Thematic paper: Value chains and market access for aquaculture products

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Affiliations

[1]: Former Director, FAO Fisheries and Aquaculture Division (FIE). [2]: Professor. Faculty of Economics, Nha Trang University, Nha Trang, Vietnam.[3]: Senior officer, FAO FIE.[4]: Professor. University of Cantabria. Santander, Spain.

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Key messages

1. Aquaculture production and trade has experienced significant development locally, regionally and globally during the last 4 decades. Aquaculture products have become one of the most globalized food commodities. This significant development and globalization have exacerbated concerns over its impacts, in particular on the environment, in different parts of the world where production development has exceeded the capacity of planning, controls and oversight.

2. Over 80% of aquaculture production takes place in developing countries, where aquaculture commodity chains have traditionally been regulated and controlled by government institutions, with varying degrees of consultation with producers and other stakeholders. As a result of globalization and liberalization of trade, in-depth changes have occurred, impacted by the outbreak of several food and feed crises, increasing fears about food safety, spread of animal diseases, and growing concerns about the environmental and social sustainability of aquaculture. This in turn has shaped the new trade regimes for market access and driven new schemes for aquaculture value chain development and governance.

3. Value chain analysis, development and governance have emerged during the last twenty years as tools to analyze and understand the dynamics at value chain nodes of key players, economic costs and benefits, value addition and value creation and to develop policy options and suitable market instruments for the promotion of sustainable aquaculture.

4. Governments and development institutions such as FAO promote value chain development and governance as tools for targeting the achievement of societal goals, such as poverty alleviation, food security and gender equality. The interventions aim at upgrading the position of smallholder producers; either through financial and technical support for upgrading infrastructure, access to services and skills and practices at key nodes, or policies and efforts to improve equitable distribution of costs and benefits and enhance market access and terms of trade for producers, workers and other related value chain actors. However, the global aquaculture value chains have been increasingly influenced by 'extra-chain' actors such as standard setting and certification bodies, mainly non-governmental organizations (NGOs) or importing government institutions, and the standards and regulation that they impose on producers and processors. Because these international standards and regulations are intended to reflect the expectations of consumers that are remote in both geographical and cultural senses, they can be disconnected from the realities that prevail at the local level, neglecting or marginalizing local schemes, practices and knowledge dedicated to govern the use and management of natural aquatic resources,. Transparent and predictable trade regimes should promote equivalence and recognition of local schemes, practices and knowledge for market access based on the internationally negotiated codes, guidelines and standards such as the Code of Conduct for Responsible Fisheries and its supporting instruments.

5. Aquaculture producers have raised concerns regarding the cost of certification, especially for small-scale aquaculture producers. The compliance costs associated with certification to a private standard scheme are currently borne disproportionately by those up-stream in the supply chain (i.e. producers, processors) rather than those downstream (i.e. retailers, food services, importers) where the demands for certification generate. Yet the most robust evidence of price premiums suggests that they accrue to the retailers who demand certification. There should be agreed mechanisms for the redistribution of these costs and benefits.

6. Economic costs and benefits along the aquaculture value chains are relative to which costs are computed. Sustainable aquaculture value chains should integrate ecosystem services and social benefits in the aquaculture value chain analysis and governance. Consumer awareness and education programs should promote consumer willingness to pay more for the real cost of the product, if the social and environmental costs were to be internalized.

7.The increasing penetration of digital platforms (e.g. Ali Baba and Amazon) and technologies (e.g. blockchain) into fish and seafood trade and logistics that seek to virtualize supply chains, creating direct links between producers and consumers, the performance, structure and conduct of value chains is set to change dramatically. It is unclear, however, who will ultimately benefit from these shifts, nor whether they can foster sustainable aquaculture practices and markets for sustainability. It is important that small scale operators are considered as key operators and that local practices are not ignored and marginalized. Likewise,, blockchain based technologies offer the prospect of enhanced traceability and transparency throughout supply chains, and thus have significant potential to transform sustainability governance, food safety regulation and consumer access to information, in ways that are only just beginning to unfold.

8. The concept of circular economy is emerging as a key principle for the efficient use and reuse of aquaculture waste through value chains. One conspicuous gap that requires considerably more attention is the use of aquaculture related wastes and byproduct recovery.

1. INTRODUCTION

The sector of fisheries and aquaculture makes a significant contribution to food and nutrition security, employment, trade, culture, and economic development in the world. Global fish production was estimated at 178 million tons in 2019, supplying around 20.3 kg/capita per year and 17 percent of global animal proteins and many essential micronutrients. Likewise, around 60 million people are employed in the sector. Upstream and downstream activities in capture fisheries, fish farming, processing, transport and logistical services, insurance, consulting and other financial services provide significant employment and economic benefits, such as foreign exchange earnings from export to many countries and coastal communities (FAO, 2020).

Fish production from capture fisheries has stagnated in the range of 86 to 93 million tonnes since the late 1980s, except for 2018 when it reached a high record level of 96.4 million tonnes. At the same time, the global demand for fisheries and aquaculture products has continued to rise. Consumption has more than doubled since 1973. The perceived health benefits of fish and the technological developments enabling its farming, processing and availability in the form of a wide range of fish products, including convenience products suited to modern and affluent lifestyles are key drivers of the growth in fish demand and consumption. Most of the increase in fish availability is the result of a robust increase in aquaculture production, estimated at an average 6 percent yearly growth during the period 2001-2018 (FAO, 2020).

As a result, aquaculture production and product utilization have experienced significant developments locally, regionally, and globally during the last 4 decades. Aquaculture products have become one of the most globalized food commodities, attracting interest of investors, agribusiness and retail companies, international development and financial institutions (IDFIs) and Non-Government Organizations (NGOs) who scrutinize the industry developments, in particular through the lenses of the Global value chain (GVC) approach. This approach, originally known as the global commodity approach, explores how production, distribution and consumption of a given food commodity and its actors, economics and services are globally interconnected (Kelling and Young, 2010).

Over 80 percent of aquaculture production takes place in developing countries, mainly in Asia. At the same time, the major fish markets are in Europe, North America, and Japan. These markets accounted for 60 to 70 percent of world fish import in value. To participate actively in international trade, the institutional and operational capacity of the producing countries is challenged to guarantee food safety, animal health and compliance with international social and environmental regulations and standards. Concerns have been raised following recurrent outbreaks of food and feed crises, increasing fears about food safety, spread of aquatic animal diseases, uncontrolled usage of antibiotics and the environmental and social impacts of aquaculture.

For over two decades, there has been concern that, in different parts of the world, growth in aquaculture production has exceeded the capacity of planning, controls, and oversight (Schlag, 2010; Oglend, 2020). These developments have progressively shaped the trade regimes for international market access and market entry and driven new schemes for aquaculture value chain development and governance.

Value chain analysis and governance have emerged during the last twenty years as valuable tools to analyse and understand the dynamics of key players, economics of costs and benefits, value addition and value creation and to develop policy options and suitable market instruments for the promotion of sustainable aquaculture (Bush et al., 2019). Governments, IDFIs and NGOs promote value chain development and governance as tools for planning and monitoring the achievement of:

- ✓ societal and environmental goals, such as economic growth, poverty alleviation, food security and gender equality, and
- ✓ environmental goals such as the prevention of disease and pollution, of antimicrobial resistance development, mangrove protection and restoration., etc.

These interventions are enacted through:

- ✓ fiscal reforms, financial and technical support for upgrading infrastructure, access to inputs and services, skills and best practices at key nodes of the aquaculture value chains,
- ✓ policies and efforts to improve equitable distribution of costs and benefits and enhance market access and entry and terms of trade for producers, workers, women, and other related value chain actors.

Different from the value chains of other traded commodities, the global aquaculture value chains have been less influenced by tariffs but have become more influenced by market entry requirements, in particular the Non-Tariff Measures (NTMs) imposed on producers, processors and exporters in the form of regulations and standards. There is a growing concern that these requirements and their costs can be disconnected from the realities that prevail at the local level, distorting the role and influence of value chain actors and favouring the "lead firms", the regulatory institutions and standard setting NGOs. This in turn is neglecting or marginalizing local schemes, practices and institutional or traditional knowledge that govern the use and management of living aquatic resources.

This thematic paper addresses the current status and the issues and challenges of value chains and market access/entry for aquaculture products. It focusses on developments and main drivers of these issues for the last two decades and their implication for the future of aquaculture development and fish trade.

The preparation of this paper coincided with the onset of COVID-19 and its spread worldwide. This has had far reaching implications for the aquaculture value chains and international fish trade. Some of these implications have been incremental and transitory while others have taken a transformational and disruptive trajectory. They are likely to become mainstream approaches in the post-COVID-19 future both as a means of addressing immediate needs and as a way of re-orienting development for the future challenges. This paper addresses some of these long-term implications of COVID-19 for aquaculture value chains and international trade.

2. CURRENT STATUS

2.1. GLOBAL AQUACULTURE PRODUCTION, UTILIZATION AND TRADE

Aquaculture makes a significant contribution to the socio-economic development of many countries (Table 1). Global aquatic animal production was estimated in 2019 at 85.3 million tonnes, valued at USD 260 billion and contributed 54 percent of total fish for human consumption. It represented 48 percent of the total fish production, up from 25.7 percent in 2000. It was dominated by finfish (56.4 million tonnes), molluscs, mainly bivalves (17.6 million tonnes), and crustaceans (10.5 million tonnes). In addition, 34.7 million tonnes of aquatic plants, mainly seaweeds, brought total aquaculture production in 2019 to an all-time high of 120.1 million tonnes (FishStatJ, 2021).

Table 1. Fifty years of selected socio- economic indicators of global aquaculture (FishStatJ, 2021)

	1970	1980	1990	2000	2010	2018	2019
Production (million tons)	2.6	4.7	13.1	32.4	57.1	82.4	85.4
Production (USD billion)	-	-	24.9	48.2	131.5	250	259.8
percent total fish production	4	6.5	13.4	25.7	39.4	46	48
percent total fish consumption	7	8	15	32	45	52	54
Export (million Tons)[1]	7.9 (1976)	10.4	17.1	26.1	34.3	41.5	-
Export (USD billion)[2]	8 (1976)	15.5	35.3	55.8	111.4	166.7	-
Employment (million people)	-	-	4.0	12.6	18.5	27.5	-

An estimated 20.5 million people were engaged in aquaculture in 2018 and another 7 to 7.8 million additional employment opportunities occurred along the aquaculture value chain from harvesting to distribution, including 19 percent women. Of all those engaged in production and processing, most are in small-scale operations in developing countries.

A global in-depth study on employment in aquaculture (Philip et al., 2016), supported by nine country case studies and an in-depth community level consultation concluded that these data were highly underestimated. The study estimates between 27.7 and 56.7 million full- and part-time jobs

[1] Fish trade statistics do not distinguish between wild capture and aquaculture products.

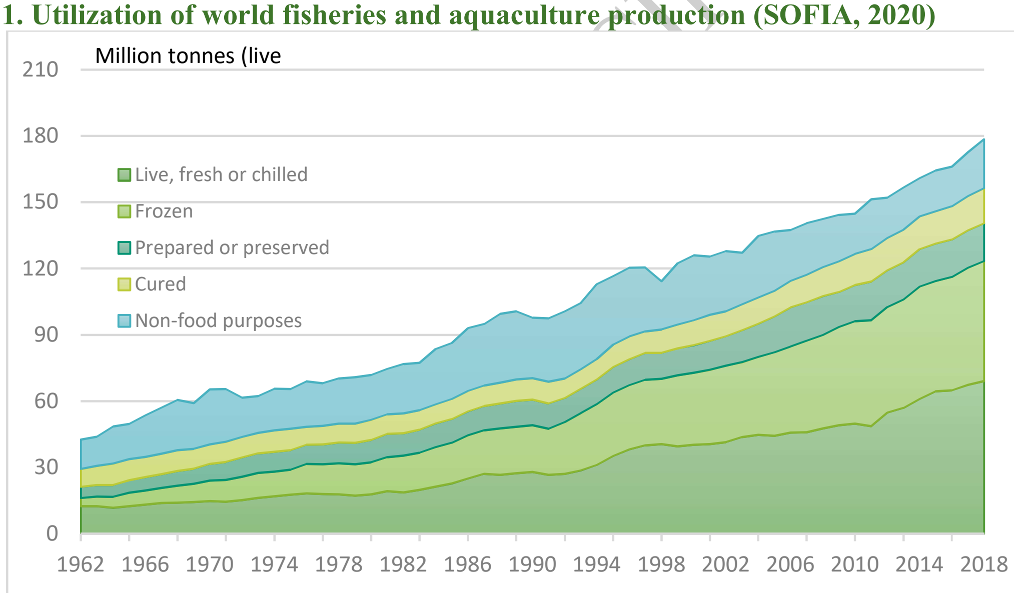
[2] Ibid

in aquaculture. Of the 11.4 million people employed in aquaculture in the 9 countries studied, 6.5 million were employed in small-scale aquaculture value chains, compared with 4.9 million employed in medium- and large-scale value chains. Employment of women in aquaculture value chains in Indonesia, Viet Nam and Zambia was estimated to range between 40 and 80 percent and women were found to be active in post-harvest activities in many countries and to assume important roles in household-based aquaculture such as feeding, managing ponds and marketing.

Some 88 percent of the fish harvested by fisheries and aquaculture in 2019 was used for direct human consumption, as compared to 67 percent in the 1960s. It was distributed live, fresh or chilled (44 percent), which is the most preferred and highly priced product form. The other fish supplied for human consumption were frozen (35 percent), canned (11 percent) or cured (salted, fermented, smoked: 10 percent) (Figure 1).

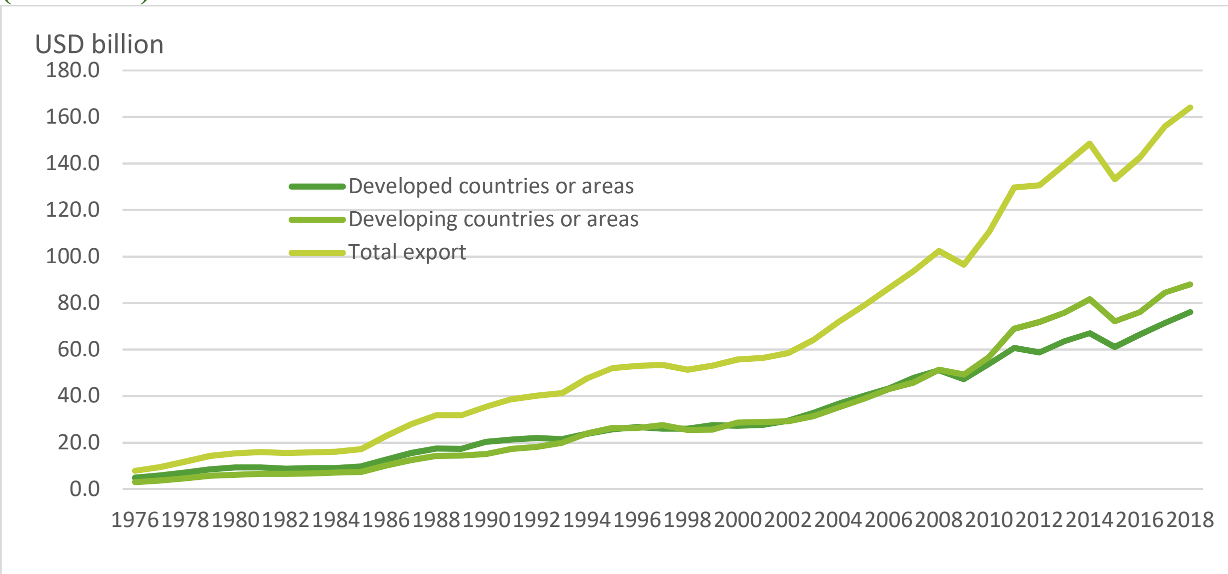
Despite the significant growth in fed-aquaculture, less wild fish, 18 million tonnes in 2019, were used for fishmeal and fish oil production, compared to around 30 million tonnes in the 1990s. Among the reasons, a growing share of fishmeal and fish oil, estimated at 25–35 percent, is produced from the by-products of fish processing, previously often discarded or used as direct feed, in silage or in fertilizers. Other aquaculture organisms, including seaweeds and aquatic plants, are the subject of promising bioprospecting research and pilot projects for use in medicine, cosmetics, water treatment, food industry and as biofuels (UNCTAD, 2018, Naylor et al., 2021).

Figure 1. Utilization of world fisheries and aquaculture production (SOFIA, 2020)



Fisheries and aquaculture products are among the most traded food commodities in the world. In 2018, 67.1 million tonnes or 38 percent of total fish production, were traded internationally (table 1). A total of 221 States and territories reported some fish trading activity, exposing about 78 percent of fisheries and aquaculture products to competition from international trade. Overall, the value of global fish exports increased from USD 7.8 billion in 1976 to peak at USD 164 billion in 2018, at an annual growth rate of 8 percent in nominal terms and 4 percent in real terms (adjusted for inflation) (Figure 2). Over the same period, global export volumes increased at an annual growth rate of 3 percent. Exports of fisheries and aquaculture products represent 11 percent of the export value of agricultural products (excluding forest products) (FAO, 2020).

Figure 2. Value of export of fisheries and aquaculture over the period 1976 – 2018 (FishStatJ)



Developing countries have increased their share of international fish trade from 38 percent to 54 percent in value and from 34 percent to 60 percent in volume between 1976 and 2018 (figure 2) (FAO, 2020). In addition to being the major fish producer, China has been the main exporter since 2002 and the third major importer since 2011. Norway has been the second major exporter since 2004, followed by Viet Nam (since 2014), India (since 2017), Chile and Thailand (Table 2). In 2018, the European Union was the largest fish importer (34 percent in value), followed by the United States of America (14 percent) and Japan (9 percent). In 1976, these shares were 33 percent, 22 percent and 21 percent, respectively (FAO, 2020) (table 2).

The main traded farmed species are shrimp, salmon, catfish, tilapia, shellfish (figure 3). Among these, farmed shrimp, salmon, tilapia and catfish represent a large and increasing proportion. The value of farmed shrimp and salmon in 2019 were estimated at USD 40.7 billion and USD 23.2 billion respectively (FAO, 2021).

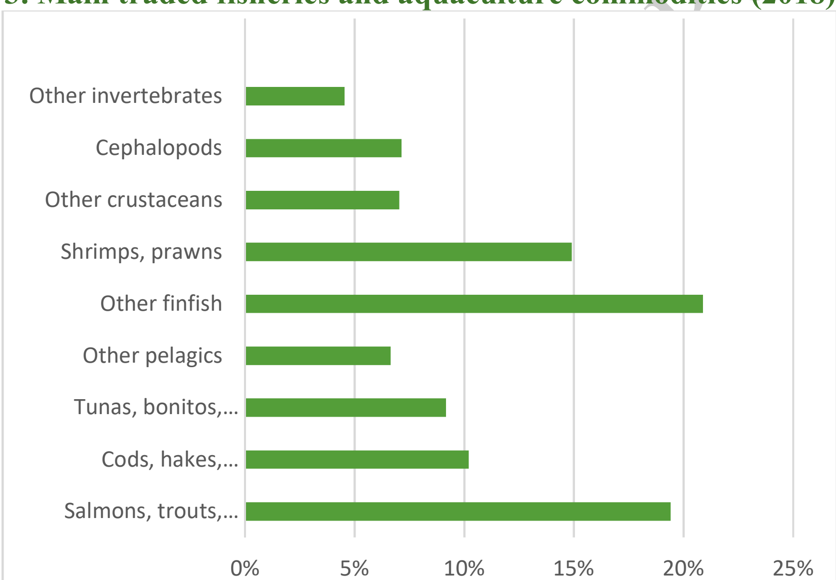
Table 2. Major exporters and importers of fish and fish products in percent of export value (2018)

Major exporting countries (percent of total export value)		Major importing countries (percent of total import value)	
China	13.2	USA	14.8
Norway	7.3	Japan	9.6
Viet Nam	4.4	China	9.0
India	4.2	Spain	5.4
Chile	4.1	Italy	4.4
Thailand	3.7	France	4.4
USA	3.7	Germany	3.7

Netherlands	3.4	Korea Rep	3.7
Canada	3.3	Sweden	3.5
Russian Federation	3.2	Netherlands	2.8
Others	49.4	Others	38.7

While the markets of developed countries still dominate fish imports, the importance of developing countries has been steadily increasing. Urbanization and expansion of the middle class have fuelled demand growth in developing markets, outpacing that of developed nations. Imports of fisheries and aquaculture of developing countries represented 31 percent of the global total by value and 49 percent in quantity in 2018, compared with 12 percent and 19 percent, respectively, in 1976. Oceania, the developing countries of Asia, Latin America and the Caribbean region remain solid net fish exporters. Europe, North America and Japan are major fish importers. Africa is a net importer in volume terms, but a net exporter in terms of value. African fish imports, mainly affordable small pelagics and tilapia, represent an important source of food and nutrition security, especially for populations that are otherwise dependent on a narrow range of staple foods.

Figure 3. Main traded fisheries and aquaculture commodities (2018) (FAO, 2020).

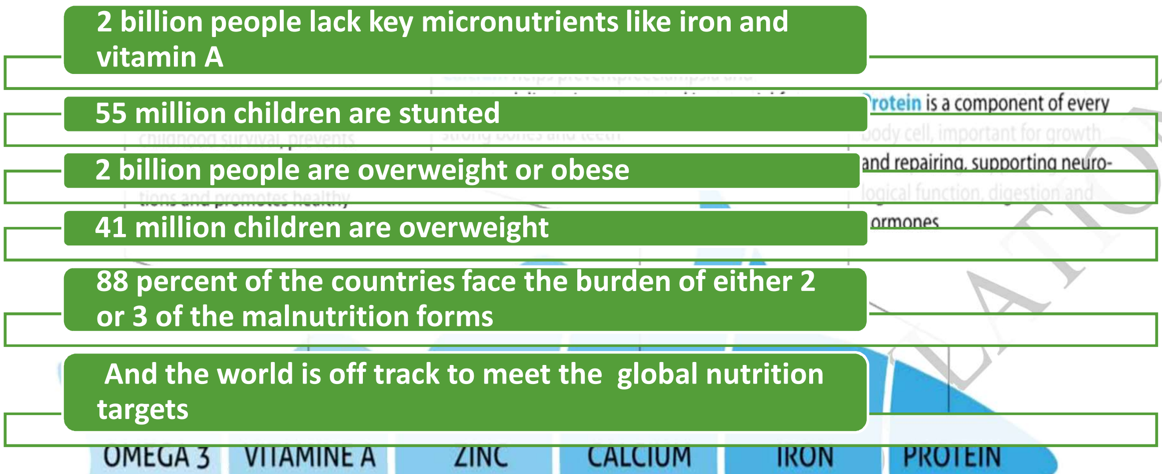


2.2. MAIN DRIVERS OF GLOBAL AQUACULTURE PRODUCTION, UTILIZATION AND TRADE

2.2.1 FISH CONSUMPTION, HEALTH, NUTRITION AND SOCIETAL CHANGES

Throughout the world, major shifts in dietary patterns during the last 40 years have led to a nutritional transition associated with rising rates of obesity and chronic diseases, in particular cardiovascular disease and cancer (figure 4). These diseases have been associated with the consumption of high calorie, high fat refined food that were low in fibre and poor in micronutrients. To reverse this trend, health authorities, consumer associations and the media have sustained policies and campaigns to promote diversified and balanced diets and healthy lifestyles, including higher consumption of fisheries and aquaculture products (figure 4) (Kerney, 2010; De Clerck, 2019).

Figure 4. Scale of the challenge for healthy diets from sustainable food systems (De Clerck, 2019)



A wide scientific literature confirms that fisheries and aquaculture products are healthy, nutritious, and easy to digest. They are a good source of highly nutritious proteins and of a wide range of essential micronutrients and fatty acids (Tilsted et al., 2014; HLPE, 2014) (figure 5).

Figure 5. Nutritional attributes of fisheries and aquaculture products (De Clerck, 2019)

Fish fats contain up to 40 percent of polyunsaturated fatty acids, known as omega 3 fatty acids and highly valued for their health benefits (anti-thrombotic activity for adults and brain development of babies and young children).

Fish proteins contain all the essential amino acids and have a very high biological value. As such, fish proteins improve significantly the nutritional value of cereal-based diets, which are poor in certain essential amino acids. This is the case for many coastal communities in Africa and Asia whose diets contain predominantly rice and fish. Also, fish meat is generally a good source of the B vitamins and, in the case of fatty species, of A and D vitamins. In terms of minerals, fish is a valuable source of calcium, phosphorus, iron, copper, selenium and iodine (figure 5).

World fish consumption has increased continuously from an average of 9.9 kg in the 1960s to 20.3 kg per capita in 2019. This increase has not been uniform across regions and countries of the world, reflecting different food cultures and traditions, availability of fish and other foods, consumer preferences, prices and socioeconomics. Differences are also evident within countries, with consumption usually higher in coastal areas.

A recent review of fish consumption patterns in the USA during the period 1990 – 2017 (Shamshak et al., 2019) shows a shift towards a limited number of species that are primarily imported and predominantly sourced from aquaculture. The five leading species in 1990, representing 61 percent of total seafood consumption, were canned tuna, shrimp, cod, Alaska pollock, and salmon, where the shrimp and salmon were still primarily sourced from wild fisheries. By 2017, the top five species consumed had shifted significantly toward aquaculture species. They included shrimp, salmon, catfish, tilapia and canned tuna, the only wild species. More importantly, the share of these top five species had increased to 70.2 percent of total consumption, with a peak of 78.4 percent in 2013.

Similar trends have been reported in studies on fish consumption in Europe (EUMOFA, 2017), Australia (Bogard et al., 2019), Japan (Kobayashi, 2015) and other countries of Africa, Latin America and the Caribbean (FAO, 2020). White finfish species are among the most preferred by consumers in Northern Europe and in North America, whereas cephalopods are mainly consumed in Mediterranean and Asian countries. Crustaceans, high-priced commodities, are consumed worldwide, mainly by middle and high-income consumers. Increased production of farmed shrimps and prawns has made crustaceans more affordable with a per capita availability increasing from 0.4 to 1.5 kg between 1961 and 2018. The same trends hold for shellfish, whose availability increased from 0.6 to 2.0 kg per capita. The other broader groups of fish did not show significant changes in availability, with demersal and pelagic finfish species averaging 3.0 kg per capita.

In addition to health concerns, societal changes have emerged as important factors that influence decisions of consumers and consequently producers, technologists, traders and retailers. These include rising incomes, urbanization and greater female participation in the workforce, demographics, education and related health awareness. Also, with evolving lifestyles and better disposable income, consumers want convenience, diversity and immediateness. All these factors, coupled to the influence of media in consumer choices, have driven the demand for product diversification, higher-value products, semi-processed and processed products that are ready to eat or require little preparation before serving.

While growing urbanization has led to many challenges for the environment, mobility and health, it revealed to be a good driver of dietary patterns, both quantitatively and qualitatively, changing the lifestyles of individuals and stimulating development in infrastructure, in particular transportation, distribution, markets and cold chain infrastructure (Kearney, 2010; Philip et al., 2016).

2.2.2. TECHNOLOGICAL AND MARKETING DEVELOPMENTS

Developments in fish farming has played a significant role in satisfying the growing demand for human consumption of fish. The average contribution of aquaculture to per capita fish available for human consumption rose from 7 percent in 1973 to 14 percent in 1986 and 54 percent in 2019 (table 1), popularizing world consumption of several affordable species, such as tilapia and catfish or high-value species, such as shrimps, salmon and shellfish. These species have shifted from being primarily fished 30 years ago to being currently primarily farmed.

A key advantage for aquaculture species over wild capture species is the possibility for reliable and consistent supply of market size and quality allowing an increasing degree of standardization in the hotel, restaurant, and catering sector, a demanding but highly lucrative market segment. There is also less loss and waste in fish farming over capture fishing. This development was led initially by salmon, catfish, and shrimp, followed by an increasing number of species like seabass, seabream, tilapia and pangasius which have gained prominence on menus, especially in North America and Northern Europe (Fernandez Polanco et al., 2014).

2.2.2.1 TECHNOLOGICAL DEVELOPMENTS

To rise to the challenge of meeting the increasing global demand for fish products at prices that are affordable and competitive with other food commodities, the aquaculture industry has invested in innovations and technologies both in production and post-harvest operations. The innovations have embraced a wide range of areas from fish breeding, feed formulation, seeds and fingerlings, disease management, food processing, packaging, food services and distribution logistics.

There is limited knowledge of how innovation processes in aquaculture have been approached in terms of focus and scope and their management. Joffre et al. (2017) reviewed the aquaculture literature, analysing the approaches used to conceptualize and manage innovation. These innovations and technology development in primary aquaculture production are addressed by other thematic papers of this Global Conference on Aquaculture (GCA). Likewise, technological innovations in processing, storage and distribution are driven at the food industry levels with current major orientations towards clean technologies that enable saving of water and energy, reduced pollution, increased efficiency and recycling.

2.2.2.2 MANAGEMENT, ECONOMICS AND MARKETING

To embrace efficiently these innovations and technological developments, research and support institutions developed management tools, practices and skills, many adapted from other areas of the food industry and agribusiness. The Cost – Benefit analysis (CBA) at the farm level catalysed the choice of production systems and the promotion of alternative production technologies for similar species that are more efficient, energy saver and environmentally friendly.

Improved efficiency in aquaculture has used bioeconomic modelling to optimize combinations of production factors, return on investment and costs. These models analyse the impact of a range of production inputs (labour, feed, fingerlings, energy, etc.) and environmental conditions (temperature, salinity, water quality) on the economic performance of the farm at given market prices, using complex algorithms and artificial intelligence. Likewise, price transmission analysis assesses whether a shock in the prices at the ex-farm level is transferred to the downstream levels of the value chain. By transferring the changes in their prices, farmers are able to adjust them to the changes in their costs, and so maintain the profitability required to sustain their business.

The dynamics of price transmission in aquaculture value chains has been a research topic of special interest for economists in the last decade, given the implications in the negotiating power among agents in the value chain and in the sales margins at its different levels. These works are based on the application of price integration methods to the fish markets in general and aquaculture in particular. Most of these studies have focussed on the products marketed in developed countries (Asche et al., 2014; Scuderi and Chen, 2018; Fernandez Polanco et al., 2021). They conclude that price transmission improves in differentiated high value species, like smoked salmon in contrast with fresh seabream. Further, producers' concentration, whether in large companies, cooperatives, clusters or associations become critical to mobilize bargaining power in front of the downstream actors, to transfer shocks in costs to the last end of the value chain by mean of prices.

Likewise, branding at the retail level has driven product differentiation and the development of market niches targeting consumers conscious of environmental and social considerations of fish farming and distribution, far beyond the traditional safety and quality. This is however not specific to aquaculture products, although the concerns and their causes are on a different scale and have different impacts as compared to other food systems.

2.2.2.3. COMPETITION WITH WILD FISH SPECIES AND OTHER FOODS

Competition of aquaculture products with other food commodities and the substitution across fish species and food products has reshaped market segments and their delimitation. Interest of food firms has been initially focused on the substitution of wild fish species by the same farmed species. However, the competitive dynamics is now more complex, affecting multiple species of both farmed and wild origins. Competition between domestic and imported seafood has been a recursive topic, particularly in developed countries. In this frame, international competition across aquaculture producers of the same species is the more evident and easier to assess. On a wider scale, import of large volumes of low-cost freshwater species (tilapia and pangasius) by developed countries has revealed a highly dynamic system of competitive linkages and substitution among a large range of white fish species. Similar trends for frozen tilapia, and to a lesser extent for pangasius, are reported in African markets. All these examples highlight the pre-eminence of price as the main competitive tool in aquaculture (Fernandez Polanco et al, 2012; Bjorndal & Guillen, 2017).

2.2.2.4. THE CHALLENGE FOR SMALL SCALE AQUACULTURE

Adoption of new technologies and practices in small scale aquaculture has been a great challenge because of the large fragmentation of small-scale producers and their inability to absorb individually the costs, to acquire skills and upgrade practices, and to exercise negotiating power over prices and access to services. In many countries, these barriers have been circumvented by organizing farmers into cooperatives or clusters. Cooperatives or clusters represent networks and partnerships between farmers and other actors within the value chain, such as input retailers, hatcheries and nurseries, extension services and buyers. They have been shown to influence the relationships between producers and other actors within the value chain and improve the flow of knowledge, technology, market information and support services (Philip et al., 2016).

Recent studies in Vietnam by Nguyen and Jolly (2019) and Joffre et al., (2020) looked at the role that farmers' cooperatives or clusters play in the adoption of practices and technologies by shrimp farmers in Vietnam. The studies confirmed that:

- ✓ Horizontal integration into a cooperative was a necessary and efficient way forward to enable small scale farmers meet market access and certification requirements.
- ✓ Formation of a cooperative of small-scale farmers, collectors, and providers of supporting logistics to the value chain, vertical backward integration with input providers and forward integration with processing plants, were sufficient conditions to enable small-scale producers to attain certification and improve product standards in Vietnam. Farmer clusters are key organizational platforms to the adoption and dissemination of sustainable aquaculture practices, both for private and public extension services,
- ✓ membership in farmer cooperative or cluster increases interactions with and influences trust in different sources of knowledge, ultimately improving the adoption rate of technology and aquaculture practices.
- ✓ shrimp farmers who are members of a cooperative or a cluster are more likely to adopt better management practices such as water quality management, feed input, and disease control practices.
- ✓ Farmers' cooperatives or clusters increase trust and tighten relationships between members.

2.3. RULES GOVERNING INTERNATIONAL TRADE, MARKET ACCESS AND MARKET ENTRY

The World Trade Organization (WTO) is the international organization dealing with the rules of trade between nations. These rules are enshrined in the WTO agreements, negotiated and signed by its members and ratified in their parliaments. The trade rules are based on a set of common principles. These include non-discrimination, freer trade, predictability, and promotion of economic development and growth (Table 3).

The General Agreement on Tariffs and Trade (GATT) and the General Agreement on Trade in Services (GATS) schedules list commitments that individual countries have made to allow different products and services into their markets. The WTO achieves the principle of predictability through these binding commitments and by enforcing transparency. A country can change its bindings after negotiating with its trading partners, which could involve compensation for loss of trade. Transparency is maintained through regular notification by WTO members. Further, the WTO conducts regular reviews of member nations' trade policies.

Table 3. Basic structure of the WTO trade rules and agreements

	Agreements establishing the WTO		
Basic principles	1.Non-discrimination, 2. Freer trade, 3. Predictability, 4. Promotion of economic development and growth		
	Trade in goods (GATT)	Trade in services (GATS)	TRIPS

Additional details	Annexes describe agreements on various goods (e.g. AoA, SPS, TBT, textiles)	Annexes describe agreements on various services	Minimum standards on the protection of covered categories of intellectual property right
Market access commitments	Countries' schedules of commitments	Countries' schedules of commitments (positive list)	
Dispute settlement	Dispute settlement body		
Transparency	Regular notifications by member sand trade policy reviews by WTO		

The complexity of international trade and its rules, and the national and sometimes diverging interests at stake regularly produce trade disputes, which the WTO often acts to settle. The WTO enforces its rules with panels of trade and legal experts and an appellative body set up to adjudicate compatibility disputes under the auspices of the WTO Dispute Settlement Body (table 3).

2.3.1. TARIFFS AND MARKET ACCESS

The wide diversity of fisheries and aquaculture products entering international trade makes their classification critical and complex. The Harmonized System (HS) is an international standard nomenclature designed to allow traded goods to be classified on a common basis for customs purposes. It comprises a commonly used six-digit code system, encompassing approximately 5,300 product descriptions arranged in 99 chapters, grouped in 21 sections. The HS system is also used for statistical, taxation, control, and monitoring purposes. All exported and imported products are classified using the HS system (FAO/WCO, 2021; UNCTAD, 2020). Current HS codes do not differentiate between wild harvested and farmed products. Countries can, however, create additional digits in their national classification for specific purposes, in particular to distinguish specific species of fish as well as to differentiate products from wild-capture or aquaculture origin. For example, USA and Canada have specific nomenclature codes for farmed salmons, trouts, oysters, and mussels. Mexico and New Zealand have adopted similar approaches of creating specific codes for inputs used for aquaculture production.

Incorrect classification of fisheries and aquaculture products can result in non-compliance penalties, border delays or product seizures, or denial of import privileges. Any disruption in the trade flow associated with product classification can bring additional problems considering the highly perishable nature of both wild and aquaculture products. Furthermore, misclassification of products can lead to increased import duties when any preferential market access is lost and can also create a mistrust in importing from a specific country.

Tariffs are classified basically into three types: bound tariffs, applied tariffs and preferential tariffs. Bound tariffs are tariffs agreed upon during negotiations and deposited at the WTO. Bound tariffs function as ceilings to reference the maximum import duty a country can impose on a product or service. Applied tariffs are the effective import duty imposed on a product or service by a country at a specific time. In most countries, import duties do not change regularly, and, in many cases, any tariff change is linked to a particular transparency and information mechanism. Nevertheless, when an applicable tariff is changed upwards, the ceiling for a new tariff is the bound rate which is usually unchanged. On the other hand, preferential tariffs are reduced tariffs associated with certain agreements and conditions. Most of the preferential tariffs are associated with the negotiation of trading agreements involving two or more countries to enhance trade opportunities or unilateral concessions by a granting country.

The Generalized System of Preferences (GSP) sets tariff preferences granted unilaterally by a developed country on specific products to given developing countries. It was established within UNCTAD in 1971[3], and currently, 13 countries grant unilateral tariff preferences under the GSP schemes. GSP Schemes are applied on a non-reciprocal basis, and there is no need for any underlying agreement between the involved countries or recommendations governing any condition of entitlement.

In practice, under the GSP schemes of preference, selected products originating in developing countries are granted reduced or zero tariff rates over the Most-Favoured Nation (MFN) rates[4] when being exported to a specific developed country. To benefit from this tariff reduction, the exported product must comply with particular requirements of rules of origin and have a document or statement certifying its origin.

Another type of unilateral tariff benefit is associated with the preferences granted by a country, on an entirely autonomous basis, to a country classified as a Least Developing Country (LDC). Every three years, the UN Committee for Development Policy (CDP) reviews the list of LDCs and makes recommendations for inclusion in or graduation of countries from the category of LDCs[5].

Tariff escalation is one explicit restriction of market access for fisheries and aquaculture products easily identifiable by analyzing the applied tariffs but also in some preferential agreements. Tariff escalation occurs when a country imposes higher import duties on semi-processed products than raw materials and higher still on finished products. In most cases, tariff escalation is associated with national policies towards protecting domestic processing industries, creating disincentives for developing additional value-added activities in the countries where raw materials originate.

Development in international fish trade has been facilitated by favorable tariffs that are not particularly high, in comparison with other commodities, and have been decreasing slowly since 2011. Applied tariffs were estimated globally at about 4.8 per cent on average for raw fish and fish fillets in 2014, a decrease from 6.7 per cent in 2009 (UNCTAD, 2016). However, tariff escalation is commonly found on tariff lines that cover processed fish products. For example, EU tariffs for processed fish and fish products are subject to tariff peaks of 25 per cent for processed tuna, 20 per cent for processed shrimp and 12 per cent for canned sardines. It is worth noting that fishery products from ACP countries benefit from the EU GSP[6].

Fish trade between developing countries has been increasing steadily. To enhance this trade, the Global System of Trade Preferences (GSTP) is highly needed. Its acceleration is foreseen once the Sao Paulo round of negotiations (SPR) concluded in 2010 enters into effect, reducing applied tariffs by at least 20 percent for over 70 percent of the national tariffs list. Eleven countries[7], including significant aquaculture producers, exchanged tariff concessions and adopted SPR. Fish

[3] https://unctad.org/en/Docs/td97vol1_en.pdf)

[4] MFN tariffs are the tariffs countries impose on imports originating from other members of the WTO when entering their territory when there is no lower preferential rate.

[5] https://www.un.org/development/desa/dpad/wp-content/uploads/sites/45/CDP-2020-Criteria-review-outcome.pdf

[6] https://trade.ec.europa.eu/doclib/docs/2013/may/tradoc_151173.pdf

[7] Argentina, Brazil, Paraguay and Uruguay (forming Mercosur), the Republic of Korea, India, Indonesia, Malaysia, Egypt, Morocco and Cuba, of which five have ratified (Argentina, India, Malaysia, Cuba, and Uruguay).

products are often included in the schedule of commitments of the SPR. The future rounds of the GSTP should focus the negotiations on goods that contribute to environmental protection and sustainability to achieve SDGs targets while creating additional opportunities for South-South cooperation and further integration of value chains.

2.3.2. NON-TARIFF MEASURES FOR MARKET ENTRY

Aquaculture products are widely traded, and trade-liberalization has expanded opportunities for many producing countries to compete in international markets. While reduced tariffs have been a facilitating factor in trade-driven development, much of the focus has shifted to examining the role of NTMs in determining trade flows. Non-tariff barriers play an essential role in regulating trade in fish, such as enabling trade by ensuring that imports meet domestic standards. Yet, NTM are often supposedly made harder to comply with and less transparent than tariffs. NTMs regulations must be enacted in line with WTO principles of transparency, based on relevant international standards or other scientific justification, non-discriminatory, and not more trade-restrictive than necessary.

Especially relevant for fish trade is compliance with human, animal, plant, environmental, and manufacturing standards under the WTO agreements on Sanitary and Phytosanitary Measures (SPS) and Technical Barriers to Trade (TBT). Both agreements play an essential role in structuring trade regulation and dictate policy space countries have when setting the standards that aquaculture products must comply with. The majority of SPS and TBT measures applicable to fish and fish products are not explicitly implemented for aquaculture products. Instead, they are intended to regulate the safety of fish and fish products from all sources. Nevertheless, measures with specific mention to aquaculture form a significant proportion of total notifications with almost a quarter of all SPS notifications involving fish in a given year mentions aquaculture.

In addition, NTMs can be associated with environmental and social measures, often enacted by private standard-setting bodies and certification organisms, mainly NGOs. A comprehensive review of NTMs and their implications for fisheries and aquaculture products has been published following the last AGC (Ababouch, 2013). Many of the findings are still valid nowadays.

It is claimed that NTMs result from the increasing awareness and demand of consumers for safe, high quality, socially and environmentally responsible food systems. As a result, consumers are claimed to expect the fisheries and aquaculture products they purchase:

- ✓ to be safe and of acceptable quality regardless of how and where it is produced, processed or ultimately sold,
- ✓ to come from sustainably managed fisheries and aquaculture operations,
- ✓ to be legally fished, farmed and processed, in full respect of social and environmental protection requirements.

NTMs have been classified into 15 chapters comprising technical and non-technical measures[8]. Two major groups are relevant to fish trade: The SPS measures and environmental and social measures. They are enacted by government institutions in the form of technical regulations and conformity assessment procedures, and/or by private standard setting bodies and certification organisms, mainly NGOs. A comprehensive review of these NTMs and their implications for fisheries and aquaculture has been presented at the last GCA (Ababouch, 2013). Many of its

[8] https://unctad.org/webflyer/international-classification-non-tariff-measures-2019-version

findings are still valid nowadays and will not be addressed here. Instead, this thematic paper will take stock of more recent developments and challenges faced and draw lessons for the future market entry requirements for aquaculture products.

2.3.2.1 SANITARY AND PHYTOSANITARY (SPS) MEASURES

A range of national and international SPS measures, consisting of animal health, food control and certification systems across national borders, and private standards are commonly implemented to ensure animal health and consumer protection, which remains the most important requirement for smooth market entry. Modern food and feed safety and quality systems to meet international SPS measures require the implementation of best hygienic practices during farming, harvesting, landing, processing and distribution (Ryder et al., 2014). Depending on the fish species, the key SPS measures include:

- ✓ Monitoring harvesting areas to prevent and control their pollution by chemical and biological agents originating from land or water- based activities (urban, human, agriculture, industry).
- ✓ Implementing Good Aquaculture Practices (GAP), Good Hygienic Practices (GHP) and Good Manufacturing Practices (GMP) during production and post- harvest stages.
- ✓ Enforcing animal health, food safety and quality regulations and management systems.

Government authorities are responsible for monitoring the farming and harvesting grounds and certifying that good practices are adhered to in hatcheries and fish farms and during post-harvest processing and distribution. The industry has the primary responsibility for implementing good practices during farming, harvesting and the post-harvest stages, under control by the Government authorities that are responsible for certifying that good practices are adhered to along the fisheries and aquaculture products value chain.

International guidelines for animal health, food safety and quality, promoted respectively by the International Organization of Animal Health (OIE) and the *Codex Alimentarius*, provide advice to national authorities on strategies to strengthen animal health and food control systems to protect public health, prevent fraud and deception, avoid food adulteration and facilitate trade (Ryder et al., 2014). They assign to national animal health and food control systems the following objectives:

- ✓ Protecting animal and consumer health by reducing the risk of animal disease and foodborne illness.
- ✓ Protecting animals and consumers from disease, unwholesome, mislabelled, or adulterated food; and
- ✓ Contributing to economic development by maintaining consumer confidence in the food system and providing a sound regulatory foundation for domestic and international trade in food.

Four building blocks are needed to implement robust national food control systems:

- ✓ Laws for Animal health, food and environment and their supporting regulations,
- ✓ Animal health, environmental protection and food control management,
- ✓ Food control, monitoring and inspection services,
- ✓ Information, education, communication and training.

The overall patterns of SPS notifications remained relatively unchanged since 1995. In 2020, the most frequently cited objective of the notification is food safety (68 percent), followed by animal health (23 percent) and plant protection (18 percent), while for emergency notifications it is animal health (84 percent), followed by food safety (32 percent) and protection of humans from animal/plant pest or disease (29 percent) [9].

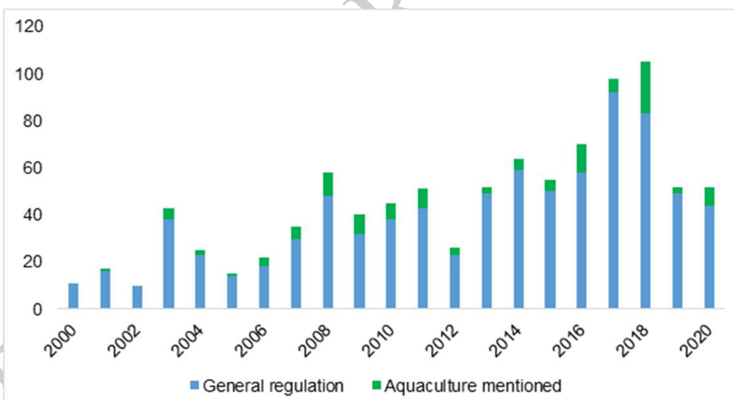
The SPS agreement accounts for most notified measures applicable to fisheries and aquaculture products. The number of SPS measures notified to the WTO varied during the last 20 years, from 11 in 2000 to a high of 108 in 2018 (figure 6).

2.3.3. ENVIRONMENTAL AND SOCIAL STANDARDS

While animal health, food safety and quality remain a primary concern, consumers have been increasingly concerned by technical measures related to the social and environmental impacts of the food they consume. These measures are the subject of media coverage and activism by conservation NGOs and social welfare CSOs. For fisheries and aquaculture products, this means in a nutshell that more consumers expect that:

- ✓ wild fish stocks are managed sustainably,
- ✓ aquatic ecosystems and related plant and animal life are protected,
- ✓ aquaculture is environmentally sustainable, and
- ✓ social responsibility is exercised throughout the aquaculture value chain, from farming through to distribution (FAO, 2020).

Figure 6. SPS notifications for fisheries and aquaculture products since 2000

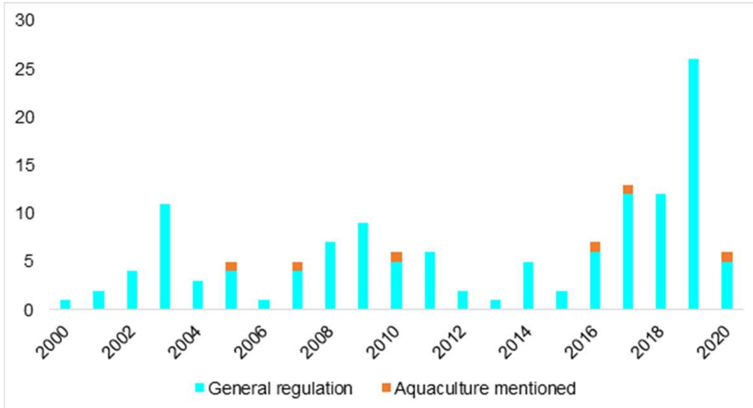


The number of total notifications under the TBT agreement peaked in 2019 at 3252. From 1995 to 2020, trading countries were concerned mainly about protection of human health and safety (14,230 notifications), quality requirements (4,975), protection from deceptive practices (4,896), protection of the environment (3,686), consumer information and labelling (3,111) and harmonization (1,247), much lower than reducing trade barriers and facilitating trade (1,130), cost saving and productivity enhancement (170) and national security requirements (113)[10]. The TBT notifications for fisheries and aquaculture products varied from 1 in 2000 to 27 in 2019.

Figure 7. TBT notifications for fisheries and aquaculture products (2000 – 2020)

[9] https://docs.wto.org/dol2fe/Pages/SS/directdoc.aspx?filename=q:/G/SPS/GEN804R13.pdf&Open=True

[10] http://tbtims.wto.org/en/PredefinedReports/NotificationReport



The FAO Technical Guidelines on aquaculture certification (FAO, 2011), which have been developed through a 6-year wide process of consultation with governments, NGOs, industry and traders, provide guidance for the development, organization and implementation of credible aquaculture certification schemes. They address animal health and welfare, food safety, environmental integrity and socio-economic aspects associated with aquaculture production. The guidelines define the minimum substantive criteria for these four areas and cover:

- ✓ standard setting processes required to develop and review certification standards,
- ✓ accreditation systems needed to provide formal recognition to a qualified body to carry out certification, and
- ✓ certification bodies required to verify compliance with certification standards.

Since 2014, the FAO has conducted multistakeholder consultations, called "The Vigo Dialogue on Decent Work", focusing on the benefits of promoting decent employment in fisheries and aquaculture. These dialogues aim to discuss labour issues and propose priority actions to accelerate implementation of relevant international and national legal frameworks and instruments by governments, IGOs and NGOs, civil society and industry. In 2016, FAO Members highlighted the increasing concerns about social and labour conditions in aquaculture. They confirmed the significant importance and relevance of those issues in the fish value chains, particularly the recognition and protection of human and labour rights at national and international levels.

Currently, FAO is developing voluntary guidance to facilitate compliance towards social responsibility in fisheries and aquaculture value chains focusing on actors their roles and activities. The FAO guidance in preparation, which will not create any new instrument but will compile existing international instruments into a coherent and simplified guidance document to be used by IGOs, NGOs, CSOs, governments, research and academia working in the field of socially responsible fisheries and aquaculture value chains. UNCTAD, IMO, the ILO and the OECD have been supporting and cooperating with FAO in this process to ensure wide consultation and multidisciplinary perspective.

2.3.4. PUBLIC VS PRIVATE REGULATIONS, STANDARDS AND CERTIFICATION SCHEMES

In addition to the various public regulations and measures, a whole range of private standards has been adopted by producers, importers, traders and retailers. These voluntary standards are driven mainly by NGOs and have become key to enter international markets. Despite noticeable success stories, most exporting developing countries currently supply market segments that occupy the lower end of the international market, and these have been largely unaffected by voluntary private standards, although public animal health and sanitary measures remain mandatory.

Public and private standards in food trade are usually underpinned by certification schemes. Harmonization of public regulations is achieved through equivalence and recognition arrangements between regulatory authorities of the trading countries in accordance with the provisions of the SPS agreement. On the other hand, private standards related to animal health, food safety and quality are typically business-to-business (B2B) arrangements, whereas those related to sustainability, social or environmental protection, or directed to other niche markets such as organics or fair trade, typically follow a business-to-consumer (B2C) model recognized through a label. NGOs play an important role through their labelling and certification schemes (Ababouch, 2013). Their actions aim to influence consumers and their choices of food purchase. They operate according to 4 basic modes:

- ✓ Red listing overfished or endangered fish species and encourage consumers to avoid their consumption[11].
- ✓ Report on the environmental performance of retailers and inform the public accordingly [12].
- ✓ Organize a « *Name and Shame Campaign*», often in the presence of media, to denounce an influent actor of the value chain (e.g., a retailer, an importer, a company) or even a country, for practices considered harmful to the environment or socially irresponsible.
- ✓ Engage key market players to adopt eco-labels and certification schemes (e.g., Naturland, Global GAP, GAA, etc.).

Since the adoption of the FAO technical guidelines on aquaculture certification, many aquaculture certification and labelling schemes claim their alignment and conformity to these guidelines. This raised concerns as to:

- ✓ who should be responsible for verifying these claims,
- ✓ what assessment methodologies to use,
- ✓ who should carry out any benchmarking exercise, and
- ✓ for what purpose (e.g., as an assessment tool, a formal benchmark or to achieve mutual recognition).

The Global Food Safety Initiative (GFSI)[13] was created by major food retailers in 2000 to promote mutual recognition of food safety management standards worldwide. Likewise, the Global Sustainable Seafood Initiative (GSSI)[14] was launched in 2013 as a public private partnership (PPP) to address the same concern for seafood sustainability. In 2015, GSSI developed a global tool for benchmarking sustainability certification schemes.

2.3.5. TRACEABILITY

ISO (ISO 9000:2005) defines traceability as "*the ability to trace the history, application or location of that which is under consideration*". When considering a product, traceability relates to the origin of materials and parts, the processing history and the distribution and location of the product after delivery.

[11] https://www.greenpeace.org/usa/oceans/sustainable-seafood/red-list-fish/
[12] https://www.greenpeace.org/usa/2018-supermarket-seafood-ranking/
[13] https://mygfsi.com/
[14] https://www.ourgssi.org/

For food safety considerations, the Codex Alimentarius (FAO, 2006) defines "*traceability/product tracing as the ability to follow the movement of a food through specified stages of production, processing and distribution*". This definition has been adopted into a regulation by the EU to signify "*the ability to trace and follow a food, feed, food producing animal or substance intended to be, or expected to be incorporated in a food or feed, through all stages of production, processing and distribution*" (EC, 2002).

Chain of custody is a more specific concept and guarantees not only the ability to trace products but also to ensure their integrity throughout the value chain. It aims to guarantee that a certified product is not mixed with a non-certified product. Retailers and brand owners find traceability schemes most compelling because they provide valuable guarantee and risk-management functions, in particular when there is a lack of confidence in public institutions or in another value chain actor, whether in food safety or environmental and social areas. Traceability is especially important in the context of increasingly complex value chains where products pass through multiple actors in multiple countries before reaching the final consumer. Robust traceability and chain of custody mechanisms also prevent fraud, whereby non-certified products being passed off as certified.

Current development focus on the opportunities that innovations in information technologies offer, and on how these can change the way aquaculture sustainability issues are generated, documented, interpreted and communicated. Blockchain has good potential to improve traceability, accuracy and accountability along aquaculture value chains, although significant constraints remain (Blaha and Katafono, 2020)[15]. it consists of a linked chain that stores auditable data in units called blocks. It can be used to record, track and monitor physical and digital assets in aquaculture value chains. It offers opportunities to integrate and manage, in real time, processes, product attributes and transactions that are added by supply-chain actors and the Internet of Things (IoT), such as sensors and other devices. It can provide an online traceability infrastructure for the permanent storage and sharing of key data elements (e.g., production area, species and product type, production or expiry date) along with critical tracking events (e.g., harvesting, landing, product splits or aggregation and processing). Blockchain is already used as a digital ledger for recording transactions of products between supply chain actors (FAO, 2021).

2.4. THE EMERGENCE OF VALUE CHAINS IN GLOBAL AQUACULTURE

The concept of value chain analysis, development and governance has emerged during the last 20 years as an approach to analyze and understand the dynamics at value chain nodes of key players, economic costs and benefits, value addition and value creation and to develop policy options and suitable market instruments for the promotion of sustainable aquaculture (Bjorndal et al., 2014; Bush et al., 2019).

A value chain describes the range of activities, actors and services required to bring a product from the initial stage, through the various phases of production and processing, to its final market destination. The production and processing stages comprise a combination of physical transformations and the participation of various actors and services (Bjorndhal et al., 2014).

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[15] www.fao.org/3/ca8751en/CA8751EN.pdf

As the name suggests, incremental value is added to the product in the successive nodes of a value chain either by value addition or value creation. Value addition can result from processing to convert raw fish into a semi-elaborated or elaborated product that has more unit value or longer shelf life in the marketplace. Value creation results by differentiating product attributes such as geographical location (e.g., Mediterranean seabass). The value addition or creation can include economic gains (higher price, greater competitiveness, longer shelf life, expanded market, etc.), but also social gains (e.g., more employment, secured access rights to natural resources, gender balance, better nutrition) or environmental gains (e.g., reduced pollution and carbon footprint).

Value Chain Analysis (VCA) studies interactions and synergies among actors and with their business and policy environment, and how entry barriers are created and how costs, benefits and risks are distributed. VCA can help government institutions and private actors to develop a shared vision of how a specific aquaculture value chain performs and to identify collaborative relationships to improve its performance. For policymakers, value chain analysis is a means of identifying policy interventions, public investment and capacity building opportunities, fiscal and economic incentives, monitoring and corrective measures. Therefore, value chains can be viewed as empowering the various, but often fragmented stakeholders, as they recognize innovative opportunities to contribute and increase in a synergetic way the value of their aquaculture products.

The approach has gained much traction during the last decade in major studies on the economic, social and environmental sustainability of aquaculture and international trade. Jespersen et al. (2014) examined the upgrading trajectories of 3 aquaculture value chains (shrimp, tilapia, pangasius) in four Asian countries (Thailand, Bangladesh, China and Vietnam) and the links between their upgrading and three factors of value chain governance: coordination mechanisms, types of drivers, and domestic regulations. The study revealed instances of improving products, processes, and value chain coordination—but "moving up" the value chain was rare.

A WorldFish/FAO study (Philip et al., 2016) developed baseline information on the status of the aquaculture sector from a human development perspective, identifying the types and numbers of people employed along the aquaculture value chains and exploring their role in providing social and economic services at a global level, with a particular emphasis on small-scale stakeholders. The study was based on a global synthesis of information from various sources and 9 country case studies undertaken in Africa, Asia and Latin America. It characterized the greater role of small-scale aquaculture in providing employment and social services globally and in the different countries studied.

More recently, Bush et al., (2019) published a special issue analyzing most research conducted on aquaculture value chains. The review identified emerging themes and highlighted the need for greater attention to neglected value chain segments and categories of actors, modes of production, regulation, innovation, and patterns of access to benefits. The review affirms the need for more rigorous and diverse future value chain research to illuminate the future aquaculture development as an increasingly important component of the global food system.

Likewise, Kaminski et al., (2020) studied seven inclusive business models (IBM) commonly used in agriculture development to assess their application in aquaculture value chains. A global value chain (GVC) analysis was used to unpack the economic and social upgrading objectives of the different IBMs, as well as the types of relational coordination used between actors in the chain to achieve development outcomes. The extent to which these IBMs helped poor actors overcome certain barriers is evaluated with a focus on how they may ensure or be a risk to inclusiveness through the relations and upgrading opportunities evident in their make-up.

These developments are being considered by governments and IDFIs to promote sustainable aquaculture development, balancing economic, social and environmental considerations. For example, a recent EC funded project (FISH4ACP)[16], implemented by FAO in collaboration with the ACP secretariat covers 12 ACP fish value chains – 3 are farmed and 2 are mixed farmed/wild oysters.

3. ISSUES AND CHALLENGES

Whereas the significant growth of aquaculture and the associated food security, nutritional and socio-economic benefits for dependent rural and coastal communities are considered positive, they have also raised major concerns over the environmental impact of several unsustainable models of aquaculture development. Aquaculture sites have in several cases been carved out of important natural coastal habitats with rapid expansion exceeding the capacity of planning controls and oversight. Development in aquaculture of fed species, where poorly managed, has affected key biodiversity and ecosystem functions through mangrove deforestation, excessive nutrient release, chemical pollution and the escape of farmed species and disease agents into the natural environment (Naylor et al., 2021). Major causes of impact have been associated with feeding and nutritional wastes, the existence and spread of diseases and the interbreeding of wild and selected strains.

A wide range of approaches have been promoted with varying degrees of successes in their implementation and outcomes. These include the Eco-system Approach to Aquaculture (EAA), spatial planning, aquaculture zoning, aquaculture area management, or market instruments based on standards, certification and labelling. As a result, aquaculture science, technology and practice has gained many insights, knowledge and experience that enable us to adopt sustainable aquaculture development models that mitigate the impact of aquaculture on the environment and the health of aquatic ecosystems and address the negative perception of increasing numbers of consumers regarding modern animal food production systems, in particular its impact on animal welfare, the environment and social responsibility. These challenges should and can be addressed, through policy, innovations and market instruments.

3.1. CONSUMER PERCEPTION OF AQUACULTURE PRODUCTS:

Public perception of aquaculture varies across regions, countries, stakeholders and individuals. Being relatively new, aquaculture technology is confronted with mistrust and concern about food safety, often because of insufficient knowledge. Interest and knowledge tend to increase with the frequency of fish consumption.

For years, studies conducted in major western markets reported negative consumers perception of farmed fish. In these countries, consumers' opinions and beliefs about farmed fish have been to some extent impacted by emotion and image transfer from intensive livestock production rather than on awareness and factual knowledge of aquaculture (Verbeke et al., 2007, Froehlich et al.,

[16] http://www.fao.org/in-action/fish-4-acp/en/

2017; Fernandez Polanco & Luna, 2012; Claret et al, 2012). Scientific uncertainties and conflicting information on fish consumption have further confused the public (Globefish, 2015). The media are influential by choice-editing scientific information reaching the public, particularly in relation to food and nutrition. In fact, studies have found that, in a society of online interaction and immediacy, the majority of consumers nowadays receive information about food and nutrition through internet and the social media. Although the magnitude of influence the media has on public perception is convoluted, mass media does appear to affect and/or reflect a level of people's opinions (Froehlich et al., 2017), in particular in relation to animal health, food safety social and environmental issues. Often, negative news capture more the attention and memory, while positive news are often taken for granted and disregarded.

A study in the USA (Britwum et al., 2018) explored perceptions of aquaculture and how consumer opinions are influenced by environmental, economic, and social concerns. Although most respondents believed that aquaculture relieves pressure on wild fish populations, there were concerns it has similarly negative environmental impacts as agriculture. Aquaculture benefits were not viewed significantly higher than its risks, and both loss and gain-framed messages influenced perceptions of wild fishing. These combined findings indicate a potential openness to aquaculture and suggest that there are still avenues to highlight its benefits and boost the image of farmed seafood.

A FAO/Globefish report (Bacher, 2015) provided a global overview and synthesis of studies on perceptions of aquaculture in both developed and developing countries, with the aim to better understand the main concerns of the public and diverse stakeholder groups and serve for the industry as the basis for arriving at recommendations for reducing uncertainty about its products and farming practices, enabling more-effective communication strategies. The findings show that – apart from objective knowledge – personal experience, preconceived ideas and the demographic and regional contexts strongly influence perceptions of aquaculture. The strongest consumer concerns regard the health and safety aspects of farmed products. Evidence is mixed on whether people perceive aquaculture as causing environmental and animal welfare problems, and it differs among countries and regions. Interestingly, when purchasing fish, the majority of consumers are not aware of the farmed or wild origin of the seafood they buy. Other factors, such as quality, price, experience, taste and convenience, likely play more-important roles, whereas sustainability aspects are only taken into account by a limited number of consumers. To improve public awareness of aquaculture, the study recommends a more-open, broader dialogue by the industry to increase transparency in the sector, with greater collaboration with other stakeholder groups viewed as credible by the public.

Another global research assessed the public sentiment around aquaculture and how it differs over large spatial and temporal scales, with a particular emphasis on marine and offshore aquaculture (Froehlich et al., 2017). It quantified the relative sentiments and opinions of the public around distinct forms of aquaculture, using thousands of newspaper headlines from developed and developing nations, ranging over periods of 1984 to 2015. The study found an expanding positive trend of general 'aquaculture' coverage, while 'marine' and 'offshore' appeared more negative. Overall, developing regions published proportionally more positive than negative headlines than developed countries.

3.2. WHO BENEFITS FROM INTERNATIONAL TRADE OF AQUACULTURE PRODUCTS?

International trade of agricultural commodities has been promoted as a means for economic growth of many developing countries (Rivera.Ferre, 2009). In this context, aquaculture has been considered as a contributor to poverty alleviation, being an important source of employment, value addition and income for hundreds of thousands of people. Aquaculture is also an important source of high-quality animal proteins and micronutrients, contributing to food and nutrition security. This contribution comes from local production in many countries of Asia, Latin America and Africa, but also through international trade which makes available affordable fish species such as tilapia and pangasius to larger proportion of consumers, both in high- and low-income countries. Finally, aquaculture has contributed significantly to the stabilization of fish prices. The irruption of new and cheaper species, like tilapia and pangasius. In fact, irruption of aquaculture products in developed countries was initially opposed by local fishers of unfair competition, including in relation to food safety, animal health, environment and social issues (Little et al, 2012). However, today it is filling a important gap in supply as we close to the limits to what we can sustainably harvest form the sea, lakes, rivers and other wetlands.

In general, it is assumed that export-oriented aquaculture, in a framework of liberalization policies, facilitates economic growth and this is associated with poverty reduction and the improvement of food security (World Bank, 2007). This concept has been questioned by many who looked critically at the benefits of global fish trade in respect to its costs, particularly in relation to food security, social and environmental implications (Rivera-Ferre, 2009; HLPE, 2014). From the perspective of the international financial institutions (IFIs), the globalized nature of aquaculture products' flows plays a role in debt repayment schemes and structural adjustment programs nested within the international market system (Armitage 2002).

Using the example of aquaculture shrimp development in South East Asia and South America since the 1970s, Rivera Ferre (2009) analysed the sustainability of the industry within the mainstream concept of development based on liberalized markets, international trade, foreign direct investment (FDI), and economic growth. The export-oriented model of shrimp aquaculture has transitioned from a traditional system of shrimp captured at sea and taken to local market into a globalized industry requiring inputs of feed, fertilizers and chemicals, skills, with the shrimp produced being exported into Japan, North America and Europe. Shrimp exports became a significant source of foreign exchange earnings in Thailand, Bangladesh, India and Ecuador, to cite only few. The high profitability and the generation of foreign exchange, which attracted national governments and IFIs, the increasing consumption fostered by the growing offer and price reduction, the private sector initiatives promoted by IFIs, and the industrialization of the production system, were major driving forces for the global expansion of shrimp aquaculture.

Supporters of the development of export-oriented shrimp aquaculture argue that it leads to substantial socio-economic benefits such as increased nutritional levels, income, employment, and foreign exchange and brings vastly un-utilized and under-utilized land and water resources under culture. It also supports a large number of associated industries and services such as input suppliers or post-harvesting actors and brings additional sources of income to the governments through taxes, licenses for shrimp processing, fishmeal firms, shrimp traders, or export certificates.

Opponents (Barbier and Cox, 2002) argue that companies, including transnational corporations and wealthy individuals, outside the local community, were the primary beneficiaries of public funds for aquaculture development. Likewise, the global shrimp value chain was controlled, from 1985 to 1995, by some of the world's largest agro-industry players, replaced nowadays, by input suppliers and food retailers which are able to push for increases in costs of inputs as well as for keeping down the farm gate price. A WB report estimated that divergence between producer and consumer prices may have cost commodity-exporting countries more than USD100 billion per year, suggesting the existence of distorted competition at the intermediary level, i.e., by international trading companies (Morisset, 1997). Employment creation and the emergence of supporting industries and services can probably be the main consequence with a direct economic benefit into the local population. However, there is not a clear trend to confirm this assertion as production is becoming increasingly capital and technology intensive.

On the other hand, aquaculture has been associated with negative environmental and social impacts. The main environmental problems are the deforestation and degradation of mangrove forests, pollution of coastal ground and surface waters due to pond effluents and dispersion of chemicals and nutrients into the environment and the loss of biodiversity because of:

- ✓ the use of small pelagic fish to produce fishmeal instead of its use for consumption by coastal communities,
- ✓ the collection of wild female shrimp and of post larvae seed,
- ✓ the introduction of exotic species, which provokes depletion of indigenous species through predation, browsing or competition, and genetic alteration through hybridization,
- ✓ the introduction of pathogens, leading to major disease outbreaks that affect wild species.

Additionally, some of the antibiotics used by the industry are also used in humans, increasing the resistance of human pathogens.

Regarding employment and livelihoods, major areas have been transformed from subsistence into a largely commercial aquaculture activity, with most of the farm production processed for export or into ingredients for animal feeds. This may have deprived poor people of easy access to their traditional source of proteins while the improvement in employment opportunities was not always sufficient to secure access to fish food because of the higher prices paid by processing factories, high demand for export, the decline of fisheries to feed intensive farming. Under these conditions, development of commercial shrimp industry can worsen food insecurity in some countries. Likewise, poverty alleviation has been often presented as an explicit goal and justification of further aquaculture expansion (Lewis et al. 2003). But several studies (Stonich and Bailey 2000; Bergquist 2008) suggest that there is not necessarily a correlation between aquaculture expansion and real improvement for poor local people.

Important environmental and societal impacts have questioned the sustainability of fish farming. IDFIs, governments, the industry and NGOs have recognized this situation for over 20 years and committed to promote policies, strategies and investments in environmentally friendly and socially responsible aquaculture using innovative market forces and technological advances.

A recent comprehensive review (Naylor et al., 2021) analysed the developments in global aquaculture during the last 20 years. It concludes that aquaculture has become more integrated into the global food system, with rapid growth in production and major transformations in feed ingredients, production technologies, farm management, and value chains. Despite its impressive gains, the aquaculture sector still faces serious challenges that, in some cases, undermine its ability to achieve sustainable outcomes in the long term. The review concludes that the sector has generally embraced environmentally and socially sound practices, with globally traded finfish and crustacean progressively improving their environmental performances, in response to government regulations, private and public standards, and market incentives. However, many aquaculture systems still lack the motivation to meet sustainability criteria as they target markets which do not require these criteria for entry.

The review concludes that over the past 20 years, trends in the production and environmental performance of aquaculture have been positive. Destructive habitat conversion, particularly by shrimp farming in mangrove ecosystems, has declined markedly since 2000. Challenges to the industry persist, however, including the effects of pathogens, parasites, and pests, pollution, harmful algal blooms, and climate change. The aquaculture industry has become increasingly vulnerable to these stressors given its rapid expansion, its reliance on the ambient environment, and the changing world in which all food systems operate.

The wide diversity of aquaculture systems across species, geographies, producers, and consumers prevents the development of a single strategy to achieve sustainable and healthy products. Governance systems need to be designed with clearly articulated, science-informed goals, but without overly proscriptive standards and regulations for realizing those goals. Such flexibility is needed to support the abilities of industries, governments, and NGOs to innovate while still providing clear end points and requirements for monitoring, reporting, transparency, and accountability.

3.3.NON TARIFF MEASURES FOR MARKET ENTRY

As aquaculture value chains became globalized, technical regulations, standards, certification and labelling have gained prominence as key instruments for international market entry to promote sustainable aquaculture. Given that most producers in developing countries could not afford the cost and requirements of certification, they supplied market segments of the international market which have been largely unaffected by certification. One remedial approach pursued aquaculture improvement projects (AIP) whereby aquaculture operators were assisted to improve skills and practices, which could ultimately lead to certification and labelling. These AIP have been promoted by NGOs, often the same NGOs involved in certification schemes. Although several initiatives of AIP were undertaken successfully, a study is needed to assess the impact of the AIPs, feasibility and challenges, in particular continuity of the improved practices once external funding and technical assistance have ended.

Regardless, several issues for NTMs as market entry measures remain unresolved. The wide range of private standards remains a source of confusion for producers and processors trying to decide which certification scheme will bring the most market returns, and for buyers trying to decide which standards have most credence in the market and will offer returns to reputation and risk management. Government institutions, when not challenging voluntary private standards, struggle to decide where do they fit into the VC strategies for food safety, animal health, social and environmental management.

Evidence suggests that meeting and maintaining equivalence to mandatory public standards of international markets should continue to be the focus. Any technical cooperation in developing countries would be best focused on getting the public systems right to enable exported farmed products to meet the mandatory regulatory requirements in importing countries.

The debate over whether private standards are inconsistent with SPS obligations when they go beyond relevant international standards, with no scientific rationale, is still unresolved. Many exporting countries argue that private standards allow importers to impose their domestic policy frameworks and/or other standards (e.g., labour, human rights), offering grounds to discriminate against developing-country products. For the time being, the market imposes the policy, based on those of the most influential actors of the value chains. A decade ago, the issue was that, as the boundaries between public and private standards and requirements are blurred, the trade implications need to be closely monitored. Do private standards complement, duplicate or compete with/undermine public regulation and policy frameworks? Duplication is still more likely to be the issue, if not in relation to the content of requirements, then in methods of compliance and verification (including multilevel documentation).

Whether or not private standards incentivize better management of aquaculture is still open for debate. Are private standards an efficient mechanism for achieving public policy goals of food safety assurance and sustainable aquaculture? If they are compensating for perceived shortfalls in public governance, then they might be simply treating the symptoms when a more effective solution would be to invest in strategies to improve those public systems.

3.2. VALUE CHAIN ANALYSIS AND GOVERNANCE

As the demand for fish increased, the aquaculture industry has undergone major changes to support expansion of production and changes in distribution and consumption patterns. Whereas it is accepted that different approaches can contribute to aquaculture sustainability, value chain analysis and governance can be well suited to address the diversity and rapid expansion of the industry and provide integrated analyses of the sector's contribution to global food security, poverty alleviation, economic development and social and environmental sustainability.

Value chain analysis can be used to study modes of production, policies and regulations that promote sustainable practices, the formation of value and sector-wide innovation. It can provide a clearer understanding of what shape and function these chains take, but also assist in the design of public and private interventions aimed at expanding and regulating sustainable aquaculture.

In a special issue covering a wide range of studies on aquaculture value chains, Bush et al., (2019) summarized the major challenges of aquaculture value chain analysis and governance under 5 major themes:

- ✓ A shift away from an emphasis on unidirectional South-North flows of aquaculture trade driven by Northern 'lead firms', to a growing 'multi-polarity' driven by competing producers, traders and consumers across, within, and between Southern and Northern countries.
- ✓ The growing diversity and scale of production and trade, that does not conform to the 'traditional, small-scale'/'modern, industrial' systems.
- ✓ The dynamics of transformation, referring to changes in value chain structure and actor practices across all value chain nodes, in response to systemic changes in the global food system (e.g., urbanization and diet change).

- ✓ The performance and equity of value chains, related to the complex mix of positive, negative, and indeterminate outcomes for people, communities and environments incorporated into, excluded from, or located in the vicinity of key value chain nodes.
- ✓ The extent and means by which processes of technical and institutional innovation can foster better chain performance, whether in terms of technical efficiency, productivity and profitability, or environmental impact and social equity.

Value chain governance systems should be designed with clearly articulated, science-informed goals, but without overly prescriptive standards and regulations for realizing those goals. Such flexibility can enable the private sector, governments, and NGOs to innovate while still providing clear end points and requirements for monitoring, reporting, transparency, and accountability (Naylor et al., 2021).

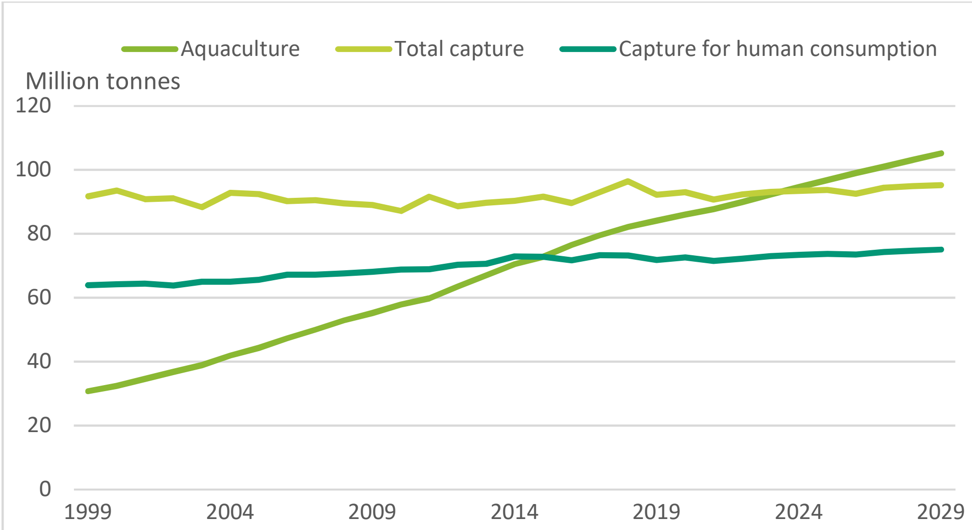
4- FUTURE DEVELOPMENTS

During the last 20 years, aquaculture has become more integrated into the global food system, with rapid growth in production and major transformations in feed ingredients, production and processing technologies, farm management, and value chain governance. The wide diversity of aquaculture systems across species, geographies, producers, and consumers has enabled the sector to supply more fish for human consumption than capture fisheries since 2014. This has provided consumers, from low- to high-income countries, year-round availability and access to aquatic foods. In addition to fish, shellfish and algae for direct human consumption, aquaculture also generates products used in food processing, feed, fuels, cosmetics, nutraceuticals, pharmaceuticals, and a variety of other industrial products, and it contributes to a range of ecosystem services (Naylor, 2021).

4.1. PRODUCTION

According to FAO/OECD projections for the period 2019-2029 (FAO/OECD, 2020), global fish production is to reach 200 million tonnes by 2029, increasing by 25 million tonnes (or 14 percent) from the base period (average of 2017-2019), though at slower pace (1.3 percent p.a.) than over the previous decade (2.3 percent p.a.). By 2029, aquaculture production is projected to reach 105 million tonnes, as compared to 95 million tonnes for capture fisheries (figure 8).

Figure 8. Projection of fisheries and aquaculture production for the period 2019-2029



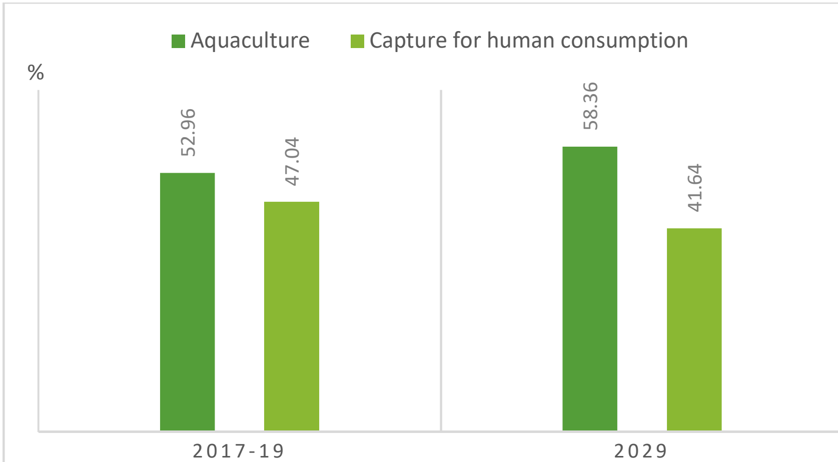
Relatively low feed prices are projected to drive the future growth of aquaculture, and profitability in the sector is expected to remain high in the next decade, especially for species that require small amounts of fishmeal and fish oil. The share of capture fisheries production transformed into fishmeal and fish oil will remain stable at about 18 percent, though total fishmeal and fish oil production are projected to increase by 10 percent (by 2024) and 17 percent (by 2029), mainly due to a greater use of fish residues in their production. By 2029, the proportion of fishmeal and fish oil obtained from fish waste is projected to grow from 24 percent to 28 percent and from 41 percent to 45 percent respectively.

4.2. CONSUMPTION

By 2029, it is projected that 90 percent of global fisheries and aquaculture production will be consumed as food. The volume of fish for human consumption is projected to expand on all continents, increasing by 16.3 percent to reach 180 million tonnes by 2029. However, the magnitude of the rise will vary from one continent to another, reflecting different fish consumption baseline levels and population growth rates. The highest growth rate is projected in Africa (+25.4 percent) and the lowest in Europe (+5.8 percent), where consumption levels per capita are high near saturation. With +17.3 percent, Asia will be by far the largest fish consumer, accounting for 75 percent of the additional amount of fish consumed by 2029, with 40 percent by China alone.

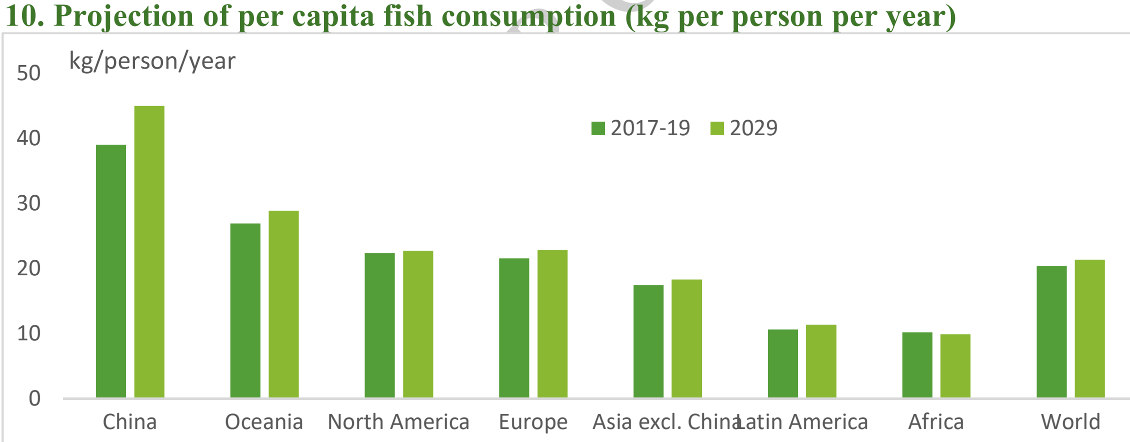
The share of farmed fish in total food fish consumption will continue to increase year after year. By 2029, 58 percent of the fish available for human consumption is projected to originate from aquaculture, up from 53 percent in 2017-19 (Figure 9). On a per capita basis, apparent fish consumption is projected to be 21.4 kg in live weight equivalent by 2029, up by 4.7 percent from 20.4 kg in 2017-2019 (Figure 10). This represents a lower increase than in previous decades. Overall, per capita apparent fish food consumption is projected to increase by 0.5 percent per year during the outlook period, compared to 1.3 percent per year over the previous decade. However, this trend will differ across and within countries in terms of quantity and product forms, reflecting the diversity of geographic, economic and cultural factors.

Figure 9. Share of aquaculture and fisheries in total fish for human consumption.



Fish consumption per capita is projected to rise on all continents, except Africa with a projected strong growth in population. In Africa, fish consumption per capita is projected to decrease to 9.9 kg by 2029, down from a peak of 10.6 kg in 2014 and 10.2 kg in the base period. The decline will be even more significant in Sub-Saharan Africa. This situation is of particular concern because the region has the highest prevalence of undernourishment in the world and because fish is an important source of proteins and micronutrients in many African diets. Fish contributes on average to 23 percent of total animal protein intake in Sub-Saharan Africa, compared with 17 percent at the world level.

Figure 10. Projection of per capita fish consumption (kg per person per year)

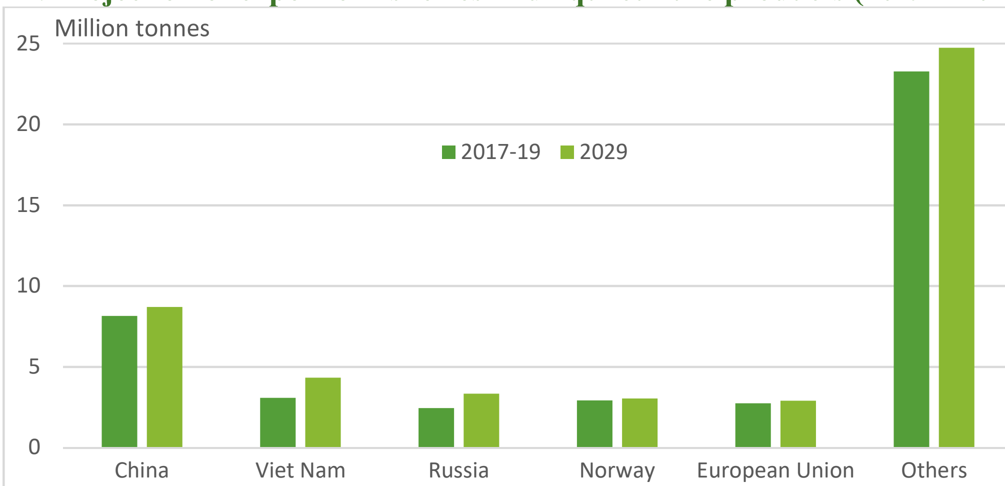


4.3. TRADE

Global trade in fish and fish products is expected to expand over the coming decade, though at a slower pace compared to the previous decade. High demand, increasing fish production, improved logistics, and globalisation of food systems should further expand international fish trade. By 2029, it is projected that about 36 percent of production will be traded. World exports of fish for human consumption are projected to reach 47 million tonnes by 2029, an additional 4 million tonnes in absolute terms when compared with the base period. This represents a rise of 9.4 percent in the next decade, as compared to 23.0 percent increase in the previous decade (figure 11).

The bulk of the growth in fish exports for human consumption is projected to originate from Asian countries, which will account for about 67 percent of the additional exports by 2029. Their share in world exports for human consumption is projected to increase from 48 percent to 50 percent as a result of further expansion of their aquaculture production. China will remain the largest exporter of fish for human consumption, although its share in global fish exports is projected to decline to 18 percent by 2029, compared with 19 percent in the base period.

Figure 11. Projection of export of fisheries and aquaculture products (2019 – 2029)



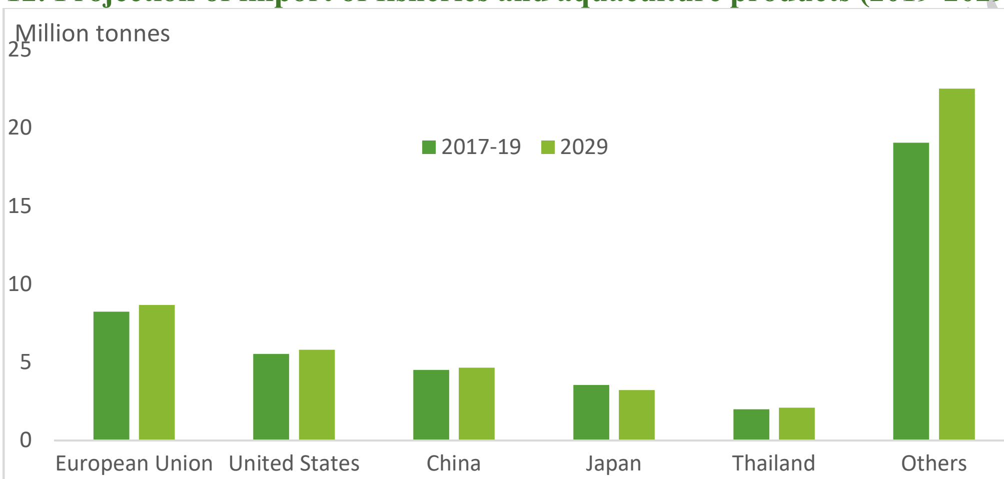
The EU, USA, China, and Japan will continue to be the leading importers of fish for human consumption, accounting for 19, 12, 10 and 7 percent of global imports respectively by 2029 (Figure 12). Imports by the EU, USA and China are projected to increase over the next decade (+4.9, +3.9 and +5.6 percent respectively), but at a slower pace than in the previous decade. In Japan, the decline in imports is projected to accelerate (-9.2 percent), as younger generations favour meat over fish and the decline in population accelerates. In the USA and the EU, imports are expected to grow at a slower pace as consumption levels of animal products are near saturation. In China, imports are projected to decline at 0.4 percent p.a. in the next decade compared with a growth of 4.3 percent p.a. in the previous one. This significant slowdown also reflects the Chinese policy to increase aquaculture for domestic consumption. It is also linked to more moderate population and income growths compared with the previous decade. Among the leading importers, the Russian Federation is one of the few countries where growth in imports should be stronger in the next decade compared with the past ten years (+51 percent compared to –42 percent). Rising imports are also projected for Africa (+39 percent). With stronger projected growth in imports than in production, Africa is expected to become increasingly dependent on fish food imports. The share of imports in its fish food supply is projected to reach 40 percent by 2029, compared with 36 percent in the base period.

Many factors can influence the evolution and dynamics of world fish production, consumption and trade. As a consequence, a range of uncertainties exist when projecting into the future. These include external factors (climate, environmental conditions) and policy factors (fisheries and aquaculture management and governance, trade policies, market and price fluctuations). The implications of these uncertainties depend upon the extent to which they differ from the assumptions, and the sector's capacity to adapt to them.

4.4. SUSTAINABLE DEVELOPMENT OF AQUACULTURE VALUE CHAINS

Aquaculture contributes significantly to international fish supply to meet demand and stabilize fish prices, in particular during the periods of price hikes of other food commodities. In some countries, it has contributed to reducing overfishing by providing alternative business opportunities to fishermen. Its future development requires better focus on minimizing social and environmental impacts on coastal communities and ecosystems, with careful siting of aquaculture systems underpinning their commercial and environmental success. Indeed, prudent siting and scaling are essential for maximizing the ecosystem services provided by farmed species and for mitigating critical challenges associated with pathogens, coastal pollution, and climate change.

Figure 12. Projection of import of fisheries and aquaculture products (2019-2029)



It should be highlighted that, although very diverse, aquaculture is still dominated by molluscs, herbivorous and omnivorous species using entirely or partly natural productivity. The rapid growth in the production of fed species such as salmon, shrimp, seabass, seabream, tilapia and catfish has been driven by trade globalization and favourable economics of semi- intensive and intensive farming practices. The marked gains that have been made in the efficiency of marine resource use and in fish nutrition, may be more difficult and costly to expand further, though increasing costs of fishmeal and fish oil will provide continued incentives for innovation.

Most aquaculture systems rely on non-costed environmental goods and services. Their inclusion into company accounts and the consequent effects this would have on production economics remains a critical issue for the future. Failing that, increased competition for natural resources will force policy makers to allocate strategically land and water or leave the market to determine their use depending on activities that can extract the highest value (ref).

Further uncertainties include the extent of the impact of climate change, future fisheries supplies (for competition and feed supply), practical limits in terms of scale and in the economics of integration and the development and acceptability of new technologies. In the medium term, increased output is likely to require expansion in new environments (e.g., offshore mariculture), further intensification and efficiency gains for more sustainable and cost-effective aquaculture.

The future of robust aquaculture value chains will continue to depend on the continued optimization of the key production factors (labor, technology, energy and inputs such as feed and seed), innovation and technology, marketing and market information and management. Value addition can occur at different nodes of the chain, as aquaculture inputs are converted into harvested fish which then changes through steps in processing, distribution and marketing. Value creation can also occur by focusing on the production practices and marketing to achieve higher quality and better branded aquaculture products.

Policy on global aquaculture value chains needs to place more attention on species and markets in the global South, in particular the emergence and characteristics of domestic value chains in Asia and Africa. Indeed, most aquaculture value chain studies to date has focused primarily on transnational chains supplying shrimp, salmon and pangasius (Bush et al., 2019). Most studies have focused on how lead firm coordination sets the conditions for product specification and market entry and on the spatial organization of support services, divisions of labor, and the creation and capture of value along transnational aquaculture supply chains. The scope of aquaculture value chain development interventions, once predominantly focused on the transfer of technology, has increasingly widened to include questions of market compliance, benefit sharing and gendered approaches to livelihoods.

Multi-polarity is also observed in the diffusion of regulatory drivers shaping aquaculture development. As highlighted by Little et al. (2018), categories of values and qualities originating from major markets often do not correspond with the social conditions of major producers. Therefore, these market-based forms of governance are losing leverage with the rise of alternative markets emerging in Asia and Africa, which are demanding alternative criteria to those currently included in international eco-certification. This raises questions about what norms will hold the greatest influence and shape the sustainability of aquaculture production in future.

Most importantly, more attention needs to go to neglected categories of chain actors, modes of production and regulation that affect the formation of value, sector wide innovation, social and environmental sustainability. This can provide a clearer understanding of what shape and function these chains take, but also assist in the design of public and private development interventions aimed at the further expansion or regulation of sustainable aquaculture.

Digitalization and information technologies (e.g., blockchain) have entered into seafood trade and logistics, seeking to virtualize value chains by creating direct links between producers and consumers. As a result, the performance, structure and conduct of value chains is set to change dramatically. It is unclear, however, who will ultimately benefit from these shifts, nor whether they can foster markets for sustainable aquaculture products. Blockchain based technologies offer the prospect of enhanced traceability and transparency throughout supply chains, and can have significant potential to transform governance, traceability and consumer access to information, in ways that are only just beginning to unfold.

Circular and blue economy are emerging as a set of principles and approaches for sustainable and efficient use and reuse of waste flows through value chains. The use of aquaculture related wastes and by-product recovery requires considerably more attention. To date, virtually no work has been done on the volume, value, structure, performance or conduct of these secondary chains.

Future value chain policy and research must be broader in geographical and theoretical scope, and more firmly grounded in the realities of an increasingly complex and multi-polar world if it is to yield insights that can inform more effective policy and practice, and by doing so ultimately contribute to shaping a more sustainable, inclusive and equitable global aquaculture value chains.

4.5. DEVELOPMENT OF AQUACULTURE VALUE CHAINS IN A POST COVID-19 ERA

The COVID-19 pandemic has had severe impacts on societies and economies worldwide. Fisheries, aquaculture and countries that depend on them are no exception, with significant revenue losses throughout because of restriction on people's mobility, travel and tourism, port and airport closures, and supply chain disruptions. As with many crises, it is the most vulnerable groups, such as coastal communities, informal workers and many women in post-harvest activities, that have been hit hardest. As fisheries and aquaculture do not operate in isolation from other economic sectors, this has led to cascading and interrelated impacts across the sector's economy, coastal inland and marine ecosystems and societies.

The economic environment of aquaculture production and markets was highly volatile and uncertain following the onset of the pandemic. The sector struggled to sustain its activity or maintain its planned production cycles, as supplies of production inputs (seeds, feed), market demand and access to credit were disrupted. The overall demand of the food service has decreased substantially, while retail sales have been marked by extreme volatility initially, before increasing as demand for direct delivery to households increased through the emergence of online fish selling platforms, creating and strengthening direct connections with domestic markets and local household consumers (Globefish, 2020; Love et al., 2021). In 2020, most if not all seafood trade events around the world have been cancelled, leading to lost transactions between major buyers, traders and sellers who depend on these regional events. As a result, some far-reaching changes experienced by the fish and seafood market are likely to persist in the future. Consumers subjected to lockdowns and concerned about future waves, have shifted their fish preferences towards preserved and prepared products, while demand for fresh fish has waned and the demand for luxury products decreased because of the economic downturn.

Like other economic sectors, the measures implemented to support fisheries and aquaculture were diverse and complex, associating funds to compensate loss of wages and revenues, financial packages and fiscal incentives to resume production and processing, stimulate demand and support export. The type of measures and the extent of their application varied widely across countries, scales and value chain nods depending on the resources available and the priorities set. Unfortunately, informal sectors including a large proportion of small-scale aquaculture and vulnerable groups such as women were often excluded.

History of past global crises teaches us that after recovery, each crisis leaves behind permanent structural changes. COVID-19 is no exception. The impacts of COVID-19 on health and socioeconomics have been devastating. However, measures to recover have created opportunities that are likely to reshape the economy, unleash technological innovation, and redefine consumers' needs and behaviors and the role of society and companies. As the world emerges from the crisis and we adapt in the future, successful innovations are likely to become mainstream opportunities, for addressing immediate needs and as a way of re-orienting development for the future challenges.

As a result of the disruption of trade, government and companies have been considering how and where fisheries and aquaculture products gets produced, processed and sold, with companies wanting more control over the supply chains. Export businesses that rely on few buyers whose countries closed imports were faced with unsold products and losses of perishable goods. This is the case of fish export with over 60 per cent of the trade destined to 3 main markets which closed down in 2020 one after the other as the pandemic moved from Asia to Europe and into the Americas. Concurrently, domestic markets have expanded by direct delivery using online fish selling platforms and direct connections with local consumers. Expanding domestic markets and exploring new markets, in particular regional markets, represent an opportunity to diversify markets, products and value addition.

Prior to COVID, the use of automation technology and digitization have been driven mostly by cost efficiency and competitiveness. Now, in a world concerned about pandemics, health and safety considerations have also become a central motivation. The pandemic is driving adoption of risk-mitigating procedures designed to track employee health, reduce human to human interactions, and upgrade physical barriers during production and processing. Increased production costs, restrictions on travel and mobility, and social distancing have accelerated digitization and automation technologies, such as electronic and mobile payments, robotics, artificial intelligence and vision systems for measurement, monitoring and tracking. As the crisis continues, technologies that improve safety at work and generate efficiency gains are likely to be retained beyond the crisis [17]. Countries and companies prepared to deploy these innovations and technologies would gain competitive advantage and market access.

Teleworking accelerated the use of internet applications that were previously feasible but not widely adopted. Born out of necessity, the use of video conferencing, remote learning, virtual webinars and electronic surveys and administrative actions have developed at an unprecedented scale and are becoming a regular part of the new normal for both government institutions and private operators. The coronavirus has exposed slow procedures, complex bureaucracies and rigid hierarchies that delayed actions even when resources were available. The emergency forced many to break through these rigid systems and adapt rules using electronic exchange of documentation, clearances and approval. The feasibility of remote administration actions, working, learning and conferencing varies across regions, countries and activities. Whereas most white-collar activities and services are adapted to virtual technologies, others like food production and processing, hospitality and retail require physical presence.

E-commerce has great potential for diversifying the scope and geographic reach of trading opportunities and expanding the range of both established businesses and new enterprises. It also plays an increasingly important role in the supply and distribution of both goods and services in domestic markets. Aquaculture is presently catching up with digital trading solutions. These are already well developed in countries with modern aquaculture systems and being pioneered in countries with many small-scale farmers, such as Indonesia, India, Ecuador or China. However, most of the platforms available today are mainly on selling what farmers produce rather than what buyers want or the needs from the market. There are a number of factors that are important to address in setting up these systems such as developing mutual trust between farmers to produce high-quality product and buyers to pay a fair price for the crop, ensuring data reliability. consistency and transparency and security of financial payment schemes (Maduningtyas et al., 2021).

[17] https://www.investmentbank.barclays.com/our-insights/The-post-COVID-economy.html

The growth of e-commerce is still inhibited in many developing countries by a range of barriers in infrastructure, finance, resources and governance. Countries that overcome these barriers and establish enabling frameworks for e-commerce will be better placed to leverage its potential benefits and address challenges, both domestically and internationally. In the absence of measures to take advantage of e-commerce, there is a risk that digital innovations will increase inequality rather than advancing equity (UNCTAD, 2021). Small scale fish farmers are used to face-to-face transactions. They need transitioning to online transactions for selling their products. This requires internet access to follow information campaigns on digitalization and learn to use and trust the digital marketplaces. Most platforms work with a membership system and getting farmers and buyers to participate. A clear financial incentive should enable the digital buyer having better access to reliable supply and quality and paying more than the farmer would normally receive from the existing trading system (Maduningtyas et al., 2021).

The ability of businesses to participate in domestic and international markets depends increasingly on the quality of digital connectivity available to them, while that of citizens to shop online or use online commercial services depends on the availability of reliable communications networks, the existence of online platforms and services, the presence of digital payment mechanisms, and the individuals' own capabilities and digital literacy. Policies should be put in place to bridge barriers, address the adverse effects of the digital divide, not least for inland and marine coastal and low-income households, and build trust and confidence in online business. Consumer protection against unfair trade practices, such as unreasonable price increases, product safety and cybersecurity concerns have been amplified in the pandemic context.

Governments, IDFI and NGOs have prioritized policy goals and greater incentives for investment in green and clean economies and environmentally friendly solutions. Despite the unprecedented economic recession, this focus on green and clean economies has snowballed, with governments, donors and IDFIs prioritizing their integration in their recovery and investment plans. This offers a unique opportunity to aquaculture decision makers to streamline social and environmental protection in their post-COVID recovery and investment plans.

Real opportunities exist for developing countries to build back better fisheries and aquaculture and coastal eco-tourism. These opportunities require re-focusing priorities to enact effective management and conservation plans and to promote transparent and predictable markets that incentivise sustainability instruments such as traceability, eco-labelling, and social and environmental responsibility. Sustainable aquaculture offers real possibilities, especially for small coastal and island states, to invest in shellfish and seaweed farming, some of the most environmentally friendly aquaculture systems, with products in high demand. This requires policies that can create an enabling environment for investors taking advantage of the stimulus and recovery plans, national, regional and international opportunities for capacity building, transfer of know-how, access to services and financing.

The pandemic presents both an enormous challenge and tremendous opportunities towards achieving the 2030 Agenda and the Sustainable Development (ASD). Its SDGs are a roadmap that encompass every aspect of the wellbeing of humans and the planet. The pandemic has impacted every one of these aspects and stressed the wisdom of what is already inherent in the SDGs, the challenges we face cannot be dealt with in isolation. Like a double helix, the SDGs and the COVID-19 pandemic responses are intertwined and cannot be tackled by a piecemeal approach.

The timing is unique to instil coherence in the measures and actions and implement integrated solutions to tackle emergency, support recovery and achieve SDGs[18].

The pandemic has demonstrated the value of preparedness to protect and build resilience against health and other natural or man-made disasters, ensuring actions are evenly distributed across demographic groups, regions and economic sectors. This requires strengthening the capacity of all countries, in particular developing countries, for early warning, risk mitigation and management of health risks and other natural and man-made shocks.

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