a strategic plan to expand and strengthen the tilapia industry development; Guangxi AR government encouraged converting low-lying land into tilapia pond; and Hainan provincial government supported the establishment of tilapia farms as export-oriented demonstration area.

2004-2010: The industrial policy focused on operational improvement of the tilapia industry chain in China. Along with the rapid development of the tilapia industry, more and more companies and scientific research institutes made joint efforts to improve sectoral performance, such as improved

breeding technology by using modern biotechnology in traditional genetic breeding practices. The continuous progress on genetic improvement in terms of growth performance has greatly improved tilapia production efficiency. In 2005, the “Eleventh Five-Year Plan for the Tilapia Industry development in Maoming city” set an annual supply target of 800 million quality tilapia seeds.[10] In 2006, Hainan Province issued the “Tilapia Industrialization Action Plan”, which illustrated China's tilapia industry entered a rapid growth stage. In 2008, tilapia industrial technology system was included as one of the five national aquaculture industrial technology systems in the second batch of modern agricultural industrial technology systems jointly supported by the Ministry of Agriculture and the Ministry of Finance of China. In 2011, tilapia was listed as a pilar commodity of the fishery economy in the "Twelfth Five-Year Plan for Modern Fishery Development in Guangdong Province". The government of Guangxi AR supported the establishment of a tilapia breeding center in Hainan for the purpose of an all year around supply of quality tilapia seeds to Guangxi AR in 2012.

2011 to present: The industrial policy has been set to improve the quality of tilapia products. Through the development of standardized green and healthy aquaculture, the stocking density was reduced for producing fish of large harvest size, as well as increased profit with higher product quality and price. The major tilapia producers, such as Guangdong Province, Guangxi Zhuang Autonomous Region, Fujian Province, Yunnan Province, and Hainan Province, have included the development of the tilapia industry in the provincial "Twelfth Five-Year" and "Thirteenth Five-Year" development plans, with increased financial support to improve infrastructure. The monitoring system for the quality and safety of farmed tilapia has been strengthened significantly. There has been increased funding in research and technology development for green and healthy ecological aquaculture and establishment of modern agricultural industrial parks. Guangxi's Finance Department had allocated a special fund of 10 million US dollars to implement a standardization of tilapia ponds, and Yunnan Province provided a subsidy of USD 138/ha[11] to farmers for standardization of infrastructure of tilapia farms. All these have contributed to the healthy development of the tilapia industry in China.

2.2 Farmed channel catfish sector in China

Introduction of channel catfish (*Ictalurus punctatus*) and promotion of its farming in China was largely because of its characteristics of fast growth, large harvest size, high meat quality and good potential for export. It has become a popular species of freshwater aquaculture in China (Zhong *et al*., 2017). China is the largest producer of farmed channel catfish in the world, contributing above 60 percent of the global production (FAO, 2020). A complete and developed industrial chain, covering seed supply, grow-out production, processing and export, has been established in China.

2.2.1 Development history

Channel catfish was first introduced to China in 1984. In 1989, the induced breeding of channel catfish succeeded after years of study and the fish adapted well to the local conditions (Xia, 2010). In 2003, the fast expansion of channel catfish culture sector in China was stimulated by the increased demand from the international market (mainly USA and European markets) but exports have shrunk since 2012 and the domestic market expanded in the meantime.

Earthen pond is the most popular farming system for channel catfish farming in China and the fish is also cultured in cages, raceways, circulating tanks and reservoirs. The normal yield of channel catfish monoculture in pond is about 15 tonnes/ha with an average production cost of about USD 21 428/ha, for a profit of about USD 10 714/ha (Research department for Economics of major cultured non-carp freshwater finfish species, 2020). According to statistics, channel catfish industry employs about 115 000 technical professionals and workers along the channel catfish industrial chain in China. It is reported that about 6 000 people are engaged in catfish breeding and grow-out production, about 9 000 people are engaged in associated second industry such as feed manufacturing, fish medicine and

[10] According to the report from Research department for Economics of major cultured non-carp freshwater finfish species
[11] According to the data reported from Standardized Farming Regulations for Tilapia.

machinery, harvesting, processing and transportation. Catfish related tertiary industry, such as retailing and catering services, employs about 100 000[12] people.

2.2.2 Production and distribution

The channel catfish farming in China was in the initiation stage with relatively small production volume during 1984-2002. In 2003, the channel catfish was first listed as an individual aquaculture commodity in the China Fisheries Statistical Yearbook for its significant aquaculture production. From 2003 to 2008, China's channel catfish production showed a rapid growth, with an average annual growth rate of 37.6 percent. But during 2008 to 2011, the production declined because of a sharp reduction in the export demand. The export to the United States was affected due to the drug residue issue. Since 2012, China's channel catfish production started to recover and grow again with the stimulation of the growing demand in the domestic market.

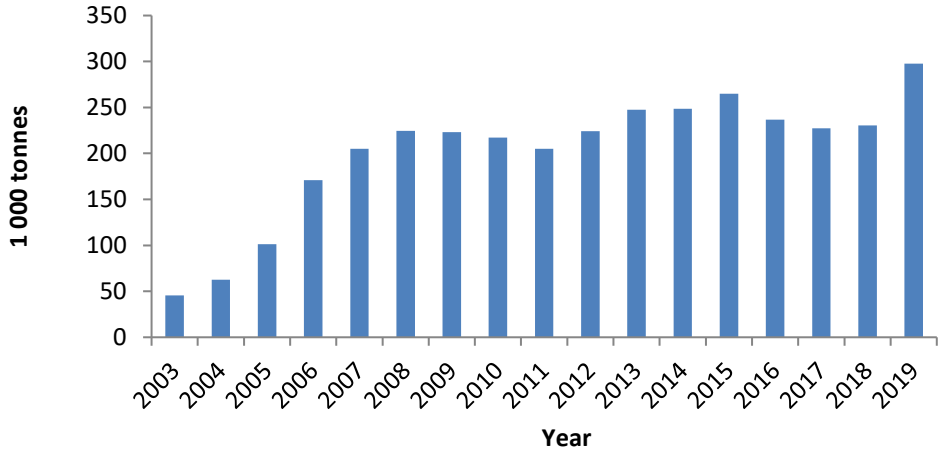

Figure 2-4 Channel catfish production in China from 2003 to 2019
Data sources: China Fishery Statistical Yearbook (2004-2020)

In 2017, farmed channel catfish production slightly declined to 227 500 tonnes because of banned cage culture in reservoirs in adopting stricter environment protection regulations.[13] Recently, the channel catfish production rebounded with the increasing area of channel catfish culture in earthen ponds. In 2019, China's farmed channel catfish production reached 297 700 tonnes (Figure 2-4), accounting for 0.93 percent of the country's total freshwater aquaculture production (BoF, 2020). Twenty-six provinces/NRs reported production of farmed channel catfish in China's National Fisheries Statistics in 2019 and the major producing areas are Sichuan, Hunan, Hubei, Guangdong and Henan provinces (Figure 2-5).

[12] According to consulting experts from the Catfish Branch of the China Fisheries Association
[13] Hubei promotes the removal of cages in rivers and lakes [EB/OL], 2016,11,11, http://www.hubei.gov.cn/hbfb/bmdt/201611/t20161111_1512354.shtml

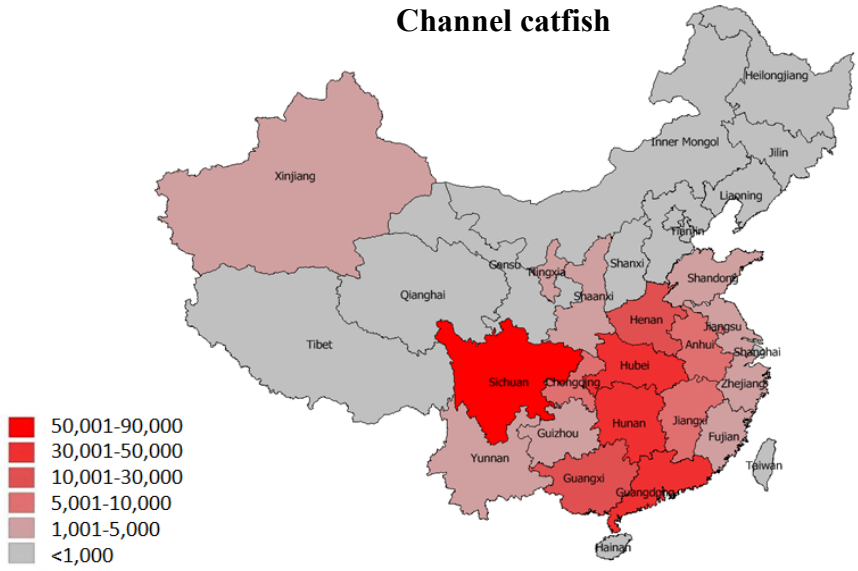

Figure 2-5 Distribution of farmed channel catfish production in China 2019
Data source: 2019 China Fisheries Yearbook, BoF, 2020

2.2.3 Value chain structure

2.2.3.1 Seed production

According to statistics, approximately one billion fingerlings of channel catfish are produced annually in China (Xiao, 2015). The two main production areas for channel catfish fingerlings are Jiayu county in Hubei Province and Meishan city in Sichuan Province. Jiayu county produces one billion fingerlings each year[14] which are supplied to farms nationwide. Meishan city produces about 150 million fingerlings annually, which are mainly supplied to local farms. A small quantity of fingerlings are produced in Anhui, Hunan, Jiangxi, and Jiangsu, and used for farming locally.

2.2.3.2 Grow-out production

In 2019, the total farming area of channel catfish in China was about 20 000 hectares, accounting for about 0.77 percent of the total freshwater aquaculture area in China. The main production areas are located in the Yangtze River Basin and the Pearl River Basin. Channel catfish farming is conducted by different types of producers, i.e. professional farmers, family farmers and corporations. In recent years, farmers have expanded the area of channel catfish culture in earthen ponds due to the ban of cage culture in reservoirs. Pond culture of channel catfish includes intensive monoculture and polyculture. The stocking density varies from 15 000-18 000 ind./ha in intensive monoculture model to 4 500-5 250 ind./ha in polyculture (Wang *et al*., 2020). Usually, the production cycle of channel catfish is two years, i.e. first year for rearing fry to fingerling (50-150g) and the second year for growing the fingerling to marketable size (750-1 000g).

2.2.3.3 Processing

Before 2003, channel catfish was mainly sold in fresh and live forms and consumed in domestic markets. Since 2003, processed channel catfish has gained access to the American market, and stimulated the processing industry of channel catfish in China (Qin *et al*., 2010). In recent years, the annual volume of processed channel catfish has remained around 40 000 tonnes. The major processed channel catfish product types are frozen fillets and prepared or preserved channel catfish. The processed

[14] Jiayu won the honorary title of "Hometown of Catfish in China" [EB/OL], 2018,10,20,http://szb.xnnews.com.cn/xnrb/html/2018-10/20/content_304389.htm

products of channel catfish were exported to eight countries, namely the Cameroon, Congo DRC, Congo ROC, Equatorial Guinea and the United States etc.

2.2.3.4 Export

In 2010, the China export volume of channel catfish reached a peak of 9 389 tonnes. It declined in 2011 and 2012 and then recovered in 2013 and 2014. The export volume was 8 305 tonnes and 8 313 tonnes in 2013 and 2014 respectively. However, the export declined again in 2015 by 34.95 percent due to the Rule on Mandatory Inspection of Fish of the Order Siluriformes and Products Derived From Such Fish adopted in the USA.[15] From 2015 to 2019, the export volume was low and experienced fluctuation. In 2019, the export volume was 6 239.24 tonnes and the export value was USD 35.86 million (Figure 2-6). The top three export markets are the United States, Cameroon, and Congo (DRC). In China, the major channel catfish exporting provinces are Guangdong, Hubei, Guangxi, Anhui and Jiangsu. The major exported product types are prepared or preserved channel catfish (Table 2-2).

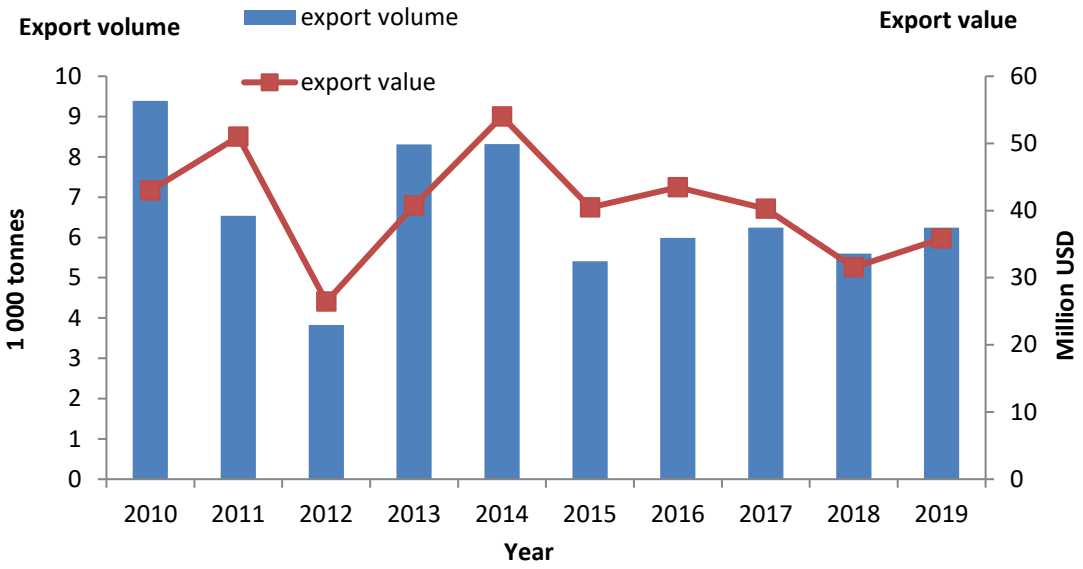

Figure 2-6 Volume and value of export of channel catfish (2010-2019)
Data sources: Statistical Yearbook of China's Aquatic Products Import and Export Trade 2010-2019

[15] Mandatory Inspection of Fish of the Order Siluriformes and Products Derived From Such Fish [EB/OL], 2015,12,02 https://www.regulations.gov/document/FSIS-2008-0031-0337

Table 2-2 Export volume of channel catfish in 2019 (tonnes)

Province	Channel catfish frozen fillets	Channel catfish (prepared or preserved, not minced)	Export volume
Anhui	596.11		596.11
Guangdong		3 843.27	3 843.27
Guangxi		569.61	569.61
Hubei	884.18		884.18
Jiangsu	346.07		346.07
Total	1 826.36	4 412.88	6 239.24

Data sources: China Customs

2.2.3.5 Domestic market and consumption

Presently, farmed channel catfish in China is mainly for local consumption and the demand in domestic markets is growing gradually. The major consumption of channel catfish is concentrated in Chengdu, Chongqing, and Guiyang in southwestern China, followed by Xi'an and Xining, Taiyuan and Shijiazhuang in the north and west of China. There has also been a growing demand in the metropolises of China, such as Beijing, Shanghai, and Guangzhou. In 2019, the total consumption of channel catfish in China was about 190 000 tonnes,[16] which accounts for 95.35 percent of the total production. In 2019, the average farmgate price of channel catfish was CNY 19.96 [17]/kg (Figure 2-7) in China.

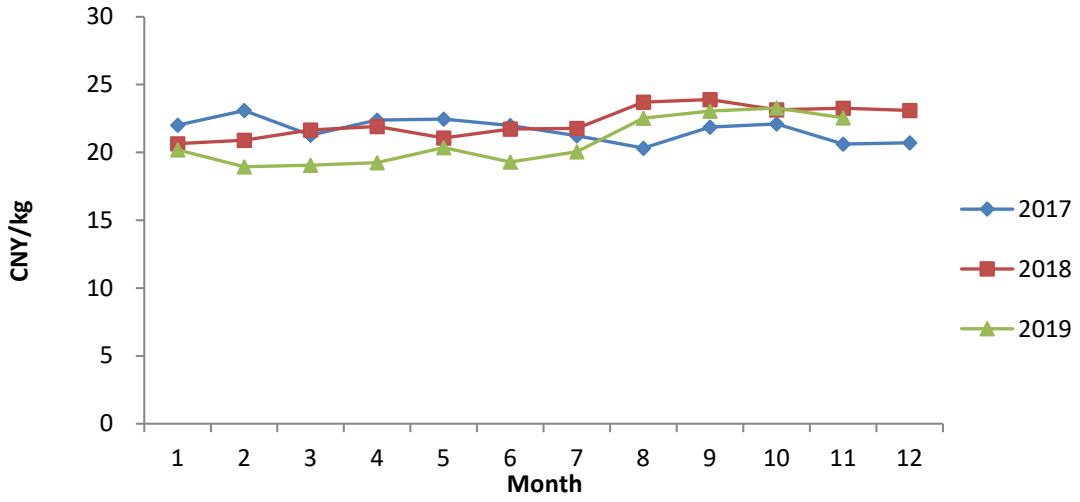

Figure 2-7 Farm gate price of fresh and live channel catfish in China (Size: 500-1000g)
Data sources: Industrial economic database of major cultured non-carp freshwater finfish species industry technology system

[16] According to the report from Research department for Economics of major cultured non-carp freshwater finfish species
[17] Exchange rate: USD 1.0=CNY 6.5

2.2.3.6 Feed manufacture

The common farming mode for channel catfish in China is intensive pond culture. Formulated commercial feed is applied throughout the production cycle. There are three forms of commercial channel catfish feed used in the culture cycle, i.e., powder for fry nursing, extruded floating pellet and sinking pellet for grow-out farming (Huang, 2009). In 2019, the total production of feed specialized for channel catfish was around 500 000 tonnes, with the total value of USD 285 million. The price of commercial feed for channel catfish ranges from USD 857/tonne to USD 1 070/tonne, and the feed conversion ratio ranges from 1.5 to 2.0.

2.2.4 Sectoral development policy and strategy

In China, government policy for the channel catfish sector has evolved according to development and can be divided into three stages.

Before 2010: The industrial policy for channel catfish was mainly to increase the production through expansion of the farming area. A series of industrial development plans was published at the national and provincial levels. Government of Jiangsu Province issued the "Special Aquatic Industry Development Plan of Jiangsu Province" in 2003, which emphasized the aquaculture development of channel catfish and other species. The Ministry of Agriculture issued the "Eleventh Five-Year Plan for National Fisheries Development (2006-2010)" in 2006, which provided guidance to strengthening the infrastructure of production and processing for freshwater aquaculture species (include channel catfish) in order to enhance its international competitiveness. Furthermore, the Jiangsu Provincial Government optimized the spatial planning for the aquaculture industry at regional level and guided the expansion of channel catfish aquaculture development in coastal areas. The "National Zonation Plan for Advantaged Agricultural Products (2008-2015)" was developed in 2008, and channel catfish was listed as one of the export aquatic products with an allocated development zone in the Yangtze River Basin.

2010-2016: The industrial policy for channel catfish mainly aimed to increase the production of cultured channel catfish and its contribution to rural development. In 2013, Hunan Province established a production area plan for channel catfish in Huaihua, Yiyang, and Xiangxi Autonomous and strengthened the capacity on prevention and control of channel catfish disease. In 2016, Ningxia Hui AR and Hubei Province implemented supporting policies for the development of competitive agricultural industries, under which, subsidy for using seed of fine breed were provided to the pond culture of channel catfish. Hubei Province supported the establishment of a channel catfish production park by providing financial support for infrastructure, such as fillet processing workshops, cold storage, and an international trade facility.

2016 to present: The industrial policy was set up to improve the quality of channel catfish products and promote sustainable aquaculture development. It stopped cage culture in reservoirs, supported development of healthy ecological aquaculture models and upgraded the processing industry of channel catfish. The Jiayu county government of Hubei province has actively implemented the branding plan of "one county, one product", by promoting channel catfish pond farming and establishing aquaculture parks. It attracted a well-known processing company to setup a processing plant in Jiayu, and greatly improved the value chain and the economic benefits, as well as sector resilience. In 2020, the Sichuan Provincial Department of Agriculture and Rural Affairs issued the "Guidelines to Fisheries and Fishery Management", which highlighted the development of channel catfish and other high-value aquaculture products. Following the technical guidelines, aquaculture insurance for channel catfish was well planned and implemented.

3. IMPACT OF COVID-19 PANDEMIC ON FARMED CHANNEL CATFISH SECTOR IN HUBEI PROVINCE AND FARMED TILAPIA SECTOR IN GUANGDONG PROVINCE

3.1 Farmed channel catfish and tilapia sector in Hubei and Guangdong provinces

Hubei Province is in the middle reaches of the Yangtze River and has a water surface area of about 1.67 million hectare and ranks the first in China in terms of freshwater resources. Hubei Province has 176 indigenous species of fishes and 164 indigenous species of aquatic plants.[18] The province has a long tradition of fish farming, which has provided a good foundation for the development of a modern aquaculture industry. With decades of development, Hubei Province became the largest freshwater aquaculture producer in China, and one of the major areas for channel catfish production. Hubei also has the largest seed production center for channel catfish in China.

Guangdong Province is in the southern part of China and has abundant water resources and a favorable climate for aquaculture. It is the area where tilapia was first introduced and cultured in China. Currently Guangdong has the largest farming area, production, and export of tilapia (Liu, 2017). Guangdong Province has established a complete industrial chain of farmed tilapia, covering feed production, tilapia hatchery, grow-out farming, and processing and trade, supported by relevant research institutes and educational institutions.

3.1.1 Development history

In 1985, channel catfish was first introduced in Hubei Province from the United States of America. After years of research and pioneer farming on cage culture, channel catfish farming has developed rapidly since 2003 and has become one of the top ten aquaculture species in Hubei Province. In 2019, the farming area of channel catfish in Hubei Province was 9 100 hectares. In Hubei Province, culture in earthen ponds has become the major culture system for catfish. The normal yield of channel catfish from pond monoculture is 15 tonnes/ha, and the profit is about USD 19 300/ha in Hubei province (Research department for economics of major cultured non-carp freshwater finfish species, 2020). In 2019, channel catfish farming engaged about 10 000 people in Hubei Province. A full industrial chain of farmed channel catfish has been developed in Hubei Province, which covers broodstock maintaining, seed and grow-out culture, feed supply, processing and trade. The local channel catfish consumption is relatively low, and most of fish produced are delivered to markets in other provinces (Guo, 2010).

Tilapia was first introduced to Guangdong Province in the 1950s. Taking advantage of the favorable climate and progress in hatchery technology, farmed tilapia production has continued to increase in Guangdong Province since the 1990s (Chen, 2014). The main species/strains of cultured tilapia in Guangdong Province include GIFT tilapia, Aoni tilapia and red tilapia. Among them, GIFT tilapia has the largest share in production, accounting for about 90 percent, Aoni tilapia and red tilapia accounts for about 5 percent each. Tilapia farming modes include pond culture, cage culture in reservoirs and integrated farming. Pond culture is the main farming system. Two crops per year or three crops per two years of tilapia can be harvested in Guangdong Province. The average yield of tilapia monoculture is about 30 000 kg/ha, with annual profit of about USD 5 375/ha and benefit-cost ratio of around 1.2 (Yuan *et al*., 2016). In 2019, about 100 000 people were engaged in the tilapia industrial chain in Guangdong Province.

3.1.2 Production and distribution

From 2003 to 2006, channel catfish farming in Hubei Province had rapid growth, with an average annual growth rate of 98.7 percent. In 2007, it declined due to reduced demand in export. From 2009 to 2014, production recovered steadily because of the increase in the domestic market. In 2014, production reached the highest level of 48 000 tonnes. Channel catfish production in 2016-2019 was adjusted after the routine validation of national aquaculture statistics data in 2020. The revised farmed channel catfish production in Hubei province was 26 900 tonnes in 2016 and 27 500 tonnes in 2018 respectively. The

[18] Hubei's total amount of freshwater aquatic products ranks first in the country and becomes the first province in freshwater fisheries [EB/OL], 2015,10,20, http://news.cnhubei.com/xw/jj/201510/t3412433.shtml

production of farmed channel catfish increased to 41 900 tonnes in 2019 due to the drastic expansion of intensive pond culture, which increased by 50.4 percent from the previous year (Figure 3-1).

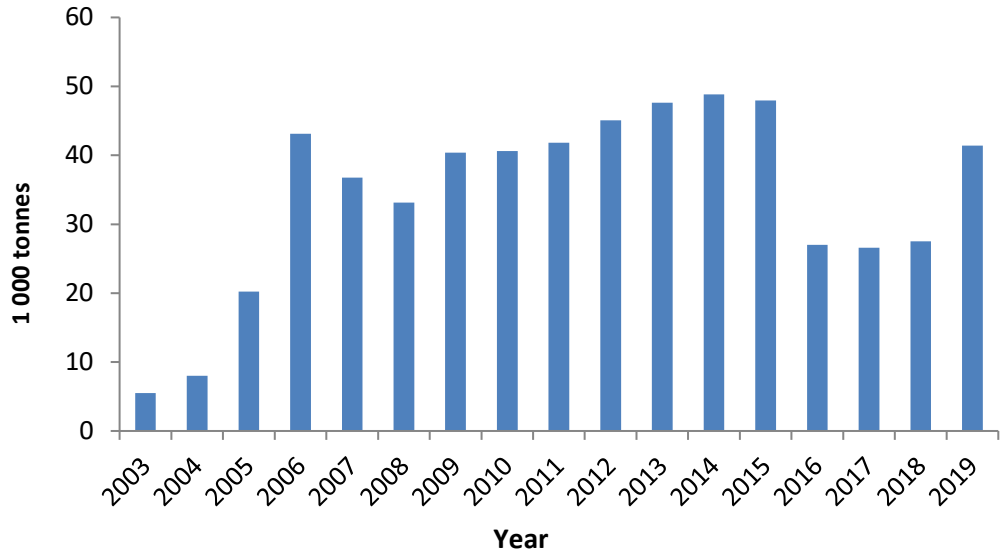

Figure 3-1 Farmed channel catfish production in Hubei province from 2003 to 2019
Data sources: China Fishery Statistical Yearbook 2004-2020

Farmed tilapia production was first listed in the China Fishery Statistical Yearbook as an individual commodity species in 1989. From 1989 to 2007, the production of farmed tilapia in Guangdong province had rapid growth, with an average annual growth rate of 15.8 percent. The tilapia production dropped significantly in 2008 due to extreme cold weather in the winter. After 2009, the sector began growing again in Guangdong province although the growth rate was lower. In 2018, the production of cultured tilapia in Guangdong province reached a historical high of 750 000 tonnes, while in 2019, it declined to 740 000 tonnes (Figure 3- 2), which accounted for about 45 percent of the country's total production. The main areas of tilapia production of Guangdong province are concentrated in the southwestern part of the province (Maoming, Zhanjiang, and Huazhou mainly) and the Pearl River Delta (Guangzhou, Zhuhai, Zhaoqing and Huizhou). Among them, Maoming city has the largest tilapia farming area; its farmed tilapia production also ranks the first in Guangdong province (Luo, 2019).

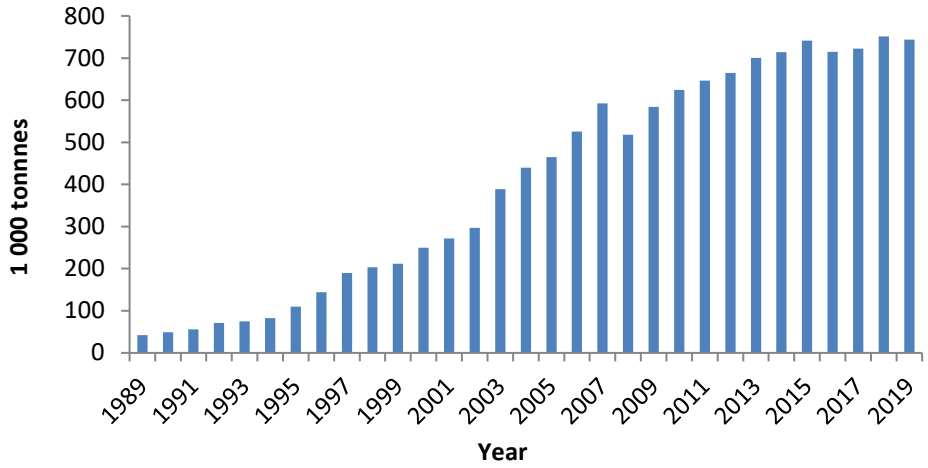

Figure 3- 2 Farmed tilapia production in Guangdong province from 1989 to 2019
Data sources: China Fishery Statistical Yearbooks (1990-2020)

3.1.3 Value chain structure/character

Along with the development of farmed channel catfish and tilapia, a well-structured industrial chain has been established for farmed channel catfish in Hubei province and tilapia in Guangdong province.

3.1.3.1 Seed production

Hubei province was reported as the largest channel catfish seed production center in Asia. The channel catfish seed production is mainly carried out by commercial seed companies, with an annual production capacity of 900 million ind. (value exceeds USD 28.57 million), which contributes 90 percent of the channel catfish seed supply in the country (Tao, 2017). Jiayu county, the production center of channel catfish in China, hosts a state registered channel catfish seed bank and 26 hatcheries, and maintains 153 000 pairs of broodstock (Li *et al*., 2018). In 2019, Jiayu county produced about 900 million channel catfish fingerlings, of those 600 million were sold and 300 million were reared to large-sized fingerlings.[19] The buyers of the seed were mainly from Jiangsu, Hubei, Guangdong, Guangxi, Henan and extensively Gansu, Xinjiang, Shenyang, etc. Normally, the channel catfish fry can grow to the size of 20-30 pcs/kg after six months of nursing.

Guangdong Province is the largest producer of tilapia seed in China. Tilapia seed produced in the province is considered to have the best quality, with good growth performance and a high male rate. The percentage of fine tilapia strains used as broodstock in tilapia seed production has reached over 90 percent in Guangdong province (Wang *et al*., 2016). In 2019, Guangdong province produced over 10 billion tilapia seeds, which accounted for 47.30 percent of the national tilapia seed production.[20] The majority of tilapia seed producers in Guangdong are private seed companies. In Guangdong province, the local seed companies supplied 70 percent of seed for tilapia grow-out culture in the province, while the remaining 30 percent are supplied from Hainan, Guangxi, Fujian, and other places. Tilapia seed companies in Guangdong province are mainly located in Maoming, Zhanjiang, Meizhou and Huizhou. Among them, Maoming has the largest tilapia seed production in Guangdong, with 28 tilapia seed companies producing 1.1 billion tilapia fingerlings annually. The seed production methods include rearing in earthen ponds, cages, and cement tanks (National tilapia research system, 2016).

3.1.3.2 Grow-out production

Channel catfish grow-out culture in Hubei province involves mainly professional farmers (contracted), family farms and corporative farms. Intensive pond culture is the major model for channel catfish grow-out production. Recently, recirculating aquaculture systems have also been adopted for channel catfish grow-out production. Polyculture with filtering fish species is a common practice in intensive channel catfish pond culture, which facilitates the biological manipulation of water quality in the pond. The production cycle is 1-1.5 years from fingerling (>50 g) to marketable size (750-1 000g). The stocking density varies from 15 000 to 18 000 pcs/ha. Commercial formulated pellet feed is applied throughout the farming cycle.

In recent years, the total area of tilapia culture has remained relatively stable in Guangdong province, which was 51 300 ha in 2019.[21] The majority of producers for marketable tilapia in Guangdong province are family farmers, and the average culture area of each family is about 2 hectares. There is an increasing number of large-scale companies and cooperatives engaged in tilapia grow-out farming in the province. Tilapia farming models in Guangdong province include intensive monoculture (one tier and multi-tier culture mode) and integrated farming mode. In the main tilapia farming areas, there are well-organized large-scale tilapia farming bases adopting intensification, standardization, and high-tech. Tilapia fingerlings are usually stocked in March and April, with the stocking size of 3-4 cm in body-length and the stocking density of 30 000-45 000/ha. The survival rate in grow-out

[19] "Hometown of Catfish in China"-Jiayu County, Hubei Province. [EB/OL]. 2018-10-20, http://www.shuichan.cc/news_view-372399.html
[20] Data source: China Fishery Statistical Yearbook 2020
[21] Data source: Guangzhou Comprehensive Experimental Station of the major cultured non-carp freshwater finfish species research System of China's Modern Agricultural Research System

culture can reach 90 percent or higher. The normal yield of tilapia from intensive pond culture is around 30 tonnes/ha. In general, two crops of tilapia (750 g or larger) can be harvested in the western part of Guangdong province in a year, through implementation of good aquaculture practices (GAP) and using seed from improved tilapia strains (Shao *et al*., 2018).

3.1.3.3 Processing and export

Processed channel catfish products include whole dressed fish, fillets, strips, and steaks et.al. The major form of processed channel catfish in Hubei province is frozen fillet (Cai, 2016). In 2019, about 3 000 tonnes of channel catfish were processed in Hubei, which was mainly exported to the United States market.

The export volume of channel catfish in Hubei province reached the peak of 5 532 tonnes in 2014. The export volume declined between 2015-2018 due to the implementation of Channel Catfish Act by the United States of America in 2014 (Figure 3-3). The export volume of channel catfish in Hubei province reached the lowest rate at 550.62 tonnes in 2018 and rebounded slightly in 2019, with a total export volume of 884.18 tonnes for frozen fillets and an export value of 5.26 million US dollars.

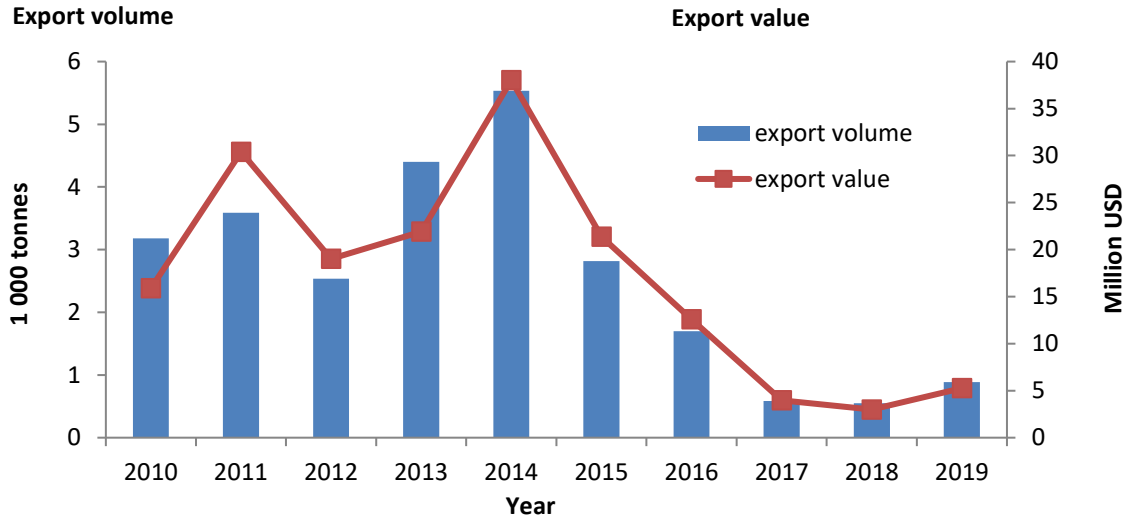

Figure 3-3 Export volume and export value of Channel catfish in Hubei province 2010-2019
Data sources: Statistical Yearbook of China's Aquatic Products Import and Export 2010-2019

In 2019, the number of aquatic product processing plants in Guangdong province was 1 022 with a total processing capacity of 2.26 million tonnes of aquatic products (BoF, 2020). Some 20 processing companies are engaged in tilapia processing, which process about 350 000 tonnes (about 50 percent to total cultured tilapia production in Guangdong province) of tilapia annually. Tilapia processing plants are mainly concentrated in Maoming and Zhanjiang cities in western Guangdong. Maoming city is the largest processing base in China for tilapia exportation. In 2019, the total volume of processed tilapia products for export from Maoming was 98 000 tonnes, with a total value of USD 310 million.[22] The size of tilapia for processing is mainly 400-800g in Guangdong. The processed product types include frozen whole tilapia, frozen tilapia fillets, prepared or preserved tilapia, and deep processed products such as fish meal, fish oil and fish lysate etc. The processed products are mainly for exportation and destined to nearly 50 countries and regions. The United States, Russia, and Canada are the top three target counties of exportation (Dai *et al*., 2020).

Guangdong is the largest tilapia export province in China. From 2010 to 2018, tilapia export in Guangdong province showed a continuous growth trend. The average annual growth was 10.37 percent.

[22] Guangdong Maoming branded tilapia is exported to 49 countries and regions. [EB/OL]. 2020-07-24, http://www.shuichan.cc/news_view-405301.html

The highest volume of tilapia export was recorded as 263 700 tonnes in 2018 (Figure 3-4). Largely affected by increased tariffs resulting from the Sino-US trade conflict, the tilapia export volume declined slightly to 255 100 tonnes in 2019, accounting for 58.5 percent of the China's total tilapia export. The total value of tilapia export from Guangdong province was 806 million US dollars in 2019.

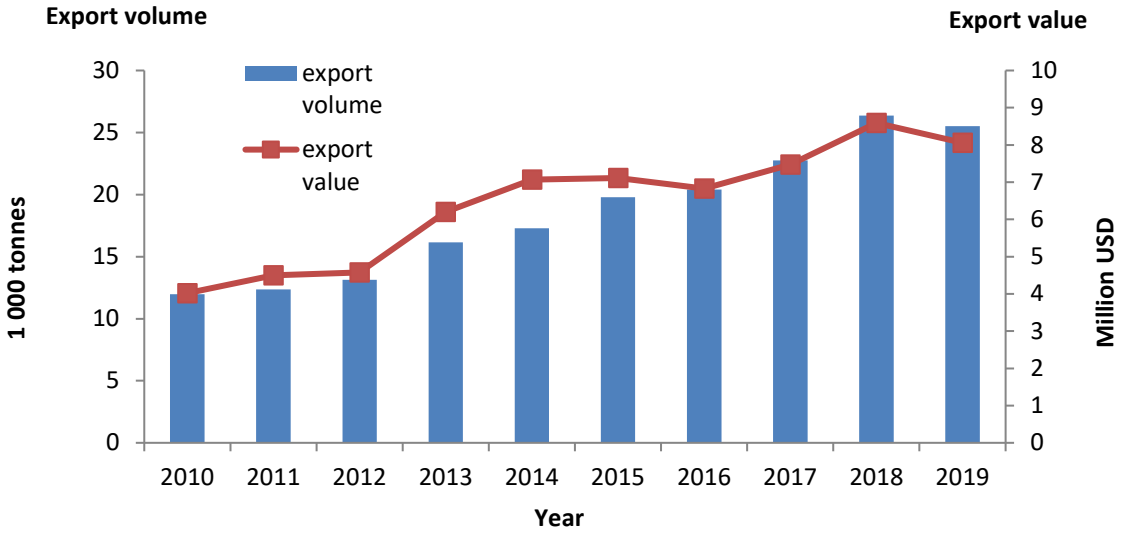

Figure 3-4 The export volume and value of Tilapia from Guangdong province (2010-2019)
Data source: Guangzhou Comprehensive Experimental Station of China's Modern Agricultural Research System

3.1.3.4 Domestic market and consumption

Channel catfish produced in Hubei province is mainly sold to other provinces rather than consumed within the province. Fresh and live channel catfish are preferred by domestic consumers and are commonly available in retail markets and restaurants. There are size preferences in different markets. For instance, the smaller sized channel catfish (less than 0.9kg/pcs) is preferred in the southwestern region, i.e., Chengdu, Chongqing, and Guizhou etc., while bigger sized fish (0.9-1.5 kg/pcs) are preferred in the north of China (e.g., Beijing and Jinan) (Jiang, 2016).

Guangdong province is the largest domestic market of tilapia products. Nearly 400 000 tonnes of farmed tilapia are sold for domestic consumption in Guangdong, which accounts for more than half of the farmed tilapia production in the province. Generally, tilapia is marketed live or fresh in agro-food markets, seafood markets, wholesale markets and supermarkets. The marketing size of tilapia varies between 400-600g and the price fluctuates according to the markets. Large-sized tilapia (>1.5 kg) is usually sold to restaurants and hotels. The large-sized tilapia usually have higher farm gate prices, around USD 2.3/kg, and wholesale price between USD 3.28-3.71/kg. The price of tilapia farmed in a marine environment is about USD 0.3-0.6/kg higher than that of tilapia cultured in freshwater (China Fisheries Circulation and Processing Association, 2017). In addition, a small amount of canned and other processed tilapia products are consumed locally.

3.1.3.5 Feed manufacture

Channel catfish is a carnivorous species that can be taught to take commercial pellet feeds. There are large feed companies, such as Tongwei and New Hope, and various small and medium-sized companies which have developed specific formulated feed for channel catfish and production capabilities to meet the upscaling of intensive aquaculture. At present, the total sale amount of commercial feed for channel catfish in Hubei market is about 60 000 tonnes. The pellet feed has a crude protein content of 30 percent

and a feed conversion ratio of about 1.8. Specialized formulated extruded floating feed for channel catfish can have a crude protein content of 34 percent. The feed cost accounts for about 70 percent of the total cost in intensive Channel catfish pond culture.[23]

There are about 30 feed companies producing specialized tilapia feed in Guangdong province, and the total annual tilapia feed production is around 1 million tonnes.[24] At present, there are two types of tilapia feed, sinking and extruded pellet feed. In Guangdong province, the feed conversion ratio of tilapia extruded feed and sinking pellet are 1.2-1.5 and 1.8 respectively.

3.1.3.6 Sectoral development policy and strategy

Before 2010, the Hubei provincial industrial policy for channel catfish farming focused on culture area expansion and cage farming in reservoirs. From 2010 to 2016, the industrial policy focused on quality improvement in fingerling production and establishment of a broodstock supply system. In 2012, Hubei province provided financial support to the infrastructure upgrading of breeding centers of channel catfish serving as exporting agricultural products bases. In 2013, the "Twelfth Five-Year plan" for fisheries development in Hubei province clearly identified the development of a complete value chain for farmed channel catfish as a priority. In 2014, Tianmen city started to promote the branded products for channel catfish and marketing as a specialty of local aquatic products.

In 2016, the industrial policy focused on the improvement of the entire industrial chain of farmed channel catfish. In 2018, Hubei province set the goal to develop channel catfish farming as a major agricultural industrial chain with an annual output target of USD 1.43 billion. In 2019, Jiayu county published a blueprint of the industrial development for channel catfish (2019-2023), [25] which supports the complete channel catfish industry chain through establishing aquaculture parks that encompass hatchery, grow-out production, processing, and trade.

In 2003, Guangdong province identified farmed tilapia, eel and shrimp as competitive aquaculture commodities in line with the national plan and zone development of advantaged agricultural products by the Ministry of Agriculture. Farmed tilapia in Guangdong was also listed as the only agricultural product with competitiveness in an international market by the Ministry of Agriculture. In 2004, Guangdong province published a plan to establish the "Golden Triangle" tilapia industrial zone, with an annual tilapia production of 200 000 tonnes in Maoming city. In 2005, the "Eleventh Five-Year Plan" of Maoming city included the establishment of a dozen tilapia demonstration farms (individual size of 7 ha), standardization and adoption of non-hazard farming code.

Since 2010, Guangdong provincial and municipal governments have implemented a series of strategy and policy measures to support the development of industrial chains of farmed tilapia, which included but were not limited to:

- financial assistance to technical upgrading, aquaculture mechanization, improved efficiency and energy saving technology and recycling economy;
- support to the establishment of leading enterprises in the tilapia industrial chain, establishment of demonstration zones for export-oriented aquaculture products, establishment of modern agriculture industrial parks;
- promote pollution-free tilapia farming zones, certification of origin and the code of conduct for pollution-free farming practices;
- provide financial assistance to promote seed of fine-strain tilapia; and
- provide financial assistance to the upgrading and standardization of tilapia ponds.

[23] Prospects of Channel Catfish Industry Benefit in Jiayu County, Hubei Province [EB/OL]. 2011-11-03, https://www.nczfj.com/yangyujishu/20105051.html

[24] Guangdong aquafeed market volume exceeded 4.5 million tonnes. [EB/OL]. 2017-03-29, http://www.shuichan.cc/news_view-317249.html

[25] Jiayu: Strive to build catfish industrial chain with value of CNY ten billions. [EB/OL]. 2018-11-05, http://www.xianning.gov.cn/xwzx/xssm/201811/t20181105_1417715.shtml

3.2 COVID-19 epidemic and the containing measures in Hubei and Guangdong provinces

The first confirmed case of COVID-19 in Hubei province (Wuhan city) was reported in mid-January 2020, after which Wuhan city was locked down from 23 January 2020. On 11 February, all residential communities in Wuhan implemented a complete lockdown. On 16 February, Hubei province adopted the top-emergency response and all urban and rural villages, communities and residential areas started to implement strict lockdown protocols. Major containment measures were enforced, such as the interruption of all public transportation, closure of airports and railway stations, restricted movement between communities, avoidance of physical contact, and closure of all schools, factories, wholesale markets, shops, restaurants, theaters, and other entertainment facilities. In the meantime, quarantine, monitoring, and testing were strengthened, household delivery services were organized by the community authorities to ensure basic living supplies. Government employees and volunteers were organized to support households with difficulties. On 25 March 2020, the outbound transportation was resumed in Hubei province except Wuhan city, which indicated the epidemic was under control in Hubei and the whole of China. On 8 April 2020, Wuhan lifted all travel restrictions, resumed its social and economic activities.

Now the epidemic in Hubei province has been effectively controlled, and livelihoods have returned to normal. As of 31 August 2020, there were no new confirmed cases, no new suspected cases, and no new deaths in the province.

According to the published statistics, a total of 68 139 confirmed cases of COVID-19 and 4 512 deaths have been reported in Hubei province.[26]

In Guangdong province, the first suspected case of COVID-19 was found on 14 January 2020. The emergency response mechanism for epidemic prevention and containment was initiated on the same day. On 24 January 2020, the Guangdong provincial government launched the top-emergency response on COVID-19 in Guangdong province,[27] which included intensified surveillance and screening of new cases, restriction of gathering, travel restriction and mandatory quarantine, followed by closure of schools, factories, restaurants and hotels etc. On 24 February 2020, the epidemic was generally under control, and the level of emergency response was downgraded to the second class. In early March 2020, the epidemic in Guangdong province was effectively controlled. On 25 March, the lockdown measures were lifted and social and economic activities resumed. From April 2020, Guangdong province started to strengthen prevention and mitigation measures on imported cases from abroad.

3.3 Impact of COVID-19 pandemic on industrial chain links in the two provinces

The COVID-19 epidemic and the containing measures had significantly disrupted the normal operation of the aquaculture industrial chain in Hubei and Guangdong provinces. The impact on the stakeholders along the industrial chain is of different magnitude as the severity of the epidemic and containing measures taken differed in the two provinces.

Twenty-three questionnaires were completed in each province. The stakeholder's profile, challenges to normal operations, impact on production performance, and financial status were analyzed. The survey also included the expectations of different stakeholders in the industry chain on the overall performance of their business in 2020. During the survey, 1 April 2020 was used as the demarcation between epidemic containment period and recovery period as the lockdown measures was lifted at the end of March 2020.

[26] COVID-19 epidemic situation in Hubei Province, 30 August 2020 [EB/OL]. 2020-09-01,http://wjw.hubei.gov.cn/bmdt/ztzl/fkxxgzbdgrfyyq/xxfb/202008/t20200831_2877947.shtml

[27] Guangdong Province decided to initiate a primary response to major public health emergencies [EB/OL]. 2020-01-23, http://www.gd.gov.cn/gdywdt/gdyw/content/post_2878901.html

3.3.1 Impact of COVID-19 pandemic on channel catfish and tilapia farms

The survey aimed to analyze the impact of the pandemic and the containment measures on different aspects of farm operations, business management and farmers engaged in seed production and grow-out farming of channel catfish in Hubei province and tilapia in Guangdong province. The results are summarized in following sections.

3.3.1.1 Impact on production management and operation

Figure 3-5 and Figure 3-6 show the main impacts on production management and operations of channel catfish and tilapia farming during the period of strict containment and recovery phases. During the period of strict containment, aquaculture production management was severely affected, including disrupted feeding, hold-up of harvestable stock and delayed re-stocking in ponds and prolonged production cycles. The transportation restrictions interrupted the delivery of feed to farm, transport of fingerlings and the harvest. Feeding was the most severely affected farm operation activity. All channel catfish farmer respondents and 57 percent tilapia farmer respondents reported their normal feeding was completely disrupted. The second major impact was hold-up of stock of ready-sale channel catfish and tilapia in the ponds, which occurred in 90 percent of surveyed channel catfish farms and 57 percent of surveyed tilapia farms. In addition, 85 percent of channel catfish farms postponed stocking or failed in starting a new production cycle. Other impacts include the interruption of basic services and the increase in transportation costs of production input in the early stage of the epidemic.

The routine production activities had not yet fully resumed even three months after the lift of the strict epidemic containment measures. Results showed that all the surveyed channel catfish farms and 43 percent of surveyed tilapia farms could partially resume their production and business activities. Nearly two thirds of surveyed channel catfish farms and one third of surveyed tilapia farms were still affected by transportation restrictions. Normal feeding had resumed in most surveyed farms. However, the survey result showed the problem of backlogging of fish stock in ponds and delayed stocking in channel catfish fingerlings and tilapia grow-out fish still remains unsolved or even more significant.

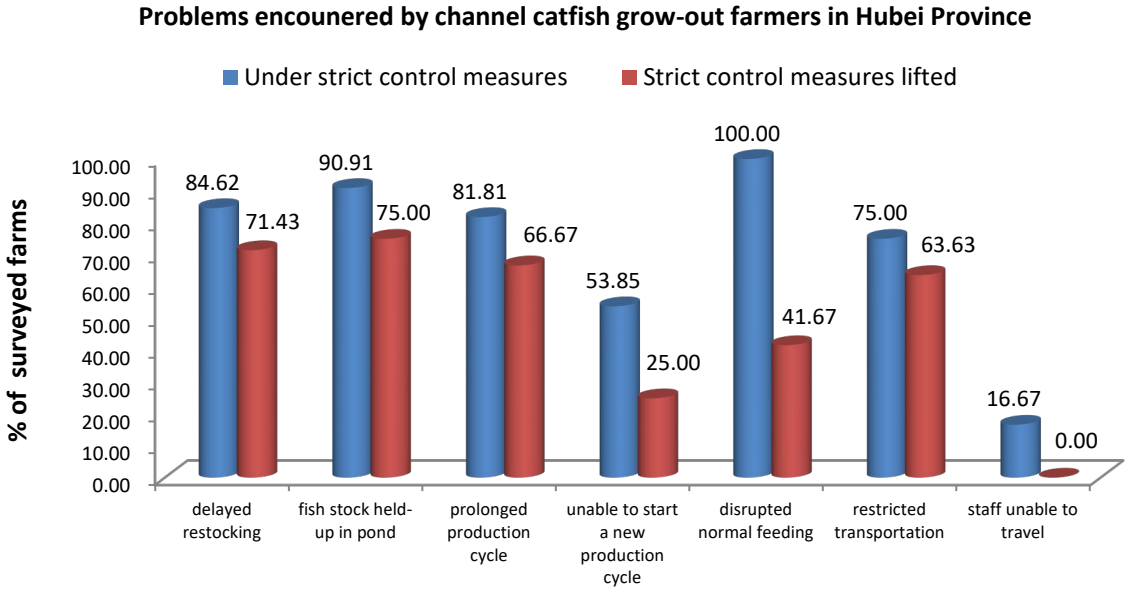

Figure 3-5 Impact on management and operation of channel catfish grow-out culture
Data source: Survey on impact of COVID-19 pandemic on channel catfish farming in Hubei province conducted during July-August 2020

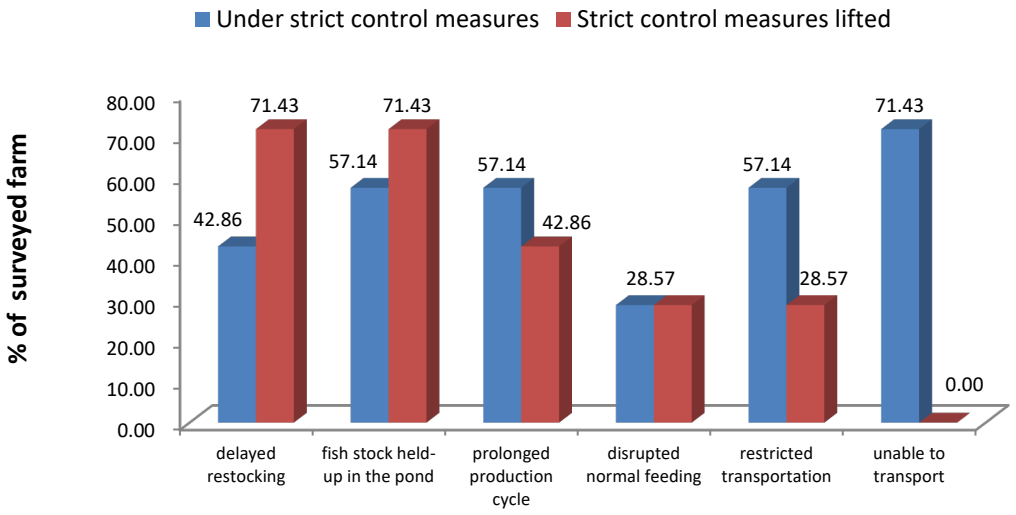

Figure 3-6 Impact on management and operation of tilapia grow-out culture
Data source: Survey on impact of COVID-19 pandemic on tilapia farming in Guangdong province conducted during July-August 2020

3.3.1.2 Impact on the production of the current crop and the whole 2020

Table 3-1 shows the continued impact of the pandemic on channel catfish and tilapia farms operations after the lift of strict containment measures, and all respondents reported that the production would be reduced by 20-50 percent during the containment-measure period, mainly due to short supply of production inputs, such as seed, feed, and medicine, disruption of stocking and normal feeding, lower stocking density, the fish help-up in pond, the prolonged production cycle, and interruption of scheduled harvest.

All respondents expected that channel catfish production would drop by 20 percent and tilapia production would drop by 13 percent in 2020 on average. The surveyed farmers expected the unit yield would decrease by 15 percent for channel catfish and 23 percent for tilapia. Over 90 percent of the respondents predicted that the total stocking area and stocking density would be reduced by nearly 20 percent in channel catfish farming in 2020 on average largely due to the low sales price. But, nearly 90 percent of surveyed tilapia farmers forecasted there would be no significant changes in the culture area and stocking density in 2020.

The production of seed would be reduced by 30 percent for channel catfish and tilapia because many grow-out farmers missed the stocking season and the stocking areas were estimated to be 30 percent lower, and the stocking density would be 20 percent lower than 2019.

Table 3-1 Foreseen impacts on the grow-out production of the current crop and in 2020

	Channel catfish	Tilapia
Current crop		
Production	Reduced by 20-50%	Reduced by 20-50%
Yield	10-30% lower (average 20%)	10-20% lower (average 13%)
Stocking pond area	no change	Reduced by 18% (average)
Stocking density	no change	Reduced by 17% (average)
Year of 2020		
Production	10-40% (average 19%) lower than normal forecasted by 70 % of the respondents	20% (average 16%) lower than normal forecasted by 72.7% of the respondents

3.3.1.3 Impact on product sale

Table 3-2 shows that all surveyed farmers encountered difficulty in acquiring information on marketing and selling of products during the epidemic containment period. The surveyed channel catfish farmers reported a reduction of more than 40 percent (average) in actual sales compared to the same period in the previous year. Over 70 percent of surveyed tilapia farmers reported a reduction of 15-30 percent in the actual sales compared to 2019. The surveyed seed producers reported a reduction of 30 percent in orders and actual sales. More than 80 percent of the surveyed channel catfish farmers reported that the sale price was 28 percent lower than previous years. More than 70 percent of the surveyed tilapia farmers indicated that the market price was 10-20 percent (average of 18 percent) lower than that of previous years. The sales prices for channel catfish and tilapia seed were 25 percent and 20 percent lower than the previous year respectively.

The survey results showed that over 90 percent of the surveyed farms still had difficulty in obtaining adequate marketing information after the lift of strict epidemic containment measures. For channel catfish farmers, it was projected that sale orders would be reduced by an average of 27 percent for 2020 compared to the previous year. But the impact on tilapia product orders was less significant. Over 90 percent of the surveyed channel catfish farmers predicted that the actual sale would be decreased by an average of 32 percent in 2020, while 80 percent of the surveyed tilapia farmers predicted a reduction on average of 24 percent in actual sales in 2020. Over 90 percent of the surveyed channel catfish farmers projected significantly lower (on average 27 percent) sales prices of the products in 2020 than the previous years, while 70 percent surveyed tilapia farmers forecasted an 18 percent lower sale price of their products.

Table 3-2 Impact on sales of product

		Order		Actual product sales		Price	
		Range (%)	Average (%)	Range (%)	Average (%)	Range (%)	Average (%)
Channel catfish	Crop under strict containment measures	10-100 (100) *	42.30	10-100 (100)	41.67	10-80 (84.61)	28.63
	whole 2020	20-50 (90.91)	27	20-50 (90.91)	32.22	10-80 (90.91)	27.27
Tilapia	Crop under strict containment measures	15-30 (71.43)	21	15-30 (71.43)	18.75	10-20 (71.43)	18
	Whole 2020	0-30 (28.57)	15	5-40 (85.71)	24	10-30 (100)	18

* Number in brackets refers the percentage of surveyed farms

3.3.1.4 Impact on input supplies

Figure 3-7 and Figure 3-8 show the main impact on aquaculture input supplies during the strict containment measures and the recovery after the lift. Supply of seed and feed were the most significantly affected among all production inputs. Over 90 percent of the surveyed farms encountered inadequate supply of feed and 30 percent of the surveyed farms encountered a limited supply of seed or seed below the required size. Over 50 percent of surveyed farms reported increased price of inputs by 10-20 percent.

The supply of production inputs had recovered gradually after the lift of the pandemic containment measures. However, 45 percent of the surveyed channel catfish farms still have problems of insufficient seed supply or seed of required size. More than 90 percent of the respondents reported a 20 percent increase in seed price on average. The supply of feed had resumed to normal, but the surveyed farmers reported an increase in feed price by 10-20 percent.

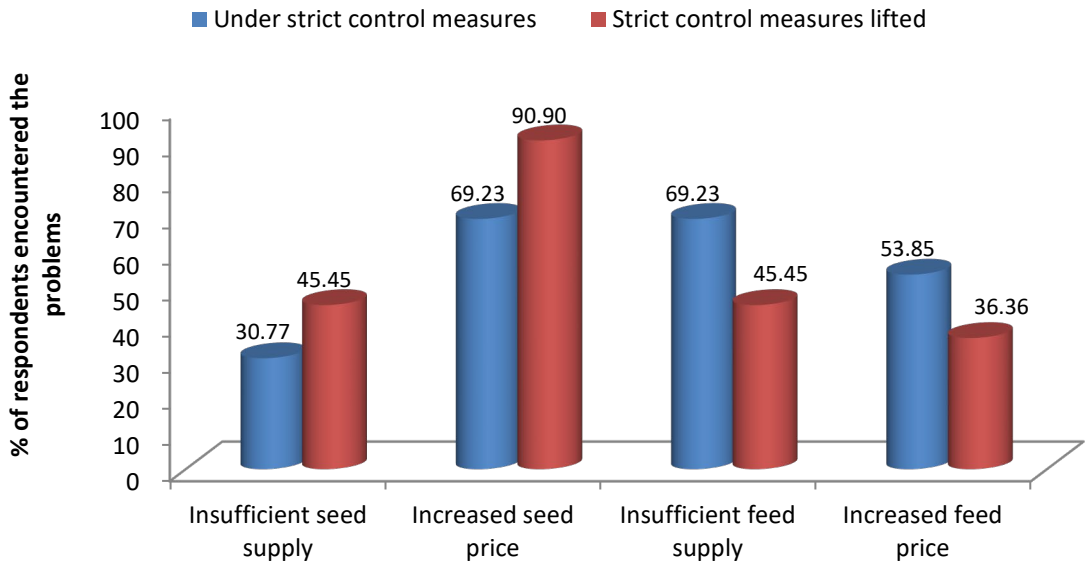

Figure 3-7 Impact on aquaculture input supply for channel catfish
Data source: Survey on impact of COVID-19 pandemic on channel catfish farming in Hubei province conducted during July-August 2020

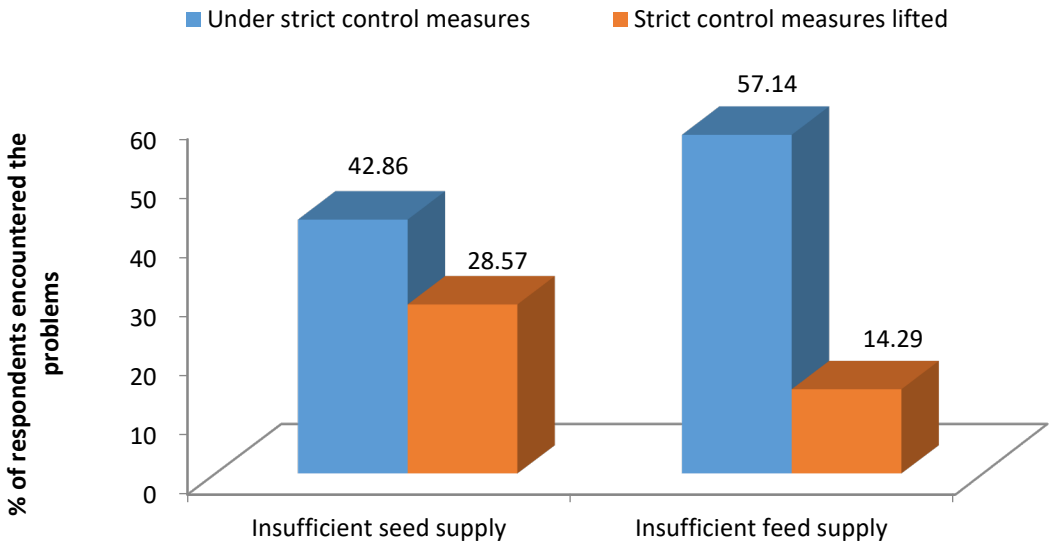

Figure 3-8 Impact on aquaculture input supply for tilapia
Data source: Survey on impact of COVID-19 pandemic on tilapia farming in Guangdong province conducted during July-August 2020

3.3.1.5 Impact on channel catfish and tilapia growth and product quality

The interruption of aquaculture inputs supply, operational and management activities inevitably affected the performance of farmed fish, indicated by mortality, reduced growth, and low dress out rate. Forty percent of the respondents reported that fish growth was reduced by 10-30 percent during the strict containment period. Over 40 percent of the respondents reported lower dress out rate and over 50 percent of surveyed channel catfish farms encountered high fish mortality (up to 30 percent) (Figure 3-9), mainly caused by disrupted routine management activities and disease control.

Although the strict pandemic containment measures were lifted in late March 2020, more surveyed channel catfish farmers indicated that the problems of slow growth and low dress out rate remained. Over 40 percent of channel catfish respondents reported a fish mortality rate ranging from 10 percent to 30 percent. The reduced growth and low dress out rate of tilapia grow-out had not improved (Figure 3-10). The impact on the dress out rate, harvesting size and mortality of tilapia was less significant than for channel catfish.

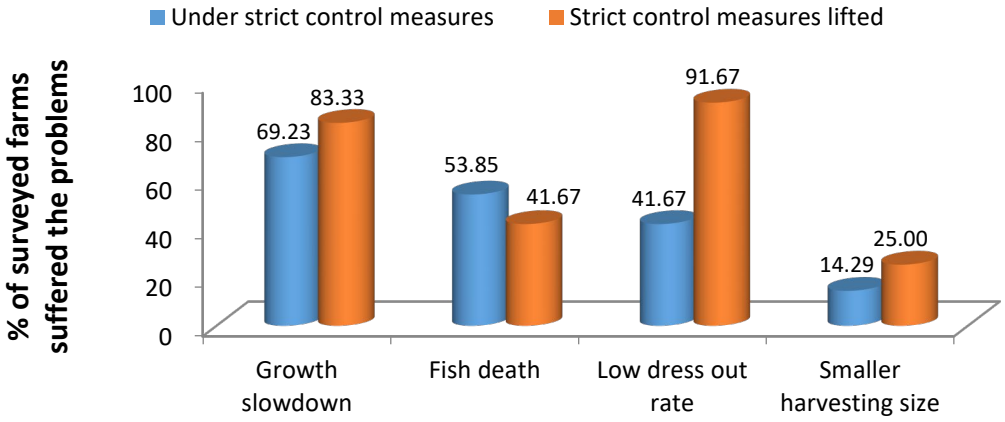

Figure 3-9 Impact on growth and product quality of channel catfish
Data source: Survey on impact of COVID-19 pandemic on channel catfish farming in Hubei province conducted during July-August 2020

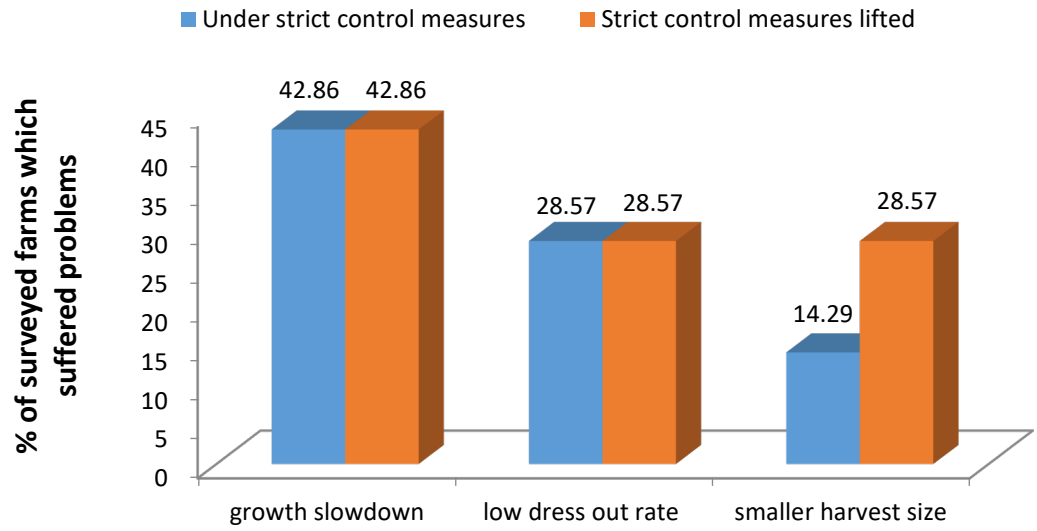

Figure 3-10 Impact on growth and product quality of tilapia
Data source: Survey on impact of COVID-19 pandemic on tilapia farming in Guangdong province conducted during July-August 2020

3.3.1.6 Expectations for channel catfish and tilapia sector in 2020

During the three-month implementation of strict measures to contain the epidemic, farm management activities such as transportation, personal access to farm and marketing etc. were seriously affected and this had a significant impact on growth and survival of fish and overall farm revenue in 2020. As a part of the questionnaire result, the surveyed farmers also provided their forecast on the production, sales and profits of channel catfish and tilapia farming in 2020 based on the current production situation and foreseeable market demand.

All interviewed farmers believed that there would be a significant impact on the overall sector performance of channel catfish and tilapia farming in 2020 (Figure 3-11). Respondents predicted a decrease of production by 20 percent for both channel catfish and tilapia. The respondents also expected a reduction of stocking area by 22 and 18 percent for tilapia and channel catfish respectively, and a reduction in stocking density by 26 and 17 percent for tilapia and channel catfish. All respondents forecasted that there would be decreased demand from foreign markets by 25 percent for tilapia and 30 percent for channel catfish respectively. Most respondents (>90percent) forecasted that the production cost would be 10-15 percent higher than previous years due to increased feed cost, labor cost and prolonged culture cycle. All respondents predicted that the annual profit would decline by 23 percent for tilapia and 26 percent for channel catfish in 2020. Figure 3-12 showed expectation of surveyed seed producers on their operational performance in 2020, which was almost the same as the grow-out farmers.

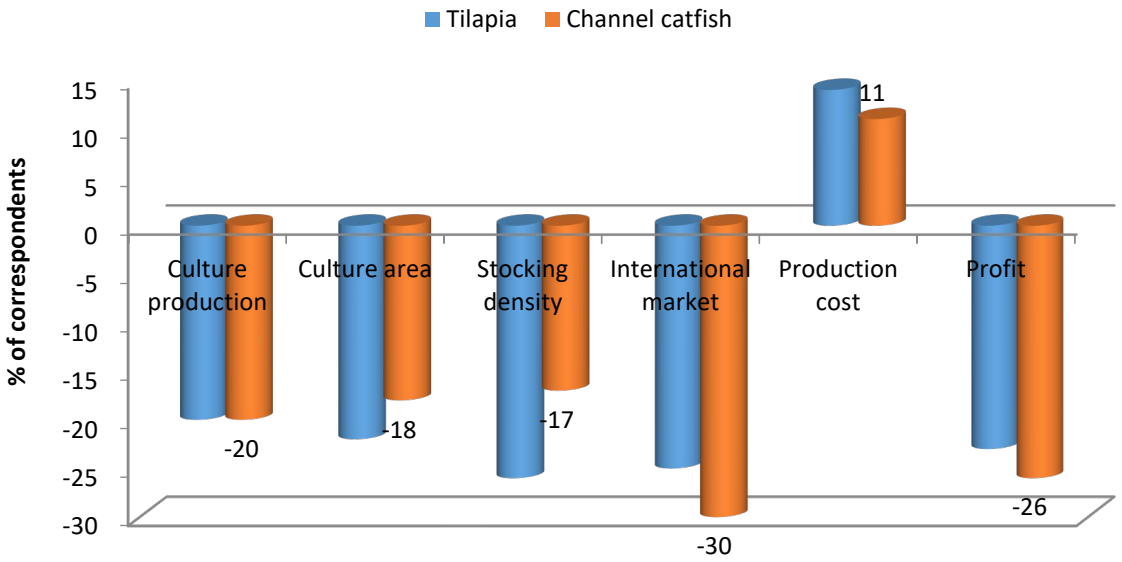

Figure 3-11 Expectation of surveyed grow-out farmers to their operational performance in 2020 in comparison with 2019
Data source: Survey on impact of COVID-19 pandemic on channel catfish farming in Hubei province and tilapia farming in Guangdong province conducted during July-August 2020

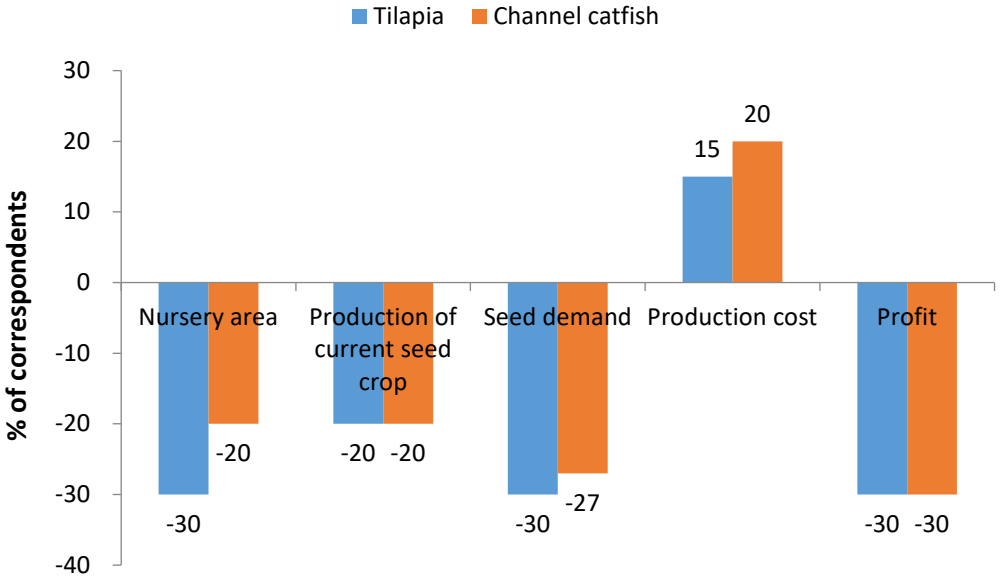

Figure 3-12 Expectation of surveyed seed producers to their operational performance in 2020 in comparison with 2019
Data source: Survey on impact of COVID-19 pandemic on channel catfish farming in Hubei province and tilapia farming in Guangdong province conducted during July-August 2020

3.3.2 Impact of COVID-19 pandemic on channel catfish and tilapia processers

3.3.2.1 The impact during and after the strict containment of the epidemic the recovery after strict epidemic containment measures lifted

Table 3-3 showed the major impact of the pandemic on channel catfish and tilapia processers during the strict containment measures of the epidemic and the recovery after the measures were lifted. Since

the enforcement of the containment measures, the new purchase orders from the domestic markets reduced by 30 percent for channel catfish compared with the same period in the previous year. Most tilapia processers did not receive new orders from the domestic buyers since the epidemic started. For international trade, tilapia processors encountered breach/cancellation of orders/contracts by 20-50 percent. The surveyed tilapia processors indicated a decrease in new orders by at least 20 percent compared with the same period in the previous year.

The actual sales of processed channel catfish and tilapia decreased by at least 30 percent compared with the previous year and product sales prices dropped by 5 percent during the strict epidemic containment period. The survey respondents projected the decreasing trend would continue due to the low demand. Survey results also showed there was an impact on the supply and transportation of fish harvest due to logistic difficulties and poor communication with fish suppliers.

Table 3-3 showed the recovery in operations of the processing plants after the lift of strict epidemic containment measures. Production of channel catfish processing plants had recovered to 40 percent of the same period of the previous year and tilapia processing plants had resumed 80 percent of its production in the same period of the previous year.

There was a lasting impact on the order and sales of channel catfish and tilapia processing plants after the lift of the strict containment measure. The surveyed channel catfish processors reported reduction of orders from domestic and international buyers. The respondents reported that orders for the channel catfish decreased by 50 percent compared to the previous year. It was reported that the orders from the domestic market were recovering, but the processing plants still had difficulties in delivering the finished products ordered. On the other hand, new orders received by surveyed tilapia processors from domestic buyers have increased by 10-20 percent. On the international markets, channel catfish processors had difficulties in fulfilling the orders placed due to insufficient supply. The new order for processed channel catfish and tilapia received were 60 percent and 15 percent lower than the same period as the previous year respectively. The actual sales of processed products decreased by 50 percent for channel catfish and 10 percent for tilapia compared to the same period in the previous year. In addition, there was still insufficient supply of raw material fish due to the disruption at farms. It is expected that the impact would continue on the processing sector for the rest of 2020 and recover slowly.

Table 3-3 Impact on channel catfish and tilapia processors in Hubei and Guangdong province (in comparison with the same period in 2019)

	Under strict containment measures		Strict containment measures lifted	
	Channel catfish	tilapia	Channel catfish	tilapia
Processing output	reduced by at least 20%	reduced by at least 15%	Processing recovered to 40%	Processing resumed 80% of the same period as the previous year
Raw material fish supply	insufficient	insufficient, price was lower 11.5%	insufficient	insufficient
Domestic order	existing orders decreased 10%; new orders decreased 30%	reduced existing orders by 40%, no new order	Existing orders decreased 50%. new orders decreased 60%	new orders increased by 10-20%
International order	signed orders cancelled 20-50%, new orders decreased 50%	new orders reduced by 20-30%	new orders reduced by 60%	new orders reduced by at least 15%
Actual product sales	reduced by 50%	reduced by 30%	reduced by at least 50%	reduced by at least 10%
Price	5% lower	No change	No change	No change

3.3.2.2 Expectations for 2020

Although the strict containment measures in China were lifted at the end of March 2020, the impact on operations and business performance of the processing sector will continue for the rest of the year. It will take time to recover the fish supply from farms and to resume the full business operation of processing plants. The lasting global pandemic situation would have significant prolonged impact on the processing sector, which implies great uncertainty in the international aquatic food market. The survey included the expectations of the respondents on their business operations and performance in 2020.

(1) Forecast on annual processing volume

Most respondents predicted that the demand for exports would be reduced by at least 20 percent, and the processing quantity would also be reduced by 20-30 percent although some respondents considered that the processing volume and export volume would not be significantly affected. Respondents predicted that overall sales in the domestic market would increase by about 10 percent in 2020, with increased sales at least by 5 percent at local and 10 percent at markets outside the province for channel catfish (Hubei province) and tilapia (Guangdong province).

(2) Forecast of annual benefits from the processing

The surveyed channel catfish processers projected that operating costs would increase by 30 percent and the profits would decrease by 30 percent in 2020 compared with 2019. As for tilapia processing, the operating costs would increase by 20 percent and the profit would decrease by 30 percent (Figure 3-13).

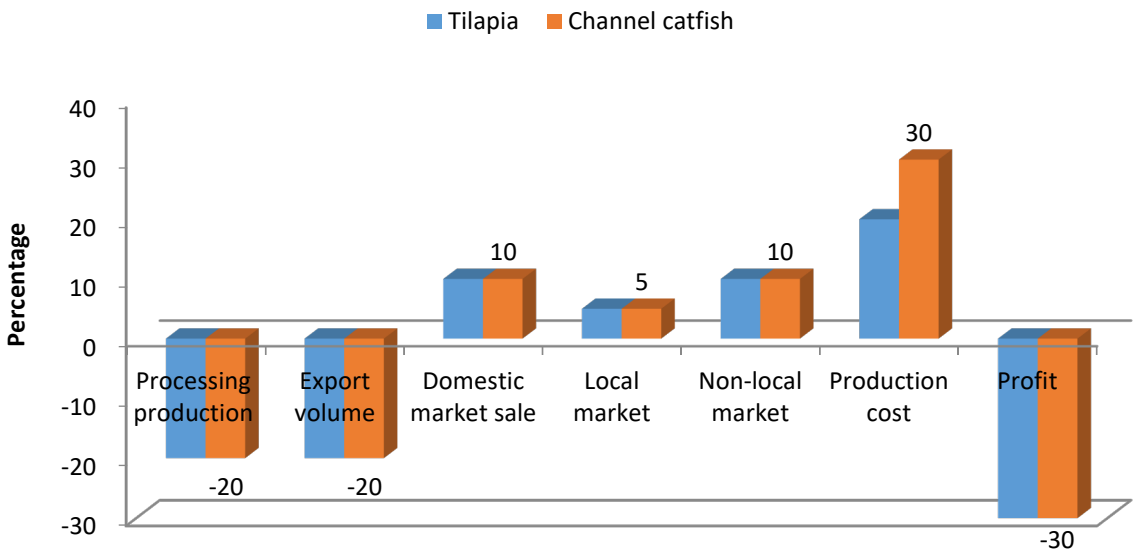

Figure 3-13 Expectation of surveyed processers to their operational performance in 2020
Data source: Survey on impact of COVID-19 pandemic on channel catfish farming in Hubei province and tilapia farming in Guangdong province conducted during July-August 2020

3.3.3 Impact of COVID-19 pandemic on channel catfish and tilapia traders

3.3.3.1 Impact during strict containment of the epidemic and recovery after the lift of strict epidemic containment measures

Figure 3-14 and Figure 3-15 showed the major impact on channel catfish and tilapia trade business during the strict epidemic containment and after the lift of the containment measures. During the epidemic containment, there was strict control of transportation, port closures, market closures, and interrupted circulation of goods. Businesses and operations recovered gradually after the lift of strict containment measures. The fish traders still faced the problem of insufficient supply of products, shortage of workers, and increased costs in labor and transportation (Figure 3-14).

The survey result showed that there was a significant impact on product sales of channel catfish and tilapia during the period with strict epidemic containment measures. As shown in Table 3-4, the orders placed were reduced by 30-60 percent for channel catfish and by 10-30 percent for tilapia compared with the same period in the previous year. The actual sales of products were decreased by 35-60 percent for channel catfish and by 10-80 percent for tilapia. The sales price was 10-30 percent lower, with an average of 18 percent than the previous year for channel catfish. Respondents indicated no new orders received during the strict containment period and the new orders received after the lift of the strict containment measure, was 30 percent less than the same period of the previous year for channel catfish and 20 percent less for tilapia.

Four months after the lift of strict containment measures, the survey showed fish trade and business operations resumed by an average of 30 percent compared to the same period of the previous year. Problems such as insufficient product supply and under-stock of goods still remained. The business profits dropped significantly due to low sales prices and sales volume. The total volume of ordered fish decreased by at least 20 percent compared to the same period of the previous year. Product sales prices were 10-40 percent lower than that of previous years, with an average reduction of 20 percent. The domestic sales of tilapia products had largely recovered. Seventy-five percent of respondents indicated that the orders and actual sales recovered to the level of the previous year.

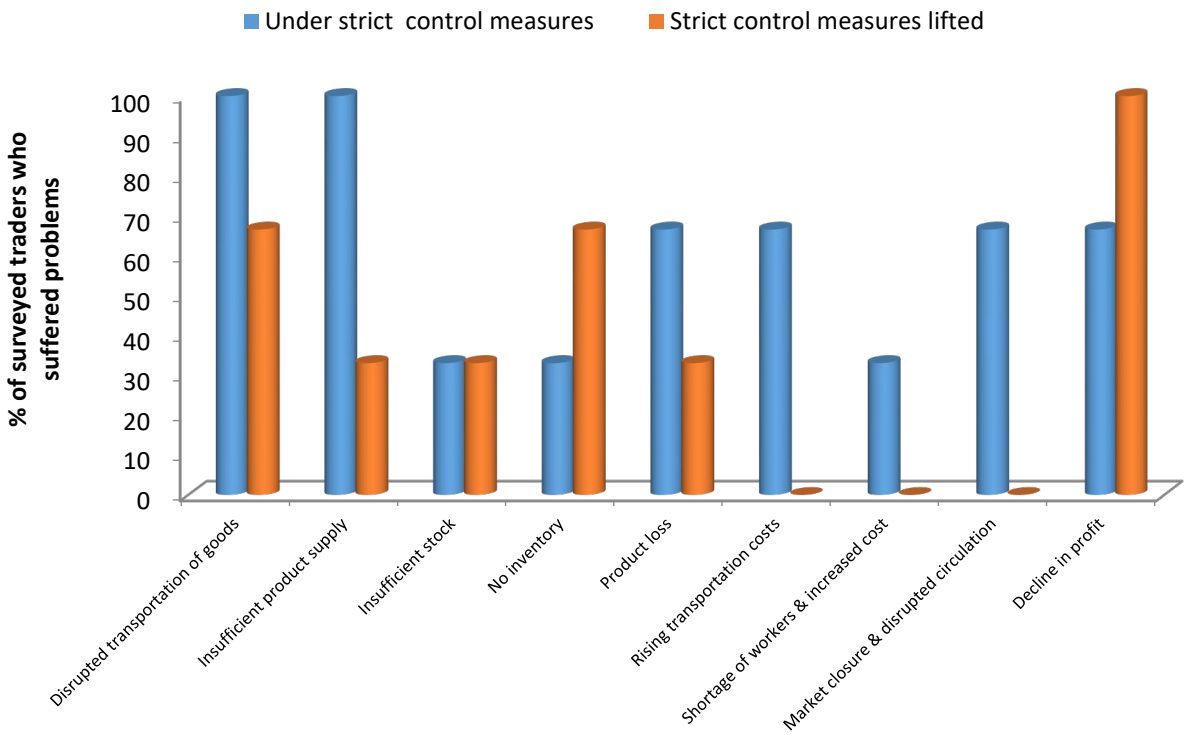

Figure 3-14 Impact on channel catfish trade business
Data source: Survey on impact of COVID-19 pandemic on channel catfish farming in Hubei province conducted during July-August 2020

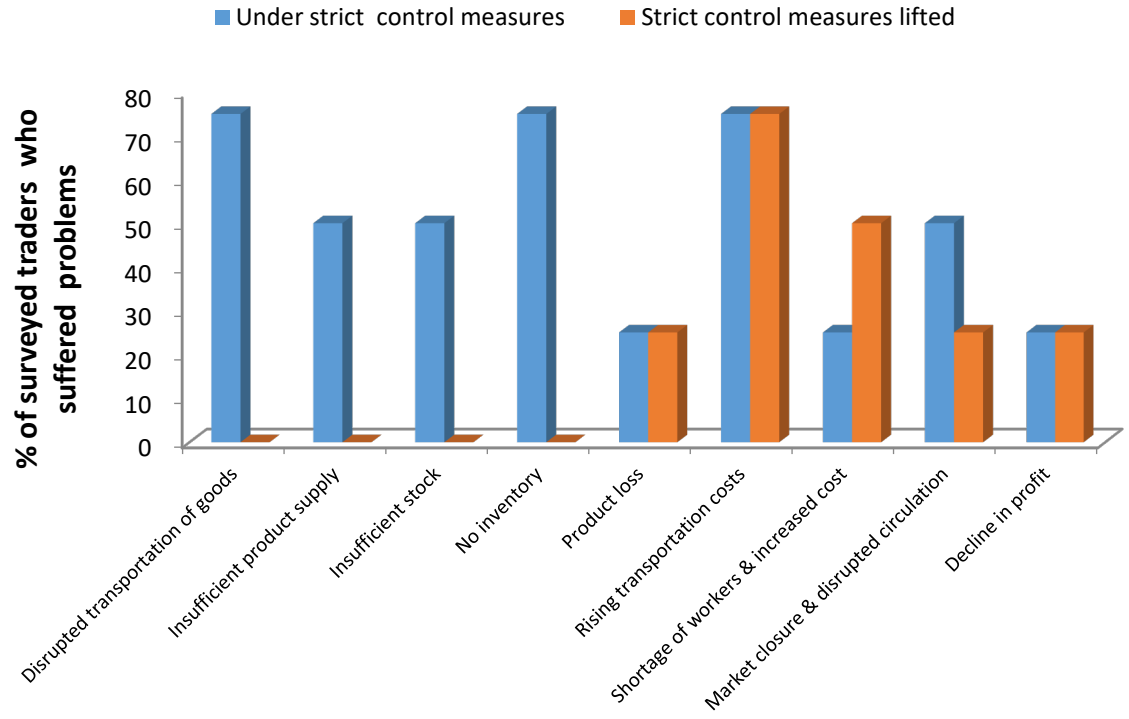

Figure 3- 15 Impact on tilapia trade business
Source of data: Survey on impact of COVID-19 pandemic on tilapia farming in Guangdong province conducted during July-August 2020

Table 3-4 Impact on sales of product

		Reduction in order received		Reduction in actual product sales		Price drop	
		Range (%)	Average (%)	Range (%)	Average (%)	Range (%)	Average (%)
Tilapia	Under strict containment measures	10-30 (50)*	20	10-80 (75)	40	10 (25)	10
	Strict containment measures lifted	30 (25)	30	30 (25)	30	10-20 (50)	15
Channel catfish	Under strict containment measures	30-60 (100)	46.67	35-60 (100)	41.67	10-30 (100)	18.33
	Strict containment measures lifted	40-50 (100)	46.67	30-70 (100)	50	10-40 (100)	18.33

Nation-wide, the average tilapia wholesale price in domestic market was CNY 15.96/kg from January to July in 2020, declined by 3.91 percent year-on-year (National aquatic products wholesale market price information collection system, 2020).

3.3.3.2 Expectations for 2020

The epidemic outbreak started just before the Chinese New Year and the strict epidemic containment lasted for two full months. The survey indicated that the enforcement of strict containment measures and lockdown would have significant impact on the trade business of channel catfish and tilapia in 2020.

All surveyed channel catfish traders projected that the sales of channel catfish in the domestic market would reduce by 20-50 percent (average of 30 percent). Three quarters of the surveyed tilapia traders predicted that tilapia sales in domestic markets would decline by 10-30 percent (average of 23 percent) (Figure 3-16). One quarter of the surveyed tilapia traders projected that the sale volume at wet-markets would increase by 10 percent and the sales through supermarkets and online would increase by 5-10 percent.

Due to the increased labor cost and declined sales volume, the respondent traders reported difficulties in capital liquidity. Surveyed channel catfish and tilapia traders forecasted that their operational cost would increase by 30 percent and 15 percent respectively compared with the previous years. The annual profit would decrease by 23 percent for tilapia traders and 30 percent for channel catfish traders compared to previous years (Figure 3-16).

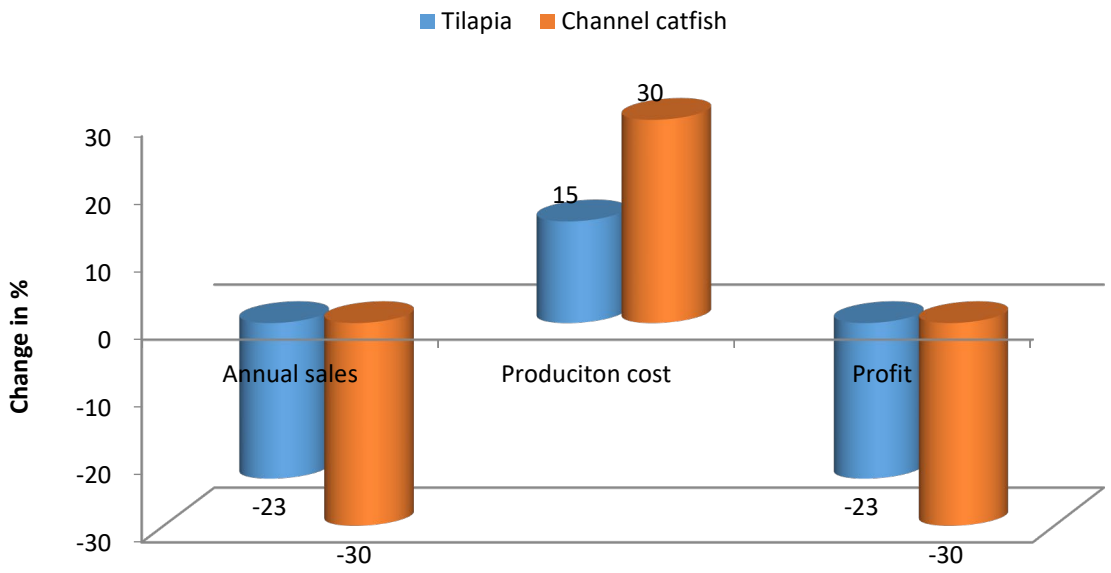

Figure 3-16 Expectation of surveyed fish traders to their business performance in 2020
Data source: Survey on impact of COVID-19 pandemic on channel catfish farming in Hubei province and tilapia farming in Guangdong province conducted during July-August 2020

3.3.4 Impact on the international trade of channel catfish and tilapia

The investigation showed the significant impact of the pandemic on the exportation of channel catfish and tilapia of China. According to China customs, the total volume of exported channel catfish was 72.56 tonnes during January-July in 2020 (Table 3-5) and decreased by 27.02 percent compared with the same period in 2019. The total export value of channel catfish was USD 1 459 791 and decreased by 28.54 percent compared with the same period in 2019. According to the export data of previous years, the total export volume from August to December was slightly higher than that of January to July. The total volume of exported channel catfish was 1 452 tonnes from August to December 2020.

Table 3-5 Export volume and value of China's channel catfish from January to July in 2019 and 2020

	2019	**2020**	**Year-on-year change %**
Export volume (tonnes)	99.4	72.6	-27 percent
Export value (1000 UDS)	643.5	459.8	-28.5 percent

Data source: China Customs

According to China customs, China's total tilapia exports were 222 139 tonnes from January to July in 2020 and decreased by 2.08 percent compared with the same period in 2019 (Table 3-6). The total tilapia export value was USD 602 million and decreased by 12.24 percent year-on-year compared to same period in 2019. The total export volume from August to December was slightly lower than that from January to July, the total volume of exported tilapia was 206 167 tonnes from August to December 2020.

Table 3-6 Export volume and value of Tilapia during January-July in 2019 and 2020

	2019	2020	Year-on-year change %
Export volume (1000 tonnes)	226.82	222.1	-2.08
Export value (million UDS)	686	602	-12.24

Data source: China Customs

3.3.5 Impact of COVID-19 pandemic on channel catfish and tilapia feed manufacturers

3.3.5.1 The impact during strict containment of the epidemic and the recovery after the lift of strict epidemic containment measures

The survey showed significant impact of the epidemic on aquafeed manufacture, because the supply of raw materials was greatly affected and the operational cost increase. The respondents reported that the price of feed ingredients increased by 5-20 percent over the previous year. The surveyed channel catfish feed companies reported no significant effect on the actual sales during the pandemic, while two thirds of surveyed tilapia feed companies reported a drop in purchase orders of 5-30 percent (averaging 20 percent). Half of the surveyed feed companies indicated there was no significant difference in sales price compared with previous years.

The survey showed that the production and business activities, such as staff recruitment, supply of bulk feed raw materials and additives, have been resumed after the lift of containment measures. No significant impact on the feed orders and actual sales was reported after the strict containment measures were lifted. The product prices remained the same of the previous years. The demand for feed products was not affected, and sales were recovered to levels of those from previous years.

3.3.5.2 Expectations for 2020

The survey respondents expected that the production costs would increase by 5 compared to previous years, and the profit would decrease by 5 percent, and there would be no impact on capital liquidity. The surveyed feed companies expected that there would be no significant impact on their sales after the pandemic.

3.4 Impact on external services

The survey also covered the impact on external services to the aquaculture sector, including power supply, water supply, credit services, insurance services, technical guidance services, and maintenance of facilities and equipment. Nearly 40 percent of the surveyed channel catfish farmers in the grow-out sector reported a shortage of power supply, with a gap of 10 percent. More than 10 percent of tilapia respondents indicated a shortage of water supply, with a gap of 40 percent. One third of the respondents reported difficulty in obtaining credit and insurance services for both channel catfish and tilapia sectors. In terms of technical guidance services, more than half of the surveyed tilapia farmers and feed manufacturers indicated that they were unable to receive the needed services on time. Channel catfish seed producer and feed manufacturers reported that their need for technical guidance was partially met. Increased cost of equipment maintenance was reported in the grow-out sector by 15-20 percent, and half of the respondents reported difficulties in maintaining facilities and equipment in the channel catfish seed production sector.

3.5 Impact of COVID-19 pandemic on livelihood of people engaged in channel catfish and tilapia industrial chain

3.5.1 Impact on livelihood of households engaged in the supply chain links

Although no COVID-19 infected cases were reported in all surveyed production units and related households, the impact on their household livelihoods was significant. In the grow-out fish farming sector, respondents reported a decrease in household income from January to March by up to 25 percent. In the seed production sector, all respondents reported a decrease in household income from January to March by over 50 percent. In the trade and marketing sectors, half the respondents reported a decrease of household income from January to March by less than 25 percent, and the other 50 percent of respondents indicated a decreased household income of 20-50 percent. All respondents indicated that the purchase of food and other daily necessities were not significantly affected but overall daily expenditure reduced. All the respondents indicated they were able to work normally although their travel was much reduced.

3.5.2 Impact on living and livelihood of staffs engaged in the value chain

The survey showed there was no cases of COVID-19 among the staff in all surveyed business units engaged in channel catfish and tilapia sectoral chain. There was an impact on their living and livelihoods to a certain extent. Forty percent of the respondents in the channel catfish sector reduced the salaries of their staff, while the respondents indicated no salary reduction in tilapia sector. Half the surveyed channel catfish farms reported layoff of staff during the strict containment period and a quarter of respondents reported livelihood difficulties for families of staff. There was no decreased salaries and layoffs reported in the hatcheries, processing and feed, and trade and marketing sector. One third of the respondents indicated the scheduled work of their staff was affected due to travel restrictions.

3.6 Special impact on women associated to the channel catfish and tilapia industrial chain

The questionnaire included a special component to investigate the particular impact on women's livelihoods and their role in aquaculture business operation. The results are summarized as follows:

3.6.1 Impact on women's daily living

The results showed that there was an increased burden on women in caring and educating their children due to school closures. Women were also under greater pressure in maintaining the basic living of the family. The survey showed women in grow-out and seed production households encountered difficulties in purchasing food and daily necessities due to road transportation restrictions. The survey indicated nearly 20 percent of women spent more time on online shopping and increased purchase of personal protection equipment (PPE) and sanitary items. The survey also showed that women paid more attention to diet composition and food nutrition during the epidemic period.

3.6.2 Impact on working time of women engaged in the supply chain links

There was significant impact on the time women devoted to production management during the epidemic. More than 80 percent of the surveyed channel catfish grow-out farmers reported reduced time women devoted to production management. Half the surveyed seed producers reported increased time of women in the seed production activities. Half the respondents reported increased working time of women in the market and processing sector. The survey respondents reported no change in the working time of women in aqua-feed production sector.

The survey showed there was an impact on the time women spent on the sale of products. About half the respondents indicated that the time women devoted in the sale of products increased significantly in grow-out farming, fish processing, and feed business, while the time women spent on the sale of products reduced in seed production and fish trade.

3.6.3 Impact on employment of women engaged in the supply chain links

The survey result showed that there was no significant difference between men and women engaged in the industrial chain links in terms of salary reduction and job layoffs. The survey result showed the epidemic affected more women engaged in channel catfish female grow-out farming than in tilapia grow-out farming in terms of salary reduction and job layoffs. Less than one third of surveyed tilapia farmers indicated that the epidemic affected women more than men in terms of salary reduction and job layoffs. In fish seed production, processing and feed sectors, there was no difference in terms of salary reduction and job layoffs between female and male staff. While in the fish trade business, the survey result showed female staff had been less affected than male staff in terms of salary reduction and job layoffs caused by the epidemic.

4. ACTIONS FOR MITIGATING COVID-19 IMPACT ON AQUACULTURE SECTOR AND SUPPORT ITS RECOVERY

4.1 Government strategy and measures adopted

While taking firm actions to stop the spread of the epidemic, governments in the two provinces adopted strategic and mitigation measures to ensure the basic livelihoods of the people and to maintain operations of the industrial chain. Relief aid was provided to families who encountered livelihood difficulties (elderly, disabled, sick, etc.), guidance and support was given to farmers and enterprises to maintain business activities and resume production after the lift of strict containment measures as well as to minimize economic loss caused by the pandemic.

4.1.1 Provide emergency relief support to ensure the basic livelihood of stakeholders

During the strict containment period, local governments provided unemployment insurance and basic livelihood support to people engaged in grow-out and seed production and fish processing sectors. For instance, the government provided nearly 10 million US dollars as a living allowance for 141 900 vulnerable people[28] in Jiayu county of Hubei province.

In Guangdong province, the government encouraged the enterprises to avoid or minimize staff layoffs by refunding 50 percent of the total unemployment insurance premium paid by the enterprises in the previous year. For families and individuals with difficulties in maintaining basic livelihoods during the epidemic, relief measures, such as provision of hardship subsidy and basic living materials, were adopted in a timely manner. Since the outbreak of the epidemic, the province had distributed relief funds of 300 million US dollars.[29] Nearly two thirds of the surveyed grow-out farms and 50 percent of the surveyed seed farms indicated they benefited from the unemployment insurance or were included in the minimum livelihood security scheme for urban residents. Fifty percent of the surveyed seed farms and fish traders and two thirds of the surveyed feed manufacturers received the government hardship subsidy in the form of shopping vouchers.

4.1.2 Support the normal production and operation of all links in the industrial chain

In order to support fish farmers in maintaining production and management activities during the strict epidemic containment period and resume production after the lift of the containment measures, fisheries extension agencies and research institutes provided specific technical support and online guidance to the farmers. In the meantime, government agencies strengthened the monitoring and surveillance of aquatic animal diseases as well as the early warning system.

For the fish trade sector, the government encouraged fish sellers to resume business operations with PPEs, practical and feasible COVID-19 prevention protocols while ensuring safety first. The local government adopted green passage for transportation of fresh and live food products and improved cold

[28] Jiayu distributed over CNY 10 million to support the social relief and assist the vulnerable under the epidemic [EB/OL] http://news.xnnews.com.cn/xwjj_1/202002/t20200228_1936518.shtml

[29] Guangdong Province has issued more than CNY 2 billion relief fund since the outbreak [EB/OL].2020-3-24, https://life.dayoo.com/money/202003/24/154561_53223784.htm

chain logistics systems etc. Measures were also taken to maintain market circulation of aquatic products, improve the product reputation through branding, and organize various online promotion events as a platform to link the producers and buyers. For example, “National aquatic products production and marketing platform" was established to collect and disseminate information on aquatic products production and demand, to solve the problems of asymmetry of marketing information.

For the fish processing sector, the government published special protocol on sanitation measures to prevention and containment of COVID-19 while maintaining operations and production activities in aquatic product processing plants. To keep up the circulation of aquaculture products, the government supported market and storage upgrading with automation and intelligent equipment. To facilitate fish exporters, government agencies accelerated the dissemination of information on aquatic product trade control measures adopted in importing countries and implemented measures to facilitate international trade of aquatic products.

4.1.3 Financial assistance

The government provided financial assistance to fish farmers and enterprises in the aquaculture industrial chain to cope with the difficulty caused by the strict containment measures under the pandemic, which included tax exemption, government subsidized loans, special fund support, exemption of some government funds and administrative charges. Other measures adopted to support the sector included exemption of fees for entry and exit inspection and quarantine, incentive for purchase and storage of aquatic products, preferential loans (0.5 percent low interest rate) and extension of loan payback date (up to 6 months) etc.

Guangdong provincial government issued a number of financial assistance measures in order to help enterprises to overcome the financial difficulties during the epidemic. For example, the government provided nearly 20 million USD policy subsidies for processing and trade companies to purchase and store aquatic products and poultry during the epidemic. The enterprises received a subsidy of USD150/tonne when purchasing aquatic products. It was targeted for processing and trade companies to purchase and store minimum 43 690 tonnes of aquatic products.[30] The government provided an allowance of USD 150/person for enterprise staff to return to work.

Figure 4-1 showed the percentage of surveyed stakeholders who benefited from government financial assistance measures. The result indicated that grow-out fish farms benefited mainly from the tax reduction and preferential loan subsidized by the government. Seed producers benefited more from tax exemption, exemption of government administrative fees, preferential loans and extensions of loan payback period. Fish traders mainly benefited from temporary financial incentives for purchasing fish products. Feed manufacturers mainly benefited from the tax exemption. Among all the financial assistance measures, tax exemption benefited the stakeholders most.

[30] Guangdong has allocated 120 million CNY to guarantee the "vegetable basket" for the purchase and storage of poultry, aquatic products, vegetables and fruits. [EB/OL]. 2020-03-11, http://www.gd.gov.cn/gdywdt/zwzt/yqfk/gdzxd/content/post_2928671.html

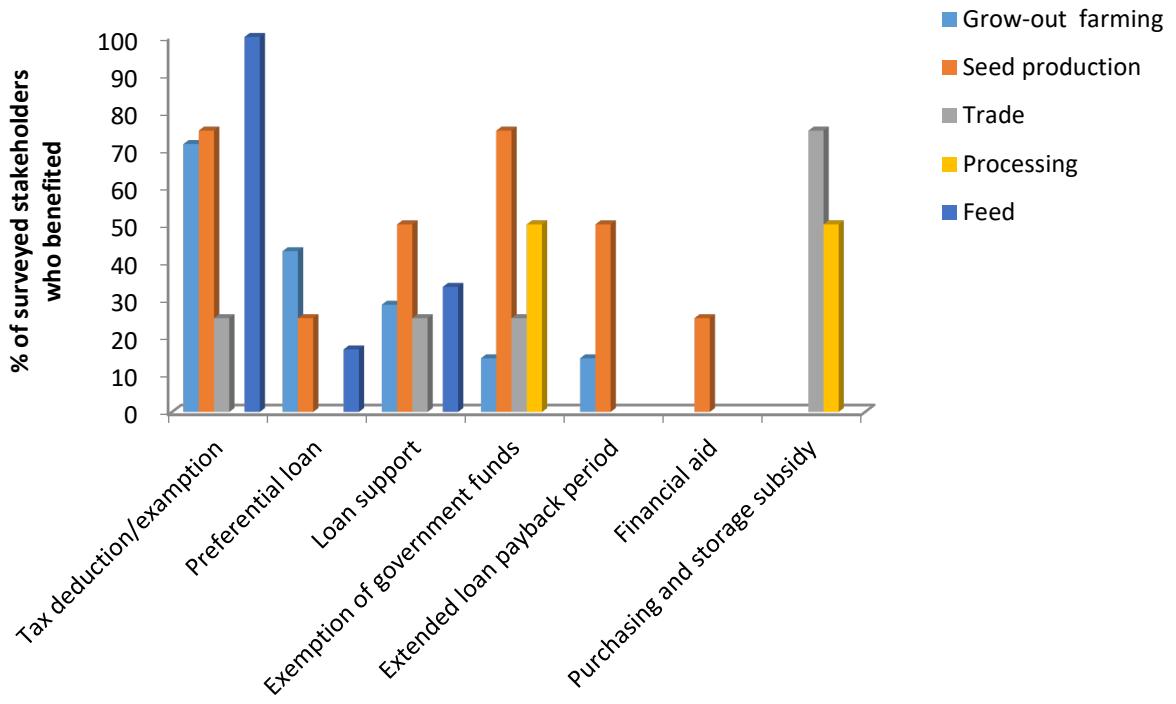

Figure 4-1 Surveyed farms and enterprises benefited from the financial assistance measures adopted by the Government during the epidemic period
Data source: Survey on impact of COVID-19 pandemic on channel catfish farming in Hubei province and tilapia farming in Guangdong province conducted during July-August 2020

4.2 Measures taken by sectoral stakeholders to mitigate the impact of the pandemic

The survey also attempted to assess the effectiveness of measures adopted by the stakeholders to mitigate the impact of the pandemic on their business. The surveyed farmers indicated that their association/cooperative provided measures to assist them to cope with the impact of the epidemic, which included adjustment of production plans, animal disease monitoring and surveillance, technical guidance for business resumption and, measures to reduce economic loss. The farm associations/cooperatives also assisted in organizing the marketing of products, the sharing of sales channels and the enriching of product types for diversified marketing. Over 80 percent of the surveyed grow-out farmers indicated they increased the number of processed products in selling their goods. One sixth of surveyed farmers explored innovative measures to increase product sales, such as create new selling channels, new product types, and improved resilience by prolonged production cycle and reduced feeding.

The mitigation measures taken by the surveyed seed producers included: reduced stocking area (15 percent), lower stocking density (15 percent) and operated e-commerce platform for online sales (5 percent). All respondents have taken mitigation measures, such as suspended operations, reduced/suspended purchases, and sales at negotiated low prices for bulk items, to address the immediate operations risks.

The surveyed processing plants indicated they have adopted measures to mitigate the impact of the epidemic, including adopting new processing techniques (e.g. frozen tilapia fillet breading and liquid smoking of tilapia fillet), producing higher value products, and increasing e-commerce and online sales. The surveyed fish traders indicated they increased the proportion of processed products and promoted the sales of their goods through online live broadcast to reduce the impact of the sale of fish products. The surveyed feed companies reported they adopted various mitigation strategies, such as enriching product types, improving the quality of feed, and selling promotional packages during the epidemic.

4.3 Anticipated further government support by the stakeholders for the sectoral recovery

In the questionnaire survey, all respondents expressed their anticipated further support from the government and public sector in the business recovery, which are summarized as below.

4.3.1 Support the recovery of farm production and business operations along the sectoral chain

- ensure the supply of production input, such as seed, feed ingredients, fishery medicines, etc.;
- provide technical guidance and demonstrations on resilient production, processing, and marketing in the context of global pandemic;
- support development innovative models and practices for both seed and grow-out production that are more resistant to various disasters;
- support enterprises to enhance their capacity on processing and storage of aquaculture products; and
- facilitate smooth logistics for feed manufacturers to source feed ingredients domestically and internationally.

4.3.2 Support enterprises to explore potential markets

- facilitate the expansion in domestic demand, reasonable price policy and diversified sales channels;
- enhance the market information system and capacity on analysis and timely dissemination of information to sectoral stakeholders;
- support the enterprises in developing new products to satisfy the domestic demand;
- support enterprises in product branding, certification and market promotion;
- support the e-commerce development of aquatic products and improvement of e-commerce logistic infrastructure and systems, which can lead to transformative changes in marketing of aquaculture products; and
- support the establishment of aquatic product traceability system to enhance consumers' trust on quality and safety of aquatic products.

4.3.3 Financial assistance

- extend the period of government financial support such as tax reduction and exemption, preferential loan subsidized by the government, extension of loan payback period, exemption of certain government funds and administrative fees; and
- improve aquaculture insurance schemes and favorable policies.

5. POST-COVID-19 PROSPECTIVE OF FARMED TILAPIA AND CHANNEL CATFISH SECTOR IN CHINA

With effective enforcement of the strict containment measures throughout the country, the COVID-19 epidemic situation had been effectively controlled in China by late March 2020. Since April 2020, the whole industrial chain of the aquaculture sector has been in a gradual recovery. Fish farms and enterprises along the sectoral chain have gradually returned to normal operations and production. The logistic systems related to aquaculture products is running smooth and the marketing and trade of live/fresh aquatic products has returned to its normal track. However, the lasting impact and evolving global pandemic would significantly affect the performance of tilapia and channel catfish farming sector in China in 2020 in the coming years. In order to have a general picture of the impact on the sector, a preliminary overall prediction was made on the farming scale, annual production, sales of products, volume of processing and economic performance of farms of tilapia and channel catfish in China in 2020 based on the result of the questionnaire survey, literature review and expert consultation.

5.1 Prospective of farmed channel catfish sector in 2020

According to the prediction by the experts, the total culture area of channel catfish is likely to increase by 10 percent in 2020 (second half of the year). It is expected that there would be an increase of production from the main channel fish farming areas and the consumption in China. The domestic demand for channel catfish is expected to increase in the second half of 2020. The total production would decrease by 10 percent and domestic consumption would remain the same for the whole of 2020. The total export of channel catfish may increase by 2 percent in 2020. However, the profit in the farming sector is likely to decline by 10 percent, as the operational cost will increase.

According to National Aquatic Products Wholesale Market Price Information Collection System, the average wholesale price of channel catfish was CNY 22.40/kg from January to July 2020, an increase of 12.11 percent compared to the same period of 2019. The market price is expected to increase in the second half of 2020 as the projected domestic consumption will increase.

5.2 Prospective of farmed tilapia sector in 2020

According to the prediction by the experts leading the national industrial programme, the total culture area of tilapia and stocking are likely to decrease by 5 percent respectively in 2020 in China. The total production of farmed tilapia is expected to decrease by 5-10 percent compared with 2019. The export of tilapia could have a small increase of 5 percent in 2020. However, the export price would be 5 percent lower than 2019. The profit in farming production would be 10 percent lower than the previous year.

6. RECOMMENDED GOVERNMENT STRATEGY AND MEASURES TO MITIGATE THE IMPACT OF COVID-19 PANDEMIC AND OTHER DISASTERS ON AQUACULTURE SECTOR

The COVID-19 pandemic had a significant impact on aquaculture sector globally. This survey analyzed and evaluated the actions taken by the government and sectoral players for mitigation and relief and recovery of the sector during and after the strict containment of the epidemic in China. This section summarizes recommended strategies and specific measures to minimize the impact on the aquaculture sector and livelihoods of the stakeholders as well as improve sectoral resilience to various risks. It is hoped these recommendations could serve as a reference to other FAO Members to enhance emergency and disaster preparedness for the aquaculture sector.

6.1 Strategy

6.1.1 Strengthen disaster early-warning system and capability in risk management

- strengthen monitoring and early warning system on public health emergencies and other hazards;
- improve the preparedness of the sectoral stakeholders in production planning, input supply and management;
- support monitoring and in-depth analysis of global aquaculture production and market information (both international and domestic) during and after the pandemic and provide strategic guidance to the sectoral stakeholders; and
- collect and disseminate on time information on import restrictions imposed by importing countries, provide technical support to enterprises engaged in export of aquaculture products to meet customs inspection and quarantine standards recognized by importing countries.

6.1.2 Promote innovation, advanced aquaculture technology and production system for better resilience and preparedness for disasters

- support development and adoption of aquaculture technology and innovations, such as distant and real-time monitoring, manipulation of cultural environment, auto-feeding, animal health management, vaccination and adoption of disease resistant strains;

- promote advanced aquaculture production systems and practices, such as reduced production cycle, aquaculture parks integrated with coordinated production, marketing and service facilities, supported with big-data on supply and demand;
- support the infrastructure development to facilitate the adoption of Internet of Things (IoT), Artificial Intelligence (AI) and big data in aquaculture to increase the resilience and preparedness of aquaculture sector to various risks such as COVID-19 and other hazards in addition to improved efficiency of production; and
- support the capacity building and knowledge sharing of aquaculture producers in applying different kinds of modern technologies, individually or collectively, to improve efficiency and increase resilience and adapt to the changing markets and consumer preferences.

6.1.3 Support the development of modern trade/marketing mode for aquaculture products

- support infrastructure improvement and development of logistics systems for modern trade/marketing modes for aquaculture products, such as E-commerce platform, internet+, online purchase and point to point delivery service;
- build the capacity of producers individually and collectively to effectively utilize a modern marketing platform to sell their products, particularly when the conventional marketing mode is disrupted by external strikes;
- incentivize producers and processors to develop new forms of products to adapt to the needs of modern trade/marketing modes; and
- support enterprises to improve cold chain facilities for increased storage capacity of aquaculture products to meet the changing market requirements.

6.1.4 Promote a dual circulation development pattern of the sector to satisfy the domestic and international markets with better resilience of when facing disasters such as COVID-19 and other market uncertainties

- strengthen the analysis of international market demand and the patterns of changes when the markets are stricken by major human hazards and natural disasters and develop specific strategy for the sector to tackle the challenges; and
- expand the demand of domestic markets for aquaculture commodities, which has been targeting heavily at international market traditionally and develop new forms of production to meet the changing preference of domestic consumers.

6.1.5 Improve social security and protection systems covering aquaculture sector

- strengthen overall social security and disaster response systems and mechanisms through well-coordinated financial and taxation policies and insurance systems at central and local levels to protect the entire sector when challenged by disasters like COVID-19 and other natural hazards; and
- strengthen the institutional arrangements and human capacity in providing emergency assistance and disaster relief to the sectoral stakeholders at different levels.

6.2 Specific measures for mitigation of COVID-19 impact

6.2.1 Provide emergency relief support to ensure the livelihood of stakeholders

- strengthen social relief to the vulnerable population to secure livelihoods severely impacted by the pandemic, particularly under restricted containment measures and provide timely livelihood support to families who are in difficulty through local government, public services and communities;
- establish special assistance for families with income below the local cost of living standard and households encountering serious livelihood difficulties due to family members being infected with COVID-19 or the related epidemic containment measures and provide timely emergency relief and medical assistance.

6.2.2 Establish green passage for logistics related to production transportation and products marketing of aquatic food sectors

- effectively implement green-passage mechanisms to ensure the normal delivery of aquaculture inputs and avoid backlog of farmed stock (both table fish and seed);
- support the farmers in timely harvesting and marketing of products and restocking to avoid significant disruption of normal production cycle;
- support the full operation of processing plants and maximize purchase of raw materials from farmers assisted with a minimal protective price subsidized by the government; and
- encourage fish traders to take temporary measures to purchase and store aquatic products in order to release farmers' pressure of "difficulty to sell" and enhance the confidence of the aquaculture industry.

6.2.3 Support the normal operation of the sector through strengthened sectoral monitoring and analysis and information dissemination

- strengthen real-time monitoring of farm production, marketing and trade of major farmed species and advise the sectoral chain players to take timely measures to respond to the changes and challenges;
- strengthen the monitoring of farmed animal diseases (including quarantine inspection of seed) and the infection of COVID-19 in the production and marketing chain to avoid the transmission of COVID-19 through farmed animals;
- strengthen the monitoring of operational status of processing plants, input supply for farming operations and changes in consumer markets and international trade to guide the normal operation of the entire value chain;
- strengthen sanitary measures, including recording of personnel movement and health checking and protective measures against COVID-19 infection at farms along the cold chain; and
- ban the trade of wild aquatic animals and stop the movement of wild aquatic animals for any purpose during the epidemic.

6.2.4 Facilitate e-commerce and internet-based marketing

- support establishment of e-commerce marketing platform for aquaculture products and facilitate individual delivery through chain retailers;
- encourage internet platform operators to facilitate online purchase/sale through lowering the entry conditions for individual businesses and platform service fees;
- facilitate the catering sector to provide cooked/prepared dishes through on-line orders and deliveries;
- support the farmers' organization, such as cooperatives, to play a more active role in collective marketing of products and business development including both online and offline marketing; and
- set up information sharing platform to vigorously publicize epidemic prevention and containment measures through full use of public websites, television, radio, new media (e.g., Tiktok, Wechat, etc.), mobile text messages, passenger stations, video on public transportation vehicles and other channels.

6.2.5 Encourage processing plants and farmers to develop new forms of products adapting to new marketing mode and market needs

- support processing plants and farmers in developing new products, such as semi-cooked, ready-to-eat and prepared fish dishes, which are more suitable for online sale and distant delivery to replace live and fresh whole fish through conventional marketing;
- promote diversified and convenient fish products of high nutritional value and health standards, which better address consumers' concern over health and food safety after the epidemic; and

- improve processing packaging and safety standard of fish products to facilitate the transportation, long shelf life and diversified modes of marketing.

6.2.6 Improve public services to companies engaged in international trade

- expedite the administrative procedures related to import and export, including custom clearance, quarantine inspection and required certifications through online services as much as possible, etc.; and
- provide the companies with up-to-date information on international shipment regulations and arrangements and related custom requirements and procedures during the pandemic.

6.2.7 Provide financial assistance to ease the difficulty along the industrial chain

- implement preferential financial policy measures to enterprises and farmers along the aquaculture industrial chain for them to maintain normal operations and mitigate the impact of the pandemic, which include extension of pay-back period of existing loans, subsidization of loan interest, reduction and exemption of administration charges taxation etc.;
- provide subsidy to companies on cost of electricity, fuel and logistics during the pandemic; and
- establish fast track and simplified procedures for SMEs in aquaculture industrial chain in obtaining loans from banks to overcome financial difficulties during the pandemic.

The COVID-19 epidemic has been under control in China since April 2020 and the entire aquaculture sector industrial chain has gradually recovered its operations, particularly in production and domestic marketing. However, the COVID-19 pandemic would have lasting impact on consumers' purchasing behavior, market demand and prices of aquatic products. There is great uncertainty to the overall aquaculture industrial performance in China and globally with the rebounding wave of COVID-19 pandemic after the summer 2020 in many importance economies. This report mainly presents the results of the survey on channel catfish and tilapia industrial chain in China during and after the strict containment measures. These surveys should be considered an assessment of sample case studies on the impact that COVID-19 had on producers (grow-out and seed), feed manufacturers, processors and traders. FFRC will continue to monitor and analyze the lasting impact of COVID-19 on aquaculture in China based on the eventual actual performance of the sector in 2020 and years to come.

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The COVID-19 pandemic has seriously impacted the overall aquaculture sector and the stakeholders along the value chain since its outbreak. FAO and the Freshwater Fisheries Research Centre of the Chinese Academy of Fishery Sciences jointly carried out an investigation into the impact of the pandemic on channel catfish (*Ictalurus punctatus*) farming in Hubei Province and tilapia farming (*Oreochromis spp.*) in Guangdong Province in China. The investigation also covered the strategy and measures taken by the government and the sectoral stakeholders to address the impact of the pandemic on the sectors. It was expected that the investigation would provide good information for FAO and its Members to better understand the impact of the pandemic on aquaculture sector with a view to developing appropriate strategies to cope with the pandemic and similar risks in the future. This circular is the full report of the investigation.

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