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Safe and sustainable aquaculture intensification

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1. The Big Picture

Fisheries and aquaculture play a key role in providing food security and livelihoods to hundreds of millions of people for their social, economic and nutritional benefits. Since 2016, aquaculture contributed almost half of all fish consumed globally. FAO estimates that although global per capita consumption is likely to fall by some 15% over the next thirty years, fish production must nonetheless rise in order to meet the needs of a projected 25% world population increase. Because the great majority of fish stocks remains fully or over-fished, future increases in fish and shellfish supplies must come from aquaculture. To increase production, intensification seems the most realistic prospect to sustain future growth, but there are alternatives. Like other components of global food production, climate change will create opportunities and risks for the sector.

2. Key considerations

2.1 Policies that promote sustainable intensification of aquaculture production systems

Policies for sustainable aquaculture development must be consistent with existing frameworks for sustainable economic development, environmental protection and the right of access to safe, nutritious and affordable food. To sustainably deliver safe food, agroecological approaches are now being pursued in aquaculture via, for example, the integration of fish culture in rice fields, organic aquaculture and integrated mariculture, that can be applied to small-scale farms and that generate equitable benefits throughout value chains. While integration can bring benefits, such as the mitigation of the production of excess nutrients or organic matter, some integration approaches can present additional risks; for example, the use of agricultural drainage water in fishponds to facilitate on-farm reuse of waste may also expose pond fish to contaminants.

2.2 Establishment of adequate biosecurity measures

Aquaculture is characterised by the farming of large numbers of species and by the complex interactions between farmed aquatic organisms, pathogens and the environment. Disease is thus a continual concern, outbreaks being controlled through biosecurity (both policy and farm levels), surveillance and appropriate treatment, supported by appropriate policies and trained veterinarians or aquatic animal health professionals. Universal adoption of the “One Health” approach should inform national strategies on aquatic animal health management and aquatic biosecurity governance. Exotic and emerging diseases (of known or unknown aetiologies) continue to challenge the sector largely due to the unregulated movements of live farmed aquatic animals and ecosystem changes, in addition to production-related diseases that are as equally important. Notably, climate change facilitates the proliferation of certain pathogens and can adversely affect aquatic plants and animal immune systems. The frequency and geographic spread of Harmful Algal Blooms (HABs) too are increasing due to climate and environmental change. Phytotoxins can accumulate in farmed shellfish, posing real food safety issues at certain times of the year. Implementation of robust biosecurity protocols, including the mandatory use of depuration techniques, is required.

2.3 Codes of Practice and responsible use of antimicrobials
Industry codes of practice, good aquaculture and biosecurity including aquaculture zoning, vaccines, prudent use of antimicrobials, and microbial management taking into account quorum sensing mechanisms are key prevention measures to the development of AMR. Antibiotic residue testing for traded fish needs attention to minimise product rejections. Awareness is a necessary first step in addressing AMR; efforts should be made in finding ways of reaching the hundreds of thousands of small-scale aquaculture producers. Implementation of an integrated surveillance programme within the framework of One Health that includes study of AM use and AM genes across different sectors (human, agriculture, veterinary and aquaculture) could improve our understanding of the drivers leading to selection and spread of AMR in the aquatic environment.

2.4 Breeding of domesticated farmed aquatic animals
Few species used in aquaculture have been domesticated and there is tremendous scope to develop more productive strains that grow faster, are more resistant to disease and to climate change and that differ from their wild relatives in terms of such traits as body shape. Developing such strains is costly and is often undertaken by the private sector, which charges a premium to recoup costs. Moreover, faster growth is accompanied by greater reliance on feeds, compounding issues of economic access by poor producers to productive strains. There are also concerns about the impact of escaped genetically improved strains on wild germplasm, ecosystems and the provision of ecosystem services.

2.5 Developing holistic feeding strategies: considering demand, supply, resource limitations and competing needs
Intensification of aquaculture production should reduce its reliance on feeds compounded largely from fishmeal and fish oil, products largely derived from industrial fisheries for pelagic species of low economic value. Demand for aquaculture has far outstripped supply, while at the same time the nutrition value of such materials as a direct source of human nutrition has been recognised. Alternative dietary protein and lipid sources, primarily of plant origin, have increasingly been used although excessive use in diets of omnivorous species can pose welfare issues and compromise immune systems. Novel protein and lipid sources, such as soldier fly larvae (*Hermetia illucens*), marine algae and fungi are being developed apace and are rapidly becoming commercially viable as feedstuffs. It will be important to ensure that increasing dependence on such feedstuffs does not compromise the nutrient content of farmed aquatic products.
Some types of aquaculture can produce fish efficiently with low or no direct input; these include bivalves (oysters, mussels, clams and scallops) that are grown without artificial feeding as they feed on natural materials naturally occurring on their culture environment in the sea and lagoons. Carps and tilapias are species that are in the lower trophic levels of the food chain and they are the top finfish cultured species. Increased consumer awareness on species that feed low in the food web and their consumption benefits should be encouraged.

2.6 Environmental contamination and waste management
Intensification of production often results in greater waste generation per unit production, farmed fish being more reliant on allochthonous food sources. Aquaculture waste, which includes faeces, urine, uneaten food wastes and un-metabolised medicines, are still typically discharged into the environment to be dispersed and assimilated, posing a range of food safety-associated threats (see also 2. 2 above). Treatment of such waste from conventional

pond and cage systems is difficult and expensive; novel production systems, such as recirculating aquaculture systems and aquaponics, adequately deal with waste but have yet to prove economically viable. The ecosystem approach to aquaculture development (including the application of aquaculture zoning, site selection, species selection and area management) ensures that farms have attributes that enable the necessary production with the least possible adverse impact on the environment and on society. Important factors to be considered in this approach include ecological and social carrying capacity, biosecurity and legal designation of zones as well as broad protection of the environment; these bring additional benefits of reducing risk for aquaculture investors and minimizing conflict with other natural resource users.

2.7 Livelihoods and equity

While food safety regulations and Codes of Practice help protect consumers, they may also generate inequities in production costs for smallholders while excluding them from access to markets. Small-scale producers constitute the bulk of aquaculture operations. This sector needs to be supported in terms of access to the resource base and to markets, technologies and services as well as mechanisms for enhancing skills (e.g. farmer field schools, cluster management approaches, demand-driven extension services, joint research). In parallel, there is a need to understand the sector in terms of risks, misconceptions and misunderstandings through knowledge, attitude and practice (KAP) surveys, so that obstacles and barriers to behavioral change can be integrated in any system needed to support the sector. These are necessary conditions to enhance sustainability.

2.8 Promoting research in priority areas

Priority areas for research from a food safety perspective include the impacts of climate change on HABs and oyster, clam and mussel farming, and on diseases of farmed seaweeds. More research is also required into AMR in aquatic farming systems and how to minimise risks. Other key areas include vaccine development, other alternatives to antimicrobials and risks from post-harvest practices.

3. Concluding comments

Aquaculture is a component – arguably a key component - of the global food system. The sustainability of aquaculture production should thus be viewed from a holistic global food systems perspective.

Trade-offs between the benefits and impacts of aquaculture intensification will be inevitable and situation (cultural, societal and geospatial) specific. Transparency around these interlinked environmental, health, nutritional, food safety and economic factors is essential to allow stakeholders across the chain, from producers and retailers to consumers and policy makers, to make informed benefit-risk decisions and to build trust between these actors in order to maximise the potential of this fastest growing food producing sector.