12-2022

Aquaculture in Africa: Aquatic Animal Welfare, Impact on the Environment and the Sustainability of the Sector

Mwenda M. Mbaka

Janice H. Cox

Stephen Ronan

Aquaculture in Africa: Aquatic Animal Welfare, Impact on the Environment, and the Sustainability of the Sector

Contents

Background

The United Nations Food and Agriculture Organization (FAO)'s 2022 report on the State of World Fisheries and Aquaculture[1] records that in 2020, global aquaculture production reached a record 122.6 million tonnes, with a total value of USD 281.5 billion. Aquatic animals accounted for 87.5 million tonnes and algae comprised 35.1 million tonnes. In 2020, global aquaculture production grew in all regions except Africa, due to a decrease in the two major producing countries, Egypt and Nigeria. The rest of Africa experienced 14.5 percent growth from 2019. Aquaculture growth has often occurred at the expense of the environment. It remains critical to supply the growing demand for aquatic foods in a sustainable manner.

The following table shows a snap shot of Africa's plant and animal aquaculture for the top 16 producing African countries, using the latest (2020) statistics from the FAO's database (*FishStatJ*):

2020 Africa Plant and Animal Aquaculture 16 highest producing countries	**Fish**	**Crustaceans**	**Molluscs**	**Misc. aquatic animals**	**Aquatic plants**	**In metric tonnes (1000kg = 2200lbs)**	**% of all Africa**
Egypt	1,589,750	2146				1,591,896	67.62%
Nigeria	261,621	89				261,711	11.12%
Uganda	123,897					123,897	5.26%
Zanzibar	2			10	89,671	89,683	3.81%
Ghana	64,000	10				64,010	2.72%
Zambia	45,670					45,670	1.94%
Tunisia	23,333		63		90	23,486	1.00%
Kenya	19.981				850	20,831	0.88%
Tanzania	17,401	74			1,410	18,885	0.80%
Zimbabwe	15,425					15,425	0.66%
Madagascar	143	5,273		50	8,085	13,550	0.58%
Sudan	9,850					9,850	0.42%
South Africa	1,468		4,570		3,715	9,753	0.41%
Malawi	9,393					9,393	0.40%
Mali	7,686					7,686	0.33%
Rwanda	7,055	3				7,059	0.30%
				These 16 African countries		2,312,785	98.24%
				All Africa		2,354,294	100.00%

[1] FAO. The State of World Fisheries and Aquaculture 2022. 29 June 2022. https://reliefweb.int/report/world/state-world-fisheries-and-aquaculture-2022-enarruzh

Putting this into an international perspective, Asia is the largest aquaculture producer, accounting for 92% of the live-weight volume of animals and seaweeds in 2017, with nine of the top-ten ranked countries for aquaculture species diversity located in Asia, with China leading by a wide margin. Egypt is listed as one of the major producers outside of Asia, principally producing Nile tilapia.[2]

The African aquaculture sector recorded the fastest growth in the world between 2006-2018, averaging 10% or more, and is expected to partially fill the growing fish supply-demand gap up to 2063. In 2018, there were about 1.2 million aquafarmers across the continent, an increase from 920 thousand in 2014.[3]

The aquaculture industry in Egypt experienced rapid development from 1998 due to the consistent and cumulative interventions by the Egyptian government, as well as growing private sector-driven investment. By 2018, aquaculture production in Egypt had grown so the annual production exceeded one and a half million tons with a market value estimated at over USD 2 billion, ranking the country 6th amongst the leading aquaculture producing countries globally in 2018.[4]

The "quantitative SWOT analyses of key aquaculture players in Africa" by Babatunde et al.[5] provides a useful overview of the industry. This paper compares aquaculture performance in production, technology, market, policies, and framework among Egypt, Nigeria, Uganda, and South Africa. It notes that in 2018, Africa's contribution to world aquaculture production was still insignificant (2,196,600 tons; 2.7%) albeit significantly increasing, with Egypt (1,561,457 tons), Nigeria (291,233 tons), and Uganda (103,737 tons) producing substantial quantities (91%) of the total fish production from the region.

In South Africa, oyster farming has declined, and been overtaken by mussel and abalone production in volume. The sector of shellfish aquaculture – oysters, mussels, abalone, seaweeds, and prawns – remains a key driver in the fast growth of the country's marine aquaculture.[6]

The table above shows Zanzibar (an autonomous part of Tanzania) as a significant producer of aquatic plants. A 2022 study on coastal aquaculture in Zanzibar[7] reports that although Zanzibar has been working on multi-sectoral coastal aquaculture development for over 30 years, only seaweed farming has so far established into commercial-scale production. This activity is dominated by women and became widespread in the early 1990s as a small but regular source of income. However, seaweed farming constraints such as frequent seaweed die-offs, as well as economic and institutional constraints inhibit its further development. There is no traditional system of seaweed farming in Africa. In Tanzania and Madagascar, the community-based models developed since the

[2] Naylor, Rosamond L. et al. A 20-year retrospective review of global aquaculture. 24 March 2021. https://www.nature.com/articles/s41586-021-03308-6

[3] AU-IBAR. Africa Blue Economy Programme. October 2019. https://www.au-ibar.org/sites/default/files/2020-10/sd_20200313_africa_blue_economy_strategy_en.pdf

[4] Adeleke, Babatunde et al. Aquaculture in Africa: A Comparative Review of Egypt, Nigeria, and Uganda Vis-À-Vis South Africa. July 2020. https://www.tandfonline.com/doi/full/10.1080/23308249.2020.1795615

[5] Babatunde, A., Deborah, RA., Gan, M. et al. A quantitative SWOT analyses of key aquaculture players in Africa. Aquaculture Int. 29, 1753–1770 (2021). https://doi.org/10.1007/s10499-021-00715-4. https://link.springer.com/article/10.1007/s10499-021-00715-4

[6] Oirere, Shem. The race is on in South Africa to increase oyster volumes. 24 February 2020. Seafood Source. https://www.seafoodsource.com/news/aquaculture/the-race-is-on-in-south-africa-to-increase-oyster-volumes

[7] Charisiadou, Stefania et al. Coastal aquaculture in Zanzibar, Tanzania. 15 January 2022. https://www.sciencedirect.com/science/article/pii/S0044848621009947

1990s consist of multi-stakeholder partnerships between village producers and local private companies, along with the decentralised administration and local NGOs.[8]

Seaweed is being promoted as a superfood that has the potential to end world hunger and save the planet. It grows up to two feet a day, contains numerous vitamins and minerals, and produces up to 11 times the biomass of wheat and corn per hectare. It is a massive carbon sink which has the potential to be developed globally to absorb as much carbon as the Amazon. But consumer demand for the product needs to be fuelled.[9]

Seaweed is an alternative to fish for both food and feed. In China, studies suggest that large-scale seaweed aquaculture is effective in reducing nitrogen levels, controlling phytoplankton blooms, and limiting the frequency of toxic algal bloom.[10]

Africa would do well to study some of the work already carried out at European Union level on the importance of developing the algae sector. The European Commission recently published a communication on a strong and sustainable EU algae sector.[11] This mentions that the European Union's Farm to Fork Strategy highlights the role of algae as an important source of alternative protein for a sustainable food system and global food security.

The 'Food from the Oceans' report[12] prepared by the European Commission's High-Level Scientific Advice Mechanism identifies seaweed as having the potential to satisfy the projected more than 100 million tonnes of additional biomass demand for human food in the next 20 years.

Strategic guidelines for a more sustainable and competitive EU aquaculture for the period 2021 to 2030[13] stress the need to promote the farming of algae – both macroalgae (seaweed) and microalgae[14] – as a way of contributing to achieving several objectives of the European Green Deal. The farming of algae can contribute to achieving the EU's objectives in terms of decarbonisation, zero pollution, circularity, the preservation and restoration of biodiversity, the protection of ecosystems and the

[8] African Development Bank. The Potential of Green Aquaculture in Africa: Status and Prospects for Seaweed Farming. 19 April 2022. https://www.afdb.org/en/documents/potential-green-aquaculture-africa-status-and-prospects-seaweed-farming

[9] Sherriff, Lucy. The seaweed superfood revolution could end world hunger—and save the planet. Forbes. 7 November 2022. https://fortune-com.cdn.ampproject.org/c/s/fortune.com/2022/11/07/the-seaweed-superfood-revolution-could-end-world-hunger-and-save-the-planet/amp/

[10] Naylor, Rosamond L. et al. A 20-year retrospective review of global aquaculture. 24 March 2021. https://www.nature.com/articles/s41586-021-03308-6

[11] European Commission. Communication from the Commission: Towards a strong and sustainable EU algae sector. 15 November 2022. https://oceans-and-fisheries.ec.europa.eu/publications/communication-commission-towards-strong-and-sustainable-eu-algae-sector_en

[12] European Commission, Directorate-General for Research and Innovation, Group of Chief Scientific Advisors, Food from the oceans : how can more food and biomass be obtained from the oceans in a way that does not deprive future generations of their benefits?, Publications Office, 2017, https://data.europa.eu/doi/10.2777/66235 & https://op.europa.eu/en/publication-detail/-/publication/0e91f9db-f4f2-11e7-be11-01aa75ed71a1/language-en

[13] European Commission. Strategic guidelines for a more sustainable and competitive EU aquaculture for the period 2021 to 2030. 12 May 2021. https://eur-lex.europa.eu/resource.html?uri=cellar:bab1f9a7-b30b-11eb-8aca-01aa75ed71a1.0022.02/DOC_1&format=PDF

[14] European standard EN 17399:2020 defines algae as a functional group of organisms consisting of microalgae, macroalgae, cyanobacteria and labyrinthulomycetes. Algae also refer to plant-like aquatic organisms ranging in size from single-celled organisms (microalgae and cyanobacteria) to giant multicellular forms such as seaweed (macroalgae).

development of environmental services. Algae can replace fossil-based products, and serve as raw material for plant biostimulants, bio-based chemicals and other materials, and biofuels.[15]

According to the African Development Bank, expansion of aquaculture in Africa is hampered by "the overwhelming predominance of tilapia farming, which relies heavily on the production of fingerlings from a limited number of genetically improved strains that are resistant to the many diseases affecting this species, and on the production of feed that is still largely imported". The Bank cited projections that African aquaculture would grow far more dramatically if it rapidly diversified, rather than remaining dominated by tilapia farming. In this diversification scenario, according to the bank, "seaweed cultivation could play a major role, as the production potential is considerable, the investment costs are affordable, and demand for all these products is growing rapidly... Even if seaweed does not (yet) form part of the diet of African people, it can provide an excellent opportunity to create jobs, develop multiple domestic value chains, increase exports and help reduce the trade deficit of several countries, thus improving the living conditions of many Africans. This is because, unlike conventional crops and fish farming, seaweed farming requires neither land, fresh water, seed production, feed nor fertiliser. In fact, seaweed farming helps to increase the resilience of coastal ecosystems by restoring habitats essential to fish resources, protecting coastlines against extreme weather events, fixing certain organic pollutants, and contributing to the recycling of large quantities of nitrogen and CO2". [16] Seaweed production also avoids the adverse animal welfare and environmental impacts of animal aquaculture.

This is particularly the case for crustaceans (shrimps) and carnivorous fish (sea bream, sea bass, meagre), which require regular and high-quality external feed and constant expert care to cope with various pathogens, which can be particularly prevalent where fish are housed in unnaturally crowded conditions. Aquatic plants can lower risks. In Africa, algae, for example, (mainly red algae) has only developed significantly in Tanzania, although several other African countries have also recognised the potential of cultivated seaweeds, and Namibia, Mozambique, Madagascar, Kenya and South Africa, amongst others, have been developing their industries over the last two decades. However, cultivated seaweed has a very important potential in all the countries bordering the Indian Ocean, the Atlantic coast and the Mediterranean Sea.[17]

With fishery resources continuing to decline due to overfishing, pollution, poor management and other factors, aquatic animal production is forecast to grow 14 percent by 2030. It is vital this growth goes hand in hand with safeguarding ecosystems, reducing pollution, protecting biodiversity and ensuring social equity.[18] Seaweed offers a readily-available intervention.

A 20-year retrospective review of global aquaculture by Rosamond Naylor et al. (2021) reported that at the start of this period, researchers were cautioning that the net positive contribution of aquaculture to world fish supplies could not be sustained unless the sector reduced its use of wild fish in feed as well as its other adverse environmental impacts. The review paints a picture of an

[15] European Commission. Communication from the Commission: Towards a strong and sustainable EU algae sector. 15 November 2022. https://oceans-and-fisheries.ec.europa.eu/publications/communication-commission-towards-strong-and-sustainable-eu-algae-sector_en

[16] African Development Bank. The Potential of Green Aquaculture in Africa: Status and Prospects for Seaweed Farming. 19 April 2022. https://www.afdb.org/en/documents/potential-green-aquaculture-africa-status-and-prospects-seaweed-farming

[17] Msuya, F.E., Bolton, J., Pascal, F. et al. Seaweed farming in Africa: current status and future potential. J Appl Phycol 34, 985–1005 (2022). https://doi.org/10.1007/s10811-021-02676-w & https://link.springer.com/article/10.1007/s10811-021-02676-w

[18] FAO. The State of World Fisheries and Aquaculture 2022. 29 June 2022. https://reliefweb.int/report/world/state-world-fisheries-and-aquaculture-2022-enarruzh

increasingly intensified industry, more integrated into the global food system, with rapid growth in production and transformations in feed ingredients, production technologies, farm management, and value chains. However, the paper notes that: "the aquaculture sector still faces serious challenges that, in some cases, undermine its ability to achieve sustainable outcomes".[19] Intensification inevitably increases challenges to animal welfare, and poor animal welfare impacts sustainability. This is also the case where the pursuit of short-term profitability leads to reduced investment in provisions for animal welfare.

The Naylor et al report noted that over-intensification of cage production has caused nutrient pollution, pathogen-related production declines and mortality from anoxic conditions. Also, the trend to intensify freshwater systems is increasingly linked to globally-sourced feed ingredients that represent a critical area of the overall environmental impact of the aquaculture sector. A major concern reflected in a prior aquaculture review by Naylor et al (2000) had been the increasing proportion of annual fishmeal and fish oil production for aquaculture feed, and the consequent impacts on wild forage fish landings and stocks as well as marine ecosystems - reflected in biodiversity loss in these ecosystems. However, the 2021 report notes an increasing share of plant-based ingredients in mariculture feed types, coupled with the steady growth in feed use in freshwater aquaculture. No doubt partly fuelled by increased prices for fish meal and fish oils, this appears at face value to be a welcome change, given pressures on fish stocks. But this has led to a new set of controversies surrounding resource use and the environmental effects of terrestrial crop production for aquafeed. Life cycle analysis indicated that feed accounts for more than 90% of the environmental impact from fed aquaculture production. Studies modelling fishmeal replacement with plant-based proteins (for example, soy protein concentrate) in shrimp and salmon show potential increases in ecotoxicity from fertiliser and pesticide use, rising pressure on freshwater and land resources, and heightened carbon emissions and biodiversity loss from forest clearing. There are also health problems for the fish.[20]

Nutrient water pollution and pathogens are also inextricably linked to poor fish welfare. Adverse impacts such as biodiversity loss and pollution also affect the health and welfare of humans and other animals.

The review also noted that the sector now generates products not only for direct consumption, but also used in food processing, feed, fuels, cosmetics, nutraceuticals, pharmaceuticals, and a variety of other industrial products.[21]

Aquaculture was first introduced to many countries in Africa at the turn of the 20th century mainly to satisfy colonial recreational fishing needs, and later extended by colonial governments across Africa as a perceived means of sustainable food production. As the industry extended, it became more intensive.[22]

Within Africa, aquaculture development is promoted because of its potential to contribute to food security and the achievement of the SDGs. It receives funding from international donors and funding

[19] Naylor, Rosamond L. et al. A 20-year retrospective review of global aquaculture. 24 March 2021. https://www.nature.com/articles/s41586-021-03308-6

[20] Naylor, Rosamond L. et al. A 20-year retrospective review of global aquaculture. 24 March 2021. https://www.nature.com/articles/s41586-021-03308-6

[21] Naylor, Rosamond L. et al. A 20-year retrospective review of global aquaculture. 24 March 2021. https://www.nature.com/articles/s41586-021-03308-6

[22] Adeleke, Babatunde et al. Aquaculture in Africa: A Comparative Review of Egypt, Nigeria, and Uganda Vis-À-Vis South Africa. July 2020. https://www.tandfonline.com/doi/full/10.1080/23308249.2020.1795615

agencies (see below). However, aquaculture production in Africa has yet to catch up with major players globally. [23]

A paper by Catherine Ragasa et al. on "Sustainable aquaculture development in sub-Saharan Africa"[24] reports that since the year 2000, aquaculture production in sub-Saharan Africa (SSA) has grown by 11% annually on average - almost twice as fast compared with the rest of the world, with a few countries growing at 12–23% per year. Private sector investments led to aquaculture expansion across Sub-Saharan Africa's inland water, from nine cages in 2006 to more than 20,000 in 2019. Today, lakes Victoria (Kenya, Tanzania, Uganda), Kariba (Zambia, Zimbabwe), Kivu (Rwanda, Democratic Republic of the Congo), Muhazi (Rwanda) and Volta (Ghana) host 91% of the total inland cage aquaculture.
In many African countries, aquaculture is high on the political agenda for the promotion of food and nutrition security, and job creation. However, as the paper explains strategies are needed to support aquaculture growth in sub-Saharan Africa, including dealing with fish health problems (no mention of welfare), securing more environmental fish feeds and building capacity and extension services.

The Fisheries and Aquaculture Programme (2015-2020) of the New Partnership for Africa's Development - NEPAD (now the African Union Development Agency - AUDA) [NEPAD] recognised the need for African Union member states to "consider, develop and implement policy and governance reforms" in the sector, pointing out the "need to improve the overall governance of the aquaculture sub-sector in terms of environmental management, biosafety and food safety".[25]

The FAO's Regional Aquaculture Officer for Africa agreed with the above analysis: For decades aquaculture in Africa has been vacillating between crests and troughs of various waves of development with the same constraints identified time and again: lack of seed, feed, credit and extension support. All of these constraints relate to the underlying lack of policy. The FAO considered that if there was the political will to establish workable policies, solutions to these other issues may be forthcoming.[26]

Aquaculture in Development Policy and Planning

The development of aquaculture in the region was expedited through increased financial and technical assistance from bilateral and multilateral donors worth about US$ 500 million from the early 1970s to early 1990s. The FAO played a major role in the spread of aquaculture.[27]

The African Union's Agenda 2063[28] declares the Blue Economy to be "Africa's Future", and calls for strategies to be developed to grow the African Blue Economy. It states that: "Africa's Blue/Ocean Economy, which is three times the size of its landmass, shall be a major contributor to continental transformation and growth, through knowledge on marine and aquatic biotechnology, the growth of

[23] Olapade, Olufemi. The Role of International Donors in Aquaculture Development in Africa. May 2020. https://www.researchgate.net/publication/341419494_The_Role_of_International_Donors_in_Aquaculture_Development_in_Africa
[24] Ragasa, Catherine et al. Sustainable aquaculture development in sub-Saharan Africa. 2022. https://www.nature.com/articles/s43016-022-00467-1
[25] NEPAD. The NEPAD Agency Fisheries and Aquaculture Programme. 2015-2020. https://www.nepad.org/publication/nepad-agency-fisheries-and-aquaculture-programme
[26] Moehl, John, Regional Aquaculture Officer, FAO. Aquaculture in Africa: Perspectives from the FAO Regional Office for Africa. https://www.fao.org/3/x4545e/X4545e38.htm
[27] Adeleke, Babatunde et al. Aquaculture in Africa: A Comparative Review of Egypt, Nigeria, and Uganda Vis-À-Vis South Africa. July 2020. https://www.tandfonline.com/doi/full/10.1080/23308249.2020.1795615
[28] African Union. Agenda 2063: The Africa we want. 10 June 2013. https://au.int/Agenda2063/popular_version

an Africa-wide shipping industry, the development of sea, river and lake transport and fishing; and exploitation and beneficiation of deep-sea mineral and other resources".

The NEPAD has been spearheading a continent-wide effort to address industry shortcomings and to maximise the contribution of fisheries and aquaculture to Africa's food and nutrition security, well-being and wealth. This has been supported by the African Union and leading donors. The NEPAD Agency Fisheries and Aquaculture Programme 2015-2020 presented a brief review of experiences and lessons learned in the fisheries sector since project inception; and also provided a road-map for the NEPAD Agency's Fisheries and Aquaculture Program 2015-2020. Whilst this included the need to improve the overall governance of the aquaculture sub-sector in terms of environmental management, biosafety and food safety, it lacked attention to animal health and welfare.[29]

The "Blue Economy" is seen as an engine for economic growth, and for Africa's renaissance.[30] Back in 2004, the UN's Economic Commission for Africa (UNECA) had already published a policy handbook on Africa's Blue Economy, which included aquaculture.[31]

The African Union Inter-African Bureau for Animal Resources (AU-IBAR), which is a technical office of the Department of Rural Economy and Agriculture of the African Union Commission, developed a "Sustainable Blue Economy Programme" in 2019 to facilitate the implementation of its priorities in alignment with Agenda 2063. The Vison of the Africa Blue Economy Strategy is an inclusive and sustainable blue economy that significantly contributes to Africa's transformation and growth. The programme includes an Annex which is a technical report on fisheries, aquaculture, conservation and sustainable aquatic ecosystems.[32]

NEPAD had already adopted a Pan-African Fisheries and Aquaculture Policy Framework and Reform Strategy in 2014, which it revised in 2016[33]. This recognised that market-led and sustainable development strategies needed to be put in place to realise the full potential of the fisheries and aquaculture sector for wealth creation, social benefits and development of the African economy.
It also pointed out the importance of recognising that African fisheries and aquaculture are very complex and that a one-size-fits-all set of policies and institutional mechanisms are inappropriate. Policy and governance mechanisms need to take into account the specific conditions of the country or communities to which they are applied. Therefore, structures to support and implement country-specific policies need to be in place in order to develop sustainable aquaculture sectors in African Union Member States.

The African Ministerial Conference on the Environment (AMCEN) regularly considers matters pertaining to the Blue Economy, and African governments are increasingly implementing a blue or ocean-based economy as a strategy for creating economic development with a view to improving human well-being and social equity, while significantly reducing environmental risks and ecological scarcities. The African Union defines a blue or ocean economy as "sustainable economic development

[29] NEPAD. The NEPAD Agency Fisheries and Aquaculture Programme. 2015-2020. https://www.nepad.org/publication/nepad-agency-fisheries-and-aquaculture-programme
[30] AUDA-NEPAD. Blue Economy: Africa's Untapped Potential for Economic Growth 19 March 2021. https://www.nepad.org/news/blue-economy-africas-untapped-potential-economic-growth
[31] UN. UN's Economic Commission for Africa (UNECA). Africa's Blue Economy: A policy handbook. https://www.un.org/africarenewal/sites/www.un.org.africarenewal/files/Africa%27s_Blue_Economy_A_policy_handbook.pdf
[32] AU-IBAR. Africa Blue Economy Programme. October 2019. https://www.au-ibar.org/sites/default/files/2020-10/sd_20200313_africa_blue_economy_strategy_en.pdf
[33] NEPAD. Pan-African Fisheries and Aquaculture Policy Framework and Reform Strategy. Revised 2016. https://nepad.org/file-download/download/public/15742

of oceans using such technics as regional development to integrate the use of seas and oceans, coasts, lakes, rivers and underground water for economic purposes, including, but without being limited to fisheries, mining, energy, aquaculture and maritime transport, while protecting the sea to improve social well-being". Aquaculture is listed as a new or developing industry.[34]

The African Union (AU) has endorsed the Animal Welfare Strategy for Africa (AWSA), the vision for which is: "An Africa where animals are treated as sentient beings, as a leading continent in implementation of good animal welfare practices for a competitive and sustainable animal resource sector".[35] [36] It also supported the UN Environment Assembly (UNEA) resolution on the Nexus between Animal Welfare, Environment and Sustainable Development[37].[38] This resolution acknowledged that that there is a strong body of science supporting animal welfare, and that animal welfare can contribute to addressing environmental challenges, promoting the "One Health" approach and achieving the Sustainable Development Goals. It also noted that the health and welfare of animals, sustainable development and the environment are connected to human health and well-being. However, more work is needed to secure the health and welfare of animals in aquaculture systems, and to link this with minimising risks to the environment, as well as human health and welfare. The factors which contribute to environmental risks and environmental scarcity are in themselves drivers of poor animal welfare [e.g., intensification of aquaculture without regard for the welfare of the fish or other animals]. The outcomes, seen as disruptions of environmental integrity and ecological scarcity in themselves cause the suffering of animals – culminating in more disease and mortalities, which work against human welfare.

AU-IBAR is planning the establishment of centres of excellence for fisheries and aquaculture across the continent.[39] The first Centre of Excellence for Aquaculture and Fisheries Science (Aquafish) was established in Lilongwe, Malawi. The centre's aim is to train a pool of skilled and innovative graduate students, to contribute towards improved fish-based food and incomes from aquaculture and fisheries in Africa. The project is in line with, and will significantly drive the Comprehensive Africa Agriculture Development Programme (CAADP), the Science Technology, Innovation Strategy for Africa, and the Malawi Growth and Development Strategy.[40]

---

[34] The African Ministerial Conference on the Environment (AMCEN). Advancing the sustainable blue (ocean-based) economy in Africa. https://wedocs.unep.org/bitstream/handle/20.500.11822/30676/AMCEN_176.pdf?sequence=1&isAllowed=y

[35] African Union. Second Ordinary Session of the Specialized Technical Committee (STC) On Agriculture, Rural Development, Water and Environment (Ministers' Session). 05 - 06 October 2017. Addis Ababa, ETHIOPIA. STC2/ARDWE/MIN.

[36] African Union InterAfrican Bureau for Animal Resources (AU-IBAR). Animal Welfare Strategy for Africa. Executive Summary. http://repository.au-ibar.org/bitstream/handle/123456789/543/awsa_executive_summary_layout_eng.pdf?sequence=1&isAllowed=y

[37] UNEP. Resolution adopted by the United Nations Environment Assembly on 2 March 2022 5/4. Animal welfare–environment–sustainable development nexus. 7 March 2022. https://wedocs.unep.org/bitstream/handle/20.500.11822/39731/K2200707%20-%20UNEP-EA.5-Res.1%20-%20ADVANCE.pdf?sequence=1&isAllowed=y

[38] AU_IBAR. Animal Welfare, Environment & Sustainable Development Nexus Resolution Adopted during United Nations Environmental Assembly 5.2. 20 March 2022. https://www.au-ibar.org/au-ibar-news/animal-welfare-environment-sustainable-development-nexus-resolution-adopted-during

[39] The Fish Site. Africa to Establish Centers of Excellence for Fisheries & Aquaculture. 5 July 2016. https://thefishsite.com/articles/africa-to-establish-centers-of-excellence-for-fisheries-aquaculture

[40] ACE II Eastern and Southern Africa Higher Education Centers of Excellence Project. Centre of Excellence for Aquaculture and Fisheries Science (Aquafish). https://ace2.iucea.org/index.php/2018-01-22-22-04-02/aces-at-a-glance/aquafish

In 2005, the World Bank created a worldwide programme to promote and facilitate fisheries and aquaculture. The Africa Programme for Fisheries has focussed on sustainable fisheries, including improved governance of the sector.[41]

The FAO has various resources covering aquaculture. These include:

- The FAO's Environmental and Social Management Guidelines[42]. One of the guidelines' key objectives is to "Avoid agricultural, livestock, fisheries, aquaculture and forestry practices that could have adverse impacts on biodiversity, ecosystems, ecosystem services or critical habitats". A requirement is that: "Fisheries and aquaculture activities must follow the FAO Code of Conduct for Responsible Fisheries, the Ecosystem Approach to Fisheries (EAF), the Ecosystem Approach to Aquaculture (EAA) and the specific guidelines to support their implementation.

One way in which this requirement could be effectively implemented would be by making evidence of compliance a condition for fish or other aquacultural produce to be acceptable in trade; e.g., within the African Continental Free Trade Area (AfCFTA), or even within country trade in aquacultural produce. This would, of course, require the development of a traceability and certification framework. Compliance should also be required by investors and development partners.

- The FAO Code of Conduct for Responsible Fisheries[43], which provides principles and standards applicable to the conservation, management and development of all fisheries. It covers the capture, processing and trade of fish and fishery products, fishing operations, aquaculture, fisheries research and the integration of fisheries into coastal area management. The code has a section on aquaculture development which includes but is not limited to questions of environmental and social impacts, sustainability, type of species used/genetic diversity, disease, monitoring the impacts of inputs, and ensuring that local livelihoods and fisheries are not adversely affected.

However, this code appears deficient in the production stage [including stocking rates, feed quality and feeding, water quality, health services, breeding programmes, etc.] which, together with capture and transportation of live fish, is where animal welfare issues abound.

- The FAO handbook on "Ecosystem approach to aquaculture management"[44], which is a course designed for aquaculture departmental officers, economic development and environment staff, as well as related development agencies and planning staff, at either local, district, provincial or state levels who are responsible for administering or managing the aquaculture sector of their competence. It covers various issues of sustainability, including social and environmental aspects, and can be applied to any aquaculture system.

This handbook mentions animal health/health management in a number of places including in connection with the ASEAN Good Aquaculture practices (GAqP) programme and the OIE (now WOAH)'s aquatic animal health code. It does not specifically mention animal welfare, although WOAH's aquatic animal health code includes a chapter (Chapter 7) on the welfare of farmed fish.

Some African countries are promoting the development of aquaculture, as part of their Blue Economy programmes. One example is Operation Phakisa, which is an initiative of the South African government designed to fast track the implementation of solutions on critical development issues.

[41] World Bank. Africa Program for Fisheries. https://www.worldbank.org/en/programs/africa-program-for-fisheries

[42] FAO. Environmental and Social Management Guidelines. https://www.fao.org/3/i4413e/i4413e.pdf

[43] FAO. Code of Conduct for Responsible Fisheries. https://www.fao.org/3/v9878e/v9878e00.htm

[44] FAO. Ecosystem approach to aquaculture management. Handbook. https://www.fao.org/3/ca7972en/ca7972en.pdf

This includes aquaculture, together with yearly reviews of the "Oceans Economy Aquaculture Sector".[45]

In April 2022, there was a webinar on "African Aquaculture: Challenges and Opportunities", a recording of which is available online. This webinar explored "research, investment and development solutions to strengthen and scale local innovation and business environments in Africa's growing aquaculture sector". It includes an interesting presentation on One Health by Grant Stentiford, Leader, Healthy Seafood Theme, CEFAS.[46]

World Fish has received funding from the Bill and Melinda Gates Foundation. The Foundation is also supporting sustainable aquaculture projects in developing countries more broadly.[47]
Funders have an important role to play in ensuring that animal welfare issues are included as an integral component of sustainable aquaculture production and market access.

A 2022 University of Bonn, Center for Development Research (ZEF) report carried out a review of past performance to assess the future potential of aquaculture development in Africa. This spoke of the need for integration of aquaculture strategies and plans into national development plans, particularly into CAADP (AU-IBAR, 2014). In line with the Policy Framework and Reform Strategy for Fisheries and Aquaculture in Africa (PFRS), the Sustainable Aquaculture Research Networks in Sub-Saharan Africa (SARNISSA) reviewed national aquaculture policies of ten Sub-Saharan countries and made 22 recommendations aimed at better focused and more effective aquaculture policies. [48] This underscores the need for aquaculture policy reform, which should take account of animal health and welfare.

Manual Barange, Director Fisheries and Aquaculture Division of the FAO, provided an overview of the opportunities and challenges for aquaculture in Africa. He pointed out that Africa's aquaculture production is only 2.5% of world total (2016) – despite the fact that the continent is endowed with abundant land, water, human resources and conducive climate. Yet, 15.9% of world population lives in Africa (2016).[49] An important factor of relevance here is that fish is not a dietary staple for the majority of Africans. Fish as food has traditionally been important mainly to people living around lakes and the coastline, but this constitutes a small fraction of the African population. The rest have depended on other livestock and plant-based foods. Thus, this may be a question of consumption preferences, as well as a production issue.

The story of Kenya's aquaculture industry is an interesting and cautionary one. A host of public-led and non-profit organisations invest in Kenya's aquaculture sector (as well as private investors):

---

[45] Department for Forestry, Fisheries and the Environment. Operation Phakisa - Oceans Economy. https://www.dffe.gov.za/projectsprogrammes/operationphakisa/oceanseconomy#:~:text=Operation%20Phakisa%20focuses%20on%20unlocking,and%201%20million%20direct%20jobs.

[46] https://www.worldfishcenter.org/events/african-aquaculture-challenges-and-opportunities
World Fish. African Aquaculture: Challenges and Opportunities. 5 April 2022.

[47] Holland, Jason. Bill & Melinda Gates Foundation assisting sustainable aquaculture in developing markets. Seafood Source. 11 June 2021. https://www.seafoodsource.com/news/supply-trade/bill-melinda-gates-foundation-assisting-sustainable-aquaculture-in-developing-markets

[48] Hinrichsen, Etienne et al. (2022). Prospects for aquaculture development in Africa: A review of past performance to assess future potential. ZEF Working Paper Series, No. 211, University of Bonn, Center for Development Research (ZEF). https://nbn-resolving.de/urn:nbn:de:101:1-202202100155593583879 0 - https://www.econstor.eu/bitstream/10419/264364/1/1795486783.pdf

[49] Barange, Manuel, Director Fisheries and Aquaculture Division Food and Agriculture Organization of the UN. Aquaculture opportunities and challenges in Africa.
https://www.fao.org/fi/static-media/MeetingDocuments/SustainableBlueEconomy/FAO%20co-hosted%20side%20event%20on%20aquaculture/2.pdf

charities like Farm Africa (€4 million input subsidies, extension support and training, and market linkages), the Tony Elumelu Foundation (seed funding), the UK AID-funded Msingi project (feed, hatcheries, and production). The Government of Kenya, through the African Finance Corporation, provides various loans for fish production. IFAD's Aquaculture Business Development Programme is a significant investor, with a USD 143 million project aiming to expand Kenya's aquaculture sustainably between 2017 and 2026.[50]

Kenya imports more tonnage of fish than it exports, but the total value of fish exports is higher than that of imports. This is because Kenya imports low-value fish and exports high-value fish (mostly fish exports to the European Union). The export fish chain is only loosely connected to Kenya's domestic fish chains. Kenya's capture fishing for the local market, decreasing due to falling fish stocks, cannot satisfy domestic consumption. The falling fish stocks are squeezing fishers' livelihoods. At the same time, Kenya has a growing population where urbanites, in particular, eat more fish.[51] However, the media often warns people to be wary of "fish-pond produced fish", claiming that such fish contain unacceptable levels of drug residues. They also claim that unacceptable and harmful products are used to preserve the fish once captured.

Pond aquaculture gained popularity in Kenya the 1960s, after the government's "Eat More Fish" campaign. By 1970, over 30,000 ponds were dug in the Western and Nyanza regions of Kenya, but production later declined due to most farmers abandoning the ponds. Then, between 2009 and 2013, the government once again promoted pond aquaculture during its "Economic Stimulus Programme (ESP)" and the number of fish farmers increased to 49,050, with an estimated 69,000 fish ponds. However, by 2015 the number of operational ponds had reduced to approximately 60,000, due to poor water retention capacity by the ponds in some regions, among other factors.[52] Many forms of fish farming fail, for a multitude of reasons including poor business planning and management.[53] This is particularly true of pond systems, where aquaculture is seen as a low investment money-making scheme, without appreciation for the range of knowledge and management needed for success – and many ponds fail quickly, exacerbated by factors such as poor pond construction and lack of water flow.

Then from September 2020 until November 2022, 64 million fish were reported to have died in mass tilapia mortalities on the Kenyan side of Lake Victoria. The total financial loss was estimated to be more than 1.4 billion Kenyan shillings ($11.4 million). Whilst some farmers blamed industrial effluent and sewage discharges, the Kenya Marine and Fisheries Research Institute (KMFRI), suggested that the cause was upwelling – with water temperatures reaching 28°C, oxygen levels dropping below 3 mg/L and an increase in suspended sediments. They added that many of the affected farmers hadn't been following best aquaculture practices: some going way beyond the recommended stocking densities, using poor quality feed and prohibited antibiotics.[54]

These failures of aquaculture systems have caused investors and development partners to exercise greater caution in their support. A joint report by the European Commission and the French and

[50] Dekeyser, K., Obiero, T. W. 2021. AgrInvest-Food Systems Project – Increasing sustainable investments in the Kenyan cage aquaculture chain. Rome, FAO. 2021. https://doi.org/10.4060/cb6216en & https://www.fao.org/3/cb6216en/cb6216en.pdf

[51] Dekeyser, K., Obiero, T. W. 2021. AgrInvest-Food Systems Project – Increasing sustainable investments in the Kenyan cage aquaculture chain. Rome, FAO. 2021. https://doi.org/10.4060/cb6216en & https://www.fao.org/3/cb6216en/cb6216en.pdf

[52] Alando, Proscovia. The pros and cons of pond vs cage aquaculture in Kenya. The Fish Site. 25 May 2022. https://thefishsite.com/articles/the-pros-and-cons-of-pond-vs-cage-aquaculture-in-kenya

[53] Agri Farming. Common Mistakes Everybody Makes in Fish Farming. https://www.agrifarming.in/common-mistakes-everyone-makes-in-fish-farming

[54] Alando, Proscovia. Mass tilapia mortalities reported in Lake Victoria. The Fish Site. 22 November 2022. https://thefishsite.com/articles/mass-tilapia-mortalities-reported-in-lake-victoria

German development agencies on "Opportunities and challenges for aquaculture in developing countries"[55] included an examination of the risks which impact the viability of aquaculture systems under the following categories: environmental, climate change, resource use, genetic and biodiversity, biosecurity, food safety and social and ethical. The report pointed to the need for action at both business level (by value chain participants ensuring good project design) and at government level.

The lack of adequate policies, regulation and guidelines for the aquaculture sector is causing loss of investor and consumer confidence. In addition to the social and economic impacts of failed businesses, there are also clear human and animal health and welfare implications – including exposing people to unsafe inputs into the fish (at production and processing stages) and fish mortalities. Investors and development partners need to ensure that these governance issues are addressed, if they are to contribute to sustainable development rather than loss and damage. This work should include quality assurance programmes, and the necessary technical and extension services.

The French National Research Institute for Sustainable Development (IRD) network examined "Aquaculture: A key element to food security in Africa" in 2020. Their website resource underlines the need for Africa's aquaculture to grow in a sustainable way: "Aquaculture should not create a significant impact on the ecosystems. It must also be economically sustainable, socially responsible and contribute to the communities' well-being". It also suggests breeding different species in an integrated system which ensures more sustainable production through the recycling of nutrients and water and lower energy consumption due to reduced pumping costs: "For example, if a farmer produces seaweeds, they can be fed back into the system, as supplementary feeds and feed additives for other species".[56] However, where different aquatic animals are mixed, it is important that these are compatible otherwise animal health and welfare will be compromised (e.g., not mixing incompatible species, predators and prey animals, different age groups, solitary and social groups; or compelling solitary species to live in close association with each other in cages, etc.). Expert extension advice and high welfare standards are needed to ensure that production systems are sustainable and responsible.

As stated above, since 2000 aquaculture production in sub-Saharan Africa (SSA) has grown by 11% annually on average.[57] However, in his 2020 article "The Role of International Donors in Aquaculture Development in Africa" [58], Olufemi Julius Olapade stresses untapped potential for further growth, noting that in the face of increasing populations, Africa's per capita fish consumption has dropped to almost half of the global average. He cites sources identifying poor infrastructure, political instability, lack of needed R&D, poor market development, volatile prices of essential inputs, and unavailability of complete feeds and good-quality fingerlings for stocking as among the barriers to even greater growth.

Among efforts to expand the sector, Olapade references FAO's introduction of the Special Programme for Aquaculture Development in Africa (SPADA), aiming "to enhance aquaculture production, facilitate producers' access to financial services and markets, promote user-friendly regulatory frameworks, boost investment in aquaculture as well as exchange of knowledge". That programme's agenda, he

[55] European Commission, ADD, GIZ. Opportunities and challenges for aquaculture in developing countries. April 2017. https://europa.eu/capacity4dev/file/65255/download?token=ZDky6Mfb

[56] French National Research Institute for Sustainable Development (IRD). Aquaculture: A key element to food security in Africa. 26 October 2020. https://en.ird.fr/aquaculture-key-element-food-security-africa

[57] Ragasa, Catherine et al. Sustainable aquaculture development in sub-Saharan Africa. 2022. https://www.nature.com/articles/s43016-022-00467-1

[58] Olapade, O. The Role of International Donors in Aquaculture Development in Africa. 8 May 2020. DOI: 10.5772/intechopen.86569. https://www.intechopen.com/chapters/72071

asserts, is well aligned with the priorities set by The NEPAD Action Plan for the Development of African Fisheries and Aquaculture.

Too often, he writes, there had been "improper alignment of internationally funded projects to local needs and ecology, government bureaucracies, and misapplication of grants by beneficiaries". He cites "the rashness and hastiness of donors to achieve results not minding the sustainability factor and the expected long-term impact of the intervention" and that "significant portion of funds earmarked for project implementation in Africa are often spent to hire foreign experts who at times are not better than local experts who could be cheaply hired". According to Olapade, African governments have commonly deferred to international donors and development agencies that have emphasised, "promotion of technologies that require inputs (labour, feed, and fertilisers) that are probably not locally available and that are often prohibitive where they are available and beyond the means of the beneficiaries".

The African Development Bank paper on "The Potential of Green Aquaculture in Africa: Status and Prospects for Seaweed Farming"[59] examines seaweed culture as part of a series on different forms of green aquaculture to highlight its potential environmental, economic and social co-benefits. Green aquaculture offers advantages on several levels that are closely aligned to the Bank's strategy. Beyond feeding Africa, green aquaculture belongs to nature-based solutions that contribute to the industrialisation of the continent and represents local value addition with a negative carbon footprint. It thus has the potential to contribute to improving the living conditions of African people by providing them with livelihoods and long-term skills that increase their resilience, while restoring ecosystem services. However, to achieve this, it will need to be developed to produce foods which also appeal to the palate, overcoming any cultural or personal food biases. The note proposes recommendations to the Bank's regional member countries on how to best promote this promising sector.

Aquaculture and Animal Welfare

Historically, aquatic animals have been neglected in welfare advocacy and research. Their sentience is rarely recognised and their welfare is rarely taken into consideration. Now, for the first time, the FAO has issued high level guidelines that include aquatic animal welfare, which will influence the development of aquaculture for the next decade. "Recognising that developing aquaculture sustainably and equitably requires a holistic approach that values both human and animal health and welfare and further recognising that aquaculture activities should be conducted in a manner that assures the health and welfare of farmed aquatic animals, by optimising health through minimising stress, reducing aquatic animal disease risks and maintaining a healthy culture environment at all phases of the production cycle."[60]

The Global Seafood Alliance (GSA) stressed the importance of animal health and welfare in its article on "Animal Health and Welfare in Aquaculture"[61] within its Aquaculture 101 series. The animal welfare issues contained here include: water quality, stocking density, disease control, certification programmes and technology (such as drones for monitoring offshore fish farms and sensors to monitor underwater data). In the words of Dan Lee, the Standards Coordinator of GSA:

[59] African Development Bank. The Potential of Green Aquaculture in Africa: Status and Prospects for Seaweed Farming. 19 April 2022. https://www.afdb.org/en/documents/potential-green-aquaculture-africa-status-and-prospects-seaweed-farming

[60] Aquatic Life Institute. FAO Elevates Aquatic Animal Welfare. https://ali.fish/blog/fao-elevates-aquatic-animal-welfare

[61] Global Seafood Alliance. Animal Health and Welfare in Aquaculture. 26 June 2019. https://www.globalseafood.org/blog/animal-health-and-welfare-in-aquaculture/

"Throughout history, producers have learned about animal husbandry through direct observation, as with cows and pigs, etc. However, as aquatic animals live underwater, direct observation has not been possible until recently. New technology has allowed producers to get a better look into their animals' well-being, and in turn, take better care of them."

"These are sentient animals, there is a responsibility on the farmer to practice good husbandry and to keep the welfare of the animals in mind. Because we are farming them and responsible for their whole life cycle, we have a responsibility there. We count animal welfare as critical to delivering responsibly produced, modern products."

There is a growing body of evidence that many aquatic species live far more complex social and emotional lives than previously understood. Fish and decapods (e.g., shrimp) display hallmarks of the ability to experience pain. Similarly, work in various species of fish has revealed complex cognitive abilities, including tool use, individual personalities, and strong preferences about the environments in which they live. Recent work with aquatic invertebrates is also uncovering unexpected abilities. In addition to the remarkable and diverse mental capabilities of cephalopods, studies have found complex maze learning in shore crabs, sophisticated navigation in spiny lobsters, and emotional behaviour in crayfish. Many of the species involved in aquaculture—including finfish and tetrapods, decapod crustaceans, and cephalopods - are now recognised as having the behavioural, cognitive, and affective abilities that meet widely accepted criteria for moral consideration and welfare protection.[62]

According to Becca Franks et al, writing in Science Advances: "In 2018, FAO reported 82.12 million metric tons of farmed aquatic animals from six phyla and at least 408 species - 20 times the number of species of farmed terrestrial animals. The farmed aquatic animal tonnage represents 250 to 408 billion individuals, of which 59 to 129 billion are vertebrates (e.g., carps, salmonids). Specialised welfare information was available for 84 species, only 30% of individuals; the remaining 70% either had no welfare publications or were of an unknown species. With aquaculture growth outpacing welfare knowledge, immediate efforts are needed to safeguard the welfare of high-production, understudied species and to create policies that minimise welfare risks."[63]

The unprecedented growth of aquaculture involves well-documented environmental and public-health costs, but less is understood about global animal welfare risks. A 2021 study on "Animal welfare risks of global aquaculture" assessed for the first time the overall global scope and nature of the aquaculture welfare risk - the range of species used, the total number of individuals involved, and the state of the knowledge regarding their welfare. Animal welfare issues in aquaculture are also attracting increased attention, with ongoing estimates suggesting that the number of individual animals killed each year is likely greater than the approximately 70 billion individuals involved in terrestrial animal agriculture.[64]

A FAO report on "Welfare of Fishes in Aquaculture"[65] prepared by the European Inland Fisheries and Aquaculture Advisory Commission (EIFAAC) includes useful findings concerning the welfare of fishes in aquaculture. The project leading to this report was initiated by the European Commission because

[62] Franks, Becca et al. Animal welfare risks of global aquaculture. Science Advances. 2 April 2021. https://www.science.org/doi/10.1126/sciadv.abg0677

[63] Franks, Becca et al. Animal welfare risks of global aquaculture. Science Advances. 2 April 2021. https://www.science.org/doi/10.1126/sciadv.abg0677

[64] Franks, Becca et al. Animal welfare risks of global aquaculture. Science Advances. 2 April 2021. https://www.science.org/doi/10.1126/sciadv.abg0677

[65] Segner, H., Reiser, S., Ruane, N., Rösch, R., Steinhagen, D. and Vehanen, T. 2019. Welfare of fishes in aquaculture. FAO Fisheries and Aquaculture Circular No. 1189. Budapest, FAO. https://www.fao.org/3/ca5621en/ca5621en.pdf

welfare in animal husbandry is of increasing public concern and of increasing importance, and a growing concern for fish farmers. The report deals with the welfare of farmed finfish and does not address capture fisheries, be they commercial or recreational, or welfare issues related to the culture of crustaceans and molluscs. The report focuses on the welfare issues of ongrowing fish while giving little to no attention to larvae/fry and brood stock. Likewise, the report focuses primarily on the culture conditions for farming of fish and gives little attention to welfare aspects related to transport and slaughter. Finally, emphasis is given to the culture of freshwater fish, but marine species are included where appropriate. It is understood that the principal welfare issues are comparable for freshwater and marine fish culture. The report is generic, not focusing on species-specific issues (except where absolutely necessary). It was produced using European expertise, but many parts will be widely applicable.

The introduction of this report explains the importance of the welfare of farmed fish in these words: "The increasing importance of fish welfare in aquaculture comes from ethical considerations as well as from the perspective of improving standards and quality of fish production technologies and aquaculture products. The welfare status of the fish has direct implications for their production and for the sustainability of the industry as a whole. Fish kept under good welfare conditions are less stressed and less susceptible to diseases and therefore they require less medication and treatment, show better growth rates and food conversion and ultimately provide a better-quality product. Finally, the economic benefits are obvious. In addition, consumers care about welfare issues potentially associated with intensive production practices, and they expect from the fish farmers that the welfare of farmed fish is addressed." Its contents cover welfare concepts, processes and factors that can be critical for fish welfare (including staff, fish, husbandry, handling and transport; slaughter; disease and prophylaxis; and assessment and monitoring of fish welfare.[66]

The World Organisation for Animal Health (WOAH) has published an Aquatic Animal Health Code that should be respected by producers in each of its 182 Member States. That includes, as Section 7[67]:

WELFARE OF FARMED FISH	
Chapter 7.1.	Introduction to recommendations for the welfare of farmed fish
Chapter 7.2.	Welfare of farmed fish during transport
Chapter 7.3.	Welfare aspects of stunning and killing of farmed fish for human consumption
Chapter 7.4.	Killing of farmed fish for disease control purposes

African governments should now implement these agreed fish welfare standards throughout the industry, and include them in all relevant trade agreements.

More comprehensive recommendations and guidelines have been published elsewhere, particularly in Europe. In July 2022, Eurogroup for Animals issued On-Farm Welfare Standards in Aquaculture[68]. These include recommendations based on science and existing guidelines that should be implemented as legal standards. The publication states that:

[66] Segner, H., Reiser, S., Ruane, N., Rösch, R., Steinhagen, D. and Vehanen, T. 2019. Welfare of fishes in aquaculture. FAO Fisheries and Aquaculture Circular No. 1189. Budapest, FAO. https://www.fao.org/3/ca5621en/ca5621en.pdf

[67] World Organisation for Animal Health. Welfare of Farmed Fish. https://www.woah.org/en/what-we-do/standards/codes-and-manuals/aquatic-code-online-access/

[68] Eurogroup for Animals. On-farm Welfare Standards in Aquaculture. https://www.eurogroupforanimals.org/files/eurogroupforanimals/2022-07/NALB%20Annex%20-%20On-farm%20Welfare%20Standards%20in%20Aquaculture_1.pdf

"Most of the numbered recommendations in this document are amalgamations and adaptations of provisions from these four standards:

- Council of Europe. (2005) Recommendation concerning farmed fish. Standing Committee of the European Convention for the Protection of Animals Kept for Farming Purposes.
- Government of Norway. (2008) Regulations on the operation of aquaculture facilities. Ministry of Trade and Industry.
- EU Platform on Animal Welfare. (2020) Guidelines on Water Quality and Handling for the Welfare of Farmed Vertebrate Fish. EU Platform on Animal Welfare Voluntary Initiative on Fish Welfare.
- World Organisation for Animal Health. (2021) Aquatic Animal Health Code".

World Animal Protection produced a course module on "Welfare of Farmed Fish and Aquatic Invertebrates"[69] which outlines the welfare concerns in farmed fish, and describes how to assess fish welfare. This includes emerging welfare concerns for invertebrates which are farmed for human consumption such as crabs, lobsters, prawns and molluscs.

The Humane Society of the United States (HSUS) prepared a report on "The Welfare of Animals in the Aquaculture Industry". This refers to the situation in the United States, but many of its observations and findings are globally relevant. In addition to the key determinants of animal welfare in aquaculture systems, the report covers pain, perception and consciousness; observable indices of welfare; and a "Five Freedoms" adapted for fish. The latter is a simple, but useful overview of major fish welfare considerations.[70]

The Shrimp Welfare Report[71], produced by the Shrimp Welfare Project, examines the factors affecting shrimp welfare in aquaculture. This is a welcomed resource, because little research had previously been carried out to assess which factors most affect shrimp welfare. The report includes welfare concerns in the following areas: eyestalk ablation; disease; stocking density; water quality (including sufficient dissolved oxygen, un-ionised ammonia, pH levels, temperature, salinity); environmental enrichment; food; transport and handling; stunning and slaughter.

Fish culture involves a huge number of species, with each species and its respective life stages having different welfare requirements. Ideally, welfare measures are based on the understanding of the needs of the various species, but the understanding of their welfare-relevant biology is indeed very limited.[72] This is clearly an area where further research and reporting is needed.

Major Environmental and Health Impacts

[69] World Animal Protection. Module 24: Welfare of Farmed Fish and Aquatic Invertebrates (Fish Welfare Part 2) Lecture Notes. https://www.worldanimalprotection.org/sites/default/files/media/M24_LN_Farmed_Fish_Aquatic_Invertebrates_FW_P2.pdf

[70] The Humane Society of the United States. An HSUS Report: The Welfare of Animals in the Aquaculture Industry. https://www.humanesociety.org/sites/default/files/docs/hsus-report-animal-welfare-aquaculture-industry.pdf

[71] Shrimp Welfare Project. Shrimp Welfare Report. Factors Affecting Shrimp Welfare in Aquaculture. https://www.shrimpwelfareproject.org/shrimp-welfare-report

[72] Segner, H., Reiser, S., Ruane, N., Rösch, R., Steinhagen, D. and Vehanen, T. 2019. Welfare of fishes in aquaculture. FAO Fisheries and Aquaculture Circular No. 1189. Budapest, FAO. https://www.fao.org/3/ca5621en/ca5621en.pdf

Aquaculture is promoted to satisfy the increasing demand for animal protein due to the limitations of capture fisheries production. The industry is rapidly expanding around the world, in some places and for certain species, at the expense of the natural environment.[73] Indeed, aquaculture has been found to have significant impacts on the environment and natural resources[74], including contributing to global warming.[75] Furthermore, aquaculture has been over-reliant on wild caught fish as feed (fish meal and fish oil), taking food away from marine predators and impacting ecosystems and sustainability.[76]

Climate Change

With regard to aquaculture's climate change impacts, the FAO cited estimates that 385 million tonnes of CO2 equivalent were emitted in 2010, around seven percent of the emissions from agriculture.[77] Against these figures, consideration also needs to be given to the fact that fish compose a small amount of global protein intake (6.7%), which includes both fisheries and aquaculture.[78]

Conversely, phytoplankton are the main reason the ocean is one of the biggest carbon sinks. These microscopic marine algae and bacteria play a huge role in the world's carbon cycle – absorbing about as much carbon as all the plants and trees on land combined.[79]

A 2020 paper on "Climate Change and Harmful Algal Blooms: Insights and perspective" stressed that climate change is transforming aquatic ecosystems. Coastal waters have experienced progressive warming, acidification, and deoxygenation that will intensify this century. At the same time, there is a scientific consensus that fishery, aquaculture and ecosystem' impacts from harmful algal blooms have increased over the past several decades. The paper also mentions that this can lead to the contamination of seafood, potentially sickening people.[80]

Harmful algal blooms occur in aquaculture areas worldwide, and their influences on production vary widely depending on species-specific effects. Intensive and poorly managed finfish and crustacean systems can contribute to the emergence of harmful algal blooms, and shellfish, sea urchins, and sea cucumbers are common vectors for toxic microalgae. Harmful algal blooms are increasing globally

[73] World Bank. FISH TO 2030 Prospects for Fisheries and Aquaculture WORLD BANK REPORT NUMBER 83177-GLB. December 2013. http://www.fao.org/docrep/019/i3640e/i3640e.pdf

[74] Boyd, Claude and McNevin, Aaron. Aquaculture, Resource Use, and the Environment. ISBN: 978-0-470-95919-0. Wiley-Blackwell. February 2015.

[75] Shannon, Lynne and Waller, Lauren. A Cursory Look at the Fishmeal/Oil Industry from an Ecosystem Perspective. Frontiers in Ecology and Evolution. 22 April 2021. https://www.frontiersin.org/articles/10.3389/fevo.2021.645023/full

[76] Shannon, Lynne and Waller, Lauren. A Cursory Look at the Fishmeal/Oil Industry from an Ecosystem Perspective. Frontiers in Ecology and Evolution. 22 April 2021. https://www.frontiersin.org/articles/10.3389/fevo.2021.645023/full

[77] FAO. Impacts of climate change on fisheries and aquaculture. Synthesis of current knowledge, adaptation and mitigation options. FAO Fisheries and Aquaculture Technical Paper 627. 2018. http://www.fao.org/3/i9705en/I9705EN.pdf

[78] Sustainable Fisheries. What Does the World Eat? https://sustainablefisheries-uw.org/seafood-101/what-does-the-world-eat/

[79] Lisbdnet.com When an Animal or Plant Dies, Where Does the Carbon Go?? 24 November 2021. https://lisbdnet.com/when-an-animal-or-plant-dies-where-does-the-carbon-go/

[80] Gobler, Christopher J. Climate Change and Harmful Algal Blooms: Insights and perspective. January 2020. https://doi.org/10.1016/j.hal.2019.101731. https://www.sciencedirect.com/science/article/pii/S1568988319302045.

with respect to frequency, magnitude, duration, geographical ranges, and species composition, and are driven largely by anthropogenic processes.[81]

The growth of algae in sea cages can cause stress and disease among the captive fish. In the wild, they would be able to avoid the algae, but because they are confined and at high stocking densities, they cannot do this.[82]

Seaweed (which includes countless species of marine plants and algae), which is being promoted as a superfood, is a massive carbon sink which could absorb as much carbon as the Amazon.[83] Seaweed is even being developed into an alternative for plastic – with one of the winners of the 2022 Earthshot prize being a UK start-up company which is using seaweed for biodegradable packaging.[84]

A team of researchers from UC Santa Barbara, in a study in the journal Marine Policy[85] have argued that seaweed aquaculture could reduce the size and number of anthropogenic "dead zones" in the oceans, by absorbing the excess nitrogen and phosphorous in the water that cause these zones to appear. Cultivated seaweed has the potential to draw down available nutrients, the authors claim, limiting the resources for unchecked growth of nuisance algae and microbes. Seaweeds also produce oxygen, which could alleviate the development of new hypoxic dead zones.[86]

Climate change will increasingly impact marine ecosystems, fisheries and aquaculture alike. The FAO's Fisheries and Aquaculture Technical Paper on the impacts of climate change on fisheries and aquaculture documents a disturbing array of the impacts, and an even more disturbing picture of potential future trends. Short-term climate change impacts on aquaculture can include losses of production and infrastructure arising from extreme events such as floods, increased risks of diseases and parasites, as well as harmful algal blooms. Long-term impacts can include reduced incomes and food security; and conflicts from issues such as reduced precipitation leading to increasing competition for freshwater. A key message is that small-scale fishers and fish farmers are especially vulnerable to climate change because of both their geographical locations and their economic status.[87]

Research modelling the effect of climate change on chlorophyll production, ocean temperature and acidification found that most coastal countries should expect their areas suitable for aquaculture

[81] Naylor, Rosamond L. et al. A 20-year retrospective review of global aquaculture. 24 March 2021. https://www.nature.com/articles/s41586-021-03308-6

[82] World Animal Protection. Module 24: Welfare of Farmed Fish and Aquatic Invertebrates (Fish Welfare Part 2) Lecture Notes. https://www.worldanimalprotection.org/sites/default/files/media/M24_LN_Farmed_Fish_Aquatic_Invertebrates_FW_P2.pdf

[83] Sherriff, Lucy. The seaweed superfood revolution could end world hunger—and save the planet. Forbes. 7 November 2022. https://fortune-com.cdn.ampproject.org/c/s/fortune.com/2022/11/07/the-seaweed-superfood-revolution-could-end-world-hunger-and-save-the-planet/amp/

[84] The Earthshot Prize. 6.3bn Tonnes of Untreated Plastic Waste Currently Litter our Seas. Notpla shows that the Future is not Plastic, it's Seaweed. https://earthshotprize.org/winners-finalists/notpla/

[85] Racine, Phoebe et al. A case for seaweed aquaculture inclusion in U.S. nutrient pollution management. Science Direct. July 2021. https://www.sciencedirect.com/science/article/pii/S0308597X21001172?via%3Dihub

[86] The Fish Site. How seaweed aquaculture can tackle oceanic dead zones. 29 April 2021. https://thefishsite.com/articles/how-seaweed-aquaculture-can-tackle-oceanic-dead-zones

[87] FAO. Impacts of climate change on fisheries and aquaculture. Synthesis of current knowledge, adaptation and mitigation options. FAO Fisheries and Aquaculture Technical Paper 627. 2018. http://www.fao.org/3/i9705en/I9705EN.pdf & https://www.fao.org/policy-support/tools-and-publications/resources-details/en/c/1152846/

production to decline.[88] For growing bivalves that is anticipated to shrink by about 10% worldwide in the next 50 years. While suitable area for finfish aquaculture is likely to expand overall globally, that would be primarily in polar and subpolar regions. Some northern countries, such as Russia, Norway and Denmark are likely to have suitable areas expand, while for the great majority of nations it will contract. In South Africa, for example, "The aquaculture industry is likely to be negatively impacted by temperature change, increased harmful algal blooms (HABs) and ocean acidification. Sea-level rise and increasing extreme events pose increasing risks to infrastructure".[89]

In the case of Kenya: "the most important climate hazard impacting aquaculture in Kenya is drought. It is estimated that about 40% of the potential growth of the subsector is lost due to the direct and indirect impacts of climate change. However, only a handful of farmers have opted for adaptation measures mainly because they are considered expensive".[90] There have been attempts to cope through turning to caged-fish aquaculture, in Lake Victoria, for example. However, as was covered above, this led to massive deaths of fish from suffocation due to upwelling, or the receding water due to climate change. Guidelines on the placement of cages exist, but generally, poor enforcement and poor compliance by farmers leave fish in the poorly located cages exposed to inadequate oxygenation when water levels fall, as well as the vagaries of pollution from inland activities.

A 2022 report co-authored by Brian Helmuth, professor of marine and environmental science at Northeastern University recorded the findings of an investigation into the impacts of COVID-19 on fish farming. It concluded that more than 80% of the 585 fish farms surveyed worldwide reported that the economic losses from human-caused issues such as climate change, pollution, and flooding far outweigh losses from supply-chain hiccups or a loss in buyers caused by the pandemic. The investigation considered the devastating impact global warming is already having on oceans, lakes, and rivers across the planet, and Helmuth recommended that: "These businesses have to build resilience to these events in their planning, because it's only going to get worse over time". More ecologically-sustainable approaches were found to be more resilient, in part because one of the stoppages in the supply chain was getting food to feed the things you're trying to grow. One suggestion was multi-trophic aquaculture – integrated systems such as seaweed, algae and molluscs along with tilapia.[91] However, given the slow transition of the aquaculture industry to sustainability, and doubts over the effectiveness of regulatory systems, it may be cautious for authorities and investors to rather support green aquaculture, such as seaweed farming.[92] Any such transitions will need to be carefully planned and managed given an African community whose majority does not regard seaweed, algae and molluscs as food. For example, change could be anchored on a vibrant export market, hoping to convert the income to other commodities that address food insecurity; whilst undertaking longer-term measures needed to decrease cultural resistance to green aquaculture products.

---

[88] Froehlich, H.E., Gentry, R.R. & Halpern, B.S. Global change in marine aquaculture production potential under climate change. *Nat Ecol Evol* **2,** 1745–1750 (2018). https://doi.org/10.1038/s41559-018-0669-1

[89] Augustyn, Johann et al. Climate Change Impacts on Fisheries and Aquaculture: A Global Analysis. Chapter 15: South Africa. Book Editor(s): Phillips, Bruce F and Pérez-Ramírez, Mónica. First published: 20 September 2017. https://doi.org/10.1002/9781119154051.ch15 & https://onlinelibrary.wiley.com/doi/10.1002/9781119154051.ch15

[90] Adekola, Olalekan et al. Status and Outlook for Climate Resilient Aquaculture in Kenya: Stakeholders Perspectives. Case Studies in the Environment (2022) 6 (1): 1544759. 27 April 2022. https://doi.org/10.1525/cse.2022.1544759 & https://online.ucpress.edu/cse/article-abstract/6/1/1544759/164784/Status-and-Outlook-for-Climate-Resilient

[91] Chabot, Hillary. COVID-19 Changed Fish Farming, but not as Much as Climate Change. News @Northeastern. 13 January 2022. https://news.northeastern.edu/2022/01/13/covid-impact-fish-farms/

[92] African Development Bank. The Potential of Green Aquaculture in Africa: Status and Prospects for Seaweed Farming. 19 April 2022. https://www.afdb.org/en/documents/potential-green-aquaculture-africa-status-and-prospects-seaweed-farming

Pollution

Aquaculture is a key contributor – along with livestock and crop production - to the degradation of ocean and marine environments and water quality. Increasingly intensive production is combined with greater use of antibiotics, pesticides, fungicides and anti-fouling agents to keep diseases at bay, which in turn contribute to polluting downstream ecosystems.[93] The routine use of antimicrobials in industrial livestock and aquaculture systems causes dangerous wastes and residues, which can affect other marine life and human health, as they lead to deadly antimicrobial resistance.[94]

The demand for antimicrobials in animal production systems is a strong indicator of poor animal welfare practices. As a component to cope with this type of pollution, animal welfare needs to be mainstreamed in the production systems. So long as technological interventions such as antimicrobials are applied to compensate for poor animal welfare, pollution and threats to public health are inevitable.

Nutrient build up happens when there is a high density of fish in one area. Fish produce waste, and their waste has the potential to build up in the surrounding area. This can deplete the water of oxygen, creating algal blooms and dead zones.[95]

The most common methods of aquaculture include open net pens anchored to the bottom in coastal waters, offshore cages in deeper waters, recirculating aquaculture systems (RAS) built on land, raceways also known as "flow-through" systems either inside or outside, and polyculture that may co-cultivate finfish, shellfish, and marine plants.[96] Fish waste, chemicals and left-over food spill out from nets and tanks into the ocean, causing nutrient pollution, eutrophication and hypoxia which can stress or kill aquatic creatures. [97]

Aquaculture is predicted to continue increasing production by intensifying existing aquaculture practices, increasing the number and type of farms, and exploring other environments. As regards inland aquaculture, high levels of nutrients in effluent discharge to channels, rivers, or lakes.[98]

An August 2020 study[99] modelled the bioeconomic interrelations between a commercial fishery and an aquaculture industry. This showed that:

- Aquaculture influences fisheries through ecological and market mechanisms.
- Accumulated pollution from aquaculture may cause biological growth-retardation in a wild fish stock.

---

[93] FAO. Water pollution from agriculture: a global review. 2017. https://www.fao.org/3/i7754e/i7754e.pdf

[94] UNEP. Global Environment Outlook (GEO) 6. 2019. https://www.unep.org/resources/global-environment-outlook-6

[95] Global Seafood Alliance. What Is the Environmental Impact of Aquaculture? 22 April 2019. Bit positive! https://www.globalseafood.org/blog/what-is-the-environmental-impact-of-aquaculture/

[96] Today's Farmed Fish. Common Methods. https://www.todaysfarmedfish.org/common-farming-methods

[97] Scottish Government. Review and Synthesis of the Environmental Impacts of Aquaculture 2002). https://www.researchgate.net/profile/Kenneth-Black/publication/230792025_Review_and_Synthesis_of_the_Environmental_Impacts_of_Aquaculture/links/00b7d5195e29fd9535000000/Review-and-Synthesis-of-the-Environmental-Impacts-of-Aquaculture.pdf

[98] White, Patrick. 2017. Aquaculture Pollution: An Overview of Issues with a Focus on China, Vietnam, and the Philippines. World Bank, Washington, DC. https://openknowledge.worldbank.org/handle/10986/29249

[99] Berglan, Harald et al. Aquaculture, pollution and fishery - dynamics of marine industrial interactions. Science Direct. Ecological Complexity. Vol 43. August 2020. https://doi.org/10.1016/j.ecocom.2020.100853

- When the growth-retardation parameter exceeds certain threshold levels the fishery effort and the biomass are wiped out.

The West African Development Bank (BOAD) Operational Guidelines on Fisheries[100] includes information on potential environmental impacts of aquaculture, such as that from spillover from pond systems, as well as guidelines for better practices.

Biodiversity Loss

The pollution from aquaculture outlined above detrimentally impacts ocean and marine biodiversity, including aquatic life.

Leached nutrients and chemicals impact the biodiversity on the ocean floor when they sink, and lead to increased occurrences of algal blooms, and make algae even more poisonous.[101] Algal blooms can reduce the ability of fish and other aquatic life to find food and can cause entire populations to leave an area or even die. These algal blooms also create toxins that are detrimental to fish and other animals. After being consumed by small fish and shellfish, these toxins move up the food chain and can impact larger animals like sea lions, turtles, dolphins, birds and manatees. Even if algal blooms are not toxic, they can negatively impact aquatic life by blocking out sunlight and clogging fish gills. Nutrient pollution can also create dead zones - areas in water with little or no oxygen - where aquatic life cannot survive.[102]

When fish are crowded together in nets or pens, they are susceptible to stress, fostering disease and parasites that are then spread to wild species.[103]

GEO 6[104] stated that three of the (seven) direct drivers of pressures to the marine environment are agriculture, capture fisheries and aquaculture. It also made a number of observations relevant to biodiversity, including (summarised):

- Overexploitation of wild fish stocks and intensive aquaculture have detrimental effects on marine and terrestrial ecosystems.
- Aquaculture as one of the primary pressures on ocean biodiversity.
- Capture fisheries – industrial uses include feed for aquaculture.
- The rise of aquaculture can reduce pressures of exploitation for some wild species, but can also lead to invasive species, inter-species breeding, eutrophication and disease spread.

The FAO's Livestock's Long Shadow report also dealt with the important contribution of the livestock industry to the overexploitation of wild-caught fish for the production of fishmeal for livestock feed.

---

[100] BOAD. Operational Guidelines of BOAD: Fisheries. https://www.boad.org/wp-content/uploads/upload/ethique/eg_18_fisheries_eng.pdf

[101] Scottish Government. Review and Synthesis of the Environmental Impacts of Aquaculture 2002). https://www.researchgate.net/profile/Kenneth-Black/publication/230792025_Review_and_Synthesis_of_the_Environmental_Impacts_of_Aquaculture/links/00b7d5195e29fd9535000000/Review-and-Synthesis-of-the-Environmental-Impacts-of-Aquaculture.pdf

[102] The US Environment Protection Agency. Nutrient Pollution. The Effects: Environment. https://www.epa.gov/nutrientpollution/effects-environment#:~:text=Algal%20blooms%20can%20reduce%20the,recreation%2C%20businesses%20and%20property%20values

[103] Cho, Renee. Colombia Climate School. Making Fish Farming More Sustainable. 13 April 2016. https://news.climate.columbia.edu/2016/04/13/making-fish-farming-more-sustainable/

[104] UNEP. Global Environment Outlook (GEO) 6. 2019. https://www.unep.org/resources/global-environment-outlook-6 & UNEP. Global Environment Outlook 6 Summary for Policymakers. 6 August.

The world's ocean fish face serious threats to their biodiversity. The principal source of pressure is overexploitation by fisheries, which have affected the size and viability of fish populations. [105] Fishmeal and fish oil are also used in aquaculture systems, adding to the pressures on wild fish stocks.[106] Whilst replacement feeds are being explored, as was covered above, these can also bring their own environmental and/or animal health and welfare impacts.

Farmers' usage of antibiotics to prevent disease creates concern about the effect of the drugs on the ecosystem around the cages, including wild fish.[107] Another concern is that the escape of non-native fish cause wild fish to compete for food, potentially displacing the native fish. [108] Escaped farmed fish also breed with wild species and affecting the population's overall genetic diversity.[109]

Similar to other land-based production, the expansion of land-based aquaculture has resulted in substantial environmental externalities that affect water, soil, biodiversity and climate, and which compromise the ability of the environment to produce food.[110]

Aquaculture Alternatives

There are now an ever-increasing number of corporate start-ups world-wide that are developing cell-based (cultured) fish, and plant-based fish alternatives are already on the shelves.[111] Seafood alternatives come in a variety of types from plant-based products (such as tuna made from tomatoes and eel made from eggplant), to products made through microbial fermentation to provide the taste and texture of traditional seafood (for example, animal-free sea bass, cod, tuna, popcorn shrimp, and calamari) through to cell-cultured seafood.[112]

Cultured or cellular seafood, which proliferates the cells of aquatic animals in bioreactors, could largely avoid detrimental environmental and animal welfare impacts of industrial aquaculture, particularly once it is powered by renewable energy.[113] An April 2022 paper on "Alternative Seafood and Its Contribution to Food Systems"[114] examined the potential contributions of seafood alternatives

[105] FAO. Livestock's Long Shadow: Environmental Issues and Options. Chapter 5. Livestock's impact on biodiversity. 2006. https://www.fao.org/3/a0701e/a0701e.pdf

[106] WWF. Fishmeal and fish oil. https://www.worldwildlife.org/industries/fishmeal-and-fish-oil#:~:text=Fishmeal%20and%20oil%20are%20easily,a%20growing%20market%20for%20fisheries.

[107] Global Seafood Alliance. What Is the Environmental Impact of Aquaculture? 22 April 2019. Bit positive! https://www.globalseafood.org/blog/what-is-the-environmental-impact-of-aquaculture/

[108] Global Seafood Alliance. What Is the Environmental Impact of Aquaculture? 22 April 2019. Bit positive! https://www.globalseafood.org/blog/what-is-the-environmental-impact-of-aquaculture/

[109] Cho, Renee. Colombia Climate School. Making Fish Farming More Sustainable. 13 April 2016. https://news.climate.columbia.edu/2016/04/13/making-fish-farming-more-sustainable/

[110] Faunalytics. Global Fishing & Food Security. 22 April 2022. https://faunalytics.org/global-fishing-food-security/ and https://doi.org/10.1038/s41586-020-2616-y

[111] Richens, James et al. A Sustainable Ocean Economy in 2030. World Ocean Initiative. 2020. https://cdn.vev.design/private/Y00jvgKIBvZ1anyDSJNPOAQcI082/_jLT9hiqu_A_sustainable_ocean_economy_in_2030_%20copy.pdf.pdf

[112] Scott Livingston, Anne. The Vast Growth Potential of Seafood Alternatives. Euromonitor International. 29 November 2021. https://www.euromonitor.com/article/the-vast-growth-potential-of-seafood-alternatives

[113] Rubio, Nathalie et al. Cell-Based Fish: A Novel Approach to Seafood Production and an Opportunity for Cellular Agriculture. Frontiers in Sustainable Food Systems. June 2019. https://doi.org/10.3389/fsufs.2019.00043 & https://www.frontiersin.org/articles/10.3389/fsufs.2019.00043/full

[114] Marwaha, Nisha et al. Fad, Food, or Feed: Alternative Seafood and Its Contribution to Food Systems. Perspective article. Front. Sustain. Food Syst., 4 April 2022. https://doi.org/10.3389/fsufs.2022.750253 & https://www.frontiersin.org/articles/10.3389/fsufs.2022.750253/full

including plant-based, fermentation-derived and cell-based (cultured) products that mimic the taste, texture, appearance and nutritional properties of conventional seafood. The paper explains the production processes, and analyses their uptake and potential impacts. The conclusion is that, initially, the impacts will be largely concentrated in high income countries. As the demand for seafood alternatives grows, this may also lessen demand for traditional seafood products in ways that reduce pressure on seafood resources for local food security, as well as bringing positive environmental impacts.

A recent Good Food Institute "State of Global Policy Report"[115] stated that "While the alternative protein sector has received attention across many Middle Eastern and North African countries (one recent study found high demand and consumer acceptance of plant-based meat in Egypt), wealthy countries with strong R&D capabilities are currently leading government support in the region". It identified, through the end of 2021, public alternative protein R&D funding totalling approximately $360 million, with Israel, Singapore, Canada, Denmark, China and the United States among those dedicating significant funds to the sector and planning for more. It is important that Africa does not lag behind in the development and marketing of these potentially lucrative products of the future.

The development and introduction of seafood alternatives will have impacts that need to be carefully assessed in relation to both choice of sustainable and low impact products and "just transitions" for change. Impacts should be assessed across the full range of social, environmental and animal and human health and welfare criteria. Especially worth encouragement would be integrated production and distribution systems, providing local consumers what appeals to them, and exporting the rest to those elsewhere who appreciate the product, and thus acquiring foreign exchange and wealth for Africa. However, over the longer-term dietary change is also possible, particularly through sustained promotion and marketing campaigns, coupled with education and awareness of environmental and animal welfare impacts.

in September 2022, Seas at Risk, an association of 20 European environmental organisations with EU funding support, published a 36-page analysis titled, "Reducing the aquatic foodprint: Could algae and cell-cultured fish be low-impact alternatives to our current aquatic food system?"[116] This concluded that, "Given the growing urgency to reduce emissions, ensure food security, and protect global health, governments around the world have obligations and opportunities to support their alternative protein sectors with direct funding for research, private sector incentives for R&D and manufacturing, and a clear and fair regulatory regime".

Future Considerations

This report shows the importance of including fish welfare in aquaculture policy, development and capacity building.

It is particularly important to include more on fish welfare in the work of inter-governmental, governmental and development institutions – most urgently: AU-IBAR, NEPAD-AUDA, FAO, IFAD, AfDB, AfCFTA, the Centres of Excellence for Aquaculture (beginning with the Centre of Excellence for Aquaculture and Fisheries Science (Aquafish) in Lilongwe, Malawi) and the Sustainable Aquaculture Research Networks in Sub-Saharan Africa (SARNISSA).

[115] Good Food Institute. 2021 State of Global Policy Report with highlights from the first half of 2022. https://gfi.org/wp-content/uploads/2022/10/POL22005_State-of-Global-Policy-Report.pdf

[116] Seas at Risk. Reducing the aquatic foodprint: Could algae and cell-cultured fish be low-impact alternatives to our current aquatic food system? September 2022. https://seas-at-risk.org/wp-content/uploads/2022/10/Aquatic-foodprint-Final-.pdf

There is also a real need to keep building sustainability – environmental and social – into aquaculture policy and development. This would include the need to diversify Africa's aquaculture industry, including greater emphasis on green aquaculture, and specifically algae farming.

There is also an economic, environmental and health imperative to develop Africa's role in the development and marketing of alternative plant-based and cultured seafood products.

Where animal aquaculture is still being carried out, this should be developed in ways which ensure sustainability, including moving from single-species culture to multi-trophic aquaculture – integrated systems such as seaweed, algae and molluscs along with tilapia – and greater environmental enrichment, building supportive ecosystems which also improve animal welfare and sustainability.

However, given the slow transition of the aquaculture industry to sustainability, and doubts over the effectiveness of regulatory systems, it may be cautious for authorities and investors to rather support green aquaculture, such as algae farming.

African governments need to support research into what is needed to ensure the development of sustainable aquaculture systems which minimise social, environmental and human and animal health and welfare risks. They should also invest for the future by supporting alternative protein sectors.

African governments should be held responsible for the introduction of effective regulation and enforcement of the aquaculture sector to deal with social, environmental and human and animal health and animal welfare concerns. This should follow the agreed One Health approach which is "an integrated, unifying approach that aims to sustainably balance and optimize the health of people, animals and ecosystems"[117]. This should be supported by effective government systems and structures, including expert extension services.

Development partners, international financial institutions and other investors should make effective regulation and proven sustainability conditions for their support. They should recruit aquaculture experts to ensure that projects meet the guidelines for sustainable and high welfare aquaculture production systems in order for applicants to qualify for finance. This would include compliance assessments along the value chain; including production, capture, transport, and slaughter.

Further research and strategic analysis of the aquaculture sector in Africa is needed, including both consumption and production aspects, and the opportunities for African businesses from transformation towards sustainable food systems, including alternative protein sectors and dietary change.[118]

Mwenda Mbaka, Janice H. Cox and Stephen Ronan
December 2022

[117] WHO. Tripartite and UNEP support OHHLEP's definition of "One Health". 1 December 2021. https://www.who.int/news/item/01-12-2021-tripartite-and-unep-support-ohhlep-s-definition-of-one-health

[118] UNEP. GEO for Business. The Role of Business in Transforming Food Systems. 2021. https://wedocs.unep.org/bitstream/handle/20.500.11822/36755/GEO4B3.pdf