Innovations

Enhancing the Agri-aqua Food Value Chain through Smart Technologies and Partnerships towards Food Resiliency in the New Normal in Central Luzon, Philippines

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Abstract
Problem: *The COVID 19 pandemic brought disruptions to the whole supply and value chains including that of the tilapia industry bringing about declining production due to delays in stocking and difficulty in accessing input supplies aggravated by mobility restrictions that similarly impeded the transport of inputs and produce. These situations led to lower supply, consumption, and distribution and marketing of tilapia that pushed the surge in price making it less affordable and available to consumers with low spending capacity due to lost jobs. Even the persons involved in tilapia industry such as the fish vendors, processors, suppliers and transport workers lost their jobs due to the current health crisis. Improving the food supply and value chains in the new normal is imperative to adjust the management of the flow of goods and services towards increasing agricultural productivity and competitiveness.* ***Design/Methodology/Approach:*** *To demonstrate the convergence of technology transfer modalities, the supply and value chain improvement approach in multi-locations was employed with focus on building community-based food production enterprises and improving the operations of agri-aqua technology business incubators (ATBIs) to ensure food resiliency in the new normal.* ***Findings:*** *The tilapia farmers in Pampanga and Nueva Ecija were independent and hands-on in their tilapia farming business. They were generally exposed to high economic risks (i.e., declining farm gate prices of tilapia amidst rising feeds and fertilizers costs) and organizational risks (i.e., lack of unity among fishpond operators such that they sell their produce at a lower price compared with that offered by the other tilapia farmers in the area). Their concerns may be categorized into three: production, processing and marketing. The project expanded the production area, increased the raw material supply intended for processors' use and provided support mechanisms to the players in the entire food value chain in order to achieve an all-inclusive supply chain for tilapia in the region.* ***Conclusion:*** *The challenges faced by the tilapia farmers, the unanticipated impact of COVID-19 and the prevailing market conditions magnified the need for a more forward-looking policy package that focuses in the promotion of sustainability and resilience of the tilapia farming ecosystem in the region. This policy package must underscore science and technology interventions, maximization of the science and technology community-based farms (STCBF)-technology business incubation (TBI) interface, promotion of the food value chain, and support to programs for sustainable tilapia farming ecosystem in Pampanga and Nueva Ecija to address the immediate and medium-term needs of the tilapia farmers beyond the crisis. All these can reshape and build a resilient tilapia farming ecosystem in the region.*

Keywords: *food value chain, food resiliency, agri-aqua technology business incubation, tilapia, aquaculture, smart technologies*

Introduction

The COVID-19 pandemic evidently disrupted the global food value chain with border closures, quarantines, and market, supply chain and trade interruptions. The "new normal" put to fore the need for adaptation in our food supply and value chains. Nearly every aspect of our food system has been affected, causing bottlenecks that lead to food insecurity, inaccessibility and wastage. Improving the food supply and value chains in the new normal is imperative to adjust the management of the flow of goods and services towards increasing agricultural productivity and competitiveness.

The Food and Agriculture Organization (2014) of the United Nations defines a sustainable food value chain as *the full range of farms and firms and their successive coordinated value-adding activities that produce particular raw agricultural materials and transform them into particular food products that are sold to final consumers and disposed of after use, in a manner that is profitable throughout, has broad-based benefits for society, and does not permanently deplete natural resources*. Ensuring that food systems are integrated is a key driver towards food sustainability and economy. This project demonstrates the convergence of technology transfer modalities using the supply and value chain improvement approach in multi-locations, focusing on building community-based food production enterprises and improving the operations of agri-aqua technology business incubators (ATBIs) towards food resiliency in the new normal.

The participation of key stakeholders and the weight of external factors, such as local policies, socio-economic demography, and environmental conditions were taken into consideration in the implementation of this project. This project also unified the government's and the private sector's initiatives for achieving a more efficient, inclusive and sustainable food system in the region.

More importantly, government and institutional (e.g., university) regulations for entrepreneurship have a positive effect between business start-up and entrepreneurship development. Concerns in establishing a business, such as cost, time, number of processes required, and stable supply of raw materials, are relevant to the creation and life of new businesses. The government and institution policies and actions related to businesses are essential factors to the heterogeneity of the external and internal environments in which entrepreneurship activities of incubatees (producers and/or processors) reside and are part of social embeddedness.

In general, the national government and the institutions support entrepreneurship to generate jobs, create competition in the market and bolster innovation. Thus, to boost the innovation process, the national government and the institution improve the policies that support the creation of new business, i.e., Republic Act No. 10055 (Technology Transfer Act of 2009), Republic Act No. 10679 (Youth Entrepreneurship Act of 2015), Republic Act No. 8289 (Magna Carta for Small Enterprises), the CLSU Technology Transfer Policy and the CLSU-AFTBI Incubations Manual.

The project generally aimed to enhance the food value chain for tilapia in Central Luzon, Philippines towards improving agricultural productivity, competitiveness, efficiency and inclusive food sustainability.

Theoretical Background

Second to milkfish, tilapia is the most cultured freshwater fish in the country. Based on the 2019 Philippine Statistics Authority (PSA) data, fresh tilapia production in the Philippines totaled to 1,344,382.36 metric tons (MT) with Central Luzon contributing 644,113.05 MT or 47.91% to the total

national production. Central Luzon, a low-lying region north of the capital, provides substantial suitable freshwater ponds for tilapia production and has the advantage for being located near the biggest market for tilapia, the National Capital Region. The largest tilapia-producing province in Central Luzon is Pampanga which recorded 553,872.78 MT in 2019, contributing 86.0% to total regional production. Bulacan and Nueva Ecija contributed smaller production with 25,821.86 MT (4.01% contribution) and 22,316.90 MT (3.46% contribution), respectively.

The Department of Agriculture – Bureau of Fisheries and Aquatic Resources (2022) reported that the tilapia industry registered a 6.91% contribution (304,326.59) to the country's total fisheries production of 4,400,373.01 MT in 2020. With topography that allows the establishment of vast fishpond areas for culture, Central Luzon is credited for the majority of the production contributing 45.73% to the total tilapia production in 2020. The annual per capita consumption of tilapia in 2019 was 2.9 kg per year.

Guerrero (2019) reported that farmed tilapia production in the Philippines has generally been declining. He found out that while there was an increase in the production of farmed tilapia by 240% from 2001 to 2011, the production increase was only 7% from 2007 to 2016. The reasons for such as indicated by 55 tilapia farmers in Luzon and Mindanao in the study include high water temperature, lack of government assistance, poor breed of tilapia, high cost of production, and lack of capital.

While official data indicate no utilization for tilapia processing, Jamandre, et al. (2011) on their supply chain assessment of tilapia in the Philippines reported that tilapia fillet and whole frozen fish are preferred than whole live fish in the case of specialty shops and food chains. Specialty restaurants selling fish soups, tilapia belly and deep-fried tilapia skin absorb by-products of filleting. Specialty shops require consistent fillet size and volume. The total volume requirement of these institutional buyers is 1000 kg daily with a fish size of 1-2 pieces per kg (450- 600 g fish).

Jamandre, et al. (2011) also indicated that too few farms that could provide regular supply of the desired quality and volume of tilapia for processing, lack of capital for market expansion, and competition with cheaper imported counterparts concern processors.

Recently, the COVID-19 pandemic disrupted the whole tilapia supply chain bringing about declining production due to delays in stocking, difficulty in accessing input supplies aggravated by mobility restrictionsvis-à-vis transport of tilapia inputs and produce. These situationsled to lower supplies, and access and consumption concerns on tilapia distribution and marketing that pushed the price higher and made it less affordable and available to consumers with low spending capacity, taking into account the lost jobs of players in the supply chain such as the fish vendors, processors, suppliers and other transport workers.

Below is the framework by which an inclusive supply chain for tilapia in the region was achieved through expansion of the production area, increase in the raw material supply for processors and provision of support mechanisms.

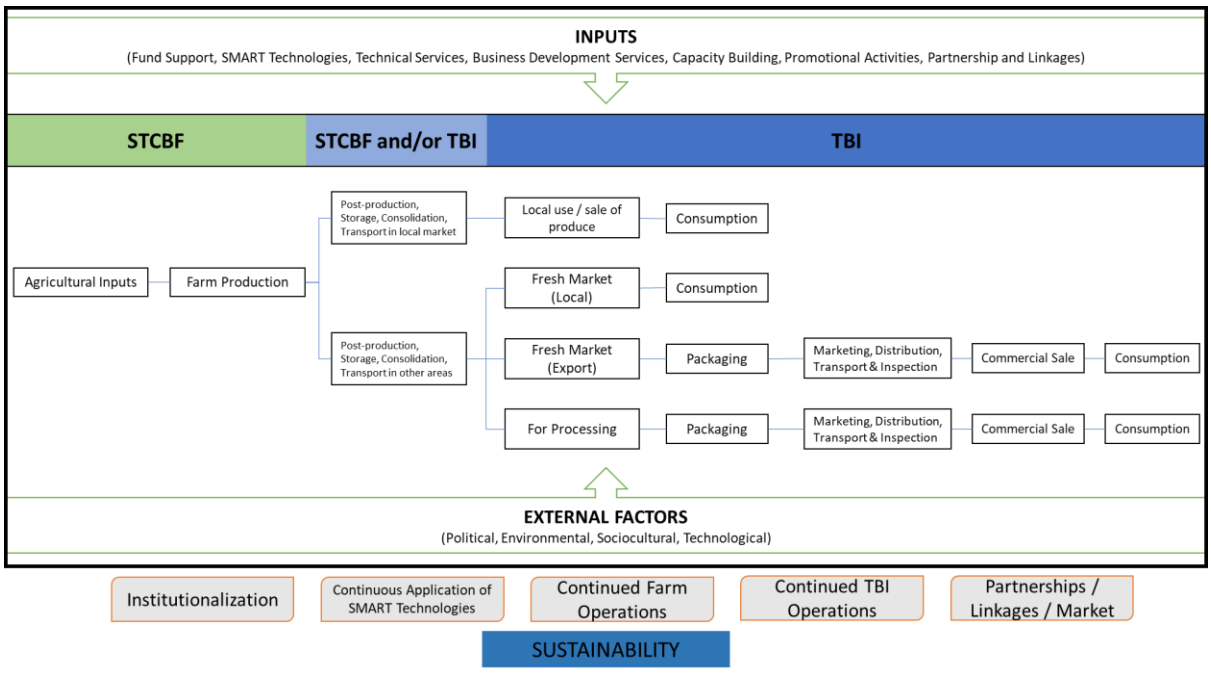

Figure 1. The conceptual framework used in the project

Method

Personal interviews, phone conversations, and focus group discussions were used to collect data. Visits to the farms of the cooperators in Pampanga and Nueva Ecija were also undertaken. The pond area, location, and accessibility of the respondents were taken into account. The results were determined using descriptive statistics based on the instrument used for the purpose: a questionnaire for both focus group discussions and individual respondents.

Sample

A total of 65 respondents comprised the final sample. This includes respondents from Nueva Ecija (71%) and Pampanga (29%).

Results and Discussion

Description of Fish Farmers' Practices

Farmers' current production practices in Nueva Ecija and Pampanga are as follows:

a. ***Location/site of production***

a. Pampanga - large pond size ranging from 1 ha – 5 ha per fish pond
b. Nueva Ecija – small pond size ranging from 200 sq.m. to 5,000 sq.m. per fish pond

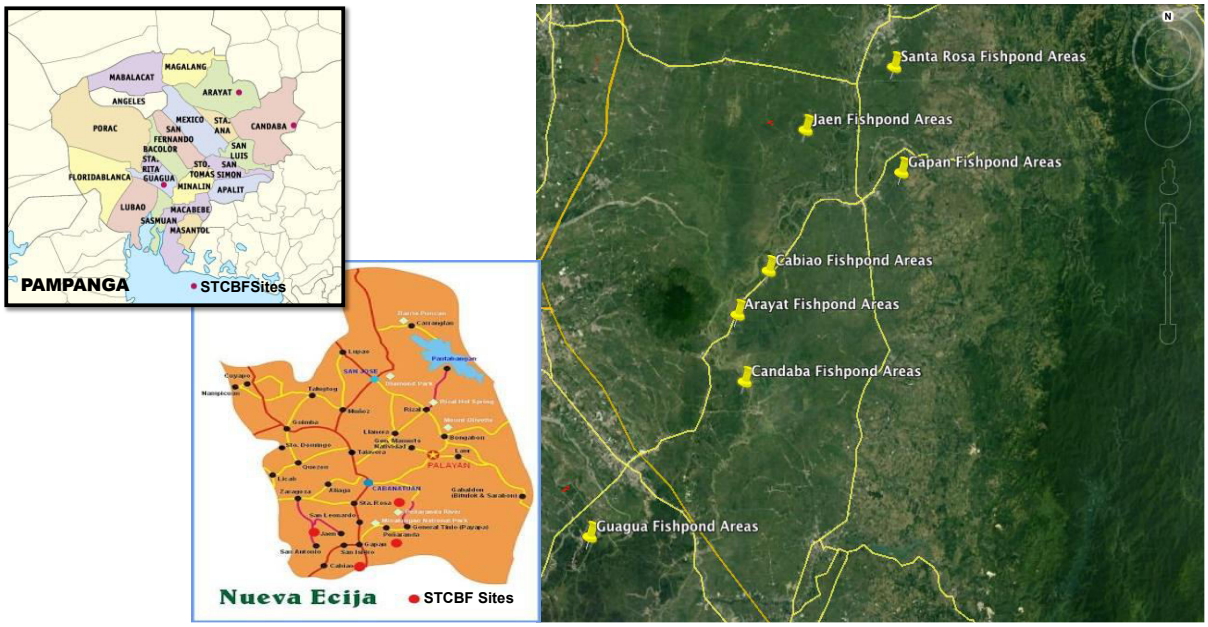

Figure 2. Project sites/STCBF locations in Pampanga and Nueva Ecija

b. ***Level of Management/Operation***

a. Pampanga – Semi-intensive to intensive commercial-scale operation which demands high number of fingerlings during stocking resulting to stocking of fingerlings with different size and sourced from different tilapia hatcheries

b. Nueva Ecija – Extensive to Semi-intensive small-scale operation requiring fingerlings that can be sourced out from a single hatchery

Overstocking and/or understocking based on available fingerlings is a concern of the tilapia farmers.

c. ***Feeding Management***

a. Pampanga - most of the fish farmers are influenced by technicians from feed companies, which results in bulk feeding without conducting sampling activity. Amount of feeds given is calculated based on the number of fingerlings alone resulting in overfeeding, high cost of production and low profit. Overfeeding also poses some environmental concerns.

b. Nueva Ecija – mostly follows the recommended and conservative feeding practices based on the size of the fish, determined thru fish sampling.

d. ***Nutrient Management***

a. Pampanga – Intensive application of inorganic fertilizer depending on the water condition is still practiced. Some farmers with integrated farming use organic fertilizers from their poultry or swine business

b. Nueva Ecija – Conservative application of inorganic and organic fertilizers

e. ***Water Management***

a. Pampanga – Main source of water is the Pampanga River and the irrigation system locally known as “delta”. Draining of pond water is usually done by pump due to the elevation issues of ponds and rivers.

b. Nueva Ecija - Most farms in Nueva Ecija are irrigated, but farmers also have deep well pumps to supply the ponds with fresh water. Some farms with drainage facilities can drain the ponds by gravity while some uses pump to completely drain the pond.

f. ***Harvesting***

a. Pampanga – Farmers with large ponds practice partial harvesting which may take up to a week or more.
b. Nueva Ecija – Total harvesting is usually practiced per pond and it takes a day or two to complete the harvest and prepare for the next culture period.

g. ***Marketing and Post-harvest Handling***

a. Pampanga – Most of the harvested fish are sold as live and in whole form to markets outside the province, mainly to NCR, Bulacan and as far as Isabela and Cagayan Valley.
b. Nueva Ecija – Locally-produced tilapia are usually sold in the local market as live in and whole form; some are processed into other products like tilading and smoked-fish.

The tilapia farmers in Pampanga and Nueva Ecija are independent and handson in their tilapia farming business. They are generally exposed to high economic risks (i.e., declining farm gate prices of tilapia amidst rising feeds and fertilizers costs) and organizational risks (i.e., lack of unity among fishpond operators such that they sell their produce at a lower price compared with that offered by the other tilapia farmers in the area).

Their concerns may be categorized into three: production, processing and marketing as shown in Table 1.Results show that all respondents from Nueva Ecija and Pampanga experienced problems on production particularly on high prices of inputs (feeds and fertilizers), unpredictable climate patterns, prolonged grow-out period, and over stocking (40k-50k fingerlings per hectare) as a strategy to meet the target volume of produce despite high mortality due to climate pattern fluctuations.

With regard to processing, a vast majority of the respondents encountered problem on lack of storage facility, while all of them mentioned that opportunities for value adding activities are limited.

As to marketing, all respondents reported that they suffered from financial losses due to price monopoly by traders and low price/fluctuating price of tilapia during harvest season. More so, most of them complained the high shrinkage allowance required by traders, and experienced extended growing period due to disrupted buying schedules of traders.

Examining these concerns, S&T interventions, maximization of the STCBF-TBI interface, promotion of the food value chain, and support to programs for sustainable tilapia farming ecosystem in Pampanga and Nueva Ecija are recommended to address the immediate and medium-term needsof the tilapia farmers beyond the crisis. All these can reshape and build a resilient tilapia farming ecosystem in the region.

1. **S&T Interventions**. To effectively complete the value chain, all available technologies, whether DOST or non-DOST supported, may be utilized. If technologies are not available at the host agency, those developed by other R&D institutions may also be applied. Depending on the needs of the farmers and in consultation with technical experts, the following baskets of S&T interventions/smart technologies on production and processing of tilapia can be utilized:

For Hatchery Operators:

a. *Aquashade for Increased Tilapia Seed Production During Warm Months*. Made of netting materials and a metal frame, aquashadedecreases the temperature in shaded ponds and positively impacts the reproduction and spawning rate of tilapia. It is especially helpful during the summer months of March to June when the temperature in the country hit over 36°C.
b. *Selection of Proactive Breeders for Higher Seed Production*. Each breeder is isolated in an aquarium and the eye color pattern (ECP) of each fish is observed daily. In determining the ECP values, the circular area of the eye is divided into eight equal parts using four imaginary lines. The ECP value is marked by fractional changes of the color of the iris and sclera around the pupil, which is transformed into scores ranging from 0 (no darkening) to 8 (total darkening). After two to three days, breeders with ECP values of 0 to 3 can be selected and are expected to produce more eggs and fry than those with ECP value of more than 4.
c. *Phytoandrogen, a Plant-Based Testosterone for Sex Inversion of Nile Tilapia*. Phytoandrogen is a substance produced by plants which has similar effects to testosterone in animals. Pine pollen is an example of phytoandrogen and is the male fruit of the pine tree, the richest seedbed of testosterone. On-farm trials indicated a 98-99% sex re-direction. The used of this plant-base hormone is also a supplement in boosting survival and immunity.

For Grow-out Operators:

a. *Use of Sex-reversed Fingerlings of Improved Strain of Tilapia.* Tilapia growers should be stocking the appropriate density of fingerlings based on their management practices and must secure quality fingerlings with uniform size and known strain upon stocking to minimize variation and achieve uniform size at harvest.
b. *Modular Culture System (MCS) for Increased Tilapia Production*. MCS aims to optimize yield per unit area, sustain natural food productivity during the culture period, increase survival rate at the end of the production cycle, control population of unwanted species, and improve cash flow. In this technology, the fish are transferred from one pond to another larger pond as the fish grow bigger. In this aquaculture system, higher production is expected because of the increased survival rate and production cycles per year. Size ratio of the ponds to be used can be 1:2 or 1:3 in case of using twoponds or 1:2:3 in case of using three ponds for the production of larger fish which can be marketedin fillet form. Fish can be stocked at 15 pcs/m^2during the first two months of culture, then4 pcs/m^2during the next two months and finally 2 pcs/m^2during the last two months.
c. *CRSP Alternative Reduced Feeding Strategies*. Reduced feeding technologies to control management costs can be deployed without compromising marketable fish production. The goal is to observe a variety of options for feeding that allow farmers to select the cost-cutting strategy that best suits their individual farm situation and production approach.

For Post-harvest Processors:

a. *Tilading Production*. The technology was conceptualized basically to maximize the use of the small tilapia left after harvesting the ones of marketable size. For dedicated *tilading*production, tilapia are raised for two months and harvested when they reach the ideal size for processing. *Tilading* is a processed tilapia product made from 20-30-gram split tilapia mildly salted and dried. The product has lesser salt content (around 6%) as compared with the ordinary dried fish sold in the market. *Tilading*is a tilapia processing procedure developed to prepare and produce healthy and clean processed tilapia. Due to the sanitized way of preparing the product, it has a longer shelf life that could last for six (6) months.
b. *Smoking (Tinapa).* It is the process of curing tilapia by salting, drying, heating and exposing it to smoke from burning or smoldering material.

c. *Tilapia Fillet Production*. It is the process of threading or stripping off the flesh of tilapia that has been cut or sliced from the bone and removing its scales.
d. *Freezing.* In this procedure, tilapia is placed in an airtight plastic wrap or heavy duty freezer bag and put in the freezer to prolong its shelf life.
e. *Canning.*It is the process of preserving tilapia in oil or brine in tin-plated and lacquered steel can, jar or similar container by heat or high pressure.
f. *Ice cream production technique using tilapia fillet and carabao's milk.*Tilapia fillet is processed to eliminate its fishy aftertaste and smell to make it a delectable dessert such as ice cream and cookies. The tilapia ice cream is made from steamed and roasted tilapia, carabao's milk, nuts and cheese, and is a rich source of protein and other vitamins.

2. **Maximization of the STCBF-TBI Interface**. The S&T community-based farm (STCBF) tilapia production systems are directly linked to the processing system based at the ATBIs. STCBFs are expanded S&T-based farms that showcase the effectiveness of an upscale application of S&T interventions to improve productivity, address the needs and capacitate clusters of tilapia farmers in selected areas of Pampanga and Nueva Ecija. Technological interventions are introduced in the locale by innovating the traditional method of tilapia production to achieve higher production and productivity. Sustainability and reliability of production at the farm level is also ensured by adopting staggered production and establishment of community-based enterprises. Community enterprises will supply 10% of tilapia produce to the ATBI incubatees and graduates, while the rest will be made available for the fresh market. This strategy will ensure the stable and increased access to and availability of both fresh and processed food products while contributing to the upliftment of livelihood and income of the food producers, processors and their beneficiaries.

CLSU AFTBI shall identify the critical resources needed to improve the business performance of its incubatees using tilapia technologies while the STCBF shall ensure the availability of such resources to improve the entrepreneurship ecosystem. Consequently, business incubators create value by combining the entrepreneurial spirit of start-ups with the raw materials that are produced by STCBFs.

3. **Promotion of the Food Value Chain**. To promote the sustainability of the food value chain, the hereunder procedure shall be undertaken:

Step 1. *Collection of stakeholders information*. The stakeholders include the general public, food value chain actors, customers and the environment. This information will serve as an essential input in defining the major sustainability-related concerns in the food value chain that must be addressed by the food value chain actors (input suppliers, farmers as primary producers, wholesalers as agents/traders, processors, manufacturers and retailers). The objective is to identify the relevant concerns and opportunities for sustainable food value chain.
Step 2. *Collaboration of food value chain actors*. This requires active participation from the representatives to each food value chain activity, specifically meetings (virtual or face-to-face) in the forms of open fora and workshops. During the meeting, identified concerns and opportunities in Step 1 will be discussed with the food value chain actors. At the end of the meeting, potential solutions to address the concerns and ways to implement the strategies in taking advantage of the opportunities shall be proposed.
Step 3. *Designing and selecting the best solutions, and assigning responsibilities to each food value chain actor.* This allows the development and utilization of a realistic value proposition to

ensure the sustainability of the food value chain. Such value proposition must be responsive to both the needs of the stakeholders and technology generators.

Committed to effect a significant contribution to income and knowledge generation, the Central Luzon State University operates the CLSU Agriculture and Food Technology Business Incubator (CLSU AFTBI). It is a facility that assists in training entrepreneurs and increasing the survival rate of innovative start-up businesses. CLSU AFTBI offers packages of specialized services on production and processing technologies of tilapia, rice, goat, mango, mushroom, vegetables and dairy carabao which are relevant to the country's economic development. Presently, CLSU AFTBIoffers a business acceleration program that provides supply chain resources and well-equipped processing lines to incubatees who need to expand their business and ensure a steady supply of raw materials.

Figure 3.The CLSU AFTBI Model for Sustainable Food Value Chain

4. **Support to Programs for Sustainable Tilapia Farming Ecosystem in Pampanga and Nueva Ecija**. Table 2 presents a situational analysis of the Pampanga and Nueva Ecija tilapia farmers. The following are the proposed sustainability strategies congruent to their experiences:

   a. *Enhancing Collaboration*. Food value chain collaboration is an essential partnership process where two or more tilapia organizations or tilapia farmers work closely to plan and execute food value chain operations towards common goals and mutual benefits. This can be done through information sharing, goal setting, decision making, resource sharing, incentive scheme development, collaborative communication and market niching.

   Collaboration among tilapia farmers organizations enables them to work together beyond normal B2B relationships. On the other hand, collaboration among tilapia food value chain stakeholders recognizes the importance of working and operating together as an essential tool to address their common concerns and achieve their shared goals. The concept implies that the tilapia food value chain stakeholders are involved in coordinating activities that span the boundaries of their organizations or individual business operations.

Considering the differences on how tilapia farmers do their farming business, there are risks related to collaboration that needs to be considered in the food value chain of tilapia. The role of traders, the evolving consumer's attitudes as well as the existence of stricter government regulations regarding business operations during pandemics and related scenarios have encouraged collaborative attitudes among stakeholders in order to achieve performance improvements across many levels of the tilapia farming business. Significant barriers to collaborations, however, also exist, i.e., differences among tilapia farmers in terms of economic size, cultural management approach and access to support. These deteriorate collaboration intensity due to lack of trust and operational complexity.

b. *Strengthening Risk Management Program.* In order to reduce the disruption in the production process and to enhance profitability of tilapia farmers in Pampanga and Nueva Ecija, they must have advanced information on the climate conditions of the locality especially those that pertain to possible flooding and incidence of drought, among many others. Efforts in monitoring and evaluating the farms to check the quality of water and growth of the fish must be intensified.

To enhance the technical know-how of tilapia farmers, they should regularly seek sufficient technical information from BFAR and other related government agencies near them.

Government should encourage tilapia farmers to ensure the sustainability of their enterprise by designing and implementing a functional mechanism in granting non-fiscal incentives, e.g., input subsidy for tilapia production, and price support for fresh and processed tilapia.

Credit on advantageous terms through quasi-government rent schemes with deferred payment schedules shall be developed and offered to tilapia farmers in general, more specially to small-scale tilapia farmers. More so, lending institutions must encourage tilapia farmers to avail of their services by ensuring that credit is available. Since various changes in the economy are risks to the utilization of capital by tilapia farmers, a tilapia farmers organization must be established/enhanced. Such establishment/enhancement will boost the development of the tilapia industry through a number of valuable roles (market information, intelligence reports, and promotions) and technical services (technologies, and extension services like training).

c. *Ensuring Technology Transfer through Pro-Active Technology Development Approaches.* There should be more emphasis on technology transfer by employing pro-active technology development approaches to better understand the concerns and opportunities, and to develop more appropriate technologies as solutions to overcome tilapia production, processing and marketing constraints and to harness the potential of the industry in meeting the unserved demands. Among the pro-active technology development approaches to be considered are:

(1) application of appropriate technologies by small, medium and large-scale tilapia farmers;
(2) development and application of best cultural management practices to improve farm management on commercial tilapia farms;
(3) use of information and communication technology (ICT) in farm business management to improve the profitability of tilapia farm business operations - this supports the farmers by facilitating access to markets through real-time data on market prices, weather forecasts, information on tilapia predators, ponds management techniques, and other related and important information; and

(4) institutional use of pro-active technology development approaches by involving tilapia farmers in effective decision making at the technology planning and development level, and within the tilapia industry as a whole.

d. *Establishing and Empowering Tilapia Farmers Organization.* Much is expected from the tilapia industry particularly in terms of addressing the country's food security agenda. There is no doubt that tilapia farming business will continue to grow in terms of area and production volume. However, the main challenge that confronts the tilapia farmers is how this growth can be sustained in a manner that all stakeholders in the tilapia industry will benefit from it amidst the challenges faced by the tilapia farmers in Pampanga and Nueva Ecija.

In view of the high expectations from the tilapia industry to provide sustainable supply (fresh and processed), the tilapia farmers are now in a phase when the establishment/enhancement of their organizations, and forging of cooperation and stronger partnerships among all the stakeholders involved in the tilapia food value chain are crucial to catch up with the needs of the time.

The tilapia farmers in Pampanga and Nueva Ecija shared that if one is to address the concerns of the tilapia industry, i.e., declining prices despite the rising prices of agricultural inputs, there is a need to strengthen the bargaining power of the tilapia farmers through the establishment/enhancement of their organizations. Parallel efforts must also be made in the formulation of policy programs and tilapia farmers organizational mechanisms to ensure that benefits from tilapia farming and advancements in tilapia technologies will reach the small, medium and large-scale tilapia farmers and all actors in the entire tilapia industry.

Despite the benefits offered by membership to organizations, competition among the tilapia farmers is becoming increasingly intense. Not only are the organizations competing among themselves but prospective members are now presented with a smorgasbord of alternatives.

The first strategic imperative of membership to organization is to offer something unique to its members. The second is to transform and adapt to continue to remain relevant to its members' needs. The members expect their organization to keep abreast with the latest and emerging trends in tilapia production and processing technologies.

Conclusions and Recommendations

The COVID-19 pandemic truly slowed down the progress of the project. Institutions, local government units, and the national government implemented health and safety protocols to arrest the spread of the virus. Lockdowns were implemented which resulted in limited movement of people from one place to another. The project was affected since it required visits to cooperators' farms in the region. It was therefore recommended the prospects of involving tilapia farmers in nearby localities to solve the problem of accessibility.

The appropriateness of the available production technologies like stocking of sex-reversed tilapia, use of aquashade technology and CRSP feeding technology also posed limitations to prospects of adoption by tilapia farmers because of the large sizes of their ponds. It is strongly recommended that tilapia farmers from nearby localities and with pond sizes that match the ideal be scouted and encouraged to participate in the STCBF Project. Emphasis should be put on the pond sizes as the available technologies only work best on certain conditions.

Moreover, given the overwhelming challenges that confront the tilapia farmers and the untapped potentials of the tilapia industry, the following measures are hereby recommendedto improve the productivity hence promoting sustainability of the tilapia food value chain:

1. Conduct market promotion activities with emphasis on niche opportunities for tilapia;
2. incentivize small tilapia farmers, e.g., providing windows for capital, reducing logistic and transaction costs in the entire food value chain for tilapia, and helping them in marketing their produce (fresh and processed tilapia) to motivate them to participate in the tilapia food value chain activities;
3. establish/strengthen tilapia farmers organizations;
4. establish centralized market (*bagsakan*) for tilapia in Pampanga and Nueva Ecija; and
5. intensify development and transfer of appropriate technologies to tilapia farmers.

These recommendations correspond to the concerns identified by the stakeholders. However, due to evolving needs and demands of stakeholders brought about by the pandemic and the factors of production, processing and marketing, the current practices and strategies of tilapia farmers need improvement to create an enabling ecosystem that promotes and ensures sustainability in the food value chain for tilapia.

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Table 1.The production, processing and

CONCERNS	NUEVA ECIJA n= 46		PAMPANGA n= 19		BOTH PROVINCES n= 65	
	Yes	**No**	**Yes**	**No**	**Yes**	**No**
	Number of farmers who experienced problems*					
Production						
High prices of inputs (feeds and fertilizers)	46 (100%)	-	19 (100%)	-	65 (100%)	-
Unpredictable climate patterns	42 (91%)	4 (9%)	19 (100%)	-	60 (92%)	5 (8%)
Prolonged grow-out period	19 (41%)	27 (59%)	13 (68%)	6 (32%)	30 (46%)	35 (54%)
Overstocking (40k-50k) as a strategy to meet the target volume of produce despite high mortality due to climate pattern fluctuations	15 (33%)	31 (67%)	9 (47%)	10 (53%)	22 (34%)	43 (66%)
Processing						
Lack of storage facility	35 (76%)	11 (24%)	19 (100%)	-	53 (82%)	12 (18%)
Limited opportunities for value adding activities	46 (100%)	-	19 (100%)	-	65 (100%)	-
Marketing						
Financial losses due to price monopoly by traders	46 (100%)	-	19 (100%)	-	65 (100%)	-
Low price/fluctuating price of tilapia	46 (100%)	-	19 (100%)	-	65 (100%)	-
Disrupted buying schedules	12 (26%)	34 (74%)	16 (84%)	3 (16%)	25 (38%)	40 (62%)
5%-10% (500kg – 1,000kg)15% (>1,000 kg) shrinkage allowance required by traders	8 (17%)	38 (83%)	18 (95%)	1 (5%)	23 (35%)	42 (65%)

Table 2. Tilapia Farmers Situational Analysis: The Case of Pampanga and Nueva Ecija

STEP 1		**STEP 2**			
		Proposed Sustainability Plan/Strategy			
Stakeholders	Opportunities	Enhancing Collaboration	Strengthening Risk Management Program	Ensuring Technology Transfer through Pro-Active Technology Development Approaches	Establishing and Empowering Tilapia Farmers Organization
1. Society	Limited MSMEs doing value adding activities in the areas near tilapia	✓	✓	✓	✓

	farms				
2. Food Value Chain Actors	High volume of supply of tilapia: Inconsistent demand of traders. In general, the capacities of tilapia farmers (volume produced) and the demand of traders are mismatched.	✓	✓	✓	✓
	Limited number of agents/traders: Marketing practices of tilapia farmers – Tilapia farmers are highly dependent on agents/traders and they are exposed to price fluctuations resulting to tilapia farmers' low profit margins.	✓	✓		✓
3. Customers	Limited market niche both for fresh and processed tilapia	✓		✓	✓
4. Environment	Poor farm management resulting to poor water quality: Excessive use of inputs (stock management and cultural management practices)	✓	✓	✓	✓