A REVIEW OF AQUACULTURE INSURANCE SUMMARY


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Introduction
With over 580 farmed species (FAO, 2016), a large variety of different production systems exists both onshore and offshore varying largely between industrialized operators and smallholder producers. The production value of aquatic stock depends on the species and production system in terms of areal and volumetric density of stock, water loading (closed systems), exchange rate of water, hydraulic detention time and cumulative oxygen consumption (Colt, 1991). Therefore, the same aquatic species can generate different yields in function of the production environment. Farming aquatic species is highly complex and very risky with exposure to natural perils and diseases in a sector where frequently new aquatic species are introduced, and where aquatic stock is moved over large distances. Although aquaculture insurance has been trying to mitigate production risks through different products, insurance penetrations remain generally low.

Risks in Aquaculture Production
The fast-growing aquaculture sector is facing multiple challenges that include inherent production and financial risks. Compared to other food production sectors, aquaculture is often seen to be a high-risk activity with higher variability in yields and revenues (Flaten et al., 2011). This is due to aquaculture farmers having i) lower control over the production process as the growth of aquatic organisms is highly sensitive to changes in environmental conditions and ii) the immaturity of the technology used by most producers relative to agricultural and livestock producers (Kumar and Engle, 2016).

Generally, the main risks for aquaculture producers include: i) pathogen risks where harmful pathogens from imported aquatic stock, feed or equipment spread as diseases in the domestic stock, ii) food safety and public health risks which result from new pathogens, iii) ecological risks including escapes and spread of diseases from non-native species into the natural environment, iv) genetic risks through the use of genetic methods to improve aquatic stocks that can lead to loss of local adaptation and introgression of new genetics by native species, v) environmental risks through contaminated water and ecosystems, vi) regulatory risks,

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vii) financial risks related to price volatility, changes in production costs and input supplies and viii) production risks with reduced yield or mass mortality due to environmental conditions and diseases (Arthur et al., 2009). From a risk transfer point of view, risks in aquaculture can be classified into financial risks and production risks.

Financial Risks

Environmental shocks can lead to extreme price movements and are a contributing factor to short-term price volatility (Asche et al 2017). Price (volatility) risk is perceived to be key risk for freshwater pond operators especially smallholder farmers (Rahman et al. 2021). Additionally, future prices and the change in regulations were identified as key risks that aquaculture farmers must manage (Bergfjord 2009). Efforts to provide exchanges (commodity) for some of the main seafood products have mostly failed due to insufficient trading volume, lack of product homogeneity, limited price transparency, the presence of numerous types of products, small markets and fish usually being sold in a fresh form and being perishable (Ankamah-Yeboah et al., 2017).

Production Risks

The main production risks for aquaculture operators include mortality and low yield of aquatic stock related to environmental conditions (water temperature, oxygen levels, pollution), cannibalism, algal bloom, diseases, natural perils, predators, and accidents (e.g., Hohl, 2019). The common risk management approaches comprise loss prevention and risk transfer to insurance markets, and in some markets reliance on the public sector to provide compensation for culling and destruction of aquatic stock following outbreaks of epidemic diseases.

Climate change is expected to significantly impact fisheries and aquaculture production through changes in i) abiotic conditions including sea temperature and a change in oxygen levels, salinity, acidity and changes in the intensity and frequency of extreme weather events (e.g., heat waves, cyclones), and ii) biotic conditions affecting distributional patterns, growth, and sizes (Barange et al., 2018).

For aquaculture, the negative consequences of climate change are

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likely to predominate positive effects through decreased productivity related to suboptimal farming conditions (Dabbadie et al., 2018). Key measures for adaptation to climate change on aquaculture rearing systems and farms include i) controlling the environment to mitigate weather- and climate-related risks, ii) reducing risk through timing and selecting rearing environments, iii) enhancing resilience by increasing diversity, nurturing resources, and increasing the tolerance of reared aquatic species, and iv) capacity building (Lebel et al., 2020).

Aquaculture Insurance Products

Aquaculture insurance products can be distinguished into i) indemnity-based insurance that includes all-risk stock mortality and named-perils that are specifically defined; and ii) index-based insurance that cover weather perils and protect gross margins **(Table 1)**.

Indemnity-based Insurance

For aquaculture, indemnity-based insurance includes all-risk stock mortality and named-peril insurance. All-risk stock mortality insurance protects an aquaculture operator against all possible perils that lead to stock mortality but excludes natural mortality, unexplained losses, cannibalism, mysterious disappearance, sexual maturing, government-ordered culling of stock and damage from nuclear risks, sonic bangs, war, strikes, riots, civil commotion, and terrorism. All-risk mortality policies usually include a provision to cover additional incurred expenses that are based on acceptable receipts from efforts of the operator to i) reasonably minimize or avert a loss but excludes costs for routine veterinary examination, medication, and vaccines and ii) destroy and dispose dead stock according to government regulations. In some countries (e.g., Norway), all-risk mortality insurance indemnifies additionally against losses from government-ordered culling due to a notifiable disease (e.g., ISA for salmon), while indemnity is based on a predefined percentage of the lost value of aquatic stock.

As with other insurances, certain risk management standards must be assured by producers before enrolling for insurance and required data need to be accessible to insurers. At inception of the insurance policy, the aquaculture

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operator typically warrants that the aquatic stock is free of diseases, equipment is functional and is regularly serviced and infrastructure (e.g., cages, fences, dykes) is regularly controlled and maintained. Further, aquaculture insurance policies often mandate the operator to use reasonable loss mitigating measures such as vaccinating stock, mooring, or moving offshore cages to saver bays in the wake of a tropical cyclone.

Premium rates mainly depend on the production system, the species, the location, the perils insured and deductible structures and can range from 1%-12% of sum insured for all-risk stock mortality insurance and from 0.1%-6% of sum insured for named-peril insurance (Secretan, 2003, Hohl, 2019). With a base-rate of 4.5% for offshore production of salmon, the full rate for all-risk stock mortality can reach 9.25% if pollution, theft and malicious damage, flood and tidal waves, storm, drought, fire, freeze and mechanical as well as electrical breakdowns of equipment are additionally insured (Secretan, 2003). Deductibles are based on the values at risk at the time of the loss and vary between 10%-20% per culture unit and 20%-30% for a site that contains different units (Secretan, 2003, Hohl, 2019). Insurance for industrialized producers with several sites in different regions typically contains an annual aggregate deductible and loss limit.

While insurance terms for industrial aquaculture policies are tailor-made and site-specific and can therefore vary among producers of the same species and the same area, terms for smallholders are usually pre-defined with some adjustments according to management standards but with little options of the policyholder to select coverage options (e.g., deductibles, perils).

Index Insurance

For aquaculture, index-based insurance products can be differentiated into ***i) weather index covers***, where meteorological variables are directly used to quantify the indemnity and ***ii) revenue insurance*** which provides indemnity in the case prices of aquaculture products and/or costs of feed components change significantly.

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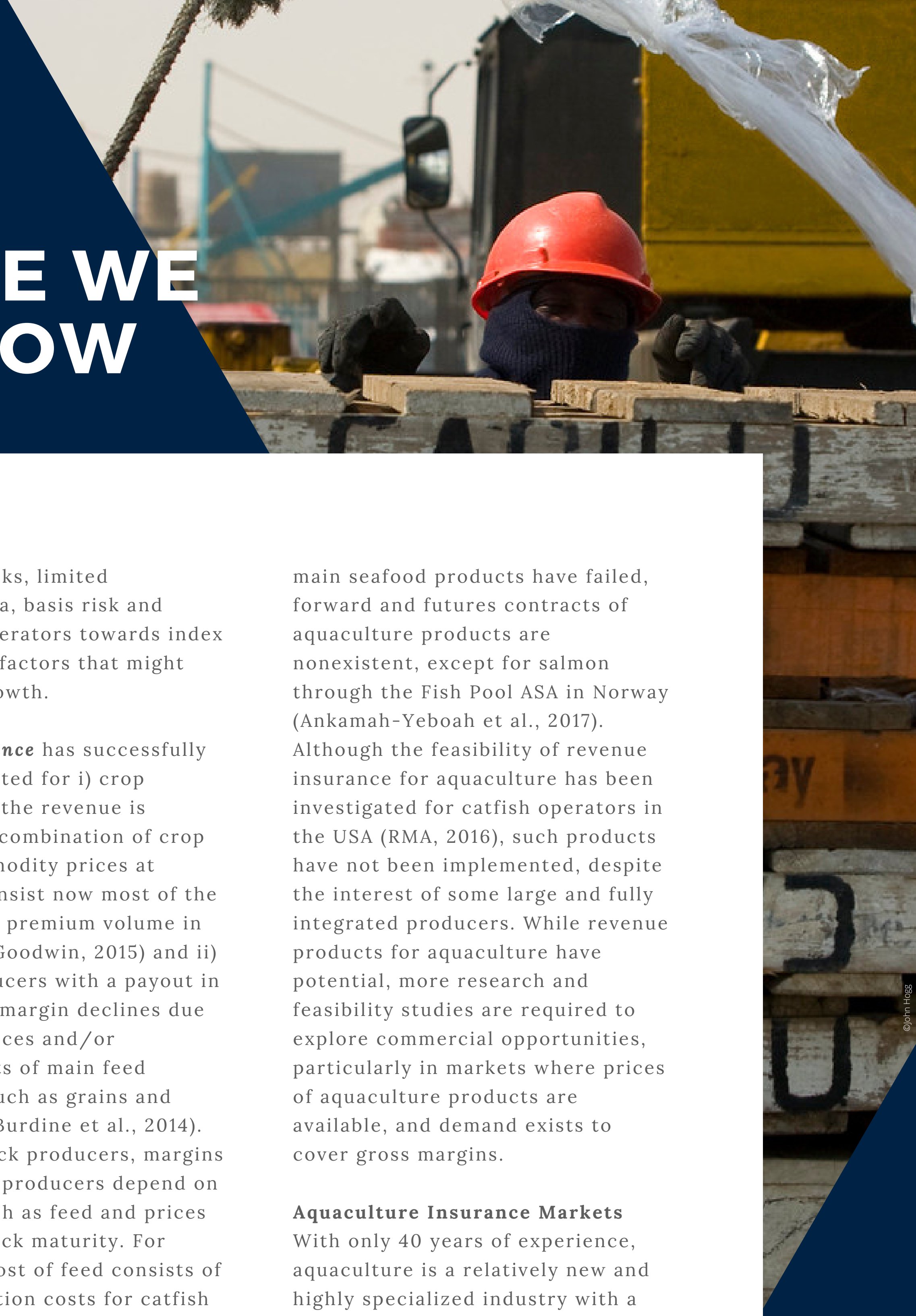
Weather insurance uses indices that are based on weather measurements (e.g., precipitation amounts, temperature) and has been promoted as a soft climate change adaptation measure for developing countries. The main advantages of weather index insurance include i) eliminated information asymmetries and moral hazard as premium rates are independent of insurance participation rates and risk levels of insureds (Berg and Schmitz, 2008), ii) lower costs since indemnity is directly established through the indices (Barnett and Mahul, 2007) and iii) faster payouts as weather data are rapidly available. However, the adaptation of weather index insurance has been slow and is related to i) basis risk, which occurs through the imperfect correlation of between the index and the actual loss, ii) limited coverage as only perils that can be measured at weather stations can be insured, iii) affordability of premiums, iv) lack of understanding of agricultural producers of insurance products in general and index concepts in particular, v) lack of weather data and vi) mistrust of policyholder towards insurance companies (Patt et al., 2010).

Weather index insurance for fisheries (Sainsbury et al., 2019) and aquaculture risks have been investigated as cost-efficient risk transfer instruments to cover increased stock mortality from wind speed and temperature. One of the first weather index insurance pilot was implemented in Jiangsu province (China) in 2014 for mitten crabs, which can tolerate air temperatures of up to 35°C and water temperatures of up to 28°C but show high mortalities during heat waves. The weather index provides indemnity to mitten crab producers after the occurrence of three consecutive heat days, defined as days with the maximum air temperature ≥37.5°C, and covers incurred costs for brood stock, feed, and labor (Artemis, 2014). In Taiwan, low temperature indices have been investigated for insurance of milkfish producers (Chen, 2011) and an excessive rainfall cover (rainfall > 480 mm for two consecutive days) has been implemented to identify grouper producer for escaping stock after overflowing ponds (Swiss Re, 2017).

Although there is a potential for weather indices to work for certain



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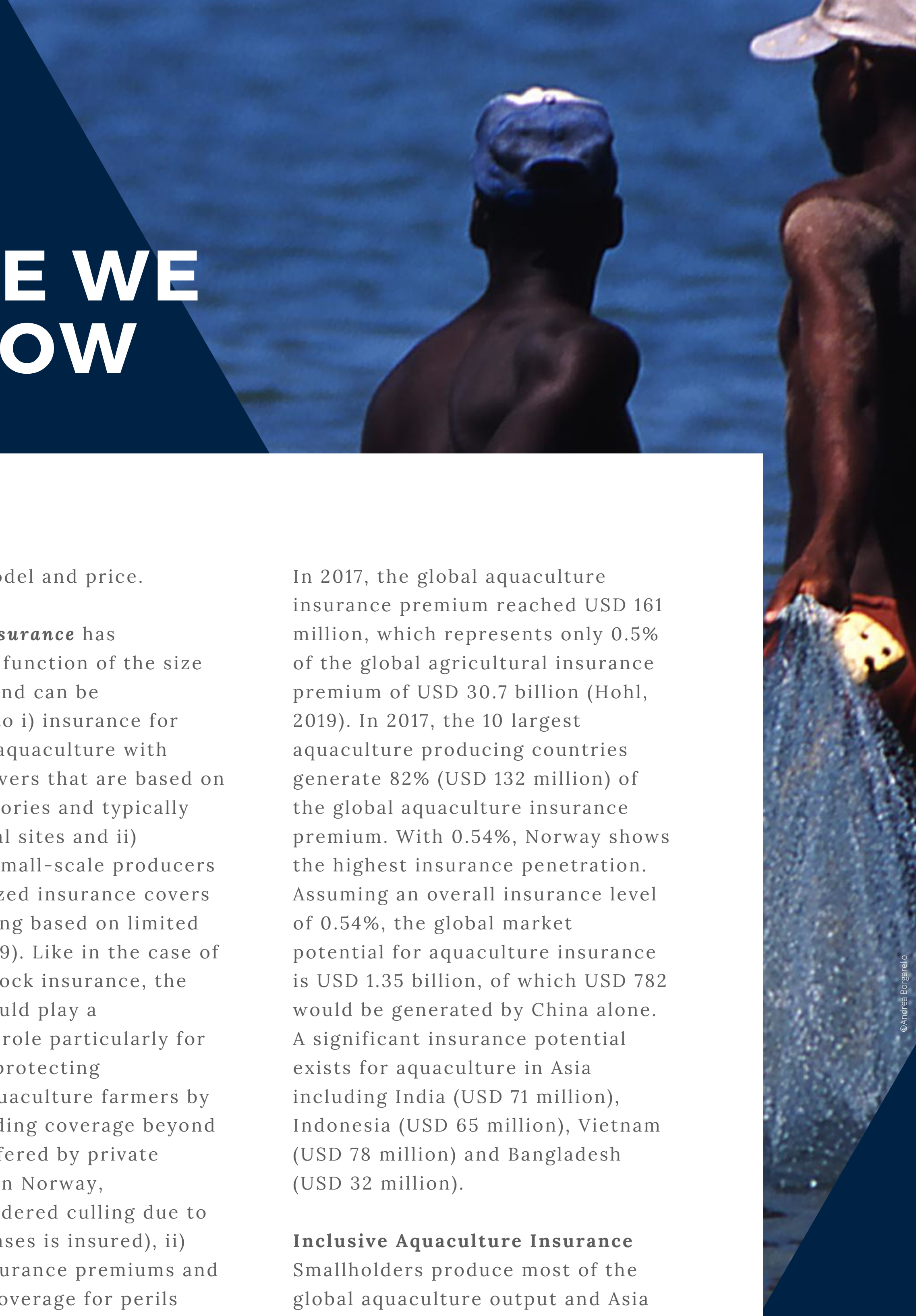
aquaculture risks, limited production data, basis risk and concerns of operators towards index insurance, are factors that might limit future growth.

Revenue insurance has successfully been implemented for i) crop farmers where the revenue is defined as the combination of crop yield and commodity prices at harvest and consist now most of the crop insurance premium volume in the USA (e.g., Goodwin, 2015) and ii) livestock producers with a payout in case the gross margin declines due to livestock prices and/or increasing costs of main feed commodities such as grains and oilseeds (e.g., Burdine et al., 2014). As with livestock producers, margins of aquaculture producers depend on input costs such as feed and prices achieved at stock maturity. For example, the cost of feed consists of 60% of production costs for catfish operators in the USA and to manage these costs, operators typically lock-in feed costs through specific agreements with feed mills (RMA, 2016).

As most aquatic products are not publicly traded and efforts to establish exchanges for some of the main seafood products have failed, forward and futures contracts of aquaculture products are nonexistent, except for salmon through the Fish Pool ASA in Norway (Ankamah-Yeboah et al., 2017). Although the feasibility of revenue insurance for aquaculture has been investigated for catfish operators in the USA (RMA, 2016), such products have not been implemented, despite the interest of some large and fully integrated producers. While revenue products for aquaculture have potential, more research and feasibility studies are required to explore commercial opportunities, particularly in markets where prices of aquaculture products are available, and demand exists to cover gross margins.

Aquaculture Insurance Markets
With only 40 years of experience, aquaculture is a relatively new and highly specialized industry with a large range of different aquatic species (~580 species) farmed under very diverse structural, technical, and managerial approaches and a concentration of production in some key producing markets. From an insurance point of view, aquaculture risks are probably the most complex risks of agricultural insurance to



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underwrite, model and price.

Aquaculture insurance has developed as a function of the size of operations and can be categorized into i) insurance for industrialized aquaculture with tailor-made covers that are based on detailed inventories and typically includes several sites and ii) insurance for small-scale producers with standardized insurance covers and underwriting based on limited data (Hohl, 2019). Like in the case of crop and livestock insurance, the government could play a developmental role particularly for the benefit of protecting smallholder aquaculture farmers by way of i) providing coverage beyond what can be offered by private insurers (e.g., in Norway, government-ordered culling due to notifiable diseases is insured), ii) subsidizing insurance premiums and iii) providing coverage for perils that the private sector is not prepared to insure (e.g., flood or cyclones) (Secretan et al. 2007). Although aquaculture has a large potential, the insurance penetration defined as the global aquaculture insurance premium (2018) relative to the total production value (2018) is low at 0.06% **(Table 2)**.

In 2017, the global aquaculture insurance premium reached USD 161 million, which represents only 0.5% of the global agricultural insurance premium of USD 30.7 billion (Hohl, 2019). In 2017, the 10 largest aquaculture producing countries generate 82% (USD 132 million) of the global aquaculture insurance premium. With 0.54%, Norway shows the highest insurance penetration. Assuming an overall insurance level of 0.54%, the global market potential for aquaculture insurance is USD 1.35 billion, of which USD 782 would be generated by China alone. A significant insurance potential exists for aquaculture in Asia including India (USD 71 million), Indonesia (USD 65 million), Vietnam (USD 78 million) and Bangladesh (USD 32 million).

Inclusive Aquaculture Insurance
Smallholders produce most of the global aquaculture output and Asia is by far the largest market, generating 69% of all aquaculture produces in 2018 (FAO, 2020). Smallholders use basic equipment and management techniques. Additionally, smallholders often fail to i) keep consistent records and stock inventories and ii) provide proof of losses that shows the size,

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number and value of stock lost has been challenging. The largest insurance programs for smallholder production exist in Asia and have evolved around i) cooperatives with one insurance policy issued per cooperative and indemnities (or claim payments) being passed on to members though the cooperative system, ii) farmer groups that produce the same aquatic species under comparable systems, iii) government agencies that promote and support insurance and iv) mutual insurance systems.

Challenges of Aquaculture Insurance

The aquaculture insurance sector has been facing multiple challenges, making it one of the most difficult lines of agricultural insurance to price, model and transact with insurers being reluctant to provide coverage to this high-risk sector. The multiple challenges impacting aquaculture insurance development are i) exposure to both high frequency-low severity losses (e.g., sea lice) and low frequency-high severity damage (e.g., algae bloom, natural perils, epidemic diseases), ii) high natural mortality in the production cycle that varies per species and production system, iii) high risk concentrations and fragmented markets that limits efficient risk pooling and risk diversification, iv) lack of reliable data on stock inventories and loss experiences that prevents the development of risk-adequate insurance rates, v) large differences in management standards and the dependence on government biosecurity regulations that influence the loss outcome from epidemic diseases, vi) limited specific veterinary and pathologic expertise for loss adjustment and vii) high moral hazard and adverse selection (Hohl 2019).

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Conclusion

Industrialized aquaculture is highly concentrated, uses the most advance production techniques and has attracted large investments, while smallholders, representing most of the global production, have generally limited access to finance, technology, and markets. Although the insurance industry has been providing coverage for production risks through different products and for a variety of perils, species and production systems, the high degree of specialization and the complexity to assess and price risks has limited a wider uptake, particularly in smallholder production systems. As a result, insurance penetration remains low at 0.06% at global scale.

Lack of data, diversity of risk management practices, moral hazard and adverse selection, affordability, lack of technical know-how, and regulation are some of the major constraints in the development of aquaculture insurance market. Options to mitigate some of these risks particularly adverse selection and affordability would be by way of bundling insurance with loans and using affinity groups such as farmer collectives.

From a product perspective, though index-based insurance seems to be attractive particularly in insuring smallholder aquaculture farmers more studies and pilot insurance programs are necessary to ensure the appropriateness of the product given the underlying risks (or perils) and production system. As aquaculture production is projected to further increase and risks are likely to grow through the introduction of new types of diseases and impacts of climate change, the insurance sector is prone to play a stronger role in transferring production risks.

TABLE 1

OVERVIEW OF AQUACULTURE INSURANCE PRODUCTS

Aquaculture insurance products can be distinguished into **i)** indemnity-based insurance that includes all-risk stock mortality and named-perils that are specifically defined; and **ii)** index-based insurance that cover weather perils and protect gross margins.

~580 SPECIES

With only 40 years of experience, aquaculture is a relatively new and highly specialized industry with a large range of different aquatic species farmed under very diverse structural, technical, and managerial approaches and a concentration of production in some key producing markets.

Insurance Type	Insurance Product	Insured Perils	Advantages	Disadvantages
Indemnity-based Insurance	**All-Risk Stock Mortality Insurance** **Named Peril Insurance**	**Offshore Sites** • Mortality due to natural perils (storm, lightning, tsunami, freezing), accidents (collision), predation, algal bloom, diseases and (in some cases) epidemic diseases • Damage to equipment from natural perils and FLEXA[@] • Optional covers for theft, malicious acts, pollution, compromised water quality, transit **Onshore Sites** • Mortality due to natural perils (flood, earthquake, tsunami, tidal waves), predation, diseases and (in some cases) epidemic diseases • Damage to equipment from natural perils, FLEXA, equipment failure (mechanical breakdown, electrical interruption, breakages of the water supply system) • Optional covers for theft, malicious acts, pollution, compromised water quality, transit **Market-Specific Covers** • Incurred costs for vaccination, disinfection, destruction of stock • Aspects of business interruption from government-ordered slaughter (epidemic diseases)	• Individualised insurance reflection site-specific conditions and standards • Optional covers (mainly for industrialised producers)	• Adverse selection and moral hazard • High costs for administration, distribution, and loss adjustment • Little options for smallholder producers
Index-based Insurance	**Weather Insurance**	Adverse weather conditions including • high temperature (e.g., heat days) causing changes in oxygen levels in the water (onshore) • low temperature causing changes in oxygen levels and freeze of stock (offshore and onshore) • deficit rainfall causing limited water availability (onshore) • excessive rainfall (flash floods) causing stock disappearance (onshore) • high wind speed causing overthrowing of cages (offshore)	• Limited adverse selection and moral hazard • Fast pay-outs • Low costs for loss adjustment	• Basis risk[#] • Reputation risk for insurer • Concept and indices difficult to understand for operators • High costs for weather data (depending on country)
	Revenue Insurance	Volatility in gross margins from • Prices of aquaculture products and/or • Costs for feed that include high components of publicly traded grain and/or oilseed commodities	• Covers gross margins of operator	• Basis risk • High development costs

@ FLEXA refers to Fire, Lightning, Explosion and Aircraft impact
# Basis risk refers to the imperfect correlation between the index and actual losses

TABLE 2

OVERVIEW OF THE TOP-10 AQUACULTURE PRODUCING COUNTRIES AND AQUACULTURE INSURANCE MARKETS

0.06%

is the insurance penetration defined as the global aquaculture insurance premium relative to the global production value

82% (USD 132 MILLION)

of the global aquaculture insurance premium generated in 2017 by the largest aquaculture producing countries

In 2017, the global aquaculture insurance premium reached USD 161 million, which represents only 0.5% of the global agricultural premium of USD 30.7 billion (Hohl, 2019). With 0.54%, Norway shows the highest insurance penetration, which is defined here as the ratio between the aquaculture insurance premium volume (2017) and aquaculture production values (2018). Assuming an overall insurance level of 0.54%, the global market potential for aquaculture insurance is USD 1.35 billion, of which USD 782 would be generated by China alone. A significant insurance potential exists for aquaculture in Asia including India (USD 71 million), Indonesia (USD 65 million), Vietnam (USD 78 million) and Bangladesh (USD 32 million).

			Production Value 2018 [USD million]	Ratio Aquaculture to Fishery Capture	Insurance Premium 2017[2] [USD million]	Insurance Penetration[3]	Insurance Potential[4] [USD million]
Country	**Aquaculture[1]**	**Fishery Capture**	**Aquaculture**				
China	47.56	14.65	144,999	76.5%	49.0	0.03%	782
India	7.07	5.32	13,178	57.1%	NA	NA	71
Indonesia	5.43	7.22	11,981	42.9%	*2.0*	0.02%	65
Vietnam	4.13	3.35	14,460	55.2%	8.7	0.06%	78
Bangladesh	2.41	1.87	5,894	56.3%	*3.0*	0.05%	32
Egypt	1.56	0.37	1,469	80.8%	*3.0*	0.20%	8
Norway	1.35	2.49	8,342	35.2%	45.0	0.54%	45
Chile	1.27	2.12	10,446	37.5%	15.0	0.14%	56
Myanmar	1.13	2.03	1,499	35.8%	*2.0*	0.13%	8
Thailand	1.71	0.89	2,701	65.8%	*4.0*	0.15%	15
Top 10	*73.62*	*40.31*	214,969	64.6%	*132.7*	0.06%	1,160
World	**82.10**	**96.43**	**250,115**	**46.0%**	**161.0**	**0.06%**	**1,349**

1 includes fish, crustaceans, molluscs (FAO, 2018)
2 numbers in italics are estimates by the author and NA stands for not advised
3 calculated as the ratio between the aquaculture insurance premium in 2017 (Hohl, 2019) and the aquaculture production value in 2018 (FAO, 2018)
4 calculated using the insurance penetration ratio of Norway (0.54%) for all countries

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