Collaborative knowledge generation and dissemination to strengthen technology development in science and technology parks as a strategy to innovate aquaculture production

Aquaculture has been growing at a significant pace over the last few decades. However, the impulse it once had is starting to wane. Projections show that the average annual growth rate of aquaculture should slow from 4.6% in 2007–2018 to 2.3% in 2019–2030 (FAO, 2020). The current COVID-19 pandemic and economic crisis will only compound the problem. To counter declines in Asia, other regions should emerge, transitioning to more intensive aquaculture with better integration of production and environment, as technological innovations take hold.

It has been recognized that farmers’ innovations are crucial in order to achieve cumulative growth, both economically and socially (Nandeesha et al., 2012). However, several factors, such as inadequate government support for science and technology development, and inefficient dissemination of aquaculture information, have hampered this process. Aquaculture began in artisanal form from the efforts of pioneers using their own knowledge and wisdom to develop husbandry practices for some species. However, this individual ability to improve production reaches a limit that is not overcome unless there is appropriation of outsiders’ knowledge through collaboration, which can be associated to best aquaculture practices from locals, all the way to state-of-the-art knowledge-based technologies developed by academic institutions or large corporations. This appropriation results in production transformation to generate additional economic worth. When successful market implementation of a process, service, or product is achieved, we have innovation. Innovative farmers are those who try new and value adding practices. In a business, the structural changes driven by innovation occur in five areas (Schumpeter, 1934):

1. Launch of a new product.
2. Developing new supply sources of raw materials and goods.
3. Application of new production methods.
4. Opening of a new market.
5. New industry structures (or paradigms).

Scientific knowledge will support incorporation of new species, new ingredients or goods, and new production methods. Even new market development (e.g., for GMO-based products) and the application of new operating paradigms (like automation) need support of knowledge-based solutions. Aquaculture is, today, more diverse than other agro industries in terms of species (Cai, Zhou, Yan, Lucentea, & Laganaa, 2019). To increase harvested aquaculture volumes worldwide, we are incorporating new species, but further diversification is constrained by limitations in technology, profitability, market development, local governance and regulations, community acceptance, environmental conditions, and sustainability. Thus, the contribution of each species to overall production is highly skewed,
with only 30 species providing almost 90% of aquaculture production (Harvey, Soto, Carolsfeld, Beveridge, & Bartley, 2017). This relates to the paucity of truly domesticated populations or purposely developed strains (such as, e.g., for salmon, tilapia, and white shrimp). To improve evenness, we need better knowledge-based technologies, supported by scientific studies on the biology of the species and their interactions with the environment. To disseminate that knowledge efficiently, it is important that we solve the apparent disconnect that exists between academia and industry. This is a threefold quest.

1. Balance scientists’ goals to study complex questions in long-term projects, with farmer needs for solutions of current problems.
2. Disseminate available knowledge effectively.
3. Improve collaboration, as technology development requires a multidisciplinary approach, and a need for better understanding economic and marketing forces.

To be clear, we need basic science that offers the foundation for applied solutions. Targeted projects, aimed at specific problem-solving, are also a necessity. There is consensus that governments should support basic research and that results must be freely available. Today, industry is tackling some specific demands, like fishmeal and oil substitution in balanced rations. However, the jury is out as to whom is responsible for developing “greener” sustainable technologies. Eco-efficient production (Madden, Young, Brady, & Hall, 2006) will be central to the discussion.

JWAS decision to move to open access is in line with the goal not only to disseminate scientific findings as widely as possible but also to bring recognition to open access publications as a means of collaboration and global knowledge sharing that reinterpret intellectual property rights of scientific advances, particularly when knowledge is generated by public funds. These efforts will invite other scientists to contribute their findings and up the discussion on relevant topics. At issue, however, the question will remain as to how to balance scientific outputs from regions with different economic capacities, on the one hand, and further knowledge development on species biology needed to support aquaculture diversification.

While future demand for protein and the role of aquaculture appear evident, the plan of action is not as clear-cut. Most governments do not have policy designed to achieve specific developmental and growth goals in aquaculture. Without strategy, stakeholder collaboration is inefficient and individual efforts fall short of desired outcomes. Science in the 21st century must achieve free flow of globalized knowledge by establishing multi-stakeholder social and technological collaboration networks. Open collaboration will improve eco-efficient production technologies. Most aquaculture ventures are small and medium enterprises (SMEs). These represent the largest proportion of businesses in most countries (up to 99%), have a high rate of failures, and suffer the majority of job contraction (Aga, Francis, & Rodriguez-Meza, 2015). To counter this, a successful strategy has been the establishment of science and technology parks (STPs) to bridge the gap between academia and industry, promote a culture of innovation and competitiveness, and facilitate stakeholder collaboration for technology incubation, development, validation, and transfer (Villarreal & Mercier, 2011). They are ideal places to associate knowledge with technology development establishing proper procedures to validate the technology readiness level (TRL). In general, in collaborative projects between academia and industry, technology transfer may occur at all levels. TRL refers to a nine-step measurement system used to assess the maturity level of a particular technology (NASA, 2010). Frequently, commercial project miscarriages occur because they are launched when the technology validation is not complete. At the parks, stakeholders work with others as equal partners and information flows organically throughout the development life cycle. This guarantees that the technology is thoroughly tested and no major adjustments are required before a spin-off company emerges or commercial operation starts.

STPs have access to high caliber talent, capable of converting science and technology into tangible inventions and innovation (Villarreal, Mercier, Naranjo, Beltrán, & Hernández, 2010). This is achieved by strengthening collaborative relationships with academia, where targeted access to faculty allows integrating knowledge rapidly, intellectual property is correctly protected, mature technologies are developed, and qualified human resources (such as students
and technicians) represent a supplemental staffing solution for enterprises and future recruiting pipeline. This contributes to leverage funds to validate and transfer technologies to the production sector, thus improving innovation at the commercial level. STPs anchoring Aquaculture Hubs in different regions will trigger innovation by channeling open source knowledge into technology development, as a place with specialized infrastructure and facilities for human resource training, and as catalysts to expedite problem solution, spearheading diversification as a driver for local and regional sustainable development. Governments, universities, and economic stakeholders in producer nations should consider STPs in their strategies to boost sustainable, knowledge-based aquaculture.

Humberto Villarreal

ORCID
Humberto Villarreal https://orcid.org/0000-0002-4125-8871

REFERENCES
Aga, G., Francis, D. C., & Rodriguez-Meza, J. (2015). SMEs, Age, and Jobs: A Review of the Literature, Metrics, and Evidence. Policy Research Working Paper; No. 7493. World Bank, Washington, DC. © World Bank. https://openknowledge.worldbank.org/handle/10986/23455 License: CC BY 3.0 IGO.

Cai, J., Zhou, X., Yan, X., Lucentea, D., & Laganaa, C. (2019). Top 10 species groups in global aquaculture 2017 (p. 12). Rome: FAO WAPI Factsheet.

FAO. (2020). The State of World Fisheries and Aquaculture 2020. Sustainability in action. Rome. https://doi.org/10.4060/ca9229en

Harvey, B., Soto, D., Carolsfeld, J., Beveridge, M., & Bartley, D.M. (Eds.) (2017). Planning for aquaculture diversification: the importance of climate change and other drivers. FAO Technical Workshop, 23–25 June 2016, FAO Rome. FAO Fisheries and Aquaculture Proceedings No. 47. Rome, FAO. 166 pp.

Madden, K., Young, R., Brady, K., & Hall, J. (2006). Eco-efficiency learning module. WBCSD. ISBN: 2-940240-84-1. 231 pp.

Nandeesha, M. C., Halwart, M., García Gómez, R., Alvarez, C. A., Atanda, T., Bhujel, R., ... Yuan, D. (2012). Supporting farmer innovations, recognizing indigenous knowledge and disseminating success stories. In R. P. Subasinghe, J. R. Arthur, D. M. Bartley, S. S. De Silva, M. Halwart, N. Hishamunda, et al. (Eds.), Farming the waters for people and food. Proceedings of the global conference on aquaculture 2010, Phuket, Thailand. 22–25 September 2010 (pp. 823–875). Bangkok: FAO, Rome and NACA.

NASA. (2010). Technology Readiness Levels Demystified. https://www.nasa.gov/topics/aeronautics/features/trl_demystified.html. Last Updated August 20, 2017. Consulted February 13, 2021.

Schumpeter, J. A. (1934). The theory of economic development: An inquiry into profits, capital, credit, interest and the business cycle. Harvard economic studies (Vol. 46). Cambridge, MA: Harvard College.

Villarreal, H., & Mercier, L. (2011). BIOHELIS: A new Innovation and Technology Park offering a great opportunity for co-incubation. Conference Proceedings of the 2011 APEC Building a Co-Incubation Network. Pages 110–121. September 6–10, 2011, Xián Conference Forum, Xián, China.

Villarreal, H., Mercier, L., Naranjo, J., Beltrán, L. F., & Hernández, S. (2010). BIOHELIS: An innovation and technology park in Mexico that promotes green growth. Proceedings of the XXVII IASP World Conference on Science and Technology Parks (IASP 2010 Daedeok) May 23–26, 2010, Daejeon Convention Center, Korea.