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Title:	Addressing challenges to aquaculture development
Author:	Jamie Whitford

Summary/short description/key points:

In the Pacific Island countries and territories (PICTs), national and regional aquaculture development has many challenges, including market access, feed sustainability, disease management, regulatory and tenure issues, access to capital, management of environmental impacts, availability of labour, management of water quality, development of genetics/domestication of species, technology adoption, and land and water resource competition.

While these challenges are also faced by governments and the aquaculture private sector worldwide, additionally in the PICTs there are also community aspirations for aquaculture, that require a nuanced approach to realise advantages of coastal resource custody. For communities, accessing finance is particularly difficult. The development of long-term industry plans with actionable and economic strategies remains important, to provide pathways for both the private sector and communities.

Government, private sector, and communities can use their experience in the development of their agricultural industries, to reidentify successful strategies, and points of difference, that may further aquaculture development, this may include the integration of communities as partners into private sector aquaculture operations.

Recommendations:

- Countries and the region produce or update aquaculture development plans that consider the challenges listed using time periods experienced for successful aquaculture development overseas, up to 20 years.
- Laws and regulations are drafted and implemented by the competent authorities, to both enable aquaculture development and protect the environments where aquaculture may take place.
- Geographical and community resource surveying be undertaken to determine areas of appropriate aquaculture development to guide the establishment of appropriate aquaculture systems nationally and regionally.

Challenges to aquaculture development in the Pacific Island countries and territories (PICTs)

1. The coastal and oceanic resources of the Pacific Island country and territories, and the experienced maritime workforce, are long valued as an opportunity for aquaculture development in the region. As aquaculture production has rapidly increased worldwide, especially in the adjacent region of Southeast Asia, the PICTs and their development partners, have pursued aquaculture development for the region, to participate more widely in aquaculture for both economic development and food security.
2. Aquaculture has contributed to the development of the region, examples include cultured pearling in French Polynesia and the Cook Islands, shrimp farming in New Caledonia, and seaweed in Kiribati, Solomon Islands and Papua New Guinea. The culture of tilapia also contributes to food security and disaster resilience across the region. However sustainable, economic aquaculture development remains difficult to implement as there are many challenges to be managed to realise the potential for aquaculture, to improve both food security and economic development in the region. These include:

Market access

3. Accessing global markets is difficult for the region, access can involve trade barriers and certification requirements, particularly for food safety. One reason for the success of pearling for example, has been the transportation and value advantages of pearls (nonperishable, high value for volume), while one of the challenges for seaweed farming is competing with the cost of production (including the cost of accessing global markets), in a global commodity market. Finding consistent markets and buyers for aquaculture products can be challenging in the region, although there is an increasing domestic market capacity to absorb aquaculture's production cost and price, and the competitive price of wild caught fish is increasing dramatically in some Pacific countries. A fondness for traditional foods by the Pacific diaspora living in countries adjacent to the region, is also an opportunity for the production and marketing of some endemic species suitable for aquaculture (*Caulerpa* seaweed, giant clams).

Feed sustainability

4. The aquaculture of finfish and shrimp particularly, requires the input of feed, and feed has proved difficult to economically source in most PICTs, and may be of a reduced quality, reducing growth performance, further impacting economics. Domestic commercial development of feed mills is correlated to a fed aquaculture production of 30 000 tonnes or more outside the region. While the unfed aquaculture of bivalves is developing in the PICTs, and the aquaculture of lower trophic species such as tilapia and milkfish can be achieved by boosting the productivity of ponds with fertilisers, much of the most economically attractive aquaculture relies on feed. Feed for high value marine finfish species, contains fishmeal and fish oil, the supply of which can strain marine ecosystems. Finding sustainable and alternative feed sources is a key challenge, but there are opportunities to supply these ingredients within domestic and regional fishery supply chains, with recent improvements in the technology available to extract and process them.

Disease management

5. The global aquaculture industry has proven susceptible to disease, which has led to significant production losses. This has also been the case for aquaculture in the PICTs, particularly for industries with scale like pearling and shrimp production. PICTs do have biosecurity advantages due to their isolation from other aquaculture industries. Developing effective disease management strategies, including vaccines and biosecurity measures, is critical for the development of aquaculture. The development of vaccines and medicines is both expensive and market driven, and the aquaculture of endemic species may be limited by the difficulties in managing disease, without the availability of treatments. National disease management strategies require a strong regulatory environment and spatial planning, which may be hard to implement in harmony with traditional marine custodial rights and expectations in the region.

Regulatory, legal issues and marine tenure

6. Developed aquaculture industries are subject to various regulations and permits related to marine tenure, environmental impact, biosecurity, and food safety. These are important to incorporate noneconomic priorities into production, and often to maintain public goodwill for the use of a public resource, the marine environment. Regulatory frameworks for aquaculture are undeveloped or non-existent in the PICTs, this for example hinders both the commercial acquisition of a marine tenure (a lease), or the application for a loan secured against the asset of a traditional marine tenure.

Access to capital

7. Establishing and expanding aquaculture operations requires significant investment in infrastructure, equipment, and research. Securing financing can be a barrier, especially for small-scale farmers. Access to capital for aquaculture in the PICTs would be improved by efforts to progress regulation for aquaculture and coastal environments. The requirements for capital can also be reduced by developing more efficient and simple farming systems.

Environmental impact

8. Aquaculture can have negative environmental consequences, such as water pollution, habitat degradation, and the introduction of invasive species. Managing these impacts and ensuring sustainable practices are carried out by an industry, is a principal challenge for regulators. Fed aquaculture of finfish and shrimp requires sound management to avoid a negative environmental impact than the unfed aquaculture of bivalves, seaweeds, and sea cucumbers. Regulating the input of feed into fed marine farms is one strategy to manage environmental impact, another is the establishment of Integrated multi trophic aquaculture (IMTA) cycling nutrients between several groups of animals and plants under culture.

Labour issues

Aquaculture operations face challenges related to securing both labour and the skillsets required, especially for seedstock production. Working conditions, wages, and access to alternative livelihoods in the PICTs, are often better than those in Southeast Asia, and extensive methods of production that have been successful there, may not be appropriate in the Pacific. Labour, especially skilled labour for engineering, management and science work required by aquaculture, may be in high demand, while opportunities in the agricultural sector with lower risks, may limit interest in entrepreneurs and those

seeking food security. Ensuring a skilled and motivated workforce is important for the industry's success.

Water quality management

9. Maintaining optimal water quality for aquaculture species is essential for their health and growth. Managing water qualities like oxygen levels, temperature, and waste buildup can be challenging, particularly in intensive aquaculture systems. Imperfect design and equipment failure can cause water quality problems in land-based systems, while overfeeding can cause eutrophication and poor water quality in freshwater and marine farms.

Genetic improvement

10. Selective breeding programmes are essential for improving the growth rate, disease resistance, and overall productivity of farmed species. However, implementing and maintaining these programmes can be resource intensive. While the PICTs can benefit from breeding programmes outside the region such as for GIFT (genetically improved farmed tilapia) tilapia, and IREMER has maintained genetically improved and domesticated shrimp in Tahiti since the 1990's, breeding programmes for domestication are still required generally across the region, to help provide efficiencies for aquaculture production.

Technology adoption

11. Acquiring and integrating new technologies, such as automation and monitoring, data and data analytics, and automated feeding and processing of aquaculture species, can enhance efficiency and sustainability, but many operations in the region will struggle to adopt these innovations, especially in the constraints encountered to investment. The collection of data is especially important, both at a farm level to calibrate normal production (to make the tracking of production difficulties clear and rapid) and to enable governments to better target their aquaculture development efforts from a measurement of the actual situation.

Land and water resource competition

12. Competition for land and freshwater resources with other sectors, such as agriculture and urban development, can limit the expansion of aquaculture. Additionally in the PICTs, the use of coastal resources for food security and tourism may cause conflict with aquaculture development. The increasing demand on freshwater resources with a changing climate will increasingly limit freshwater aquaculture opportunities, while coastal sites protected from storm damage may also be in demand for other uses in the region.

Conclusion

13. Efficient collaboration among governments, communities, industry, researchers, finance, and environmental organisations, is crucial to address challenges in Pacific aquaculture. Sustainable practices, improved tech, and responsible management are vital for long-term success. Long-term funding, preferably through regional agreements, is essential for Pacific aquaculture aspirations, emphasising biosecurity capacity.
14. Species with favourable traits are preferred for aquaculture, often leading to a narrowed selection of economically viable options. Endemic species suitable for aquaculture in the Pacific may have market

preference, biosecurity advantages, and resistance to local diseases. They are often not domesticated, and production methods may be undeveloped.

15. Challenges in aquaculture for food security and economic development are similar, requiring long-term planning and funding. A realistic assessment of species and production systems is necessary to leverage the region's advantages and safeguard against food security threats due to population growth and coastal fishery pressures and to increase economic benefit.

Plenary questions

1. Identify and rank the aquaculture species of importance for your PICT and for the Pacific Islands region.
2. Discuss the value of endemic species versus that of commodity species that may be either endemic or introduced.
3. Identify feasibility gaps to the practicality and viability of aquaculture projects in PICTs.