DYNAMICS OF AQUACULTURE GOVERNANCE (2010-2020)

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Abstract

Aquaculture is a growing industry with an annual growth rate that is far superior to the population growth rate. Most production occurs in lower- and middle-income countries, and therefore, they are able to improve the efficiency and modernize the production systems to increase exports to earn foreign exchange earnings for economic and social development. The institutional arrangements should be part of the mechanisms that ensures sustainable aquaculture growth, through the participation of all stakeholders. Sustainability is possible with good and dynamic governance through which the industry embraces the basic principles of governance, equity, accountability, efficiency, and predictability. The paper shows that over the past decade several countries made changes in governance and implemented regulations through their action plans to improve aquaculture productivity, and stakeholders profited from the changes made along the value chain. For the producers to benefit from the value-added products, they complied with the regulations imposed by the importing countries, international regulatory bodies, or their own consumers. Standards increased, and the implementation of certification resulted in changes in the industrial structure. These standards, which inflict a cost on producers, stimulated an improvement in productivity and product quality. However, during the last decade production growth declined from 5.8% from 2001 to 2010 to 4.5% from 20111 to 2018, and realization of the potential of meeting the sustainable development targets has become more elusive. There is need for a paradigm shift that encourages small-scale producers to engage in sustainable intensive aquaculture. The challenge is, therefore, to move towards production intensification and expansion, and the harmonization of national and international regulations to ensure the supply of safe and adequate fish to consumers, while maintaining a sustainable production system, and at the same time conserving the environment and maintaining social and economic stability. With good governance and the political will, the social, economic, and environmental objectives for attaining the sustainable development goals during the period 2020 to 2030 are possible if governments integrate sustainable aquaculture developments within an expanded aquatic and terrestrial food security policy framework using systems thinking and open innovation approaches.

Key messages

1. The future advancement of aquaculture development towards the SDG depends on local, national, and global actors, operating through alliances to increase aquaculture production that generates sustainable benefits to stakeholders while preserving the environment and social stability. The choices to be made involve decisions related to environmental quality, foreign direct investment (FDI), domestic capital mobilization, national economic strategies, and new globalized mechanisms supporting aquaculture production at a reasonable cost. The role of foreign direct investment in the production of traded goods and services should be directed to encourage the participation of all stakeholders in the governance of the industry.

2. Over the past decade, there has been rising concerns for the social and environmental impacts generated by large-scale investments and export-oriented trade regimes. The desire of all stakeholders is the accessibility of supportive, dedicated legislation with a lead agency to coordinate regulations that ensure public wellbeing and yet not overly constraining to permit them to cope with environmental and social challenges and approach the stipulated SDG.

3. The enforcement of good governance may result in challenges that simultaneously offer opportunities for cross-national learning and the development of best practices. Information transfer and data sharing can be interactive and assist in the solution of problems usually encountered by the most resource poor farmers or businesses. Easy communication of ideas can advance the monitoring and reporting of disease and pathogen prevalence in all countries, but the requirements in terms of testing intervals, public disclosure of information, and thresholds for mitigation and remedial action may vary substantially. Added transferred knowledge may reduce farmers' risk, increase production, and reduce losses of traded products.

4. An important point within the global market is the growing importance of international agreements that involves food (and fish) safety aspects. Aquaculture export earning is the principal driving force behind aquaculture development in many developing and developed countries. To increase or maintain market share, aquaculture producers must diversify and comply to regulations imposed by the importing countries or international regulatory bodies. The conformity to standards imposed by outside bodies generates a compliance cost due to the structural, domestic changes that must be made to receive certification. The compliance costs associated with improvement in standards and certification schemes can inflict a burden on producers to which the importers may be insensitive or unaware. The existing asymmetry of information flows may result in conflicts which can only be solved through a platform of open dialogue, as part of good governance.

5. The use of electronic marketing capabilities including i-phones, i-pads and other electronic mobile devices for information dissemination and rapid communication may influence future governance. Successful operation of these devices requires reorganization, regionalization, nationalization, and internationalization of the whole digitalization process aided by research and extension efforts for diffusion and adoption of appropriate information that result in transparency, accountability, and predictability.

6. It is hoped that in the future there will be a common electronic platform for communication of procedures and rules of engagement, certification, standards, and regulation that facilitates product and information flows through the supply chain.

   This will be possible only through a coalition of public-private partnerships in research and technological innovation with the aim to ensure sustainability. This requires the harmonization of national and international regulations that would foster an increase food quality protection and provide the drive to attain the SDG.

7. The development of aquaculture and the attainment of the SDGs are challenging using current material and technical base of farm ponds. There is a need for a new approach to increase the use of digital technologies such as the Industrial Internet, large data banks and a unified system of data storage. processing and utilization with more intense and holistic organized production systems, marketing, education and extension information diffusion. The implementation of digitalization can only ensure increase in competitiveness of production and marketing while ensuring good governance.

8. Countries with limited land and ocean resources for inland and offshore aquaculture must seek new innovative ways of aquaculture expansion. The desirability of zoning and integrated coastal planning to ensure collaboration with competing users to minimize environmental and social conflicts is a relevant consideration. This should be accompanied by new innovations and technologies that range from on-shore tanks, recirculating systems to open-sea systems. The new technologies have the advantage of enhancing the criteria for sustainability if supported by good governance.

9. Aquaculture development and sustainability face opportunities and challenges in both developed and developing countries in the attainment of the SDGs. However, the encouragement of the incorporation of the SDGs within the policies and programs of all countries will increase the awareness of all governments and stakeholders and will empower them to promote with urgency the strengthening of aquaculture governance mechanisms and ensuring fair and transparent involvement and consultation in decision-making of different interest groups concerned with aquaculture development that will foster the sustainable attainment of the SDG.

10. FAO, and specially the COFI/COFI Aquaculture as a leading agency, has a role in the global governance of aquaculture and should be supported by member states in further consideration of concrete actions for the sector in accordance with their national plans, capacities and priorities. The government should pledge support in the development of a

platform for information exchanges on the economic, social, and environmental dimensions of sustainable development and on climate change adaptation and mitigation, the development of the voluntary Guidelines for Sustainable Aquaculture as a tool towards further development of national policies for the aquaculture sector's sustainability. Emerging concepts such as the One Health, Nutrition-Sensitive Agriculture/Aquaculture and Blue Transformation to influence the development of sustainable aquaculture and its future trajectory should also be recognized and endorsed as guiding instruments towards better Aquaculture governance.

1. Introduction

Aquaculture is the fastest-growing food producing industry in the world with an annual growth rate of 9.58% from 1990 to 2018, attaining 114.5 million tonnes of live weight in 2018 at a total farm gate sale value of $263.6 billion (Food and Agricultural Organization [FAO], 2020). Unfortunately, the growth rate slowed down from 5.8% in 2001 to 2010 to 4.5% during the period 2011 to 2018. The expansion of aquaculture has been stimulated by breakthroughs in production practices accompanied by technological innovations that have lowered production costs for most aquaculture species and the supply chain (Oluwemimo & Damilola, 2013). Accompanying these changes in the structure of the supply chain are a set of stringent public and private standards for control, and greater emphasis on the social responsibility of food traders. The rise in standards has influenced the industry structure, marketing activities, actor conduct and governance along the supply and value chains and have created greater awareness by the public and private sectors for national aquaculture plans and a set of regulatory mechanisms that enforce good governance (Hammoudi *et al*., 2009). This paper examines governance of the sector, and how changes in governance assist aquaculture in attaining the sustainable development goals (SDGs). The demand for adequate protein with sufficient supply of fish, within environmental limits is enshrined in SDGs which are inclusive of the following: end hunger, achieve food security and improve nutrition (SDG 2); ensure healthy lives and promote well-being (SDG 3); promote sustained, inclusive, and sustainable economic growth (SDG 8), and conserve and sustainably use the oceans, seas and marine resources for sustainable development (SDG 14) (Stead, 2019).

1.1 A Regional Overview of Aquaculture

1.1.0 *Asia*

Asian countries dominated world farmed aquatic animals, with an 89% share in the last two decades or so, with China contributing 71% of the production. Aquaculture contribution exceeded more than 50% of all fish produced in four Asian countries in 2018, (i.e. China 76.5%, India 57%, Viet Nam 55.3% and Bangladesh 56.2%). China has remained the major fish producer, accounting for 35% of global fish production in 2018. The share of aquaculture in Asian fish production (excluding China) reached 42.0% in 2018, up from 19.3% in 2000 (FAO, 2020). Indonesia, India, Bangladesh, and Myanmar have experienced increases in aquatic production and their rank as major producing countries, while the Philippines, Republic of Korea, Japan, and Thailand have experienced shortfalls in production and have dropped in rank (FAO, 2020). The aquaculture sector contributed 3.1% to Indonesia's gross domestic product (GDP) and 21.0% to total agricultural GDP in 2012 (Ministry of Marine Affairs and Fisheries [MMAF], 2014). Most of the above listed Asian countries are also among the top ten exporting countries of aquaculture products in the world.

1.1.1. *The Americas*

Aquaculture production in the Americas was 3.1 million tons, or 3.8% of the world total in 2018. The region has experienced a 300% growth rate allowing it to surpass aquaculture production in Europe and becoming the second largest global aquaculture producing region, behind Asia. Finfish production was responsible for 2.19 million tonnes while crustaceans contributed 961 thousand tonnes, and mollusks 640 thousand tons (FAO, 2020). Chile is the principal producer due to its farmed species (salmonids), and in second third and fourth places are Brazil with 605, Ecuador with 539, and the U.S. with 408 thousand metric tons, respectively. In addition, Mexico with 247, Canada with 191 and the other countries 480 contribute to the regional total of 3,790 million metric tons.

1.1.2 *Europe*.

Europe, plus Cyprus, produced 3082.6 thousand tonnes of fish from aquaculture in 2018 or 3.7% of the world total production in 2018. Norway is the largest producer in Europe and was responsible for 44% of the total European farmed fish production (FAO, 2020). The share of farmed fish in Europe has decreased over the past decade, despite an increase in marine aquaculture production since the early 1990s, mostly due to salmon production in Norway. The most cultivated species in Europe was Atlantic salmon, while other important species include rainbow trout, European sea bass, gilthead sea bream, oysters, and carps, barbels and other cyprinids (FAO, 2020). Seven countries (Norway, Spain, Turkey, the United Kingdom, France, Italy and Greece account for 90% of all aquaculture production in Europe. Bivalve mollusks (mussels, oysters, and clams) are dominant in Spain, France and Italy. The total volume of fish and shellfish produced in aquaculture is predicted to rise by 56% to 772,000 metric tonnes, from 2010 to 2030, and the value to EUR 2.7 billion (USD 3.4 billion).

1.1.3. *Africa*

African aquaculture development is growing rapidly with a contribution of 2.2 million tons representing 2.7% of World Aquaculture (Halwart, 2020; Adeleke *et al*., 2020). The region recorded a twenty-fold production increase from 110,200 to 2,196,000 tons from 1995 to 2018, with an annual compounded growth rate of 15.6 % (FAO, 2016; Halwart, 2020). Production is dominated by small-scale aquaculture, concentrating on various tilapia species, the African catfish and seaweed (Adeleke *et al*, 2020). Donor agencies and local governments have realized the potential of aquaculture on the continent and have directed interventions at small-scale, low intensity aquaculture with limited inputs (Olapade, 2020), but this approach has resulted in unsustainability due to limited capital, low quality input regimes, and poor infrastructure systems in rural regions of Africa (Kaminski *et al*., 2018; Chan *et al*., 2019). Major large-scale investments, production intensification and increased public support in the leading producing countries such as Egypt, Nigeria, Uganda, Ghana, Tunisia, Kenya, Zambia, Malawi and South Africa explain the increase in production (Cai *et al*., 2017; FAO, 2018; Adeleke *et al*., 2020).There is need for coherent strategies for aquaculture development in the continent, and with good governance that embodies equity, transparency and accountability, the continent could increase aquaculture production that will contribute to achieving the United Nations Sustainable Development Goals (SDGs) (NEPAD, 2016).

2.0 Current status of aquaculture governance

2. 1. The need for governance

Aquaculture governance is the set of practices by which a jurisdiction manages its resources. These practices refer to the norms, institutions and processes that determine how power and responsibilities over “natural resources/fisheries” are exercised; its stakeholders participate in making and implementing decisions affecting the sector; government personnel are accountable to the aquaculture community and other stakeholders, and the respect of the rule of law is applied and enforced (FAO, 2017). The aim is to ensure long-run sustainability of the sector, balancing environmental, economic, social, and technical imperatives.

The challenge of aquaculture governance is to ensure that the right measures are implemented to guarantee environmental sustainability, without destroying entrepreneurial initiatives and social harmony. Without regulations there is the danger that farmers with short-run horizons could cause irreversible environmental damage, and social unrest. On the other hand, overly restrictive regulations could discourage entrepreneurial farmers from undertaking risky, aquaculture ventures. Governance is, therefore, a process of combining multiple and often competing objectives, ensuring consistency and fairness of decision making and implementation, while minimizing uncertainty to aquaculture stakeholders (Hishamunda, et. al.2014). An ecosystems approach to aquaculture (EAA) development can assist this process, together with a holistic governance approach that minimizes conflicts over the use of land and water (Osmundsen, *et al*., 2020). Bush *et al*. (2019a) stressed the multi-dimensional perspective of sustainable governance which goes beyond market level governance to include certification, traceability, and preservation of the ecological landscape (Bush *et al*., 2019b).

There are four key principles that guide good governance in the aquaculture sector (Hishamunada, 2014):

i. Effectiveness and efficiency- doing the right things well).
ii. Equity- must consider the interests of different groups of the current generation (gender and youth) and safeguarding future generations.
iii. Accountability- refers to the degree to which officials are answerable to the public for their actions.
iv. Predictability of rule of law-the application of laws and regulations is fair and consistent and the decision process is transparent, open, and clear.

Good aquaculture governance is achieved when those key principles are adhered to and appropriate instruments are implemented, such as a transparent aquaculture administrative structure- a clear legal and regulatory framework that includes licensing-effective civil participation in decision making; adequate aquaculture statistics and research in support of policy and planning (FAO, 2017).

Aquaculture sustainability suggests that aquaculture governance will become even more important over time. This is because all factors of sustainability – (economic, environmental, legal, social, and technical) – will encounter opportunities and challenges. An example of the need for good governance is salmon netpen farming in North America. Atlantic salmon (*salmo salar*) has the advantage of being the least risky of all aquaculture species (Mowi, 2019). Farming salmon is also generally profitable. The challenge to sustainability (and therefore governance) comes more from the environmental footprint of cage culture, and related public opposition. Escapees, lice, and diseases are among the ecological threats from cage culture. There are problems of social license both in production (site approval) and markets (consumer boycotts). This lack of public support has resulted in a moratorium on new salmon sites on the west coast of North America, both in the Canadian province of British Columbia and the US State of Washington. The latter has required all salmon farming to cease in 2022.

An illustration of inadequate governance of aquaculture

In Brazil, the Federal Government owns many reservoirs around the country and concessions of these waters for aquaculture purposes are allowed free of charge for members of low-income families, who have at least one year of residence in the municipalities surrounding the reservoir (Matias, 2012). In 2009, licenses with varying fees were issued in aquaculture parks of Castanhão reservoir, in the state of Ceará-Brazil. This reservoir became the largest tilapia production center in Ceará and one of the largest in Brazil. Jaguaribara, the main city, in this reservoir produced almost 17,000 tons in 2014 (IBGE, 2015).

The period 2012-2016 saw the driest period in the recent history of Ceará, and the large fish production, high temperature and the eutrophication processes impacted the reservoir's carrying capacity (Barroso *et.al*, 2018). These factors combined with issues of low governance, such as lack of inspection and environmental monitoring and the inefficiency in the management of aquaculture areas (by all stakeholders), caused a huge drop in production in Castanhão parks. Jaguaribara produced 3,610 tons in 2018 (IBGE, 2019), a decrease of almost 80% when compared to 2014.

Conclusion:

This case study illustrates the implications of inadequate governance in which participatory and integrated planning, monitoring and management, are not implemented. This has contributed to the loss of work, food, and income for fish farmers, adding to the socio-economic problems in this region.

2.2 Definition of aquaculture governance

Hishamunda *et al*. (2014) defined three types of aquaculture governance, *hierarchical, market* and *participatory,* although differentiation between the governance types is not rigid (Ménard, 2004). *Hierarchical* governance exists where governments, or a leading agency develop policies independently, leaving producers to manage their farms. An example of such hierarchical governance is China. China's achievement in aquaculture has been influenced by government policies, with the authorities facilitating and formulating policies and guidelines to speed up structural reform of the fishery sector, but farmers are left to make production decisions (Hishamunda & Subasinghe, 2003). Norway, as the dominant producer of farmed Atlantic salmon, accounting for more than half the global output, has a governance model that is predominantly *market oriented*, with profitability and competitiveness as key. Environmental and social issues are not ignored because the context is sustainability, but the economic orientation is reflected in simplifying administrative and regulatory procedures so that farmers retain competitive advantage (Hishamunda *et al*., 2014). *Participatory governance* occurs when industry uses self-regulation codes of practice, and co-management of the sector with industry representatives and government regulators. Examples of such forms of participatory governance include Canada which has a national code of conduct, Scotland has its "Quality Assurance" scheme, and which Thailand has its good aquaculture practice (GAP) guidelines for the responsible husbandry of shrimp. (Hishamunda et al. 2012). Saarelainen & Sievers (2011) include cooperatives and collective action organizations. These business associations support members in developing their production and business activities, protect their interests, and represent them. Activities can include lobbying, information gathering, creating market protection mechanisms, providing business services, and market research. In Viet Nam, the sturgeon industry exemplifies such business organization and is linked to a value chain both vertically (buyer-seller relationships) and horizontally (inter-firm coordination, linkages to service providers and policy makers) (Saarelainen & Sievers (2011); Nguyen *et al*., 2019).

2.3 Effects of governance on the aquaculture sector

The effects of governance on the aquaculture sector are contingent on the importance placed by policy makers on the sector's development and its relevance to the country's economic development (Murekezi *et al*., 2020). The governance process is usually elaborated as a set of constructs in the national government plans by some legal authority, stakeholders, the organizational and institutional plans of the private sector and the international organizational plans. The national government with institutions and stakeholders lays out the national plan in which is inscribed the outputs that influence the types of governance. All plans are guided by the principles of governance (effectiveness or efficiency, accountability, equity, and predictability) and the conditions of sustainability (economic, social well-being, technical, legal and environmental quality), existing in the aquaculture sector. These principles plus the type of governance influence the input and output markets which may enable the achievement of the SDGs.

The national development plans are the guiding force behind sector governance. African countries such as Egypt, Nigeria, Ghana, and Madagascar have had aquaculture development plans since 2004, while in Asia, some countries such as China, India, Indonesia, Viet Nam, and Philippines have had quantitative aquaculture development plans from the 1970s. In South America, Chile, Brazil, Mexico, Ecuador, and Colombia and in Europe, Norway, Spain, France, Italy, UK, and Greece also have aquaculture development plans (Brugère and Ridler 2004) (Appendix table 1). However, most of the African countries have only recently integrated aquaculture into their national plans while most European countries have done so for more than a decade.

In terms of governance along the value chain at the farm and market level, technical upgrading production facilities, effective adoption of farming and marketing practices to establish enhanced management standards to improve efficiency and reduced negative environmental and social impacts, are required (Anh, *et al*., 2011; Krause *et al*., 2015). This means that farmers must modify their farming practices, farm management systems and/or shared water infrastructure between farms to satisfy best farming practice recommendations (Tlusty & Tausig, 2015; Boyd & McNevin, 2014). In Asia, there has been upgrading of facilities, products, regulations, and functions due to changes in governance (Ponte *et al*., 2014). The literature describes successful technical implementation of different standards, but also includes critical reflections on the weak inclusion of small-holder producers (Vandergeest, 2007; Belton *et al*., 2011; Bush, Belton, Hall, *et al*., 2013; Hatanaka, 2013).

In countries such as Viet Nam that export much of their aquaculture output, there are challenges in encouraging large numbers of small-scale fish farmers with heterogeneous production and handling practices to implement national regulations that ensure improvement in fish quality and consumer protection, thereby maintaining market share. In response to issues such as food safety and traceability, certification and eco-labeling are becoming increasingly important. These issues are considered high priority by lead agencies, or government-appointed boards in other countries that specify quality, quantity, price, and the production process (Humphrey & Schmitz, 2002; Hishamunda *et al*. 2012).

2. 4. Changes in governance since 2010

There have been advancements in the economic, environmental, technical, social, and legal dimensions of aquaculture over the last ten years, although there are still social conflicts, environmental problems, disease outbreaks, indiscriminate use of antibiotics, and legal, that compromise the social image of the industry. Appendix 1 shows that all continents experienced an increase in the rates of growth from 1999 to 2008, but the rates of growth slowed down from 2009 to 2018. Africa had a drop of 9.52 percentage points from 1999 to 2008 and from 2009 to 2018, while Europe and the Americas had 3.88 and 3.18 percentage points respectively. Asia was the only continent with a slight positive change of 0.32 percentage points from 1999 to 2008 and 2009 to 2018. Asian and North American and Latin American and Caribbean (LAC) countries had moderate governance scores. European countries even with higher levels of governance and earlier aquaculture plans had noticeable drops in the production growth rates during the period 2009/2018. All continents had upward trends in growth rates from 1999 to 2008 but declining trends in growth rates during the second period, 2009 to 2018. Major factors that might disguise the effects of governance on aquaculture are the starting points of aquaculture as outlined in their development plans, the importance placed on the constructs of poverty alleviation, food security or economic development in the national plans and effects of existing public-private partnerships. While in Africa more weight might be given to the goal of food security, in Europe and the Americas more weight might be placed on exports, and on foreign income earning (Murekezi, *et al*., 2020).

Using Viet Nam as an example of Asian countries, value chains have undergone rapid technological change in all segments as they have been modernized (Nguyen *et al*. 2020a). This has been due both to spontaneous experimentation and intervention by value chain actors, and induced innovation in response to greater competition as a function of shrinking profit margins. Evidence for such innovations includes the growing use of pelleted feeds, and strategies such as deepening ponds, stocking fingerlings at larger sizes, and integration with poultry (Belton *et al*., 2018). Structural changes have occurred throughout the chain on all continents as farms and related firms have proliferated and become more specialized (as individual enterprises) and diversified (in aggregate). Occasionally, they have become more concentrated (such as in the case of farmed Atlantic salmon or Indian pangasius) at certain nodes, or vertically integrated across them.

Governments of small nation states, such as the Seychelles and the Caribbean islands, now view fin-fish aquaculture as an environmentally responsible form of aquatic farming and a strategic solution to mitigating food insecurity and an alternative or supplementary source of protein to terrestrial animal varieties, or marine wild-capture fisheries (Kaiser & Stead, 2002; Stead, 2019). Concerns around declining wild caught fish and depleted stocks have spurred communities to demand government actions to ensure seafood supplies and job security (Philpot et al., 2015). The hope is that small-scale aquaculture can provide subsistence or income to fishery-dependent communities (Kaiser & Stead, 2002). These island nations are investing in finfish aquaculture for the first time to improve national food security resilience. In the case of the Seychelles, part of a national policy focuses on the blue economy where marine aquaculture has been selected for investment to underpin long-term economic prosperity and social development in the islands. In the Caribbean and particularly in Cuba, Jamaica and Trinidad and Tobago attempts have been made to increase tilapia production with much government support (FAO, 2017b). Grenada has adopted the blue economy concept (Techera, 2018) and is one of the first countries to initiate a national masterplan for blue growth (Patil & Diez 2016; Stead, 2019).

Attempts have been made in post-harvest handling to improve product image and to reduce the number of fish rejected by importing countries. Improved production and logistical efficiencies that occur with commoditization and modernization have resulted in farmed fish becoming accessible to greater numbers of low-income consumers in over 140 countries (see Kassam and Dorward, 2017; Saguin, 2018; Belton *et al*., 2018). There are currently more than thirty (30) aquaculture standards available, ranging from certification schemes to recommendation lists, representing a diverse set of requirements related to food safety, quality, traceability, and environmental and social impact (Parkes, 2010; Samerwong *et al*., 2020). Many countries are adopting Best Agricultural Practices (BAPs) and other standards in all aspects of their aquaculture farming practices. China's HAACP certification was approved by the Global Food Safety Initiative (GFSI) in 2015 and 2019, becoming the first Asian country as well as non-privatization country that recognized the GFSI (Sun *et al*., 2020). In Viet Nam, 100% of the pangasius processing companies have adopted Hazard Analysis and Critical Control Point (HACCP), a mandatory international regulation for the global food industry.

The need to meet market demand has brought changes in efficient resource allocation along the value chain. There are many examples of improved efficiency of farmers' production practices. The rise in standards has affected production systems, post-harvest handling of foods, and corporate competitiveness repositioning (Giraud-Heraud *et al.,* 2012). In Norway, most hatcheries and nurseries that produce fry or smolt already use semi-closed systems, while all new ones must use recirculation aquaculture systems, drastically reducing water demand and pollution (Sandvold, 2016). At the national level, many countries have codes of conduct as part of self-regulation. In Canada, for example, there is a national code of conduct for responsible aquaculture developed by the Canadian Aquaculture Industry Alliance. This code is based on the HACCP system indicating standards for fish health, environmental quality, and product traceability. The United Kingdom has “Quality Assurance” schemes in which members must meet standards of quality and environmental management that are Internationally recognized, such as ISO 14001. At the regional level, an example of self-regulation is the Federation of European Aquaculture Production (FEAP) association. It has a code of conduct that has nine themes that cover environmental, consumer, husbandry, and socio-economic issues, as well as the public image of the industry (Hishamunda et al., 2014). Thailand has its Good Aquaculture Practice guidelines for the responsible husbandry of shrimp. It also has a sophisticated code of conduct that demands international quality standards. Viet Nam has adopted the Viet Nam Good Aquaculture Practices (VIETGAP) which is an amalgamation of almost all standard international practices and Viet Nam’s farming practices. A comparison between VietGAP and non-GAP applied farms showed that farmers in the GAP system performed well on seven control points related to quality management, especially regarding reservoir construction, water monitoring, and chemical use. The farmers in non-GAP farms appeared to have weak practices in quality control with high usage of antibiotics, leading to 64% of farmers reporting disease and 20% of tested shipments being rejected (Quyen *et al*. 2020).

While important progress in aquaculture governance has been achieved over the past ten years, many issues have not yet been resolved. Some countries have started to develop their policies in a participatory and transparent manner through Strategic Aquaculture Development Plans (SADP), considering stakeholders involvement. While many programs and projects stemming from those sectoral plans have promoted aquaculture in countries like Colombia, Peru and Paraguay, weaknesses remain, and thus impede further aquaculture development. The Policy Framework and Reform Strategy (PFRS) for Fisheries and Aquaculture adopted by all Member States in Africa aims to create an enabling environment that will lead to the transformation of Africa’s aquaculture into a sustainable market-oriented private-sector led commercial agricultural activity that can meet the African Union Ten Years (2016-2025) Comprehensive Africa Agriculture Development Programme (CAADP) objectives. The main objective of the PFRS is to jumpstart market-led sustainable aquaculture throughout Africa by using a variety of strategies.

2.5. Government support

The successful contribution of government to the process of governance requires more than funding or financial stimulation of the production and marketing process. It requires trustworthy communication, leadership, and constant interaction with all stakeholders. Interactive governance recognizes that societal problems and opportunities can be characterized by their diversity, complexity, dynamics and scale, and that governance responses must therefore come not only from the state, but also from the market and civil society (Cai *et al*., 2012). In Canada, the rights of indigenous groups over traditionally used territories are increasingly recognized in court verdicts, forcing senior governments to consult with indigenous communities about economic decisions in marine and terrestrial spaces (Newman 2009; Young *et al*. 2019). Some aquaculture companies have partnered directly with indigenous communities through agreements on enhanced environment monitoring and employment opportunities (Young and Liston 2010; Young *et al*. 2019). Decentralised governance approaches, including co-management and community-based management, are important to monitor the product along the value chain to meet the social and environmental objectives, institutional designs, and levels of community, state, and private sector participation (Evans *et al*., 2011). Similarly, coastal zone governance requires a holistic and integrative approach (Chuenpagdee *et al*. 2008). Though the role of the state remains prominent, greater private sector involvement is also necessary, especially in the formation of marine protected areas and the development of ‘rights-based approaches’ to offshore aquaculture (Allison *et al*., 2011). However, government must provide a framework for successful governance.

Technology transfer is important in the aquaculture sector and can be enhanced at the international level through policies that support international cooperation (FAO, 2014a). Government technical support for aquaculture varies widely among countries (Ponte, *et al*., 2014). The government of China has provided tax relief to farmers to expand turbot aquaculture (see Case Study below). In Thailand, the Department of Fisheries provides substantial technical support. Participation in aquaculture field schools in Odisha, India, resulted in higher fish production, investment, and household expenditure (De Kumar *et al*., 2016). In the US and many other countries, extension agents support better practices in freshwater and marine aquaculture (Knapp & Rubino, 2016).

To promote environmentally friendly development, some countries adopted subsidies to encourage the applications of green technologies. China has piloted extension projects for offshore cage culture systems. In some of these projects, the local government supports up to 50% of the investment. Indonesia, business practitioners directed its aquaculture governance regulations and practices in sustainable fisheries, but many of these business specialists had limited knowledge and preparedness on sustainable fisheries and aquaculture management and their engagement posed a problem for sustainable fisheries management, governance, and failure to protect Indonesia from future biodiversity loss (Zulbainarni. *et al*., 2020). As mentioned earlier in this paper, Norway has issued special licences for salmon farming companies wishing to develop technological alternatives to marine cages.

Trade policies for aquaculture are also a tool that can generate direct and indirect benefits to communities. Legitimate areas of concern for policymaking could be where there is communication and marketing constraints. Governments must design and enforce health and safety procedures and good aquaculture management practices to meet foreign consumer demands. To attain export objectives, government intervention could be in the form of export promotion and the development of marketing strategies; branding/certification of products; traceability; regulatory frameworks for trade (e.g. tariff rates); the availability and timeliness of market information available to producers/exporters; processing, preservation and transport technologies; and institutional development of marketing organizations. There are long-term benefits if the industry becomes more sustainable, but trade brings "losers" as well as "winners", so governments need to intervene to ensure vulnerable interest groups share in the trade benefits.

An illustration of species development: China's turbot farming

China has become the largest producer of farmed turbot (*Scophthalmus maximus*) in the world in the last decades, thanks to policies and new technologies promoting its production. The rapid development of this industry not only created many employment opportunities, but also increased the income of coastal fish farmers. This species was first introduced from Britain to China in 1992. In 1999, Chinese aquaculture experts made a breakthrough in turbot breeding and explored "greenhouse + deep well seawater", an industrialized pattern of turbot (Lei & Liu, 1991; Lei & Zhang, 2001; Cao & Yang, 2017). From then on, under the supervision of Ministry of Agriculture of China, National Technology System for Flatfish Culture Industry (NTSFCI) was established in 2008 to support the development of flatfish aquaculture, especially for turbot. It focused on the needs of the flatfish culture industry, monitoring its fluctuation frequently to discover and resolve issues. With technical support as well as intensive production system, turbot aquaculture expanded from Shandong to many coastal areas (Hou *et al*. 2016); thus, making turbot one of the most popular aquaculture flatfish species in China. With the support of NTSFCI, "Dan-Fa Ping", the first artificial cultivated species of turbot in China, which had a faster growth rate and higher survival rate, was invented in 2011. "Duobao NO.1" of turbot was invented in 2014, which not only further improved the growth and survival rates, but also increased the genetic stability of maintaining more than 90% of economic traits (Ma *et al*., 2016). Since 2017, NTSFCI was expanded to China Agriculture Research System for Marine Fish Culture Industry (CARSMFCI) and turbot aquaculture is still benefitting from technological support of this system (Cang *et al*. 2018).[1] More recently, efforts have been made in some areas to build the National Geographic

[1] http://www.ysfri.ac.cn/index.htm

Indication Certification and Traceability system to satisfy consumers demand and sustainable development of the product.[2]

To some extent, the fast growth of this industry also benefited from tax reduction measures in China. The State Taxation Administration of China remitted: i. the land tax for land directly used for aquaculture; ii. the added-value tax for self-produced, self-sold products and taxpayers who work in wholesale, retail fry, fish medicine, aquaculture machinery, aquaculture insurance, technical training, breeding, and disease prevention; iii. corporate profits tax for taxpayers who provide service for the sector, such as aquaculture product primary processing, veterinary, aquaculture technology promotion, aquaculture machinery operation and maintenance, etc. and iv. 50% of corporate profit tax for taxpayers who engage in marine and inland aquaculture.[3]

The fast development of this industry also brought some environmental challenges, such as the exhaustion of ground water in some regions. To protect the environment and the natural resources, policies to limit the improper culture pattern have been adopted in some coastal regions. Under the combined influence of these policies, urban construction and other factors, some turbot cultivation greenhouses were demolished, which caused the decline of turbot culture area in some regions. In the third quarter of 2019, its culture area in the demonstration area of the CARSMFCI decreased by 17.72% compared with the same period of 2018. However, with the technical support from CARSMFCI and other scientific institutions, its average yield per square meter increased offsetting the decline in areas to some extent[4].

Conclusion: The initial goal of China's turbot culture industry was to improve farmers' profit and meet consumers' increasing demand for high quality seafood. Under the guidance of the overall planning of aquaculture, through the establishment of NTSFCI and CARSMFCI, key technologies and services could be supplied and disseminated to famers quickly, which supported the sustainability of Chinese turbot culture industry.

2.6. Legal and regulatory framework.

In most countries a legal framework designates a ministry or department as overseeing the aquaculture sector (Hishamunda et al., 2014). Among the world's largest aquaculture producers, China's Bureau of Fisheries, India's Aquaculture Authority and Thailand's Department of Fisheries are the lead agencies for aquaculture, and all fall under their respective Ministries of Agriculture. Even when aquaculture output is relatively small and under a Ministry of Agriculture, as in Zambia, the lead agency is often a department of fisheries, so that it can be regulated separately from other forms of established agriculture like crops and livestock (Chuenpagdee et al., 2008). In other countries such as Canada, New Zealand and Norway, aquaculture falls directly under a Ministry of Fisheries (McGinnis & Collins, 2013). In Chile aquaculture is under the Ministry of Economics (Appendix 1).

Modern aquaculture is expanding rapidly in many countries and needs constant adaptation in its administration. In Norway, applicants must have permits for land and water access before they can get an aquaculture license (Hishamunda *et al*., 2014). Section 51 of the 2015 Fisheries Act of Thailand make aquaculture in rivers, as public water bodies with capture fisheries, illegal unless specific exception or

[2] China Agriculture Research System for Marine Fish Culture Industry, 2017-2020. Annual Report of China Agriculture Research System for Marine Fish Culture Industry.

[3] http://www.chinatax.gov.cn

[4] http://www.marinefish.cn

permission is granted by the province (DOF, 2015). Before this Act, cage culture in rivers had de facto support from the Department of Fisheries and other relevant bodies, and access went primarily to people who lived near the riverbanks (Lebel et al., 2014). In the meanwhile, China has established and accomplished the 12th and 13th Five-Year Plan in the last decade which covered all sectors including the aquaculture sector. Moreover, in January 2019, with the approval of the State Council of China, the Ministry of Agriculture and Rural Affairs of China (MARAC) and other nine ministries jointly issued "Several opinions on accelerating the green development of aquaculture" (shortened to "Opinions") (Ministry of Agriculture and Rural Affairs of the People's Republic of China [MARAC], 2019). Socio-economic assessments have been conducted by many Asian countries. The Republic of Korea and Japan have also conducted similar routine assessments (Jayanthi, *et al.* 2018). Japan has a special department for resource assessment for its fishery sector's sustainable development. Cambodia drafted their revised Fisheries Law that covers the practices for the discharge of waste and water quality control (Miao & Yuan, 2019). On the practice of governance and value chain development, Bangladesh set up workshops to improve communication between administrators and stakeholders on aquaculture development. The responses suggest that there is great potential for mobilising a rich store of knowledge for bottom-up construction of standards (Bremer *et al*., 2016). India's Green Certification Guidelines gave the assurance of the value chain system that can further improve its freshwater ornamental fish (Miao & Yuan, 2019). In Viet Nam the Ministry of Agriculture and Rural Development (MARD) is the main body for aquaculture decisions, with supporting ministries and regional governments for the regulation and enforcement of aquaculture laws (Nguyen & Jolly, 2020b). MARD in 2013 developed a comprehensive plan for long-term development of Viet Nam's fisheries and aquaculture that synchronizes all legal, economic, social, and environmental aspects of innovation, aquaculture in various spaces of water; processing and commercial consumption in the domestic and international markets; mechanical ship building and fishing logistics service. The Master Plan also includes strategic programs of fisheries and aquaculture development based on the real conditions, competing factors and natural characteristics in major centers of Viet Nam (Hong et al. 2017).

A further governance complication is the allocation of responsibilities in a federal system. Canada is a relatively small producer of farmed Atlantic salmon with less than 10 % of global output, but it is Canada's most valuable aquaculture species, cultivated in both the Atlantic and Pacific. The Canadian federal government through its lead agency, the Department of Fisheries and Oceans, has responsibility for marine coasts. However, in the two salmon farming provinces in the Atlantic, this responsibility has been delegated to the provinces, but not in the Pacific where the province of British Columbia administers the Crown lands adjacent to farms, the federal government regulates aquaculture operations (Mowi, 2019).

Aquaculture maintains a relatively low institutional hierarchy in Latin America. There are only two countries that have a Ministry of Fisheries and Aquaculture (Nicaragua and Venezuela). Most of the countries have the aquaculture organizational structure as part of the Ministry of Agriculture or similar; where terrestrial agricultural activities tend to have much more production volume, number of dependent families, and political weight; therefore, financial, and human resources are comparatively much lower than those allocated to the aquaculture sector. Using Ecuador as an example, there were no targeted regulations for the aquaculture sector. Instead of having evidence-based policies that are fit-for-purpose, the rules governing aquaculture had been adapted from the fisheries sector (Howell, 2020). This means that many countries cannot give the aquaculture industry the institutional expertise or support it needs to thrive and this may be a problem existing in many other developing nations. Regarding legal frameworks for the national aquaculture sectors in the region, most countries have elaborated, reformed, or updated their respective Aquaculture Laws recently.

In Africa, most of the countries do not have a stand-alone Ministry for Fisheries and Aquaculture, except for Ghana where there is a Ministry of Fisheries and Aquaculture Development. In most cases, aquaculture is domiciled in a Ministry that is responsible for either agriculture, livestock, or forestry. Often, aquaculture is one of the departments or directorates within the organizational structure. However, many African countries in collaboration with FAO have developed comprehensive aquaculture plans during the last decade.

2. 6.1 *Regulatory constraints and barriers*

While most countries have bodies that engage in legislative actions the challenge is often enforcement. Exporters must comply with regulations if they want to sell their products in a particular market. Importers try to enforce laws that will guarantee food safety and minimize health risks from food contamination. The major importers like Japan, the European Union (EU) and US either adopt a reactionary approach or a proactive approach in testing, licensing, and product triage. Until recently, the role of the Food and Drug Administration (FDA) in the US food safety control system was reactive, rather than proactive. The FDA was largely responsible for issuing and enforcing recalls of the product. The role of FDA changed when in January 2011 President Obama signed the Food Safety Modernization Act of 2010 (FSMA). Private and public law enforcement is accomplished through program participation, certification, license fee, and product rejection or confiscation. The exporting countries like China, Viet Nam, and Thailand usually follow government decrees and adhere to specifications outlined by industry leaders. In Viet Nam pangasius processors are obligated to comply with the demands of the decree and with a few requirements, including tracing the origins of processed pangasius products and applying a quality control system. Technical regulations and standards for food safety and hygiene during the manufacture and sale of aquaculture products must be followed (Khoi 2010; Nguyen & Jolly 2020a).

Many farmers, especially those in the more developed European and North American countries, perceive regulations and standards as hindrances to aquaculture development in their home countries because of the incompatibility of the standards to their conditions. The importance placed on sustainability and the burden of regulatory limits on aquaculture have crippled innovation, trade, investment, and economic efficiency in general (European Commission, 2013 & 2016). The number of environmental regulations in the US amounts to 1,300 which puts a burden on US aquaculture development (Engle & Stone, 2013). Small and medium scale producers are often burdened by legislative requirements to obtain export permits to sell their fish. Negotiation through an unwieldy bureaucracy and difficult regulatory system is both expensive and time-consuming (Howell, 2020). For instance, many producers in Latin America skip the formal process in movement along the marketing chain to market their product and operate in the informal economy. Though this makes economic sense in the short term, operating outside the legal and formal systems means that finished products cannot be certified. This diminishes the product value and limits farm profits. The lack of good governance could undermine the industry's early export success and result in the evaporation of any competitive advantage and the later could hinder the attainment of the SDG in many of these countries.

Compliance costs are a focus of concern, and producers in developing countries, especially small-scale producers, may encounter difficulties conforming to new standards. To access the US and EU markets, Vietnamese shrimp producers and processors are compelled to adhere to the standards if they want to sell their products (Nguyen & Jolly 2020a). Mandatory certification is, however, the less costly approach than standard enforcement. Standard enforcement when dealing with many small-scale producers increase transaction costs and hence exclusion of limited resource producers from global market access (Belton *et al*., 2011). Most of these standards not only increase costs to small-scale farmers but are almost impossible to implement due to the share size of the plots on which they produce (Swinnen, 2014; Marschke & Wilkings, 2014).

2.7 Zoning and resource management

The creation of zones facilitates the integration of aquaculture activities into broader areas for agricultural and non-agricultural uses. Zonation contributes to improved coordination among the public and private agencies involved in aquaculture licensing and monitoring processes and facilitates collective action and joint management and governance by stakeholders. The zoning process is normally led by national or local governments with important stakeholder participation, fed by relevant information and supported by pertinent regulations (Aguilar-Manjarrez *et al*., 2017). In Asia, Europe, and North America, for example, marine cage culture has created conflicts with other users of waterways. The growing emphasis on integrated coastal zone management (ICZM) has the potential to reconcile such conflicts over aquaculture sites (Hishamunda *et al*., 2014).

To manage conflicts between rice and rice-shrimp or shrimp systems in Bac Lieu Province in the Mekong Delta, provincial authorities designated a buffer zone in which rice is grown in the wet season, and shrimp reared in the dry season (Dung, *et al*., 2009). As returns from shrimp were much higher, farmers responded by extending the period with saline water, at the end making it impossible to grow rice. Lack of coastal zone management plans contributes to these conflicts, but even existing plans may not be enforceable. Expansion or maintenance of irrigation in coastal areas of Bangladesh may be limited by competition or conflicts over water management with traditional brackish-water shrimp aquaculture (Bell, *et al*., 2015).

Coastal zone management creates policy challenges, which may be solved locally through support for alternative livelihoods (Bernier *et al*., 2016). Azad *et al*. (2009) argue that coastal zoning, including return of illegally farmed public lands in Bangladesh, is a way to deal with expansion of freshwater and brackish-water shrimp. Thus, Burbridge *et al*. (2001, p. 195) argue that 'to achieve sustainability, mariculture must be included in strategic development plans for coastal lands and waters. Mariculture should also be granted rights of access to coastal lands and waters equal to those rights enjoyed by other forms of human development.' Increasing attention to environmental responsibility of aquaculture underscores the urgent need to understand the environmental footprints of different production systems to better manage them to promote more sustainable aquaculture (Cao *et al*., 2013).

Coastal zone management in New Zealand has become increasingly important but controversial as the impacts of land activities, particularly coastal dairy production, on marine ecosystems and salmon aquaculture, become evident (McGinnis & Collins, 2013). Under the Resource Management Act of 1991, authorities at district and regional levels manage the coast and marine environments. National policy is to expand aquaculture, putting the Fisheries Ministry in the problematic position of being 'both a regulator and a promoter of the industry' (McGinnis & Collins, 2013).

In the case of Kenya, the 2010 reform of government administration strengthened the County government's role on issues of aquaculture at the expense of the national government's State Department in charge of fisheries and aquaculture. There is lack of/inadequate support to aquaculture by some of the devolved county governments to keep the sector on the growth path. Devolution has visibly resulted in the decline in the assessment of national aquaculture data. The performance of the sector cannot be accurately determined, and hence policy recommendations to guide the sector do not inspire confidence that would attract investment in the sector

2. 8 Equity in governance

Some countries have embraced the importance of governance and have adopted practices that have promoted equity, accountability, and predictability of governance. In areas where aquaculture is developed, to reduce the dependency on wild caught fish, fishing communities that do not have capital may not be included, or benefit from the new enterprises. Attempts by government to encourage participation in new enterprises may fail unless the local communities are empowered to maintain collective ownership of their coastal resources and have strong governance structures. These communities once vested are less likely to lose access to larger interests associated with large-scale intensive aquaculture (Eriksson *et al*., 2012). The potential loss of fishing grounds due to new investments as in the case of sea cucumber farming in Zanzibar, with the creation of grow out areas designated to-take zones in favor of farms within lagoon habitats, may trigger competition for space and user conflicts. Existing evidence, however, indicates gender imbalances exists in fishing communities and along the value chain. Women do not have equal access to equal pay, capital, or voice in governance as men in aquaculture dependent communities or along the value chain. The specifics were found to vary by context and to be shaped in relation to factors such as class, needs, and social and religious norms (Kruijssen *et al*., 2018). Women in Viet Nam, like in most developing economies, have lower access to capital and technologies than men (FAO, 2011), and this decreases their participation in

Jewlet Enterprise: A successful farm run by a woman receiving partial funding

Under the Africa Solidarity Trust Funds, FAO promoted projects that established youth and women microenterprises to meet both demand and supply of seeds (fingerlings) and related aquaculture inputs, principally for tilapia and catfish. The project supported improved access to finance for investment in aquaculture-related businesses, with particular focus on accelerating private sector investments in three areas of the aquaculture value chain: feed production, hatcheries, and grow-out facilities. It also established a combination of contract farming and public-private partnerships (PPPs) models which included youth training in business to create self-employment. The project provided technical support to aquaculture supply chain investors assisting them to apply for funding and to make good use of secured external financial resources. The criteria and approach for selecting participating enterprises were:

Identify potential target beneficiary aquaculture operators/investors (both in start-up and expansion phases); Readiness to receive financial training with regards to economic performance and risks for aquaculture operations; Receipt of technical assistance (both technical and business in preparation of a business plan) to support the implementation of the selected investment projects; Success in securing new financing, including funds for the implementation of Environmental Impact Assessments to meet regulatory requirements.

The integrated partnership model had three major objectives:

Facilitate the insertion/inclusion of people into value chains through business networks that were already mastered by the Nuclear Farms

Ensure efficiency in quality input supply in the form of in-kind loans from Nuclear Farms to the Satellite Farms

Guarantee repayment of input loans by the delivery / sale of production to Nuclear Farms, and the implementation of Environmental Impact Assessments to meet regulatory requirements.

After the training workshop, a model farm, Jewlet Enterprise, run by a woman (a graduate in aquaculture) and her husband (a business graduate) was selected through an assessment of stakeholders as one of the business units to receive support to demonstrate an aquaculture model farm. The goal of the enterprise was to increase fish consumption and supply from Lake Victoria Basin. The lady received a small injection of funds and equipment from the project (25%) and co-shared the remaining 75% to convert her traditional hatchery into a recirculating system for tilapia and catfish. She and her husband also became mentors and trainers of other young farmers in the Kisumu, Homabay, Kakamega, and Nandi areas (Kenya). By the end of the project, they built a sustainable farm specializing in fingerling and post-fingerling production, and improved their own feed production while providing farm-to-farm extension services to fellow farmers, and their clients (seed & broodstock purchasers). In 2016-2017, among dozens of farmers supported with similar technology, Jewlet produced 8.14 million fingerlings generating a gross income of USD 319 450 in 24 months, with an improvement of more than 70% from their initial stage at the beginning of the project. They produced more than 375.5 tonnes of commercial fish feed due to the increased demand and acceptance by the farmers, and after receiving training on feed formulation by the project. The support from the FAO project in terms of intensive training and the introduction of new hatchery technology and equipment significantly enhanced business success because of transparency, accountability and social acceptance by the community, farmers, government and non-government stakeholders.

levels of the value chain as decision makers and confines them to lower profit nodes (Coles and Mitchell 2011). Studies in Asia have shown that greater equity can be achieved if women and youth have access to credit and financial assistance. If women and youth have investment capital, they are likely to have greater voice in decision making and able to participate in the governance along the aquaculture value chain (Kruijssen *et al*., 2018).

3. Issues and challenges of institutional good governance

3. 1 Social license acceptability

Globally, aquaculture is the fastest growing food production sector, but the rates of production and expansion vary between countries, with the slowest growth rates noticed in Europe and the Americas (FAO, 2018; Stead, 2015). The negative image associated with some types of aquacultures, for example, salmon farming, can constrain governments, willingness to support this sector when effective campaigns lobby against this activity (Stead, 2018). A global Delphi study on constraints facing aquaculture, found that respondents in all regions, except Africa and Eastern Europe, expected public opposition to be a threat to the future development of the industry over the next fifteen years (FAO, 2009). In the Americas and Western Europe, respondents expected opposition to aquaculture to have a large or very large negative impact. The negative perception was attributed to non-governmental organisations (NGOs), and even misinformation. In Asia, public mistrust was seen as having a large negative effect, the mistrust was attributed to a "sensationalist" media.

Canadian salmon farming has been handicapped by lack of social licence. Acceptability differs widely between the Atlantic and Pacific coasts (Barrington *et al.,* 2010). In the poorer Atlantic provinces, the impact of salmon farming on employment and rural development is welcomed, whereas in the Pacific province of British Columbia negative attacks in the media and by NGOs have generated consumer mistrust of farmed (rather than wild Pacific) salmon. This has translated into price discounts for farmed salmon, and difficulty locating farms in coastal waters. Much of the coastal waters are the remit of the indigenous people who, although beneficiaries of about 10 % of aquaculture, have often been hostile to cage culture (Department of Fisheries and Oceans, 2019). Social licence has not been helped by the dominance of foreign (Norwegian) companies in British Columbia (unlike New Brunswick in the Atlantic), nor by the existence of wild (Pacific) salmon and alleged sea lice transfer to them from farmed salmon.

While the lack of public acceptability has been a handicap to salmon farming in Canada (and the USA), it has been less of a problem in Norway. The difference in attitudes reflects variances in participatory governance. Norwegian governance of salmon aquaculture recognized that participation from stakeholders at the beginning of the planning process could build trust and enhance compliance with shared decisions (Hishamunda, *et.al*., 2014). The Planning and Building Act encourages community participation and transparency at the very beginning of the planning process. Such planning is part of integrated coastal zone management and has helped to recognize and reconcile different interests. In contrast, Canada initially evaluated lease applications on a site- by-site basis (Chang, *et. al*., 2009). This made site selection a contentious issue and became the major impediment to development of the industry (McConnell, 2006). Applications for a particular site faced opposition, whether from cottagers, workers in other sectors, environmental groups and the wider public. Only after litigation and erratic development has there been a more participatory approach like Norway. British Columbia now requires extensive consultation, particularly with indigenous communities, and in New Brunswick the Aquaculture Bay Management Areas has elements of integrated coastal management (Chang, *et. al*., 2014).

In Kenya, social license, is an integral part of sustainability and is a requirement for prospecting cage farmers. Prior to the submission of any application by an investor, there must be a rigorous consultative process with the communities around the proposed site up to the leadership in the host county before an application is made and accepted. Encouraging communities to participate in decision-making is important because it educates the public in all aspects of aquaculture. The 2010 reform of government administration saw the devolvement of aquaculture to the County governments at the expense of the National government (State Department of Fisheries, Aquaculture, and the Blue Economy (2019). The aim of the reform was to increase self-governance through decentralization. However, international trends in coastal zone and marine resource management are moving in the opposite direction, aiming at more integrated and ecosystem-based approaches involving the management of larger, rather than smaller, geographic regions.

> **A technique that enhances social license in farming salmon**
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> While salmon farming is a major source of non-seasonal employment, it faces several challenges that threaten to undermine the industry's sustainability. For New Brunswick, which accounts for less than 2.0% of global output and value, it is susceptible to volatile prices. Another challenge is the concern among the public about environmental problems, and perceived health concerns about eating farmed salmon. The province has recognized production and market risks of a price-taking industry that relies on a single species, and a single market (the USA). Environmentally, the region has adopted a policy to prevent disease outbreaks, based on biophysical environment risk management with a three-year rotation system (Chang, *et. al*. 2009). However, there are still escapees, and lice, that receive adverse media publicity.
>
> To mitigate environmental and social concerns one strategy is to implement Multi-trophic Aquaculture (IMTA). Projects have demonstrated the benefits of IMTA; by-products from one species become nutritional inputs for another (Soto, 2009). Environmental benefits include the reduction of nutrient release and therefore improved water quality. In New Brunswick, IMTA is being applied to the salmon industry, with mussels and seaweed grown at the same salmon site. The husbandry of several species on the same site requires more sophisticated management, which is a major constraint to widespread adoption of IMTA according to a Delphi study (Bunting, 2008). Yet its adoption in New Brunswick (without any fiscal incentive), suggests that IMTA aquaculture may be sufficiently profitable to offset risks. A further advantage of IMTA is its wide acceptance by the public (Barrington, *et al*., 2010). IMTA salmon farming is particularly favored because it is perceived as more "natural" than salmon monoculture. There is even the potential for a price premium for IMTA products (Shuve, *et. al*., 2008).

3.2 Certification and consumer demands for food safety

The rise of food safety standards in export value chains and the demand for consistent high volumes and good-quality produce have placed a burden on the resources of firms, especially small-scale producers, and forced them to integrate horizontally and vertically. The standards imposed on imports require costly investments that are beyond the reach of small-scale producers (ITC, 2011). The increase in standards has considerably influenced the structure and operation of the supply chain (Hammoudi *et al*., 2009). Challenges being faced include; the emergence of small groups of large sellers (oligopolies) in the production of certain species especially in cage farming in the great Lakes in Africa or in salmon farming in Canada, reconciling conflicts of access to land and water (competing claims to water and land with crop irrigation), the need to manage aquaculture within a deteriorating ecosystem also used by other interested parties, eg, reducing water pollution (ensuring environmental integrity), and funding of adaptive research (against academic research).

Despite considerable effort by NGOs, governments, and companies, only 6.0% of global aquaculture production is currently certified (Bush *et al*., 2013; SCRC 2019). The limited volume of certified aquaculture production is largely due to the systemic exclusion of smallholder producers. Small scale-producers who represent most of the global production, do not have the finance and/or knowledge to address the environmental or social risks that undermine the sustainability of their farm-level production practices (Bush *et al*., 2013; Bush 2018; Samerwong *et al*., 2018). Many countries are advocating the formation of cooperatives or producer associations to help organize producers so that they can circumvent some of the certification requirements (Nguyen and Jolly, 2020b). For instance, instead of the inspection of a single farm the certifier can inspect a cooperative or groups of farms, spreading the cost of certification among members.

There has been growing pressure by importing countries and certification bodies on environmental regulations. Most developing countries have attempted or are in the process of dealing with these environmental concerns. However, excessive, and complex environmental regulations constrain the growth of aquaculture in Europe (Abate *et al*., 2018, 2016) and the US (Engle & Stone, 2013). Hence, much of the recent growth in aquaculture has been in lower- and middle-income countries where regulation is more modest (Abate, *et al*., 2018). While over-regulation is a concern, appropriate regulations are often still needed (Osmundsen *et al*., 2017).

3. 3 Industrial concentration

For any product or service whose production has high fixed costs and therefore needs a large output to obtain economies of scale, new entrants face a competitive handicap. There is the likelihood that the industry will be dominated by a few large firms. In aquaculture, an example is the farming of Atlantic salmon. Farmed Atlantic salmon globally was worth more than US 17 billion in 2019, having almost tripled in value since 2009 (FAO, 2020). It is the most industrialised aquaculture species, increasingly concentrated, and even oligopolistic in certain countries (Mowi, 2019). Table 3 illustrates the growing industrial concentration of farmed Atlantic salmon between 2009 and 2019, Consolidation has been particularly acute in the smaller producing countries (Scotland, Canada, Australia and the Faroe Islands), creating oligopolies. In Scotland four companies produce 96% of its output, and in Canada the same proportion (96%) is produced by only three companies. In the second largest producing country, Chile, there has also been concentration whereby 90% of farmed Atlantic salmon in 2019 came from the top ten companies (Mowi, 2019). Even though table 3 indicates that there has been less consolidation in the largest producing country, Norway, the top ten companies produced more than two-thirds of national output.

Table 3. Number of farms producing at least 80% of national output of farmed Atlantic salmon in 2009 and 2019

Year	Norway	Chile	Scotland	Canada	Australia	Faroe Isles
2009	21	18	12	15	8	10
2019	20	13	4	3	3	2
Source: calculated from Mowi, 2019.						

Salmon farming has also become transnational with single companies operating in different jurisdictions. Moreover, not only has consolidation of farms produced concentration, but the industry is dominated by one country, Norway, which accounts for more than half the global output of farmed Atlantic salmon. One Norwegian transnational company is the largest single producer in Norway and the United Kingdom, the second in Canada and the fourth in Chile: It singly accounts for almost one-fifth of world output (Mowi, 2019).

The increased concentration, both within the industry from mergers and internationally, influences governance. It shifts the balance of power towards companies, and their bargaining power. There is also the potential for monopsonist behavior in the labor market, although this is not evident in practice (FAO, 2014a). However, concentration has also been beneficial for governance. Salmon farming is capital-intensive, which forces both farmers and processors to cooperate (Kvaloy & Tveteras, 2008). Also, the small number of actors facilitates combined action when there is recognition of shared interests. An example of cooperative behavior of global producers is the Global Salmon Initiative (GSI). Its priorities are biosecurity (sea lice) feed, meeting standards particularly those of the Aquaculture Stewardship Council, and increased transparency (Mowi, 2019). The aim of GSI is to reassure consumers that the product is safe, and that the environmental footprint is minimized. A further governance benefit of this consolidation is that surviving companies have "deep pockets". They can respond to government incentives for research and innovation. Governments encourage the new technologies that promise to enhance sustainability because salmon farming is a source of foreign exchange, and provides relatively well-paid, non-seasonal, employment, often in isolated rural areas.

The innovations have the advantage of enhancing the criteria for sustainability. Economic viability is not guaranteed because the technologies require fixed capital and therefore large output to obtain economies of scale. In addition to production risks there are market risks from sharply increased output as the retail price of farmed Atlantic salmon is strongly correlated with supply (Mowi, 2019). However, the new technologies that are presently operational have done so without much public funding, which suggests that the private sector is optimistic about risk-adjusted profitability (Department of Fisheries and Oceans, 2019).

3.4 Aquaculture expansion

Many countries are facing scarcity of land and water resources for aquaculture expansion. With increased demand for fish and aquaculture products, the search for suitable space for aquaculture development has forced producers to exploit the ocean for location of aquaculture enterprises and employ technologies that are efficient, cost-effective, and environmentally sustainable. Open aquaculture is considered by policy makers as an opportunity to reduce fish market deficit and enable the society to attain the SDG3 and 8. Open ocean aquaculture, based on research findings (Fanning *et al*., 2007; Turner *et al*., 2014), can operate culture systems for finfish and shellfish to produce safe and quality seafood. The progression from land-based aquaculture to open ocean fisheries is a movement from non-statutory to statutory, regulatory, and planning domain in marine aquaculture (Peel & LLoyd, 2008). Knowledge of spatial and temporal data, species distribution and data format issues on marine ecosystems is limited (Martin *et al*. 2014).

Open marine aquaculture has great potentials for small island states like the Caribbean and Pacific islands, with high population densities, major fish deficit, and good governance and growth potential. The engagement in open aquaculture remains unexploited because of these countries limited capabilities to attract capital through foreign direct investment (FDI). In contrast, countries like China, with less suitable, environmental conditions than the Caribbean countries, but endowed with the financial resources to promote open aquaculture can engage in larger-scale, open aquaculture enterprises. China has made huge achievements in the off-shore cage culture area, which do not only include 100,000 tons of off-shore cage culture platform, semi-submersible truss floating structure aquaculture ship, and Deep-sea intelligent fishing platform (Shi *et al*., 2020; Deng, 2020), but also the world's first fully automatic deep sea semi-submersible "intelligent fishing platform". Viet Nam's Fisheries General Department, and the U.S. Soybean Export Council (USSEC) have proposed a plan for the increase in ocean aquaculture, based on Viet Nam's draft national strategy for marine aquaculture development through 2030.

In 2018 the Chilean venture Ocean Arks Tech obtained a patent for a self-propelled fish farm—basically a 170-meter vessel that can produce 3,900 tonnes of commercial fish species such as salmon, tuna, and amberjack. In 2017, a Norwegian company SalMar began operating Ocean Farm 1, which it called the world's first offshore fish farm. The pilot facility—68 meters high and 110 meters wide—was fitted with 20,000 sensors for monitoring and feeding up to 1.5 million Atlantic salmon. Cermaq, a Norway-based fish farming giant, planned to launch its $63.7 million iFarm project with the goal of monitoring not just an entire cage of salmon, but each individual fish. Cermaq says iFarm sensors recognize individual salmon based on their dot pattern, which makes it possible to keep track of the number of fish, fish size, number of sea lice, and possible signs of disease. Many of the countries practicing marine aquaculture have established some regulatory and environmental oversight but have yet to develop comprehensive and complete frameworks for the emerging sector development (Davies *et al*., 2019). Furthermore, ocean governance is in its infancy as it confronts political, legal and economic development options for ocean use and ecosystems and the services (WBGU, 2013).

Aquaculture Ocean Expansion, Governance and Sectoral Conflicts: The Case of a Small Island State

The government of Mauritius (GoM) decided to develop offshore fish farming as an alternative to bolster its economy and to make aquaculture one of the economic pillars of the island. The government allowed zoning of the sea, a common good, and allocation of some areas for aquaculture production by private and foreign investors. Growfish International Inc, a Mauritian company whom investors are South African, submitted an Environmental Impact Assessment (EIA) report to receive a license allowing it to produce from 30,000 tonnes to 100,000 tonnes of fish per annum. The plan has sparked major debates, marches and protest against this decision. We examine the pros and cons of such a decision and provide lessons learned from a failure by the governing bodies not to adopt a participatory governance approach before such decisions are made.

The major concerns against such government decision are:

The fear that the government is selling the rights of the oceans and lagoons to foreigners;

The offshore farms will serve as a magnet for predators such as bull and tiger sharks. Fish farming will, therefore, put all the sea users at risk of a shark attack.

Shark attacks may have a devastating effect on tourism for which Mauritius economy depends heavily; Mauritius sees up to 1.42 million tourists in a year which is more than population size of 1.28 million people.

Sharks would be massively killed, which resulting in the decline in the shark populations, and thus, would go against the conservation of species already endangered.

Aquaculture has negative consequences on the environment as the fish are fed with fish, fish meal, toxic chemical products and other substances which pollutes the ocean.

The pros on the government side to permit offshore aquaculture expansion are:

The development of offshore aquaculture is part of the government's strategy to spearhead economic growth, and therefore, the government is seeking capital with up to 80 percent foreign ownership and a legal framework to regulate the business activities.

The idea is to double the annual per capita income of the island from its present 5,400 dollars in the next seven years. Refined sugar is being sold at 500 euros a ton in Europe while one ton of Red Drum fish is sold at 3,500 euros. ''This is big revenue for the island.''

Fish farming has the potential of annual production of 29,000 tons. One of the of the GoM officers indicates that investments worth about 25 million dollars would create about 5,000 jobs and bring revenue of 25 to 30 million euros or more to the island.

The debates continue and the people of Mauritius would like to have the government reconsider its plans of using offshore aquaculture expansion as a driver of economic growth.

Lessons learned:

The ex-ante participatory approach in governance can minimize societal conflicts.

Community inclusion at the conceptualization of the project can broaden the prospects of project success.

The sustainability of offshore aquaculture expansion necessitates social, economic, physical and environmental consideration which is in alignment with FAO/COFI and CCRF guidelines.

Enabling good governance in aquaculture with a wider participation in decision-making is one avenue for accountability and increased social acceptability.

Acceptance of aquaculture products in the market place may strongly impact aquaculture consumption, supply, trade and environmental pollution.

3.5 Technological advancement

For the aquaculture industry to make an on-going and sustainable contribution to food security, the industry must continue to innovate across multiple 'sites' and through multiple modes. Joffre *et al.* (2017) stated that research on aquaculture innovation has overwhelmingly focused on technology transfer and standardization at the farm-level. There have been many new experimental aquaculture practices, inspired by systemic and business-oriented innovation management approaches that have been spurred by changes in breeding systems, feeds, vaccines, improved regulatory frameworks, organizational structure, and market standards (Joffre *et al,*. 2017). The question is how well will these new technologies assist in the sustainable development of the industry and accommodate the basic principles of governance within a national and international framework? Nguyen and Jolly (2020b) and Nguyen *et al*., (2018) proposed horizontal integration of cooperatives of small-scale enterprises; and vertical integration of the small-scale farms with the large enterprises and government support through extension services as a means of technological transfer from the large firms to the small-scale farms. Salazar *et al* (2019) showed that education, secure property rights, internet access, participation in organizations, commercialization methods, government support, understanding of credit, and social learning promote innovation decisions. The process of growth must be well articulated to deal with such dynamism in this potential aquaculture governance required to house these technological advancements.

3. 6. Education, training, and governance

The advancement in innovation and technology adoption requires research supported by education and training. Training is an important tool through which effective communication is made to a prefixed target group for bringing about desired changes in knowledge, attitude, and skills for adopting improved technologies (Das, 2012). It is a growing realization that it is impossible to achieve sustainable development and responsible aquaculture production without the full participation of all stakeholders and their cooperative members, empowered through education and training, in decision-making and governance. These social dimensions of aquaculture assist in aligning technology adoption and compliance with regulations to industry needs and governance. Information on aquaculture technology adoption passes through informal networks that require little education but punctual short-term training, as is organized by farmers' field schools in India.

For research, development and administration formal education is needed (Krause *et al*. 2020). The lack of trained staff is one of the main constraints to aquaculture development in Africa and certain parts of Asia. The administration of standards and certain practices related to the principles of governance require advanced training in modern technologies that is often limited at the industry and community level. While large-scale farms usually have access to trained manpower, small-scale farmers often lack training in production practices and the value chain and are unable to effectively participate in the governance of the industry. Education for small-scale farmers will help improve their professionalism and teach them how to use technologies to improve their farm productivity. Education and training also provide opportunities for youth and women engagement in appropriate technologies along the value chain and increase their participation in dynamic governance.

3. 7 Climate change

The questions of how short-term climate shocks and long-term climate change interact with food supply chains, linking producing and consuming areas, is an emerging issue with important implications for food security (Reardon and Zilberman, 2018). Climate change and weather uncertainty are also present challenges to aquaculture governance. Some effects may be beneficial. Most of tropical Africa is experiencing global warming, with reduction in the cold/winter seasons, and increased temperatures. Kais and Islam's (2018) study evaluates how shrimp producers in Bangladesh, located at the bottom of a buyer-driven commodity chain have responded to increasing climate vulnerability, and explores whether their adaptation and coping strategies build resilience. They document the impacts of a wide variety of climatic conditions and phenomena - including cyclones and storm surges, increasing temperatures, drought, heavy rainfall, and salinity ingress and sea-level rise - on shrimp farming, and adaptive responses to these challenges on the farm, and in farming households. Growing periods for some species are being shortened, with improved growth rates and feed conversion ratios. However, some effects are negative, the decrease of fresh and fish meal caused by climate change can greatly influence aquaculture and there seems to be an upsurge of pathogens virulence and animal diseases, adverse impacts on livelihoods and community governance. Recently there is increased sea-level rise for inland lakes and river systems.

4.0 **Suggestions for Improvements in Governance**

The future of aquaculture development depends on local, national, and global actors, operating through alliances to increase fish production that generate benefits to stakeholders while preserving the environment and the social stability. Emerging decisions involve choices related to environmental quality, foreign direct investment (FDI), local and domestic capital mobilization, socio-economic development, regional development, and national economic strategies. The role of FDI and increased levels of goods, services and trade have been central to aquaculture development (Machinea and Vera, 2006). However, over the past decade, there has been rising concern for the social and environmental impacts generated by these investments and export-oriented trade regimes where production takes place. The desire of all stakeholders is the supportable and balanced fish production under a governance of sustainability. This requires improvements in good governance through the establishment of a communication platform and legal international frameworks for safeguarding equity, accountability, transparency, and predictability.

A systems analysis for prioritization of aquaculture research areas to support responsible aquaculture development to achieve SDG 2 needs attention so that the science required for advising food security policy is integrated, adequately funded, and generates relevant information to the local context where implementation is planned (Stead, 2018). Many government departments responsible for aquaculture and fisheries are separated, and research and planning are done in isolation. These sectors should work and plan together as part of a highly inter-connected system. Hence, it is important to conduct research and development, using systems thinking and open innovation in an environment of futuristic aquaculture policy making (Stead, 2018), where big data and digital technology can improve evidence-based decisions through improved participatory governance (Stead, 2005; Turner *et al*., 2017), to generate results that can enable meaningful aquaculture contribution to the achievement of SDG 3, 8 and 14.

Countries with limited land and ocean resources for inland and offshore aquaculture must seek ways to innovate and expand their aquaculture. The expansion of offshore aquaculture to produce finfish, mollusks, seaweeds and other species serves as an indicator of the future role of mariculture in supplementing the increasing gap between aquaculture and wild caught fish. Mariculture is expanding without adequate policies to regulate its growth. There have been piece meal regulations by more developed economies but there is still a need for comprehensive national and global frameworks for the governance of this emerging sector. An illustration is salmon farming where there are environmental and social challenges to traditional netpen culture in sheltered waters. Given its contribution to incomes exports and employment, governments have been pro-active with public-private research partnerships. As the technological leader in salmon farming, the government of Norway levies a small tax on exports for research, which is supplemented by industry. Therefore, it is appropriate to suggest that the time is opportune for the development of general and specific policy frameworks for the exploitation of this ocean resource.

Fisheries and aquaculture contribute little to agriculture GDP in African countries but has the potential of making an important contribution to food security and protein supply particularly to rural communities. Though aquaculture contributed 17% of total fish production in Africa (Obiero *et al*, 2019), the industry exhibited dynamic growth during the period 1999 to 2008 but growth slowed down during the period 2010 to 2018. Policies to promote sustainable aquaculture growth, and reduce post-harvest losses, within the context of good governance, which embraces the improvement in land tenure and ownership, coupled with private public investments in open ocean aquaculture can improve benefits to stakeholders and help the countries move closer in attaining the sustainable development goals.

Foreign direct investment can be promoted so that all stakeholders participate in the governance structure without alienation of even the smallest producer. Small-scale producers may not have to give up their rights of ownership, but some type of coalition between large enterprises and small-scale producers, either through vertical integration or specialization to encourage individual entrepreneurship, can be embraced. Nguyen and Jolly (2020b) showed how large cooperative entities can combine with small-scale shrimp producers in production intensification and quadruple yields and income. These processes require technological modernization. Murekezi *et al*. (2018) have suggested public-private partnerships and contract farming in aquaculture as ways of integrating women and youth in aquaculture and increasing standards. The use of electronic marketing capabilities including Phones, Pads and other electronic mobile devices can assist in information dissemination and rapid communication. Successful operation of these devices requires reorganization and regionalization of the whole process aided by research and extension efforts for diffusion and adoption of the evolving technologies. Operational management will become more transparent, along the value chain, but there must be greater accountability, planning and solid decision making guided by lead firms and guidelines from government legal framework.

The enforcement of good governance may result in challenges and simultaneously present opportunities for cross-national learning and the development and adoption of best practices. Information transfer can be interactive and can assist in the solution of problems usually encountered by the most resource poor farmers and local communities resulting in south-north dialogue. This is particularly salient in the domains of disease and pathogen management in species such as shrimp produced by limited resource farmers, but are high income earners, or disease of salmon culture practiced by higher income farmers in more developing economies. Hence, easy communication of ideas can advance the monitoring and reporting of disease and pathogen prevalence in all countries, but the requirements in terms of testing intervals, public disclosure of information, and thresholds for mitigation and remedial action vary substantially. Added transferred knowledge may reduce farmers' risk of losses of traded products.

An important point within the global market is the growing importance of international agreements that involve food (and fish) safety aspects. Aquaculture contributes primarily to domestic consumption but, at an international level, important trade has developed for several aquaculture products. About 40% of all fish produced are traded internationally, which means that there is a search for common criteria that facilitate or permit clear and transparent rules for compliance. It is hoped that in the future there will be a common electronic platform for communication of procedures and rules of governance, certification needs, standards and regulation that facilitate product and information flow through the supply chain.

If the development of aquaculture is impossible using current material and the technical base of farm ponds, a new approach is needed. It could include the automation of management system of fish farming enterprises considering advanced digital technologies such as the Industrial Internet, large data banks and a unified system of data storage and processing. The implementation of all these technologies in a single automation system can ensure the competitiveness of domestic enterprises compared to foreign fish producers thus making fish farms attractive for investment. It is proposed to create robotic aquaculture control systems, the basis of which will include automated floating feeders ensuring optimal feeding of fish. All these measures will help to achieve the main goal of the strategy for the development of aquaculture (Gorbunova *et al*., 2020) and the simplification of governance throughout the marketing chain.

With increased research and development and information diffused by modern technical forms of communication innovation there will be increasing penetration of new technologies into fish and seafood trade. These technologies will speed up information flows up and down the supply and value chains that will become difficult to sustain without dynamic governance. The beneficiaries of this injection of new technologies will be consumers and producers as more quality products flow through the system. Accountability will increase as the system becomes more transparent and prediction will be facilitated with greater equity, transparency, and access to new knowledge.

This is explicit in the PFRS for Fisheries and Aquaculture in Africa which is Africa's blueprint to support the transformation of Africa's fisheries and aquaculture which was endorsed by member states after recognizing the challenges being faced in the aquaculture sub-sector. The CAADP was also specially formulated to stimulate the necessary reforms in the agriculture sector and sustainable development

(Menezes *et al*. 2018). For aquaculture, the PFRS aims to create an enabling environment that will lead to the transformation of Africa's aquaculture into a sustainable market-oriented private-sector led commercial agricultural activity.

5.0 Conclusions

Institutions and legal frameworks can provide support for aquaculture if they adopt principles of good governance: effectiveness and efficiency, equity, accountability, and predictability that will enable the countries practicing aquaculture to attain the SDGs. Dynamic governance is not sufficient for aquaculture sustainability but is necessary. Participation of stakeholders is also a requirement. Aquaculture is an important driver of local economies, so its institutional arrangements should be part of the mechanisms of territorial development and governance and be included in territorial planning programs. It is essential to establish mechanisms for the participation of all aquaculture stakeholders (producers of different scales, representatives of fish and shrimp feed, industry, universities, support institutions, government, etc.) for the discussion of problems and sectoral strategic planning. The rapid and profitable expansion of salmon farming is due in large part to governance. In Norway, it provided the institutional and licensing framework to avoid social disruption and has spearheaded innovation into mitigating environmental damage. Other countries have followed its example. The next ten years should see the sustainability of the industry enhanced with new technologies, often promoted by governments.

In some of the European countries, with developed aquaculture programs, the production growth rates have been on a decline. Even with the establishment of national aquaculture plans and recent surges in production growth rates African aquaculture has experienced a decline in growth rates during the last decade. Countries wanting to attain the SDGs should not only have national aquaculture plans with well-articulated objectives in place but should also set targets with the mechanisms for achieving those. This indicates that not only should there be good and dynamic governance, but countries must work towards the attainment of the SDGs. It also signifies under achievement of these goals if production expansion and intensification are unsustainable in all countries.

The global aquaculture value chains have been increasingly influenced by 'extra-chain' actors such as standard setting and certification bodies, mainly 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 governing 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. To increase or maintain market share aquaculture producers must comply with regulations required by the importing countries, or international regulatory bodies. The conformity to standards imposed by outside bodies generates a compliance cost due to the changes that must be made. The compliance costs associated with improvement in standards and certification schemes can inflict a burden on producers to which the importers may not be sensitive or aware. This asymmetry in information flows may result in conflicts which can only be solved through a platform of open dialogue.

The tendency is, therefore, to move towards the harmonization of national regulations, meaning that such regulations could assure an equivalent level of food protection to consumers while maintaining a sustainable production system and at the same time conserving the environment and the social order. This increases the importance of internationally accepted guidelines, recommendations, and standards, such as those of the Codex Alimentarius. The provisions related to food trade of the General Agreement on Tariffs and Trade (GATT) compound this tendency, and all these aspects are interlinked. However, with good governance the social, economic, and environmental objectives can be attained, and the SDG targets are approachable in the next decade.

Many countries face huge fiscal difficulties, especially those from the rural areas in developing economies. However, it is necessary to guarantee support for developing activities that quickly provide work, income, and food to the people in the Post-Pandemic World. Aquaculture has already demonstrated that it can be one of those activities that respond quickly and effectively to these challenges. The biggest opportunity for positive change in the post-pandemic world is for our global food system to become more local, sustainable, equitable and standards that guarantee export flexibility. While so much of our collective attention and investor capital have been focused on providing consumer convenience foods, the pandemic has irreversibly shifted the conversation to building community resilience and export safe foods. Governments are now actively working with stakeholders across the entire fish (agricultural) supply chain to promote and invest in innovation related to indoor farming, precision aquaculture, food safety and preservation, waste reduction, and alternative proteins.

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Appendix 1: Selected countries, legal bodies, national pans, governance, production rank and changes in production and value 1999 to 2008 and 2009 to 2018

Country	Legal Body Responsible for Aquaculture	Year of First Policy plan	Description of policy plan	Governance rank	Production in USD				% Change in production value USD	
				2019	1999	2008	2009	2018	1999-2008	2009-2018
Africa					570,233	2,001,149	2,149,079	3,279,668	14.95	4.80
Egypt	General Authority for Fisheries Resources (GAFRG) 1983[1]	1985	Production plan	27.88	447,146	1,251,119	1,356,149	1,469,470	12.09	0.89
Nigeria	State Department of Fisheries	2011	National plan	12.98	46,401	409,770	430,828	839,821	26.61	7.69
Asia					35,687,784	79,669,049	91,875,207	210,190,381	9.32	9.62
Bangladesh	Ministry of Fisheries and Livestock	1998 & 2006	National Fisheries Policy and National Fisheries Strategy	16.35	977,235	1,766,182	2,351,316	5,894,683	6.78	10.74
Cambodia	Ministry of Agriculture Forestry and Fisheries	2006-2010	National Strategic Plan	9.2	-	70,470	91,548	612,730	-	23.49
China	Ministry of Agriculture	After the reform	Development Strategy	43.27	20,003,401	106,765,97 3	113,827,454	144,999,209	23.49	2.72
India	Ministry of Fisheries, Animal Husbandry and Dairying	1975-84	Aquaculture Development Plan	47.64	2,509,328	6,075,531	5,492,697	13,178,432	10.32	9.36
Indonesia	Ministry of Maritime Affairs and Fisheries	1975-1984	National Plan for Aquaculture	37.98	2,187,545	2,814,094	4,893,790	11,981,365	2.94	10.45
Japan	Ministry of Agriculture,	2002	Basic Plan in Fisheries	88.90	3,365,566	3,343,456	3,632,458	3,929,219	-0.11	0.75

	Forestry and Fisheries									
Myanmar	Department of Fisheries	2000-2003	Three year Expanded Plan	28.85	805,218	817,218	912,454	1,749,584	0.54	7.49
Philippines	Bureau of Fisheries and Aquatic Resources	2006-2007	Development Plan	31.25	678,716	1,576,141	1,485,706	1,887,247	9.80	2.69
South Korea	Ministry of Maritime Affairs and Fisheries	1997 and 2003	Aquaculture plan	76.92	586,288	1,287,039	1,360,587	2,321,683	9.11	6.13
Thailand	Ministry of Agriculture and Cooperatives	1961	Fisheries Development Plan	39.42	2,092,228	2,345,592	2,622,728	2,701,065	1.27	0.33
Vietnam	Ministry of Agriculture and Rural Development	1960-1980	Development Plan for Fisheries and Aquaculture	34.13	37,028	4,606,180	4,803,237	14,460,784	22.56	13.01
Europe					4,513,236	8,506,238	8,985,814	15,337,814	9.29	6.11
France	Ministry of Agriculture, Fisheries and Forestry Resources	1852 onwards	Various degrees regulating aquaculture	88.94	487,919	1,017,518	958,637	847,187	8.50	-0.12
Turkey	Ministry of Food Agriculture and Livestock; three Directorates	2007	Joint Decree	44.71	306,408	649,372	615,738	1,125,221	8.69	6.92
Norway	Directorate of Fisheries	2005	Aquaculture Regulation Act	97.12	1,339,487	3,138,994	3,590,060	8,342,301	9.91	9.80

Spain	Ministry of Agriculture, Fisheries and Marine Aquaculture	1942	Laws for Aquaculture	73.56	299,957	556,594	519,334	596,027	7.10	1.54
UK	Ministry of Agriculture, Fisheries and Food	1938	Legislation Relevant to Aquaculture	93.75	478,531	967,103	780,730	1,344,170	8.12	6.22
Americas					3,643,861	9,545,474	10,025,011	19,470,726	11.02	7.64
Brazil	Ministry of Fishing and Aquaculture	2003	National Plan	42.31	216,699	850,617	1,012,255	1,345,833	16.39	3.21
Canada	Federal Authority Department of Fisheries and Oceans Canada	2009 to 2010	National strategic plan	93.27	355,365	720,747	702,841	1,091,347	8.16	5.01
Chile	Undersecretariat for Fisheries and Aquaculture	2005	National Plan	83.17	908,200	4,502,789	4,668,055	10,446,268	19.44	9.35
Ecuador	Ministry of Agriculture, Livestock Aquaculture and Fisheries	2002	Fisheries Law	34.62	601,517	767,901	1,012,516	2,799,442	2.75	11.95
Mexico	National Commission on Aquaculture and Fisheries	1992	Actual Law	22.60	192,016	565,705	477,500	847,419	12.71	6.58
US	United States Department of Agriculture	1980	National Aquaculture Act	84.62	833,456	983,583	958,882	1,226,902	1.86	2.77

[1]http://www.fao.org/fishery/legalframework/nalo_egypt/en