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## The three dimensions of aquaculture's sustainability in Africa for food safety

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### Abstract

Following the exponential increase in Africa's population compared to past decades and the increased need for food production to meet this growing demand in the continent, studies on agricultural research for sustainable food production have been gradually strengthened in the face of climate change, water scarcity and increasing desertification. Aquaculture is a growing sector in Africa and has a major role to play in the role is of primary importance in ensuring food security, while reducing dependence on wild fish stocks that are often overexploited. However, this rapid growth poses challenges to the overall long-term sustainability of the agricultural sector and raises concerns in a number of respects. Sustainable aquaculture implies the integration of all three pillars or dimensions of sustainable development to ensure that this young African industry is economically and environmentally viable, but also that aquaculture farms operate in a socially responsible manner.

**Keywords:** Aquaculture, Africa, sustainable development, environment, economy, social, food security

### 1. Introduction

In Africa, agricultural development is seen as a necessity to address the food insecurity faced by many countries (Goshu *et al.*, 2013) <sup>[1]</sup>. In addition to the challenges of climate change and environmental challenges, sustainable agricultural practices (SAPs) are imperative to achieve better agricultural productivity and food security status (HLPE, 2016) <sup>[2]</sup>, especially with the continent's growing population is in itself a threat to food security and the environment.

Agricultural growth probably has a more important role to play as a factor in poverty reduction, rather than as an engine of economic growth. This is because the proportion of people working in agriculture is much higher than the share of economic output coming from agriculture (Douglas, 2014) <sup>[3]</sup>. Although at present, taking into account sustainable development thus leads to rethinking food production systems while taking into account their ecological and social interactions, which implies transforming not only production but also consumption patterns (Esnouf *et al.*, 2011) <sup>[4]</sup>. Sustainability of food production is a subjective term used to describe how the planet allows humans to use and benefit from goods and services in a way that does not interfere with the continued provision of these environmental services (Boyd *et al.*, 2020). To ensure increasing food security, sustainable agricultural innovations are needed to meet future food needs (Aba mustapha and El Bakali, 2020) <sup>[5]</sup>.

The challenge for developed and developing countries is to reverse the current degradation of the environment, and arrive at sustainable increases in crop and livestock production to secure present and future food supplies (Kaasschieter *et al.*, 1992) <sup>[6]</sup>. The challenge for developed and developing countries is to reverse the current degradation of the environment, and arrive at sustainable increases in crop and livestock production to secure present and future food supplies (Kaasschieter *et al.*, 1992) <sup>[6]</sup>, especially since agriculture contributes significantly to growth in Africa, and for many African countries, only the agricultural sector has sufficient scale and growth linkages to significantly influence overall growth on the continent (Diao *et al.*, 2010) <sup>[7]</sup>. Aquaculture is one of the fastest growing agriculture sectors in Africa. This sub-sector of agriculture, offer a promising opportunity for the diversification of rural enterprise, through aquaculture that would enable rural communities improve their incomes, food and nutritional status (AU-IBAR, 2016) <sup>[8]</sup>.

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The various water environments are designed to increase the production of the organisms beyond the natural capacity and involves cultivation of both marine and freshwater species and utilizes natural resources and interacts with the environment, this sector also indirectly affects the social and economic aspects of many stakeholders who are indirectly involved in it (Bhari and Visvanathan, 2018)<sup>[9]</sup>.

The sustainable aquaculture approach aspires to promote the sustainable development of this sub-sector of agriculture, which remains an alternative to fishing for fish production but which must be carried out with less environmental impact, economically viable and socially acceptable, the three dimensions to ensure the sustainability of aquaculture (Frankic and Hershner, 2003)<sup>[10]</sup>. In the attempt to move beyond the sustainability rhetoric and pursue a more meaningful agenda for sustainable development, a clear definition of this concept and explanation of its key dimensions are needed (Gray, 2010; Mensah and Enu-Kwesi, 2018)<sup>[11, 12]</sup>, especially for the aquaculture sector in Africa, which has undergone significant development over the last two decades.

The objective of this Review article is to introduce the reader to a reflection on the dimensions of sustainable aquaculture in Africa in the socio-economic-environmental context, by calling on the actors and professionals involved in this sector to research and use methods for the viability of the sector in accordance with the concept of sustainable development.

## 2. African Aquaculture

Despite the rapid growth of the aquaculture industry on the African continent compared to other continents of the world, Africa has a low contribution to the amount of fish produced, consumed and traded globally (Hounmanou YMG *et al.*, 2018)<sup>[13]</sup>. Consequently, Africa has been identified as the region with the greatest untapped potential for aquaculture growth (FAO, 2016a)<sup>[14]</sup>. For instance, aquaculture contributed 17-18 per cent of total fish production in Africa, equivalent to a paltry 2.7 per cent of global fish production in 2018 (FAO, 2020)<sup>[15]</sup>.

In Africa, many governments and development agencies have promoted aquaculture as a panacea for household food security, rural development, and poverty reduction (Obiero *et al.*, 2019)<sup>[16]</sup>. Although Africa has the fastest growing aquaculture industry with high biophysical potential, the sector has not yet significantly contributed to sustainable food supplies and economic development (Brummett *et al.*, 2008; Waite *et al.*, 2014)<sup>[17, 18]</sup>. Fishery products from fisheries and aquaculture, particularly fish, are increasingly playing a vital role in the well-being of people in developed and developing countries (Toppe *et al.*, 2012)<sup>[19]</sup>.

Over the last two decades, aquaculture has established itself as a competitive activity in the production of healthy food, making a relevant contribution to employment and income generation and the reduction of poverty and hunger in several regions of the world including Africa. According to the report "The State of World Fisheries and Aquaculture" (SOFIA, 2020), the Food and Agriculture Organisation of the United Nations (FAO) has demonstrated that in 2018 aquaculture production exceeds fisheries production and already accounts for half of global fish consumption. According to these SOFIA data (2020), fish landings in 2018 reached 179 million tonnes, of which 82 million tonnes came from aquaculture production, including 54.3 million tonnes of fish, 17.5 million tonnes of molluscs, 9.4 million tonnes of crustaceans and 0.9

million miscellaneous aquatic animals, while the production of aquatic plants, mainly algae, reached 33.3 million tonnes in 2018, of which 32.4 million tonnes came from aquaculture. The share of aquaculture in Africa has reached 2.196 million tonnes, and the continent's aquaculture production is expected to grow by 48% to 3.25 million tonnes in 2030 (SOFIA, 2020).

Most of Africa's aquaculture production (99%) comes from inland freshwater systems and is mainly dominated by the cultivation of indigenous and abundant species of Nile tilapia (*Oreochromis niloticus*) and African catfish (*Clarias gariepinus*), while mariculture contributes only 1% of total production, although it is an emerging and promising sub-sector (FAOa, 2018)<sup>[20]</sup>. Among the major causes of the weakness of aquaculture in Africa are: this sector is new compared to agriculture (except in Egypt), poor aquaculture facilities, dominance of the extensive system, poor quality of aquaculture feed, availability of fish seed, and lack of training in aquaculture (Adewumi, 2015)<sup>[21]</sup>, bearing in mind that the fisheries and aquaculture sectors in Africa are increasingly contributing to food and nutrition security (De Graaf and Garibaldi, 2014)<sup>[22]</sup>.

## 3. Aquaculture and Food Security in Africa

Fish and other aquatic foods from both freshwater and marine environments, referred to as "seafood", are central to meeting food and nutrition security goals (Béné *et al.*, 2015)<sup>[45]</sup>. The term 'food security', was defined by FAO (1996)<sup>[24]</sup> as 'Food security is a condition when all people, at all times, have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life'. Through the Sustainable Development Goals (SDG) (UN, 2015), the world has committed to ending all forms of food and nutrition insecurity. Yet, food insecurity remains one of the most visible dimensions of poverty, particularly in Africa (Chan C.Y *et al.*, 2019)<sup>[26]</sup>.

Africa has an estimated population of 1.3 billion people (AU-IBAR, 2017)<sup>[46]</sup>, as Africa's rapid population growth outstrips growth in fish supply, and most of the continent's wild fish populations are fully exploited. Bien que le poisson fournisse 19 % de l'apport en protéines animales en Afrique, la consommation annuelle de poisson par habitant reste inférieure aux niveaux mondiaux (Chan CY, 2019)<sup>[26]</sup>. Taken in the context of greater regional food insecurity and a projection that Africa's population will double by 2050 (UN.DESA, 2017)<sup>[27]</sup>, aquaculture is expected to play an important role in providing valuable animal protein-based foods to food-insecure populations (Kobayashi *et al.*, 2015)<sup>[28]</sup>, hence the need to develop this sector in Africa to ensure food security for Africans (FAOb, 2018)<sup>[21]</sup>, but in a sustainable manner to meet sustainable development goals.

## 4. Sustainable Development

The concept of sustainable development was formulated in 1987 by the World Commission on Environment and Development, created by the United Nations General Assembly (WCED, 1987)<sup>[30]</sup>: "development that meets the needs of the present without compromising the ability of future generations to meet their own needs". This definition integrates environmental stewardship with social responsibility and economic gain, thereby presenting an understanding that exclusive focus on economic growth ignores and impedes social development and environmental

protection (Hove, 2004) <sup>[31]</sup>. Sustainable development, a concept that emerged in the context of a growing awareness of an imminent ecological crisis, seems to have been one of the driving forces of world history in the period around the end of the 20th century (Pisani, 2006) <sup>[32]</sup>.

The approach to sustainable development has been presented as a "shared vision" (Giddings *et al.* 2002) <sup>[33]</sup>, from a conceptual point of view, which has largely been represented by the conception of the "three pillars", environmental, economic and social. The origins of the 'three-pillar' paradigm have been variously attributed to the Brundtland Report, Agenda 21, and the 2002 World Summit on Sustainable Development (Moldan *et al.* 2012) <sup>[34]</sup>. This approach reflects the mission-inspired objectives of these three pillars for sustainability by presenting three sets of economic, social and environmental objectives of equal importance as a necessity in order to achieve sustainability (Purvis *et al.*, 2019) <sup>[35]</sup>.

Aquaculture presents favourable conditions in its means of production to be carried out in a sustainable manner in Africa, being an alternative to fight a possible food shortage on the continent in the future, as well as offering conditions for social and economic development for the entire community of the region where it is developed, through its exploitation with sustainable practices.

## 5. Sustainable Aquaculture for Africa

Aquaculture is the fastest growing food production sector in the world (FAO, 2020) <sup>[15]</sup>. It is growing, expanding and intensifying in almost every region of the world. Major development trends indicate that the sector continues to intensify and diversify, and that it continues to use new species and to change its systems and practices. As a result, there is an increasing emphasis on better regulatory enforcement and governance of the sector (Subasinghe *et al.*, 2009) <sup>[36]</sup>. Most aquaculture scientists define sustainability as synonymous with "environmental sustainability." Sustainable aquaculture is however a concept broader than determinations of site-specific environmental impacts since it embodies a scientific knowledge of systematic impacts of aquaculture off-site, and impacts to combined human environmental systems (Costa-Pierce and Page, 2013) <sup>[37]</sup>.

A conceptual approach to sustainable aquaculture has been presented from three perspectives: environmental, economic and sociological (Caffey *et al.*, 1998) <sup>[38]</sup>. Sustainable aquaculture can be defined as the profitable production of aquatic organisms that maintains a harmonious and continuous interaction with ecosystems and local communities. It must be productive and profitable, with the generation and distribution of benefits. It must use natural resources in a rational way and not degrade the ecosystems in which it is inserted, as well as generate employment for the local community, increasing the quality of life and respecting local culture (Valenti *et al.*, 2011) <sup>[39]</sup>. With the expansion of aquaculture worldwide, the concept of sustainable aquaculture, which could be the key to feeding our growing population (Mitra, 2018) <sup>[40]</sup>, is increasingly recognised as integrating the spatial and temporal dimensions and focusing on the balance of the three components of environmental, economic and social parameters (Franki and Hershner, 2003) <sup>[10]</sup>, sustainable development to refer to the desirable way of producing aquatic organisms, without degrading the environment, with social benefits and advantages.

The concept of "Sustainable Aquaculture" focuses on the

balance of the three components of sustainable development to refer to the desirable way of producing aquatic organisms, the dimensions of which are :

### 5.1 The social dimension

Social sustainability is based on the promotion of well-being among the members of an organisation. According to Halwart *et al.*, (2003) <sup>[42]</sup>, the practice of sustainable aquaculture is carried out from a social development perspective, with the aim of improving the living conditions of rural people and rural communities and poverty alleviation. Its main aim is to ensure fair labour practices, but it also includes the overall objectives of reducing social inequalities, improving quality of life and defending human rights. Social sustainability in aquaculture is also linked to poverty eradication (Eizenberg & Jabareen, 2017) <sup>[43]</sup>. To involve more African women in the aquaculture sector, in order to improve the nutritional quality of children and to participate in the social development of their communities (Luomba, 2013) <sup>[44]</sup>.

### 5.2 The Economic dimension

The impacts of aquaculture on the economy of rural communities are key issues for sustainable development policies (Béné *et al.*, 2016, Au-IBAR, 2017) <sup>[45, 46]</sup>, since, the establishment of aquaculture businesses in a region can influence the availability of input factors like skilled labor, specialized suppliers, education programs, and other infrastructure (Krause and Mikkelsen, 2017) <sup>[47]</sup>. Over time, however, the development and growth of the aquaculture sector may stimulate the growth of other more or less related industries in the region, including the development of service and value chain activities (Aslesen and Isaksen 2007) <sup>[48]</sup>. This sector enhance the dependence on family labour in fish farming, leading to a reduction of hired labour (Macfadyen *et al.*, 2011). It has been reported that the establishment of commercial aquaculture is generally accompanied with a relative decline in the price of fish in markets, where low-income consumers particularly benefit, which helps Improve livelihoods (Dey *et al.*, 2005) <sup>[50]</sup>, with an economic revival of the region and the nation (FAO, 2017) <sup>[51]</sup>.

### 5.3 The Environmental Dimension

As with any food production system, increased aquaculture production will come with environmental costs. The environmental impacts, including those related to dependence on scarce source water on the continent, feed inputs, genetic risks and the release of nutrients and chemical pollutants, vary considerably as production systems are very diverse (Troell *et al.* 2014) <sup>[52]</sup>. In this context, the environmental impact of aquaculture and the prospects for its sustainability have raised concerns since the early 1990s (Folke and Kautsky, 1992; Samuel-Fitwi *et al.*, 2012; Perdikaris *et al.*, 2016) <sup>[53, 54, 55]</sup>.

Over the last three decades, environmental sustainability has become a growing concern and increasing attention has been paid to raising awareness of environmental issues in order to reduce the ecological footprint of aquaculture. Five decades ago, environmental degradation was not considered to be the most urgent concern of the sector. Today, the question of whether aquaculture production should be managed in an environmentally responsible and sustainable manner is no longer debatable (Engle and D'Abramo, 2018) <sup>[56]</sup>, for this purpose to develop research in the field of fish nutritional sciences to meet the needs of aquaculture in order to achieve a balance between fish nutrition and the sustainability of aquaculture (Mustapha Aba *et al.*, 2015), Encourage the



integration of aquaculture with agriculture to increase water productivity, through irrigation; rice-fish farming which is already successful in Africa or aquaponics systems (Mustapha Aba and El Bakali, 2020)<sup>[5]</sup>.

## 6. Conclusion

There is currently a consensus that it is possible and desirable for agricultural food production systems to be sustainable. Sustainable aquaculture can be defined as the profitable production of aquatic organisms while maintaining a harmonious and sustainable interaction with local ecosystems and communities. African aquaculture, which is growing rapidly in this continent, is considered a very important source of animal food production for food security in a continent with a growing population, aquaculture today requires the optimisation of production processes, which allow the improvement of farming systems, through the use of adequate management techniques of the natural resources it uses, and for this aquaculture to be sustainable, it should have ecological, economic and social dimensions, while maintaining a sustainable harmonious interaction with aquatic ecosystems for a rational use of natural resources without degrading them, productive and profitable, and ensure food security, it should generate employment and/or independent activities for the local community, improving their quality of life while respecting their culture.

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