

Pangasius and tilapia value chains in Bangladesh: Markets, governance and quality

**Scientific report from WP2 of the Bangfish project
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Preface

The report *Pangasius and tilapia value chains in Bangladesh: Markets, governance and quality* is part of the project *Upgrading pang as and tilapia value chains in Bangladesh*. The project is funded by the Danish International Development Agency (DANIDA project number F38A26778) from which funding is gratefully acknowledged. The results and views presented here, however, remain solely the responsibility of the authors.

While the project contain the three elements of water quality, value chains and production economics, this report limits to value chains. Separate reports prevail on water quality and production economics. This report is organized around the three sub-elements on markets governance and quality of fish. The sections on markets (2.1, 4.1 and 5.1) is written by associate professor Max Nielsen, University of Copenhagen, professor and dean Badiuzzaman and PhD student Afjal Hossain, both Patuakhali Science and Technology University. The sections on governance (2.2, 4.2 and 5.2) is written by professor Taj Uddin, Bangladesh Agricultural University, associate professor Max Nielsen, professor Badiuzzaman and PhD student Imranul Islam, Patuakhali Science and Technology University. The sections on fish quality (2.3, 4.3 and 5.3) is written by professor Mahfujul Haque and professor Ismail Hossain, Bangladesh Agricultural University, associate professor Sazedul Haque, Patuakhali Science and Technology University, senior project manager Marco Frederiksen, Eurofish and PhD student Afjal Hossain. Finally, all authors have contributed to the literature review (section 2), where the section on data collection (section 3) is written by professor Badiuzzaman. Associate professor Max Nielsen and professor Badiuzzaman have coordinated the Bangfish project as well as the writing of this report. The scientific results presented in section 4 is a collection of abstracts of articles written in the project with most published in international peer-reviewed journals. Some of the articles includes external authors.

The report contributes by increasing the scientific knowledge base on domestic and foreign markets and on the role of quality and governance in the value chains, thereby delivering an improved foundation for making upgrading of the pangasius and tilapia value chains in Bangladesh possible. The target group of the report is stakeholders in Bangladesh with an interest in upgrading, including fish farmers, hatcheries, feed companies and sellers, commission agents, wholesalers, retailers, consumers, branch organizations, NGOs, politicians and researchers. The project have been presented at three Stakeholder Conferences. *The Startup Conference of Upgrading Pangsius and Tilapia Value chains in Bangladesh* held in Dhaka, Bangladesh 1 June 2015 presented the project plans, whilst preliminary results were presented and discussed at the *The Mid-Term Stakeholder Seminar* in Mymensingh 12 November 2018. At *The Final Stakeholder Conference* in Mymensingh 18 January 2020, the results of the project were presented and formed the basis for a debate on development options for the sector.

We hope that the extensive scientific knowledge on pangasius and tilapia value chains appearing from the project facilitate continuous development of the sector and over time lead to export. We also hope that the project increase the scientific capacity to handle future challenges.

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1. Introduction

The background for this report is that large quantities of pangasius and tilapia is produced in Bangladesh and sold to domestic consumers often at low quality. With quality deteriorating both at farms and when passing long value chains before reaching the final consumers, the main challenge is to improve the quality of fish and the functioning of the value chains. For the good of the domestic consumers, for the good of the economy of farmers and other actors in the value chains and potentially for providing export earning at some stage in the future

The purpose of this report is to provide knowledge on how the pangasius and tilapia value chains in Bangladesh works and to identify how the value chains can be upgraded by providing more knowledge on fish quality, markets and governance of the value chains. Governance, markets and quality of fish are analyzed at all levels in the value chain, both domestically and potentially for export. By this, the structure and governance modes in chains are identified (Gereffi et al 2005). Contract use, power (Pietrobelli and Saliola 2008), value distribution, quality measurement and management, logistics, market integration, price setting and incentives for quality improvements in chains are investigated. Quality changes of pangasius and tilapia along the distribution chain are mapped to identify causes of and remedies for deterioration. The barriers and potential facilitating conditions of farmers in meeting international standards, as set by the Hazard Analysis and Critical Control Points (HACCP) and by Aquaculture Stewardship Council are analyzed (Belton et al 2011). Tariffs are negligible to developed countries markets due to Bangladesh's status as a Least Developed Country. Effects of water quality on price/sale are identified through determining implicit price of fish quality. International trade data from other countries exporting pangasius and tilapia, including Vietnam, is analyzed to identify potential export markets for pangasius and tilapia of different qualities from Bangladesh.

In section 2, literature on market structure, integration and demand is reviewed, while section 3 describes the data collection in the project. In section 4, scientific results achieved in the project are reported in the three groups of market structure, governance of value chains and quality of fish, while section 5 discuss implications of these results. Section 6 concludes the report.

2. Literature

2.1. Market structure

Pangasius is one of the fastest aquaculture growing species in the world (FAO, 2010). The total production of this species was 1.6 million tonnes in 2012 (Food and Agricultural Organization of the United Nations 2019). Vietnam is the largest producer contributing almost 75% of the total global production. Bangladesh, Cambodia, China, Indonesia, Malaysia and Laos, are some other Asian countries producing this species too (Food and Agricultural Organization of the United Nations 2019). In the study, Thong et al. (2017) stated that pangasius is evaluated as a necessary good in almost all existing markets and the major export markets such as Europe and North America. As a necessary good, the price is less responsive to change in consumption scale. Therefore, the global pangasius industry is relatively little affected by recessions and booms of the world economy. Pangasius companies, thus, may supply new markets in developing regions such as South Asia, South America and Africa because it is mostly consumed by low income households.

Globally pangasius production and exports are growing at a relatively stable rate without facing any risk like substantial price reductions. But it is seen that the contribution of fisheries to the diet is affected by competition from aquaculture growth when the market share of wild fish is large. The

issue of fish market integration in developing countries is interesting because fish is an important part of the diet and studies of fish market integration in developing countries are largely non-existent. Bangladesh in particular is an interesting case because only 10% of the total seafood production is exported and almost no exports of the species analysed before. Hence market integration between farmed (pangasius and tilapia) and wild (hilsha, swamp barb, prawn, wallago and long-whiskered catfish) species are important in Bangladesh.

A few theoretical studies are available on market integration between farmed and wild species. Both Anderson (1985) and Valderrama & Anderson (2010) studied the effects of aquaculture growth on commercial fisheries whereas Jensen *et al.* (2014) examined that aquaculture may be influenced by improved fisheries management. Anderson (1985) found that when farmed fish have noticeable market shares, growth in aquaculture reduced the prices of wild fish thereby reducing overexploitation, overcapacity and the number of fishers. On the other hand, Jensen *et al.* (2014) showed that improved fisheries management might limit aquaculture growth. With many inland fisheries in developing countries like Bangladesh being open access or weakly managed, it is expected that when farmed fish have a noticeable market share, aquaculture growth will result in this double gain, if the markets for wild and farmed fish are integrated.

Several studies are available on market integration between farmed and wild species are available but not conclusive. Markets for farmed salmon and salmon trout are integrated with the wild salmon in Finland (Virtanen *et al.*, 2005). Nielsen *et al.* (2007) found market integration between farmed trout and all wild fish except salmon in Germany. Nielsen *et al.* (2009) investigated market integration for several fresh and frozen fish species in Europe and found markets are integrated except for shrimp, whereas Norman-Lopez (2008; 2009) investigated the market integration between farmed and wild fish in the US market and found market integration between farmed tilapia and wild fish stating that tilapia market is different from other farmed fish. Nielsen *et al.* (2011) also identified market integration between markets for trout and wild-caught redfish (also known as ocean perch) in Germany, both at markets for fresh and frozen fish. Asche *et al.* (2001) found market integration between farmed and wild salmon in EU and USA. Ankamah-Yeboah *et al.* (2017) showed that market integration have been confirmed in most of the cases testing between cold and warm water shrimp value chain and found nodes of the shrimp value chain integrated. Ankamah-Yeboah and Bronnmann (2018) identified market integration for the species shrimp and lobster in the German crustaceans market. Bjørndal and Guillen (2017) found market integration between wild and farmed conspecifics for blackspotseabream and Atlantic cod in Spain. Bayramoglu (2019) found market integration between farmed seabream and wild seabream in Turkey while Pincinato and Asche (2016) found market integration between wild and farmed shrimp in Brazil. In both the studies, the researchers found market integration between conspecifics species. Asche *et al.* (2012) found wild and farmed shrimp compete in the same market. Despite the literatures not being conclusive results of Nielsen *et al.* (2012) indicated that price formation studies must include the whole integrated markets when considering the effect on prices of changing supplies. Based on the literature, the decline in German imports of pangasius and tilapia in 2010-2014, together with the growth of cod imports in the same period, the hypothesis is that markets for the wild-caught whitefish in Germany are closely connected to the farmed whitefish (pangasius and tilapia) markets.

2.2. Governance of value chains

Sampath and Vallejo (2018) focused on how successful innovation systems interacted with trade and global value chains participation to foster learning and technological upgrading in 74 developing countries. They concluded that in successful and outperforming countries, firms relied on several attributes of the innovation system to leverage knowledge flows within and outside of global value

chains to build export capacity and diversify horizontally into new global value chains. Kano (2018) explored the relational dynamics of global value chain governance and opined that efficiency of global value chains could be enhanced using six internal and external mechanisms which were: selectivity, inclusion of non-business intermediaries, joint strategizing, relational capital, multilateral feedback, and rules for equitable value distribution. Neela (2015) conducted a study on value chain governance of tilapia and found that wholesalers added highest value to tilapia and value chain governance was very weak in the study area. Jespersen *et al.* (2014) examined the key factors shaping selected aquaculture value chains in four Asian countries and found that the most sophisticated aquaculture operations in Asia were found in value chains led by retailers and branded processors.

Ponte *et al.* (2014) observed the upgrading trajectories of selected aquaculture value chains in four Asian countries, and found that the type of value chain drivers and the quality of the domestic regulatory framework were the main facilitators of upgrading. Hossain *et al.* (2013) reported that in the case of small, medium and large fish, value addition was 14-23%, 17-23% and 52-69%, respectively. Lee *et al.* (2011) studied upgrading of global value chains as a means of poverty reduction and revealed that dynamic monitoring of global and regional chains, joint public-private support for value chain upgrading and improved trade metrics would provide more effective policy interventions for poverty reduction in a rapidly changing global trade environment. Maurice *et al.* (2010) conducted a study on the value chain of farmed African catfish and the main findings indicated that lack of cooperation in the domestic value chain, which had led to vulnerability of farmers though the chain had potential for higher income. Akhter (2009) worked out a study on value chain analysis of dairy sector and found that processors added the highest value per liter of milk which was followed by producers, traders and retailers.

Fold and Larsen (2008) studied globalization and restructuring of African commodity flows and stated that in many export chains, governance had shifted from producers to buyers, with important implications for producers, exporters and farm workers in African countries. Gereffi *et al.* (2005) built a theoretical framework to help explain governance patterns in global value chains and pointed on three streams of literature to identify the variables that play a large role in determining how global value chains are governed and changed which were: the complexity of transactions, the ability to codify transactions, and the capabilities in the supply-base. Humphrey (2005) carried out a study on shaping global value chains for agribusiness development and revealed that the impact of increasing concentration at different points in the value chain on producers and exporters in developing countries takes place through three channels: concentration in manufacturing and processing, global processors/manufacturers and changing consumption trends and trade liberalization. Ponte and Gibbon (2005) evaluated the quality standards, conventions and governance of global value chains, and argued that global value chains were becoming increasingly 'buyer-driven', even though they were characterized by 'hands-off' forms of co-ordination between 'lead firms' and their immediate suppliers as lead firms had been able to embed complex quality information into widely accepted standards and codification and certification procedures.

The above literature identified analyses of domestic and global value chains, of fish and other products, and on upgrading strategies. But there is a limited evidence of studies incorporating pangasius and tilapia value chain analysis with internal and external governance analysis. Therefore, to minimize the research gap, this study aims to point out the pathways of improving the efficiency and effectiveness of pangasius and tilapia value chain by analyzing the internal and external factors of governance followed by the stakeholders. Efficiency of a value chain refers to the standard of stakeholders' performance in terms of cost-related advantage while effectiveness measures the preference of consumer responsiveness over stakeholders' performance (Borgström, 2005). The specific objectives of the study are: i) to develop a pangasius and tilapia value chain map and estimate the value addition by different actors; and ii) to address the governance structure and factors affecting

governance of pangasius and tilapia value chain actors. The study will analyze value chain and governance of pangasius and tilapia altogether, which will help to identify the problems of the value chain actors that are important for the government, non-government organizations, business people and policy makers.

2.3. Quality of fish

In Bangladesh, pangasius and tilapia are popular white fish species for its affordability, nutrition, delicacy, mild flavor and easy processing and preparation (Nguyen and Jolly, 2017). The farming of these species in Bangladesh is quickly adopted by the farmers due to their robust husbandry characteristics such as simplicity of artificial seed production, good response to external feeding, rapid growth rates, good survival at high stocking densities, higher yield and domestic market demand than that of indigenous cultured species (Belton et al., 2011; Ali et al., 2013; Haque et al., 2016). A large number of farmers are practicing commercial farming of pangasius and tilapia, thereby farming of these species evolved to a shape of commercial enterprise having long backward and forward networks with a wide range of value-chain stakeholders (Ahmed et al., 2012; Haque, 2012). In Bangladesh, pangasius and tilapia farms are mainly small-scale and farmer-operated, and have developed in a clustered pattern following the conversion of lowland rice-fields (Ali et al., 2013). The farmers practiced polyculture of pangasius and tilapia with indigenous and exotic carps for different reasons. The available literature showed that the polyculture system is adopted by the farmers to increase pond productivity and farm income, and thereby improve their resilience against downward fluctuations in market prices (Anwar, 2011; Ahmed and Toufique, 2014).

Pangasius and tilapia farming is affected by various factors such as inputs (labor, capital, seed, fertilizer, feed etc.), pond size, average capital-labor ratio, and average yield per unit of land (FAO, 2001). According to economic modeling, the major contributing factors are age of farmer, literacy rate, experience of farmer, age of ponds, farm area, pond depth, water source, water exchange rate, stocking density, feeding strategy etc. (Ahmed, 2007; Veerina et al., 1999). The growth of commercial pangasius and tilapia culture was supported by the development of input suppliers, in particular, those related to the production of seed and feed (Ali et al., 2013). For intensive farming of these species, farmers apply large quantities of pelleted feeds with various feed additives like antibiotics, pigments, antioxidants, immune stimulants, probiotics, etc. They also indiscriminately use a wide variety of antibiotics and other therapeutants to treat and control diseases of fish, and a variety of chemicals that include fertilizers, liming materials, disinfectants, oxidants, coagulants, pesticides, herbicides, fish toxicants, adsorbents, and minerals (Boyd and Massaut, 1999). The compounds of these drugs and chemicals are mixed with water and sediments year after year. As a result, the chemicals substances are likely to deposit in the fish body from feed as well as from sediments. In Asian aquaculture, it has been reported that farmers used water and sediment treatment compounds, fertilizers, pesticides, disinfectants, antibiotics, feed additives, hormones, etc., which are likely to be deposited in the fish meat/flesh (FAO, 1989; Rico et al., 2012). There is a lack of broader scientific investigation in this case and a huge knowledge gap existing for composition of various chemicals and other compounds being deposited in pangasius and tilapia. This has various implications for food (fish) safety in domestic fish markets in Bangladesh where the main animal-origin food is fish, and in international trade.

The linkages between the occurrence of yellow in pangasius fillets and on-farm production practices suggested that improvements to production management could be made to diminish the presence of yellow. It is necessary to monitor the water quality to control its transparency, salinity, dissolved oxygen, ammonia nitrogen and blue-green algae to avoid changes to the fillet color (Qiufen et al. 2012). Qiufen et al. (2012) also suggested to avoid oxidized lipid sources in feed for fish with

changeable body color such as yellow catfish, tilapia and pangasius. Adding enough antioxidant to the ingredients and feed products can prevent the carotenoid from oxidation with lipoxygenase and prevent fat oxidation and, subsequently, changes to the color of the fillet. Sørensen (2005) proposed control of the feed by regular sampling for analyses of composition and rancidity.

3. Data collection

Survey technique was followed to collect data. Different actors of aquaculture value chains of pangasius and tilapia were interviewed using an independent interview schedule for each actors located in the eight most important districts of Bangladesh at different phases. Actor of value chains were selected based on the stakeholder conferences and expert consultation meetings. Several focus group discussions were conducted with each actor at each selected districts. Key informant interviews were conducted with officials of department of fisheries and private fish processing companies as well. Before finalizing the interview schedule a pilot survey with 30 respondents of each actor were conducted in order to check relevance and identifying missing questions in the interview schedules.

Cluster sampling technique was used for convenience, since a database of pond aquaculture farmers doesn't exist and the infrastructure and roadways were highly undeveloped in the rural areas where most farms are located. Furthermore, cluster samplings technique is much cheaper, time saving and is a more convenient way to collect data from a huge geographically dispersed population. Most of the questions of the interview schedules were closed type, mainly in the form of the five-point Likert-type scales and dichotomous questions with only two responses. However, the data obtained information on price, costs, and volume are continuous.

In total 2962 (2407+555) interviews were conducted with farmers, nurseries, hatcheries, commission agents (agent that organize wholesale auctions against a fixed percentage in commission), retailers, wholesalers, consumers, fish processing companies, exporters and feed suppliers in order to obtain information in relation to sources of inputs, costs of production, and preferences for quality, price, markets and identifying business constraints. Furthermore, 600 farmers were interviewed in a second phase in order to obtain farm level socio-economic and market data. The surveys were conducted through face to face interview since most of the respondents were located in different rural areas of Bangladesh. Moreover, most of the respondents have a limited level of education and economic background to understand the technical terms and concepts of the questions. The distribution of respondents across actors and region appears in Table 1.

Table 1. Number of interviews of different actors of the value chain.

Sl. No	Area	Sample Size	Farmer		Hatchery	Nursery	Commission agent	Wholesaler	Retailer		Input Supplier	Feed suppliers	Consumer	
			Pangus	Tilapia	Pangus / Tilapia	Pangus / Tilapia			Pangus/ Tilapia	Pangus/ Tilapia			Pangus	Tilapia
1.	Dhaka including Gazipur	488	10	11	-	-	98	42	65	40	12	10	100	100
2.	Mymensingh	619	125	95	-	-	49	91	40	30	31	20	88	50
3.	Comilla	324	59	82	1	4	31	12	35	20	30	-	25	25
4.	Bagura	249	50	21	11	1	52	18	30	15	5	-	21	25
5.	Khulna including Jessore	274	35	29	-	-	13	72	20	15	40	-	25	25
6.	Chittagong	241	8	35	2	2	38	41	25	10	14	-	16	50
7.	Barisal including Vhola	152	31	21	-	-	15	2	15	10	8	-	25	25
8.	Dinajpur	60	8	5	-	-	-	12	20	10	5	-		
Total=2407			326	299	14	7	296	290	250	150	145	30	300	300

In addition, the data presented in Table 2 were selected on governance.

Table 2. Number of interviews specifically on governance.

Stakeholders	Sample size
Hatchery	40
Nursery	50
Trader	<u>295</u>
1) Commission agents	80
2) Wholesalers	90
3) Input Suppliera	50
4) Retailers	75
Processor	10
Consumer	150
Credit organization	10
Total	555

The information obtained from each actor at the farm level included: Nursery and hatchery-sources of inputs, fingerlings, bio-security, farm management, costs of production, access to markets and credits. At the commission agent, retailer and wholesaler level: volume of production, costs of transaction, pricing strategies, delivery and payment modes and handlings. At the consumer level: preferences for quality, species, sources of fish, and price. At the processing company level: volume of outputs, costs of processing, sources of fish processed, certification, quality controlling, compliance with HACCP and markets for processed fish. At the exporter level: markets and its

requirements. For feed suppliers: sources of inputs, barriers to access to markets, quality control, feed ingredients, pricing and modes of business.

The overall objectives of the interviews were to obtain information about the performances of each actors of value chain in order to improve the chain performance as a whole by identifying constraints such as interlocking, prices, off flavor, and access to domestic and export markets.

Some secondary data on export of *Pangasius* from Vietnam to other countries from 2007 to 2013 were collected from trade map and World Bank and wholesale price of pangasius from 2008-2017 were collected from Department of Agricultural Marketing, Bangladesh. Finally, secondary data on farm gate prices of pangasius, import prices of pangasius in Germany and retail prices on pangasius also in Germany were available.

4. Scientific results

In this section, the results of the research on markets, quality and value chains for pangasius and tilapia is reported. The section contain the abstract of scientific article and a summary of reports clustered within the subjects of markets, value chain governance and quality. For details, see the scientific articles and reports.

4.1. Markets

1. Market integration of pangasius and tilapia in relation to wild-caught whitefish in Germany

Article published in *Marine Resource Economics*. 31(4):421-432 by Bronmann, J., I. Ankamah-Yeboah and M. Nielsen (2016). Abstract. Following decade-long growth in worldwide farming of pangasius and tilapia, imports to Germany, a main European market, have been reduced since 2010. One reason for this might be supply growth of wild species at the total German whitefish market, if market integration exists between farmed and wild-caught whitefish. This article examines market integration between farmed (pangasius and tilapia) and wild-caught (Alaska pollock, cod, and saithe) frozen whitefish in Germany and finds close integration. Hence, prices of frozen pangasius and tilapia fillets in Germany are determined not only by supply of these species, but more importantly by the much larger supplies of wild-caught cod and Alaska pollock. The implication of the presence of market integration is that the small-scale Asian farmers are secured against severe price reductions in Germany arising from farm productivity growth. However, market integration also makes them dependent on quotas and supply of competing wild-caught whitefish.

2. The World Demand for Pangasius Catfish

Article published in *Aquaculture Economics and Management* 21(3), 400-417 by Thong, N. T., M. Nielsen, E. Roth, N. V. Giap and H S. Solgaard (2017). Abstract. This research described in this article aimed to investigate international market potentials for *Pangasius catfish* (*Pangasianodon hypophthalmus*). The monthly export data from Vietnam, which accounts for more than 95% of the global export value, in the period 2007 to 2014, were used to estimate a non-linear Inverse Almost Ideal Demand System of the seven market regions. Prices in all markets are found very inflexible, with own-price flexibilities on -0.200 to -0.917 , or -0.419 on average, revealing the option of expanding global production and export without inducing a substantial price reduction. Consumers in all markets except Latin America evaluate *Pangasius* as a necessary good, indicating that the *Pangasius* industry is relatively little affected by recessions and booms in the world economy. The major markets are substitutes for each other; therefore, if demand at one market region is reduced,

the presence of substitution leads suppliers to find other markets. The results reveal that demand provides stable framework conditions for the Pangasius industry.

3. Price transmission in the pangasius value chain from Vietnam to Germany

Article *Aquaculture Reports* 16(1),100266 by Thong, N.T., I. Ankamah-Yeboah, J. Bronnmann, M. Nielsen, E. Roth and B. Schulze-Ehlers (2020). Abstract. Evidence of market integration between farmed pangasius and wild-caught whitefish is provided in the literature, pointing towards pangasius prices being determined on the large international whitefish market. In the presence of price transmission in the value chain, global growth of pangasius farming does therefore not in itself reduce the farm-gate prices in Vietnam. In this paper, price transmission in the pangasius value chain from farmers in Vietnam, via export to final consumption in Germany, is tested using the Johansen cointegration framework. Price transmission is identified both between farm-gate prices and export prices in Vietnam and between export prices and retail prices in Germany. The Law of One Price was rejected in both cases, indicating imperfect price transmission. Weak exogeneity tests of market leadership identify a value chain with downstream market leadership consisting of German retailers leading exporters, which themselves lead farmers. The implication is that growth of Vietnamese pangasius farming can continue, *ceteris paribus*, without reducing prices substantially. Vietnamese farmers can invest in expansions without fearing self-inflicted price falls, but farmers and local communities remain prone to fluctuations following from supply and demand changes at the international whitefish market outside of their control.

4. Market Integration between Cultured and Captured Species in Developing Countries: Lessons from Inland Areas in Bangladesh

Article invited for resubmission from *Marine Resource Economics* by Hossain, A., M. Nielsen, I. Ankamah-Yeboah, Badiuzzaman and F. Azmal Huda. Request the full text from the corresponding author at hossainafjal@gmail.com. Abstract. Although inland fisheries are an important source of protein with a history longer than both agriculture and marine fishery, their importance remain underestimated and research on their markets is not comprehensive. In developing countries, open access prevails in many of these fisheries. Simultaneously, the aquaculture that supplies the same markets as inland fisheries grows. Hence, when inland fisheries and aquaculture compete in the same market, the emergence of aquaculture reduce price, also for capture species and thereby reduce fishing effort. In this study, the researchers tested cultured fish, including tilapia and pangasius, against the captured species of hilsha, swamp barb, prawn, wallago and long-whiskered catfish in the domestic market of Bangladesh. The researchers applied the Johansen co-integration framework to identify market integration between cultured and captured species using monthly wholesale price data for the period of January 2010 to May 2017. The study showed that the Law of One Price was rejected in all market pairs except pangasius and long-whiskered catfish pair, suggesting imperfectly integrated markets. the study revealed mixed evidence of weak exogeneity tests - including cultured- and captured-led markets as well as bidirectional relationships. Given that cultured fish accounts for a substantial market share, the implication is that aquaculture growth, all other things being equal, can reduce captured fish prices and, subsequently, reduce overexploitation, overcapacity and the number of fishers. This appears to lead to a double gain, with both fish farmers and fishers benefitting from aquaculture development.

5. Factors Determining Consumer Preferences for Pangas and Tilapia Fish in Bangladesh: Consumers' Perception and Consumption Habit Perspective

Article forthcoming in *Journal of Aquatic Food Product Technology* 28(4):438-449 by Uddin, M.T., M.H. Rasel, A.R. Dhar, Badiuzzaman and M.S. Hoque (2019). Abstract. The study was conducted to

identify the factors influencing consumer preferences and consumption of pangas and tilapia fish in Bangladesh. A total of 150 respondents were interviewed following random sampling technique from three upazilas of Mymensingh district. Data were analyzed with a combination of descriptive statistics and mathematical and statistical techniques. A majority of the consumers purchased pangas and tilapia fish 1–5 times a month. Consumers of medium income level bought the highest amount of pangas and tilapia fish per month. The study revealed that consumers' expenditure on pangas and tilapia increased by 6.7% with an increase in their income by 10%. The major reasons behind consumer preference for pangas and tilapia fish included cheaper price compared to other fish, year-round availability, and reasonable market price. Consumer preference for purchasing pangas fish was significantly influenced by freshness, color, and family income and by price, freshness, and taste for purchasing tilapia fish. The study recommended that proper authorities should monitor fish farms and fish quality as well as control fish sales price in the market to enhance consumer preferences.

4.2. Value chain governance

1. Exploring performance deficits in the Bangladeshi fish feed supply chain

Paper in progress by Islam, I., M. Nielsen, B. Schulze-Ehlers and Badiuzzaman. Abstract. Fish farmers in Bangladesh have been suffering from inefficiencies in the feed supply chain. The study identified inefficiency by measuring supply chain performance through supply chain operation reference (SCOR) model. The analytical hierarchy process (AHP) prioritized the phases and attributes and develop optimum performance of the feed supply chain. Cost is one of the criteria for performance measurement but it does not represent all transaction cost. For an accurate result, the transaction cost was calculated separately, although there is an inadequate use of transaction cost theory to determine the supply chain performance. Survey and focus group discussion were used for data collection. The inefficiency of the supply chain was identified by comparing optimum and actual performance. The study found high cost was the main reason for inefficiency, along with the reliability of product quality was also concerning issue for the chain. Both performance gap and transaction cost is high for a dealer and he is the inefficient actor in the chain. The study define specific intervention area for overcoming inefficiency in the supply chain. The study also demonstrated that transaction cost can be a determinant of the supply chain performance.

2. Drivers of captive governance in the pangasius and tilapia value chains in Bangladesh

Paper submitted to *World Development* by Islam, I., M. Nielsen, A. Bosselmann and Badiuzzaman. Abstract. The fast growth of aquaculture in many developing countries may reduce competition and thereby limit potential earning and poverty alleviation following value chain upgrading. To achieve the full potential of aquaculture, knowledge on lack of competition and inadequate governance structures is therefore needed. Founded on 1099 interviews with actors along the value chain, this article identifies power scores and power relationships, and identify drivers inducing captive governance in the pangasius and tilapia value chains in Bangladesh. The study found asymmetric power scores and unwanted captive governance in the farmer-feed seller node, but were unable to identify competition problems in the remaining part of the value chain. Using a logistic regression the study identified knowledge advantages of feed suppliers, switching costs, rigid terms of trade credit contracts and capital shortage of farmers as influential drivers of developing captive governance in the node. The policymaker can ensure easy access to bank loans, favorable trade credit contracts, proper training on financial calculation and sourcing and market analyses and information sharing for farmers to release them from captivity and create a convenient environment for upgrading the value chains.

3. How can governance improve efficiency and effectiveness of value chains? An analysis of pangas and tilapia stakeholders in Bangladesh

Article published in *Aquaculture* 510(15):206-215 by Uddin, M.T., M.A. Goswani, A.S. Rahman and R. Dhar (2019). Abstract. The study assessed pangas and tilapia value chain, and analyze the internal and external governance of the market actors at different levels. A total of 200 samples (100 for each of pangas and tilapia fish) were included in the study from some selected areas of Bangladesh. A combination of descriptive statistics, mathematical and statistical analysis was used to analyze the data. The study reveals that among all the actors, processors added the highest value which was followed by farmers. The internal and external governance issues followed by different actors could be ranked as average which reveals the improvement issue through intervention from respective authorities. Multinomial logit model explained that there were several factors having significant influence on internal and external governance of pangas and tilapia value chain. The study recommended that good governance should be ensured from the production point to consumer along all the actors of value chain. Government should take step about monitoring the feed quality and improvement of pangas and tilapia value chain governance. Moreover, respective authority should play the assigned role to train up the chain actors and provide extension services in order to explore the export potential of pangas and tilapia fish in Bangladesh.

4. Are trade credits a gain or a drain? Market power in the sale of feed to pangasius and tilapia farmers in Bangladesh

Article published in *Aquaculture Economics and Management* 24(1):1-19 by Islam, I., M. Nielsen, B. Schulze-Ehlers, Badiuzzaman and I. Theilade (2020). Abstract. Trade credits provide financing for buyers that might not otherwise be able to run a business. However, sellers may use trade credits to exploit market power and this introduces a market failure that reduces efficiency and social welfare when compared to perfect competition. The aim of this study is to identify the costs of trade credits on fish feed for fish farmers in Bangladesh and investigate the power relation as perceived by the farmers and feed sellers. The sources of power are determined by a factor analysis. A one-way analysis of variance is used to identify the most powerful party. For farmers, trade credits were more expensive than cash payment and even bank loans. The excess costs of trade credits indicate that feed sellers exploit their market power, and the identification of feed sellers as the powerful party supports this indication. Trade credits, therefore, provide gains in ensuring fish production that may not otherwise take place, but its costs decrease efficiency and introduce imbalances in the market power. Better financing than trade credit may help farmers. Alternatively, policymakers can increase efficiency and welfare by implementing corrective measures such as ceilings on the costs of trade credits; however, the remuneration of risk must be allowed for trade credits to prevail.

4.3. Quality of fish

1. Evaluation of the ability of the Bangladeshi pangasius and tilapia industry to export focusing at food safety and HACCP in the value chains

Report from Marco Frederiksen's visit to Bangladesh January 2018. Request the full text from the corresponding author at Marco.Frederiksen@eurofish.dk. Abstract The purpose of the visit was to evaluate pangasius chains and their ability to export pangasius to higher value markets. The entire production chain, (fish meal/feed factories, fish farmers, markets, processors and the managing authorities), was visited. The processors are not a bottleneck for the pangasius export. The biggest challenge are the fish farms. They are not registered with the authorities and have no contact with any advising veterinarian service. It is a risk for Bangladesh that no public system can prevent a spread of new diseases, which is inevitable in the future. Small factories produce feed without any public

control. An important part of the feed component is meat and bone meal. This is not allowed for fish feed in the EU and while this practise is maintained it will not be possible to export to the EU market. Good practice and certification from the Bangladeshi shrimp sector should be transferred to the pangasius farming sector. The main problems preventing exportation are missing registration of fish farms and proof of inspection, no training of fish farmers, missing records of production and low feed quality. It is recommended to initiate demonstration projects and a training program for pangasius farmers.

2. Secondary and primary evidences of yellow color in pangasius fillets in Bangladesh: prospects and challenges at the international market

Article invited for resubmission and resubmitted to *Journal of Applied Aquaculture* by Hoque, M. S., M. M. Haque, M. I. Hossain, S. Mahmud, A. K. Mandal, Badiuzzaman, M. Frederiksen, E. P. Larsen and M. Nielsen. Abstract. Bangladesh is the second largest producer of pangasius (*Pangasianodon hypophthalmus*) worldwide but exports are largely non-existent. One reason is that the flesh of fish is discolored yellow, where consumers at mainstream international markets prefer white flesh. Reviewing secondary evidences and analysis of primary data, this article assessed the underlying reasons for discoloration of pangasius flesh in Bangladesh, and synthesized the strategies to avoid discoloration for inducing exports. The findings indicated that farming practice with high stocking density, infrequent water exchange, high organic matter in pond water, and growth of carotenoid containing cyanobacteria contributed to discoloration of pangasius. Artificial and natural pigments in feed and poor post-harvest handling of fish are also caused for yellow discoloration. Moreover, estimations identify positive correlation between water exchange, price and yield at farm, indicating farm-gate price and yield per hectare can increase with increased water exchange. Therefore, comprehensive national action plan is needed to end discoloration, thus to establish an export-oriented pangasius industry in Bangladesh.

3. Enhancing Export Potential of Pangas and Tilapia through Quality Assurance and Safety Compliances: Case Study of Processing Plants and Exporters in Bangladesh

Article invited for resubmission and resubmitted to *Aquaculture* by Taj Uddin and Max Nielsen. Abstract. This study assessed the export potential of pangas and tilapia by considering quality standards and safety compliances of processing plants and exporters (the same companies) in Bangladesh. Primary data were collected by interviewing ten of these companies. It was found that they followed the seven principles of hazard analysis and critical control points (HACCP) as a basis of food safety management. Almost 90 % of the processing plants had a system of records documenting these rules and all of them were strict in maintaining hygienic conditions, had adequate processing equipments and product configuration systems. A comparative advantage of pangas and tilapia export from Bangladesh to the US, Europe and the Middle East as fillets, dressed and whole fish were also identified. The major opportunity of enhancing export and thereby ensure earnings and foreign currencies was identified as a continued focus on large farming quantities, combined with that processing and exporters live up to the HACCP rules. Introducing eco-labels allowing products to obey to supermarket requirements at export markets and enhancing environment friendliness in production are further opportunities. It was recommended that the companies engage in contract farming to ensure quality raw material and thereby a reasonable export price.

4. Can Bangladeshi pangasius farmers comply with the guidelines of Aquaculture Stewardship Council certification?

Paper in progress by M. M. Haque, M.S. Hoque and M. Nielsen. Request the full text from the corresponding author at mmhaque1974@yahoo.com. Abstract. Globally Bangladesh is the fifth largest aquaculture producing country where pangasius as a single species contributes major share (18 %) of total aquaculture production. Farming of this species is characterized by unregulated farming practices, domestic trade without any value addition, product development and export whereas many Asian countries have established aquaculture certification by meeting required standard practices. In this study, FAO prescribed frameworks Sustainability Assessment of Food and Agriculture Systems was applied to assess the competency of pangasius farmers comparing with the indicators of farming practices prescribed by Aquaculture Stewardship Council. Questionnaire interviews with 150 pangasius farmers was applied according to Aquaculture Stewardship Council pangasius standards, is the most robust and acceptable standards for responsible aquaculture, where the indicators of the Aquaculture Stewardship Council were customized with four dimensions of the Sustainability Assessment of Food and Agriculture Systems as good governance, environmental integrity, production and economics, and social well-being. Out of 102 indicators, 8, 15, 17 and 17 indicators were considered under four corresponding dimensions of Sustainability Assessment of Food and Agriculture Systems, which were relevant to answer by the farmers of Bangladesh. The majority of the farmers were of middle age, educated and experienced showing the potential of receiving the concept of aquaculture certification. Across four dimensions of Sustainability Assessment of Food and Agriculture Systems, the results suggest that 25 % of indicators were practiced by the pangasius farmers at an acceptable level, 31 % were at moderate to a limited level, and 44 % were at an unacceptable level of farming practices. The improvement of pangasius farming practices is required in all the dimensions of Sustainability Assessment of Food and Agriculture Systems, but the domains of Governance and Environmental integrity require most attention. A stakeholder-based intervention is recommended to customize the critical indicators of Aquaculture Stewardship Council for the farmers in Bangladesh to develop pangasius aquaculture certification, safe fish supply to the local and export market.

5. Demand for quality of pangasius in Bangladesh: A hedonic price analysis

Paper submitted to *Aquaculture* by Hossain, A., Badiuzzaman, M. Nielsen and E. Roth. Request the full text from the corresponding author at hossainafjal@gmail.com. Abstract. Pangasius farming in Bangladesh have grown fast to the current levels of mass production. While the large supply provide proteins for poor consumers, the fast development also induced low quality. The aim of this study is to analyze whether domestic consumers are willing to pay for high quality, as measured by different quality characteristics of pangasius. To identify the significant quality characteristics of pangasius, a total of 300 consumers were interviewed during pangasius purchase from different retail markets of ten districts of Bangladesh through a structured questionnaire. The hedonic price model was applied to identify the pangasius characteristics using a semi-log functional form of regression. Results show that young, middle-income and consumers under production zone purchase pangasius more than the other sub groups. Results also show that fish form and odour are the most influential characteristics for pangasius purchase. Fish size, color, appearance and belly swelling are also important for sub groups of consumers. The implication of the results is that Bangladeshi consumers are willing to pay for improved quality of pangasius, thereby providing the economic foundation for quality improving initiatives of the different actors in the supply chain.

6. Poor Consumer's Demand for Quality Fish: A Hedonic Price on Tilapia of Bangladesh

Paper in progress by Hossain, A., Badiuzzaman, M. Nielsen and E. Roth. Request the full text from the corresponding author at hossainafjal@gmail.com. Abstract. Fish consumption in Bangladesh is increasing day by day with the drastic fisheries growth. The aquaculture sector of the country is increasing simultaneously whereas the inland fishery is decreasing from the year 2009 to till 2016. The purpose of the study is to identify the tilapia attributes for the purchase decision of various consumer groups. The hedonic price model was applied over 300 interviews of farmed tilapia collected during their purchase. It was found from the interviews that on an average a consumer purchase 1.48 kilo tilapia at a time with an average price of Bangladeshi Taka 115. Results show that young and poor consumers purchase more tilapia than the other subgroups. Results also show that consumers are willing to pay more for white tilapia than non-white one. Fish size, form, color, gill color, eye position, belly swelling, presence of bones and taste are also important attributes for the different subgroups of the consumers for their purchase decision. The implication of the study is that the different actors in the fish supply chain should be careful about the fish marketing activities to ensure consumer demand.

7. The Importance of Quality in Explaining Trade Flows: A Gravity Analysis of Pangasius Exports from Vietnam

Paper submitted to *Aquatic living resources* by Hossain, A., M. Nielsen, W. Yu and Badiuzzaman. Request the full text from the corresponding author at hossainafjal@gmail.com. Abstract. Gravity models identify drivers of trade flows and thereby provide knowledge on the types of quality of market products to export to. The existing literature, however, does not consider quality of a market product differentiation that might be driven by different factors and that targets a specific type of market product. The purpose of this study is to illustrate the importance of a product quality and its influential drivers for international trade. The gravity model was separately applied in two different quality products using the price of transactions for pangasius between two countries relative to the average yearly export price as an indicator of quality of a market product. Exports data from Vietnam to 46 countries during the period of 2007-2013 were used to identify the drivers and the results indicate that gross domestic product and population of importing countries are the most influential drivers for pangasius exports. Results also indicate that the importing countries have a preference for high quality product. In that case, distance and tariff rate are also influential drivers for high quality market product. This study may guide potential exporting country to identify which market to penetrate for higher profit.

4.4. Other

Knowledge transfers from mature to emerging industries: The case of shrimp and pangasius industries in Bangladesh

Article forthcoming in *Journal of Applied Aquaculture* by Islam, I., M. Nielsen, Badiuzzaman and B. Schulze-Ehlers. Abstract. The shrimp industry of Bangladesh is well experienced and almost the sole contributor to fish export. The rapid growth of pangasius aquaculture has emerged as a new opportunity for export but the export path is uneven for a new species. This article identifies areas where the pangasius industry can use knowledge obtained from the development of the shrimp industry to develop its own export opportunities. The shrimp industry has developed infrastructure and a specific legal framework in the form of e-traceability and licensing to comply with food safety and certification requirements of its global buyers. The pangasius industry can also learn from the mistakes of the shrimp industry, particularly those concerning planned ponds and dike systems. The experience of the shrimp industry is a new school of learning for the pangasius industry to get access to the global market.

5. Discussion

5.1. Markets

Worldwide, the production of aquaculture is growing fast where the captured production stagnate. The fish demand of consumers meets by the aquaculture production and fulfills both the gap of capture fish landings and the increased fish demand following population growth, income growth and increasing preferences for healthy food such as fish. Market integration is thus expected internationally and in different markets like Bangladesh.

In Bangladesh, growing production of pangasius leads all other things equal to price reductions, since export is almost non-existent and the whole production sold to domestic consumers. A side effect of aquaculture production growth is, however, since substitution prevail between farmed pangasius and tilapia on the one hand, and wild-caught fish on the other, that prices on the wild-caught substitutes also fall. The long run implication is that wild fish stocks are positively affected by aquaculture growth, since the fishing fleet will be reduced following price reductions. This conclusion is founded on Hossain et al. (2019, section 4.1 no. 4) who conducted a study on market integration between cultured and captured fish in Bangladesh and found that the Law of One Price is rejected in all market pairs besides pangasius and long-whiskered catfish pair. The results indicate imperfect market integration. The study also infers that pangasius and long-whiskered catfish are the only perfect substitutes.

In some instances, prices of cultured and captured species determine each other. Examples are tilapia-hilsha, pangasius-hilsha and pangasius-long-whiskered catfish. In this case, both farmers and fishers are competitive in the market. In other instances, cultured species determine the market price of captured species in the long run. Examples are tilapia-prawn, tilapia-long-whiskered catfish, pangasius-prawn and pangasius-swamp barb. In this case, increases in the cultured fish output may reduce prices in the respective captured fish markets, but not vice versa. Finally, captured species determine the market price of cultured species in the long run in some cases. Examples are pangasius-wallago and tilapia-swamp barb.

The main finding of the study is that the prices of captured species are largely determined by the cultured species. The implication of the study is that aquaculture growth reduces the price; consequently reduce fisher's income in the short run. However, with open access, fishers may loose

their incentives due to low price, which ultimately cause the supply to increase in the long run. Since fishers leave in the short run and overexploitation is reduced, catches and fisher's income in the long run increase. Thus, both fish farmers and fishers gain from aquaculture growth in the long run.

Internationally, Thong et al. (2017, section 4.1 no. 2) investigated international market potentials for pangasius catfish of Vietnam and found very inflexible prices in all markets with own-price flexibilities on -0.200 to -0.917 or -0.419 on average, revealing the option of expanding global production and export without inducing a substantial price reduction. Consumers in all markets except Latin America evaluate pangasius as a necessary good, indicating that the pangasius industry is relatively little affected by recessions and booms in the world economy. The major markets are substitutes for each other; therefore, if demand at one market region is reduced, the presence of substitution leads suppliers to find other markets. The results reveal that demand provides stable framework conditions for the pangasius industry. The findings suggest that Vietnam and other countries have potential to expand their export to not only the current markets but also the new markets of less developed countries in South Asia, Africa and South America.

The result of Thong et al (2017, section 4.1 no. 2) reveal that even large supply growth doesn't affect the world market price. The reason is examined by Bronnmann et al (2016, section 4.1 no. 1), who identify market integration in Germany between pangasius and tilapia on the one hand, and wild-caught whitefish on the other. Since market integration prevail, pangasius and tilapia only supply a small share of the world whitefish market, implying that changes in supply of pangasius and tilapia only have little effect on its price. Bronnmann et al. (2016, section 4.1 no. 1) studied market integration between farmed and wild-caught frozen whitefish in Germany and found close integration between the fish. The study found two types of market linkage: a direct and an indirect relationship between the farmed and wild caught species. The direct linkage is shown between tilapia and all the wild caught species and also for pangasius and the wild species: cod and saithe. Since pangasius is integrated with saithe and saithe is integrated with Alaska pollock, pangasius might be indirectly linked to Alaska pollock through saithe. Hence, prices of frozen pangasius and tilapia fillets in Germany are determined not only by the supply of these species, but more importantly by the much larger supplies of wild-caught cod and Alaska pollock. The implication of the presence of market integration is that the small-scale Asian farmers are secured against severe price reductions in Germany arising from farm productivity growth. However, market integration also makes them dependent on quotas and supply of competing wild-caught whitefish.

While the world market price on pangasius is determined by worldwide whitefish supply, Thong et al (2019, section 4.1 no. 3) find that price changes are transmitted back in the value chain to farmers in Vietnam. This implies that the farm gate price in Vietnam are affected by changes in the world market price. Hence, Vietnamese farmers are prone to changes in worldwide supply and demand of whitefish. Thong et al. (2019, section 4.1 no. 3) studied price transmission in the pangasius value chain from farmers in Vietnam, via export to Germany and identified price transmission in both between farm-gate and export prices in Vietnam and between export and retail prices in Germany. The Law of One Price is rejected in both cases indicating imperfect price transmission. Weak exogeneity tests of market leadership identify a value chain with downstream market leadership consisting of German retailers leading exporters which themselves lead farmers. The implication is that growth of Vietnamese pangasius farming can continue, *ceteris paribus*, without reducing prices substantially. Vietnamese farmers can invest in expansions without fearing self-inflicted price falls, but farmers and local communities remain prone to fluctuations following from supply and demand changes at the international whitefish market outside of their control. Farmers in Bangladesh are, due to that export of pangasius from Bangladesh is largely non-existent, currently unaffected by international supply and demand of whitefish. But if export starts, farmers in Bangladesh might possible also be affected by worldwide supply and demand of whitefish.

The pangasius and tilapia value chain can be upgraded by increasing supplies at the domestic and international markets. At the domestic market, increased supplies induce a downward pressure on the prices. At international markets, however, even very large increases in export from Bangladesh will leave the prices at the world market unaffected, since Bangladeshi supply forms a little share of worldwide supply of whitefish. On the other hand, the Bangladeshi pangasius and tilapia industry even back to the farmers will in the case of export, be prone to price changes following supply changes in other whitefish, such as of wild-caught cod from the Barents Sea and Alaska pollack from the North Pacific Ocean. The implications are that Bangladesh may decide to develop the pangasius and tilapia production to industrial scale to satisfy the demand in both local and international markets. In this case, the sector should consider diversifying their products, focusing on quality control, making the market transparent, and developing marketing strategies to upgrade the industry in the global value chain. Upgrading the global value chain can promote pangasius and tilapia purchase to higher income households and thereafter expand the market potentials. Bangladesh can learn from the example of Vietnamese pangasius.

5.2. Value chain governance

Islam et al (submitted, section 4.2 no. 2) find asymmetric power and captive governance in the farmer-feed seller node, but didn't detect other competition problems in the value chains. They also find that knowledge advantages of feed suppliers, switching costs, rigid terms of trade credit contracts and capital shortage of farmers drives captive governance. Islam et al (2020, section 4.2 no. 4) further find that trade credits are more expensive than cash payment and bank loans, confirming that feed sellers may exploit market power. While trade credits provide gains in ensuring continued fish production that may not otherwise take place, it also lead to extra costs that reduce efficiency of the value chain by inducing imbalance of market power.

Uddin et al (2019, section 4.2 no. 3) find that the policy maker can facilitate value chain upgrading by taking steps to monitor feed quality and provide extended services including on-farm veterinarian inspections. The value chain can also be upgraded by ensuring easy access to bank loans, favorable trade credit contracts, proper training on financial calculation, financial sourcing and market analyses, as well as information sharing for farmers, to release them from captivity and create a convenient upgrading environment. Furthermore, policymakers can facilitate upgrading through implementation of corrective measures such as ceilings on the costs of trade credits, although it is important to allow remuneration of risk of giving trade credits in order to ensure continued farming.

5.3. Quality of fish

Uddin and Nielsen (submitted, section 4.3 no. 3) find by interviewing company owners that almost 90 % of the processing plants of pangasius and tilapia in Bangladesh have a system of records documenting HACCP rules and that all of them are strict in maintaining hygienic conditions, have adequate processing equipment and product configuration systems. Frederiksen (2018, section 4.3 no. 1) further find by controlling a sample of companies in the value chain that HACCP requirements are the largest challenge for farmers. It is concluded that the main problems preventing export are missing registration at fish farms, lacking proof of inspection, no training of fish farmers, missing records of production and low feed quality. On this basis, it is recommended to initiate demonstration projects and a training program for pangasius farmers. Introducing eco-labels allowing products to fulfil supermarket requirements at export markets can further improve export opportunities. Moreover, it is recommended that companies engage in contract farming with processors to ensure quality raw material thereby allowing export.

Hoque et al (submitted, section 4.3 no. 2) hypothesize that yellow discoloration of pangasius is a main reason for exports being largely non-existent, since international consumers prefer white flesh. The analysis indicate that discoloration may be caused by farming practices with high stocking density, infrequent water exchange, high organic matter in pond water, growth of carotenoid containing cyanobacteria, artificial and natural pigments in feed and poor post-harvest handling. Implementation of a comprehensive national action plan to end discoloration is suggested.

Hossein et al (submitted a, section 4.3 no. 6; submitted b, section 4.3 no. 7) identify the implicit price of quality of pangasius and tilapia among domestic consumers in Bangladesh. It is found that domestic consumers pay more for quality characteristics. In particular for avoiding odor, for the white color of the fish and for avoiding belly swelling. That accounts for young and adult consumers, as well as low- and middle- income consumers. Consumer willingness to pay for quality provide an incentive for farmers and other value chain actors to improve quality, since it may pay off. Improving fish quality for domestic sale can further prepare the industry for becoming able to export.

The qualities of pangasius and tilapia can be developed applying different ways where one of the important ways is to increase collaboration in the value chain and to some extent adopt vertical integration. Close collaboration must be ensured among processing plants, farmers, hatchery owners and feed mills in which processing plants either have own grow-out ponds and involved in producing seed, feed and trading or where processing companies through contractual relations can claim, ensure and control that farmers live up to agreed quality standards and are able to document it.

It is firstly to reduce production cost, but more importantly to ensure quality fish production and supply according to the demand. It is a simple way to ensure product quality and traceability and achieve economies of scale for export. Secondly, contract farming could be adopted to ensure quality pangasius and tilapia production. Contract farming in aquaculture is that the processing factories make contract with the pangasius and tilapia farmers both in small to large scale by a document in black and white. In this system, the processing factories can supply seed, feed, drug and chemicals for the pangasius farmers. They can also provide training and record books for the farmers how to practice aquaculture according to international certification guidelines (e.g. ASC). The farmers regularly have to note how much feed is applied in the ponds, what type of drug and chemicals are used and their dosage when affected by disease, etc. The factories can routinely check the water quality parameters of the farms and record information in the notebook. The processing factories can make contract with feed mills for collecting and supplying good quality feed to the farmers. Similarly, the processing factories can also make collaboration with the hatcheries for the supply of quality seed to the farmers and the farmers are contracted to sell back the fish to the processing plants.

While closer agribusiness collaboration and contractual relations between processing companies and farmer, as well as in relation to other value chain actors, may both improve quality and provide documentation of it, it may also lead to captive governance where farmers depends on lead processing companies. The same dependency as is observed today between farmers and feed sellers. Hence, closer collaboration must be followed by initiatives that ensure competition in the value chain. Otherwise, upgrading following from improved quality may be undermined by inefficiencies due to lack of competition. A balance between improving quality that both allow for export and for meeting domestic consumer preferences on the one hand, and doesn't reduce earnings and slow innovation among farmers that become dependent of the lead processing companies on the other, is necessary.

The dependency can be limited by implementing rules of contractual interactions by the Government to make sure that farmers continuously and with reasonable flexibility can shift to other processors. Co-management with sales cooperation between farmers is also an important instrument to make it possible for farmers to match the power of processing companies.

Such a solution that may lead to unequal power relations and captive governance may seem strange, but in a country where public control of fish quality is difficult, it may be the only way to

improve fish quality and upgrade the value chain. And even with competition problems, this agribusiness cooperation solution may upgrade the value chain, improve wealth and reduce poverty.

6. Conclusions

Based on the above it can be concluded:

1. That largely the whole production of pangasius and tilapia in Bangladesh is sold for domestic consumption. Since domestic consumers are willing to pay for quality, improved quality may pay off for farmers and intermediate buyers and induce upgrading.
2. That the main reasons for not being able to meet the HACCP quality requirements are not related to processing companies, but to missing registration at fish farms, lacking proof of inspection, no training of fish farmers and low feed quality.
3. That even large export of pangasius and tilapia from Bangladesh doesn't reduce export prices and therefore export can increase export earnings substantially and upgrade the value chain. A huge international market exist where the main reason for not exporting is the low fish quality.
4. That pangasius and tilapia value chains are competitive, except between feed sellers and farmers, where trade credits cause captive governance. Policy makers can facilitate value chain upgrading by ensuring favorable loans to farmers and through ceilings on trade credit costs, while simultaneously ensuring remuneration of risk.
5. That agribusiness cooperation through the value chain may improve quality for domestic consumers, make export possible and lead to value chain upgrading. In such cooperation, processing companies agree contracts with farmers where they claims, ensure and control that farmers live up to agreed quality standards and are able to document it. Contracts can also be settled with e.g. feed sellers. Farmers can balance the power of the processing companies and avoid captive governance through comanagement and coordinated sale.
6. That yellow discoloration of pangasius and tilapia make sale at international markets difficult. Reducing discoloration claims a broad range of initiatives, which, if successful, can increase sale of white flesh fish at international markets and upgrade value chains.

References

- Akhter, T. (2009). Value Chain Analysis of Dairy Sector in Rangpur District. Unpublished M.S. Thesis, Department of Agribusiness and Marketing, Bangladesh Agricultural University, Mymensingh.
- Ahmed, N. 2007: Economics of aquaculture feeding practices: Bangladesh. In M.R. Hasan (ed.). Economics of aquaculture feeding practices in selected Asian countries. FAO Fisheries Technical Paper. No. 505. Rome, FAO. 2007. pp. 33–64.
- Ahmed, N. and Toufique, K. A. 2014: Greening the blue revolution of small-scale freshwater aquaculture in Mymensingh, Bangladesh. Review articles, *Aquaculture Research*, **2014** 1–18.
- Ahmed, N., Young, J. A., Dey, M. M., Muir, J. F. 2012: From production to consumption: a case study of tilapia marketing systems in Bangladesh. *Aquaculture International*, **20** 51–70.
- Ali H., Haque, M. M., Belton, B. 2013: Striped catfish (*Pangasianodon hypophthalmus*, Sauvage, 1878) aquaculture in Bangladesh: an overview. *Aquaculture Research*, **44** 950–965.
- Anderson, J. L. 1985. “Market Interactions between Aquaculture and the Common-Property Commercial Fishery”. *Marine Resource Economics* 2(1): 1-24.
- Ankamah-Yeboah, I., & Bronnmann, J. 2018. “Market Integration in the Crustaceans Market: Evidence from Germany”. *Marine Policy* 87, 72-77.
- Ankamah-Yeboah, I., Ståhl, L., & Nielsen, M. 2017. “Market Integration of Cold and Warm water Shrimp in Europe”. *Marine Resource Economics* 32(4): 371-390.
- Anwar, J. 2011: Market study on some freshwater farmed fish: Tilapia and Pangas (Mekong river catfish), USAID. pp. 141.
- Asche, F., Bjørndal, T., & Young, J. A. 2001. Market interactions for aquaculture products”. *Aquaculture Economics & Management* 5(5-6): 303-318. DOI:10.1080/13657300109380296.
- Asche, F., L. S. Benneer, and M. D. Smith. 2012. “US shrimp market integration.” *Marine Resource Economics*, 27(2), 181-192.
- Bayramoglu, B. 2019. “Price interactions between wild and farmed products: Turkish sea bass and sea bream markets”. *Aquaculture Economics & Management* 23(1): 111-132.
- Belton, B., Haque, M. M., Little, D. C., Sinh, L. X. 2011: Certifying catfish in Vietnam and Bangladesh: Who will make the grade and will it matter? *Food Policy*, **36(2)** 289-299.
- Bjørndal, T., & Guillen, J. 2017. “Market integration between wild and farmed species in Spain”. *Aquaculture Economics & Management*, 21(4): 433-451. DOI: 10.1080/13657305.2016.1214629.
- Borgström, B. 2005. *Exploring efficiency and effectiveness in the supply chain: A conceptual analysis*. Proceedings from the 21st IMP Conference.
- Boyd, C. E., Massaut, L. 1999: Risks associated with the use of chemicals in pond aquaculture. *Aquacultural Engineering*, **20** 113–132.

- FAO, 1989: Aquaculture Methods and Practices: A Selected Review. Food and Agriculture Organization of the United Nations, Rome, Italy.
<http://www.fao.org/docrep/t8598e/t8598e05.htm> (Date on Access 19 March 18).
- FAO (Food and Agricultural Organization of the United Nations). 2019a. “Global Aquaculture Production 1950-2016”. Retrieved from <http://www.fao.org/fishery/statistics/global-aquaculture-production/query/%20en/en>, accessed 14 February 2019.
- Gereffi, G., J. Humphrey and T. Sturgeon (2005), The governance of global value chains, *Review of International Political Economy*, 12(1):78-104.
- Haque, M. M. 2012: Pangasius (*Pangasianodon hypophthalmus*, Sauvage, 1878) aquaculture in Bangladesh: food security, livelihoods and export potential. In: Proceedings of the Seminar of 1st International Exhibition on Dairy, Aqua & Pet Animal-2012, 8-10 November 2012. pp. 156-170. Organized by Animal Health Companies Association of Bangladesh (AHCAB).
- Haque, M. M., Belton, B., Alam, M. M., Ahmed, A. G., Alam, M. R. 2016: Reuse of fish pond sediments as fertilizer for fodder grass production in Bangladesh: Potential for sustainable intensification and improved nutrition. *Agriculture, Ecosystems & Environment*, **216** 226-236.
- Hossain, M.R., Akteruzzaman, M., Parvin, M.T., Bhuiya, M.S.U. and Hossain, S.M.A. (2013). Marketing Channel of Fish and Value Addition by Different Actors in Haor Area of Netrokona District. *Bangladesh Journal of Crop Science*, vol. 24, pp. 131-140.
- Humphrey, J. 2005. *Shaping value chains for development: global value chains in agribusiness*, GTZ, Eschborn, Germany.
- Jensen, F., Nielsen, M., & Nielsen, R. 2014. “Increased Competition for Aquaculture from Fisheries: Does Improved Fisheries Management Limit Aquaculture Growth?” *Fisheries research* 159: 25-33.
- Jespersen, S., I. Kelling, S. Ponte and F. Kruijssen. 2014. What shapes food value chains? Lessons from aquaculture in Asia, *Food Policy* 49:228-240.
- Kano, L. 2018. Global value chain governance: A relational perspective, *Journal of International Business Studies* 49:684-705.
- Lee, J. G. Gereffi and S. Barrientos. 2011. Global Value Chains, Upgrading and Poverty Reduction, *Capturing the Gains Briefing Note*, No. 3.
- Maurice, S., Knútsson, O. and Gestsson, H. (2010). The Value Chain of Farmed African Catfish in Uganda. Final Project. The United Nations University, Iceland.
- Neela, T.S. 2015. Profitability and value chain analysis of tilapia in a selected area of Mymensingh district. M.S. Thesis, Department of Agricultural Economics, Bangladesh Agricultural University, Mymensingh, Bangladesh.
- Nguyen, T. A. T. and Jolly, C. M. 2017: Macro-Economic and Product Challenges Facing Vietnamese the Pangasius Industry. *Reviews in Fisheries Science & Aquaculture*, DOI: 10.1080/23308249.2017.1379948.
- Nielsen, M., Setälä, J., Laitinen, J., Saarni, K., Virtanen, J., & Honkanen, A. 2007. “Market Integration of Farmed Trout in Germany”. *Marine Resource Economics* 22(2): 195-213.

- Nielsen, M., Smit, J., & Guillen, J. 2012. "Price Effects of Changing Quantities Supplied at the Integrated European Fish Market". *Marine Resource Economics* 27(2): 165-180.
- Norman-Lopez, A. 2009. "Competition between Different Farmed and Wild Species: The US Tilapia Market". *Marine Resource Economics* 24(3): 237-251.
- Norman-Lopez, A., & Asche, F. 2008. "Competition between Imported Tilapia and US Catfish in the US Market". *Marine Resource Economics* 23(2): 199-214.
- Pietrobelli, C. and F. Saliola (2008), Power relationships along the value chain: multinational firms, global buyers and performance of local suppliers, *Cambridge Journal of Economics*, 32:947-62.
- Pincinato, R. B. M., & Asche, F. 2016. "Market integration in Brazilian shrimp markets". *Aquaculture Economics & Management* 20(4): 357-367. DOI:10.1080/13657305.2016.1212124.
- Ponte, S. and P. Gibbon. 2005. Quality standards, conventions and the governance of global value chains, *Economy and Society*, 34:1, 1-31, DOI: [10.1080/0308514042000329315](https://doi.org/10.1080/0308514042000329315).
- Ponte, S, I. Kelling, K.S. Jespersen and F. Kruijssen. 2014. The Blue Revolution in Asia: Upgrading and Governance in Aquaculture Value Chains, *World Development* 64:52–64.
- Qiufen, D., Yong, Y. & Shi, S. 2012. Nutrition and changes in fish body color in catfish. January/February 2012. AQUA Culture Asia Pacific Magazine.
- Rico, A., Satapornvanit K, Haque MM, Min J, Phuong NT, Telfer TC, van den Brink PJ 2012: Use of chemicals and biological products in Asian aquaculture and their potential environmental risks: a critical review. *Reviews in Aquaculture* 4(2) 75-93.
- Sampath, P.G. and B. Vallejo 2018, Trade, Global Value Chains and Upgrading: What, When and How? *The European Journal of Development Research* 30:481–504.
- Sørensen, N. K. 2005. Fiskeriforskning Report 12/2005. Slaughtering processes for farmed Pangasius in Vietnam: Consultancy surveying slaughter processes and by-products handling in the Vietnamese industry, available at <http://www.fiskeriforskning.no>.
- Valderrama, D.. & Anderson, J. L. 2010. "Market Interactions between Aquaculture and Common-Property Fisheries: Recent Evidence from the Bristol Bay Sockeye Salmon Fishery in Alaska". *Journal of Environmental Economics and Management* 59(2): 115-128.
- Veerina, S. S, Nandeesh, M. C., Silva, S. S. D., Ahmed, M. 1999: An analysis of production factors in carp farming in Andhra Pradesh, India. *Aquaculture Research* 30 805-814.
- Virtanen, J., Setälä, J., Saarni, K., and Honkanen. A. 2005. "Finnish salmon trout—Discriminated in the European market". *Marine Resource Economics* 20(1): 113-119.