The fish industry and the pillars of sustainable development

A indústria de pescado e os pilares do desenvolvimento sustentável

Diana Carla Fernandes Oliveira

Francielly Corrêa Albergaria

Letícia Tavares Martins

Ana Clara do Amaral Santos

Maria Emília de Sousa Gomes

Alcinéia Lemos de Souza Ramos

ABSTRACT
Sustainability, over the years, has become one of the main concerns of modern society (PIRES et al., 2014). In addition, with population growth, increased demand for protein and the impacts caused by anthropogenic action continuously modifying the environment (SILVA, 2018), one of the main challenges of the agricultural sectors is a sustainable production of food, aiming at food security and reducing the environmental impacts generated by the activity (FAO, 2018). Therefore, for sustainable development to occur, it is necessary that there is a harmonization between economic development, preservation of the environment, social justice (access to quality public services), quality of life and the rational use of nature's resources.

Keywords: Sustainable Development, Food, Environmental.

RESUMO
A sustentabilidade, ao longo dos anos, se tornou uma das principais preocupações da sociedade moderna (PIRES et al., 2014). Além disso, com o crescimento populacional, aumento pela demanda de proteína e os impactos causados pela ação antrópica modificando continuamente o meio ambiente (SILVA, 2018), um dos principais desafios dos setores agrícolas é uma produção sustentável de alimentos, visando a segurança alimentar e reduzindo os impactos ambientais gerados pela atividade (FAO, 2018). Portanto, para que ocorra o desenvolvimento sustentável é necessário que haja uma harmonização entre o desenvolvimento econômico, a preservação do meio ambiente, a justiça social (acesso a serviços públicos de qualidade), a qualidade de vida e o uso racional dos recursos da natureza.

Palavras-chave: Desenvolvimento Sustentável, Alimentos, Ambiental.

1 INTRODUCTION

Sustainability, over the years, has become one of the main concerns of modern society (PIRES et al., 2014). In addition, with population growth, increased demand for protein and the impacts caused by anthropogenic action continuously modifying the environment (SILVA, 2018), one of the main challenges of the agricultural sectors is a sustainable production of food, aiming at food security and reducing the

environmental impacts generated by the activity (FAO, 2018). Therefore, for sustainable development to occur, it is necessary that there is a harmonization between economic development, preservation of the environment, social justice (access to quality public services), quality of life and the rational use of nature's resources.

In this context, fish farming, which is among the agricultural activities that has the most potential for food production and that in recent years has stood out from other activities (FAO, 2018), has been much questioned in relation to sustainability (ROTH, 2019), this is because during the processing of fish significant amounts of waste are generated (head, viscera, fins, tail, spine, scales, skin and meat remains) (RUFINO et al., 2019), which represent about 65% of the total biomass of fish (SOUSA, 2019), and are often discarded in the environment without any type of treatment (KRISTINSSON & RASCO, 2000; SILVA et al., 2016).

The concept of environmental sustainability refers to the systemic conditions according to which, at the regional and planetary level, human activities should not interfere with the natural cycles on which everything that the planet's resilience allows is based and, at the same time, should not impoverish its natural capital, which will be transmitted to future generations (PINTO et al., 2017). Therefore, sustainable progress must be based on technological development, maintenance of adequate environmental conditions for the existence of different populations on the planet and ensuring the perpetuity of technological and environmental factors to future generations (SUCASAS, 2011). Several aspects have been valued by consumers in several countries, such as having a lower carbon footprint, low environmental impact, not being associated with animal abuse, environmental labeling, implementing traceability and recycling waste from the production process (BRASIL FOOD TREND, 2010).

The economic pillar brings sustainability as a form of maintenance and continuity of existence of the organization, when strategically planned. However, there are no acceptable indicators to measure economic sustainability, so a long-term view is necessary, implicitly or explicitly in accounting reports, tending to the economic possibility of remaining durable during its existence as an organization (ELKINGTON, 1997).

The social pillar comprises the commitment to human capital that the organization has, in terms of adequate working conditions, fair wages and compliance with labor laws. Responsibility with its consumers, relationship with socially and environmentally responsible suppliers, with the nearby community and society in general, since their actions directly or indirectly impact everyone (ELKINGTON, 1997).

In this sense, the goal of sustainable aquaculture is to provide a continuous supply of cultivated aquatic nutrients beneficial to human sustenance without harming existing ecosystems or exceeding the planet's capacity to renew the natural resources needed for aquaculture production (BOYD et al., 2020).

2 GOAL

To analyze, through a systematic review, the actions implemented in the fish sector in relation to the three pillars of sustainable development: environmental, social and economic.

3 METHODOLOGY

This is a literature review, developed with articles published from 2017 to 2021 in the electronic databases: Portal Capes, *Scientific Electronic Library Online* - Scielo and Google Scholar, using the descriptors: self-esteem, self-image, aesthetics, oncology, complementary and integrative therapies, and their respective synonyms, in Portuguese and English. Only published articles that dealt with the subject and were available in online form were included. Articles outside the proposed period, which did not deal with the topic, were not available online and repeated articles found in different databases were excluded.

4 DEVELOPMENT

Aquatic foods offer highly accessible sources of animal proteins and micronutrients, playing a vital role in the food and nutrition security of many particularly vulnerable coastal populations. Their crucial role as suppliers of highly nutritious foods, essential for physical and cognitive development, has increased significantly in recent years.

In 2021, the FAO Committee on Fisheries (COFI) unanimously endorsed the COFI Declaration for Sustainable Fisheries and Aquaculture (FAO, 2021), which recognizes the sector's contributions to combating poverty and hunger since the adoption of the 1995 Code of Conduct for Responsible Fisheries.

Aquaculture can be a lever for social development, but it can generate negative social impacts if there is no harmony with local communities. The main ones are: the displacement or elimination of extractive areas, compromising the work of local communities; disrespect for common property, such as changes in water resources in such a way as to compromise other economic or leisure activities; and the decharacterization of the culture of local communities (VALENTI, 2002).

On the other hand, natural resources can be used effectively, with the generation of income, creation of salaried jobs and / or self-employment. New economic niches are generated, promoting opportunity for the entry of new investments. Fisheries and aquaculture already support 58.5 million jobs in the primary sector and 600 million livelihoods, and trade in aquatic products provides an important source of income for exporting countries and regions (SOFIA, 2022). In short, the implementation of aquaculture programs generates wealth, with significant gains for the regional and national economy, creating direct and indirect jobs, consequently improving the quality of life of the local population.

Social sustainability occurs whenever technologies that favor the creation of jobs and/or self-employment are applied. One should develop techniques that increase profitability with the increase of manpower.

The feeding of fish or shrimp in nurseries can be done by automatic feeder or manual feeding, which promotes the supply of large amounts of artificial food for farm animals (MELO, 2022). Since most of the feed offered to animals is not consumed, it can accumulate in the environment. Such residues can cause several problems due to high sedimentation loads of total dissolved solids, as well as nutrients such as nitrogen and phosphorus, which is one of the critical points in the advancement of fish farming in continental waters, since the excessive release of these nutrients in the aquatic environment can cause problems with eutrophication and conflicts in the multiple uses of the reservoirs, demonstrating the need for careful follow-up (AYROZA *et al*., 2013; MENEZES, 2014).

In this sense, one can develop the use of feeders, which would be inspected and supplied by employees several times a day. This management can reduce the amount of feed supplied and increase feed efficiency, with significant feed savings (MELO, 2018). Marine shrimp farms in Brazil have been adopting the technique of feeding by trays stocked several times a day according to consumption. This monitoring of the trays increased the number of employees/ha ratio of nurseries, but improved the profitability of the crops (ASANO, 2018). In addition, less feed is lost to the environment, reducing pollution. Therefore, there is an increase in economic, social and environmental sustainability, with a small change in food management.

In addition to controlled feed supply, investment in specialized additives is expected to significantly reduce the environmental impact and carbon footprint of aquaculture through formulations with more sustainable ingredients. (MARTNELLI, 2018). The nutritional requirements of non-ruminant species, particularly fish, include a high quality and quantity of protein in the diet. Fishmeal is the main protein ingredient added, which has high levels of minerals that contaminate water sources. Therefore, the industry seeks alternatives to replace fishmeal, especially raw materials of vegetable origin, such as soybeans, canola and corn. However, the bioavailability of amino acids is not equivalent to animal meal (RODRIGUES *et al*., 2020).

Thus, the development of systems of mass rearing of insects, in the face of the current crisis and rising food prices, offers interesting perspectives for their use in animal feed. The culture of insects is attractive, since it does not compete with the use of land or food resources, in addition, it promotes nutrient recycling, transforming waste, which would previously provide greater environmental pollution, into foods with high nutritional value (REIS & DIAS, 2020). In addition, it is allied to additives, such as liquid enzymes, which help the retention of nutrients and consequently a lower excretion in the environment (REIS, 2020).

Among the most consumed fish species worldwide, the Nile tilapia (*Oreochromis niloticus*) stands out. The species has great commercial interest, for presenting fast growth, rusticity, white flesh and mild odor and absence of the thorn in Y. Tilapia presents a difference in the development of males and females, the male has a higher growth rate, being more advantageous for the producer. The exclusive cultivation of males prevents overpopulation, drop in water quality and promotes rapid and uniform growth of the lot. The androgen 17-α-methyltestosterone (MT), a synthetic compound derived from the hormone testosterone. This compound is conventionally used in the sexual inversion of Nile tilapia (*Oreochromis niloticus*) because it is the most effective and economically viable technique of masculinization. Although there are other methods, however less effective, most countries currently use androgen hormones for sex reversal due to their high success rate between 98 and 100% (ABO-AL-ELA, 2018).

However, it is common for these hormones to be manipulated by employees without proper training, in addition to having their improper disposal. These procedures cause problems for employees who come into direct contact with the hormone, as well as for the environment, due to disposal without prior treatment. Still, these effects extend to the population that consumes this water, as they are dumped in the sewers and much of it reaches the water bodies and are not completely eliminated after undergoing conventional water and sewage treatments (PONTELLI *et al*., 2016).

In order to circumvent this problem, nanoemulsions have been used, as they are considered one of the transport systems with the greatest potential to promote improvements in bioactive substances, such as their bioavailability and solubility (SALEM; EZZAT, 2018). Santos (2020) found that it is possible to develop a nanoemulsion with encapsulated testosterone as a food additive for fish feed capable of performing sex reversal, providing greater safety to the rural producer, reducing the environmental impact and maintaining the profitability of the sector.

In addition, the environmental sustainability of production systems can be improved through the implementation of good management practices, such as: construction of nurseries in previously degraded areas; strict control in the fertilization program of the nurseries to avoid excess fertilizers; use of settling tanks, mechanical and/or natural filters, coupled to the effluent drainage system; do not apply chemicals in the nurseries or mix them with the feed; practice of polyculture to make better use of the nursery space; reduction in the rate of water renewal to the minimum necessary; and use of effluents as irrigation water for plantations (GERONA, 2021).

According to Pires et al. (2017) translating the dimensions of sustainability to the use of water management, the production system can be considered sustainable when it develops under the following pillars: i) economic – ensuring the efficient handling and use of water in urban and rural development; ii) social - ensuring access to quality water for the needs of economically viable production; iii) environmental - ensuring adequate protection of natural resources such as soil, biota and water; and in addition to these,

iv) institutional – ensuring adequate management to promote the principles of integrated management of water resources.

The criticality and scarcity of water, the need for its conscious use and the insecurity of the climatic conditions experienced foster the development of research and techniques that enable lower water consumption and higher productivity. Water Recirculation Systems (RAS) incorporate water treatment and reuse 90–95% of the required water. RAS offers a variety of important advantages when compared to open tank cultivation, such as reduced water and land requirements, parameter control that allows optimization of production conditions, rigorous waste management, and food safety benefits (TIMMONS; EBELING, 2013; CLOUGH *et al*., 2020).

Still, in order to optimize the RAS, this system can be combined with the integration of hydroponic vegetable cultivation, called aquaponics (FORCHINO et al., 2017). Conventional hydroponics requires mineral fertilizers to provide plants with the necessary nutrients, but aquaponic systems use fish farming wastewater that is rich in fish waste as nutrients for plant growth (GODDEK *et al*., 2015). Thus, plants associated with nitrifying bacteria provide a natural filter to remove dissolved nitrogen and phosphorus, controlling the accumulation of residual nutrients from fish farming.

The main advantages of aquaponics are: water quality control, rational water consumption, minimizes the polluting potential of organic waste resulting from the activity, enables the recovery of nutrients, reduces the proliferation of algae and fungi (off flavor), environmental conditions for production throughout the year, greater diversity and quality of products, among other benefits (HUNDLEY *et al*., 2013; BRAZ FILHO, 2014; EMERENCIANO *et al*., 2015).

The use of appropriate sanitary and environmental practices in the cultivation of fish and the use of the effluent generated, due to the organic and nutritional characteristics, in the production of plants and vegetables allow a greater integration of agriculture and aquaculture. From the dissemination of information, one can encourage production in rural areas, metropolitan regions and large urban centers, expand the supply and diversity of food and improve the participation of small producers in the local and regional market (MEDEIROS, 2019).

When researched on the economic, social and environmental impacts should be observed, in the economic scope, the cost, being one of the main limitations of its insertion, because it has an initial investment greater than other forms of cultivation, however, during the operation of the system, the amount invested is returned (CARNEIRO *et al*., 2015; CARRILLHO; GRANDSON; MILK, 2017).

By analyzing the context related to the social sphere, it is possible to affirm that its installation in urban areas is practicable, facilitating the production of local food, reducing the distance between man and food and offering people a closer contact with nature. In addition, according to FAO (2014), this method is

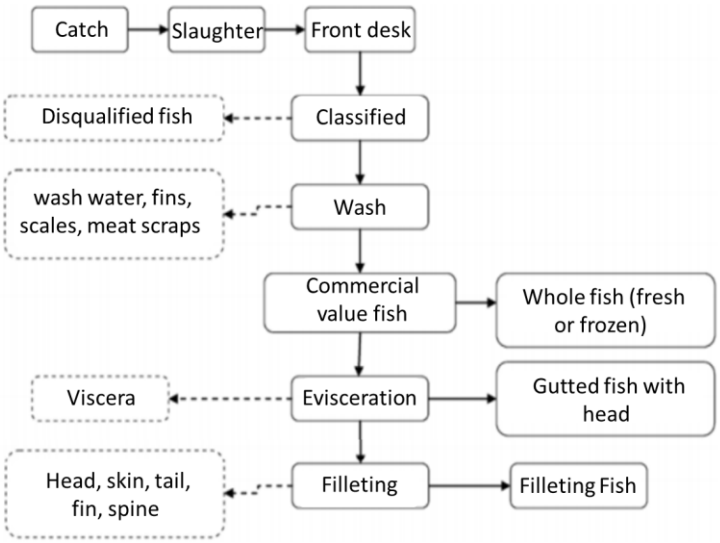
a great ally to boost family farming and generate income for families in underdeveloped countries, which suffer from water scarcity, decentralization of healthy food and few free spaces for planting.

Brazil is one of the main powers with regard to fish farming and industrialization, in 2022, the country produced 860,355 tons of farmed fish (tilapia, native fish and other species), representing growth of 2.3% over the production of 2021 (PEIXE BR, 2023). Consequently it generates a high index of residues, which can vary between 50% and 70% of the fresh weight, according to each species (COSTA, 2012; SILVA *et al*., 2014). However, in the Brazilian productive sector, the use of waste from the fishing industry is not a recurrent practice (LEITÃO *et al*., 2021). These residues are mainly viscera, tail, spine, fin, scales and remains of flesh (FELTES et al., 2010). The main destinations of this waste are landfills and direct disposal in rivers and seas, which cause serious environmental (OLIVEIRA et al., 2021*) and economic problems that can affect the viability of fishing and the aquaculture industry (ZAMORA-SILLERO et al., 2018).*

By definition, waste is any material that is not used during production or consumption, due to technological or marketing limitations, which has no use or market value, and may result in damage to the environment when not properly managed (SUCASAS, 2011; REBOUÇAS *et al*., 2012; PIRES *et al*., 2014).

During the fish processing process (FIGURE 1), several residues are generated, the co-products obtained in percentage terms are composed of muscle cuts (15-20%), skin and fins (1-3%), bones (9-15%), heads (9-12%), viscera (12-18%) and scales (5%) (MARTÍNEZ-ALVAREZ, CHAMORRO, BRENES, 2015).

Figure 1 – General flowchart of the fish processing process.

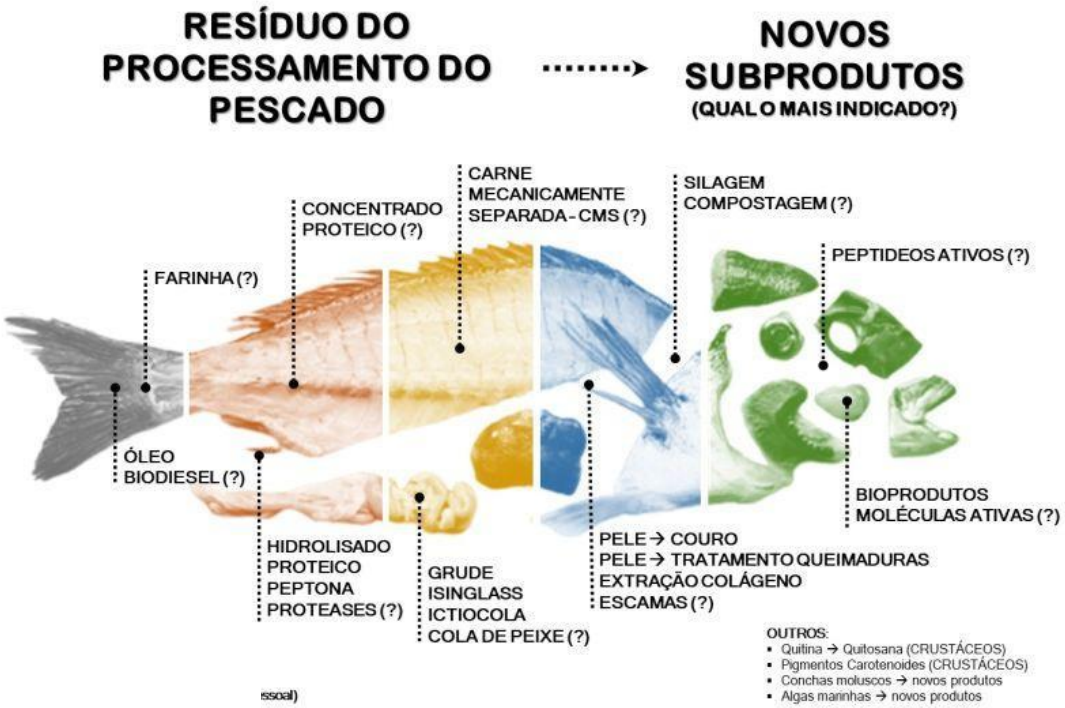


Continuous arrows: indication of processing. Dotted arrows: indication of residues
Source: Adapted from Feltes et al. (2010).

The increase in the production and consumption of fish is directly linked to the need to enable technologies for the reuse of waste generated by the aquaculture industry (CARNEIRO, 2019). Figure 2 shows the main outputs of industrial potentials for fish waste.

In general, during the processing of fish, a significant amount of waste is generated that can be sent to various types of use. The development of new industrialized products with higher added value avoids waste and generates profit (GONÇALVES, 2011). With the use of technological machines, it is possible to apply the mechanically separated meat extraction process (KIRSCHNIK, 2007). Such a process is able to recover much of the meat still adhered to the carcass (OLIVEIRA *et al*., 2012). From the mechanically separated meat (CMS) of fish it is possible to develop varieties of products and other preparations that provide energy and that favor the good acceptance of the product by the general public (BOSCOLO; Feiden, 2007; FREITAS *et al*., 2012).

Figure 2 – Diagram of potential new products from fish processing residue.



Source: Gonçalves (2023).

The use of the waste generated in the fishing activity is in line with Goal 2 - "End hunger, achieve food security and improved nutrition and promote sustainable agriculture"; Goal 12, which aims to "ensure sustainable production and consumption patterns" and Goal 14, which presupposes "conserving and sustainably using the oceans, seas and marine resources for sustainable development" (UN, 2015).

Although several technologies are viable for the manufacture of high value-added by-products from fish waste, the same has still been carried out in a non-recurring way (LEITÃO, 2021).

With the expansion of the sector as well as sustainable production, *Blue Transformation* is the vision and process by which FAO, its members and partners can use existing and emerging knowledge, tools and practices to ensure and maximize the contribution of aquatic food systems to food security, nutrition and healthy eating at affordable prices.

To this end, they are based on three main objectives: 1. Expansion and intensification of sustainable aquaculture: to support global food security goals and satisfy the global demand for nutritious aquatic food and equitable distribution of benefits. 2. Effective management of all fisheries: to provide healthy stocks and ensure livelihoods.3. Updated value chains: to ensure the social, economic and environmental viability of aquatic food systems and ensure nutritional outcomes.

The United Nations General Assembly has declared 2022, the International Year of Artisanal Fisheries and Aquaculture (IYAFA), highlighting the importance of small-scale artisanal fisheries and aquaculture for food systems, livelihoods, culture and the environment.

The IYAFA 2022 Global Action Plan is structured around seven interconnected pillars, namely:

Pillar 1 – Environmental sustainability: Using biodiversity sustainably for the longevity of small-scale artisanal fisheries and aquaculture

Pillar 2 – Economic sustainability: Supporting inclusive value chains for artisanal fisheries and small-scale aquaculture

Pillar 3 – Social sustainability: Ensuring the social inclusion and well-being of small-scale artisanal fisheries and aquaculture

Pillar 4 – Governance: Ensure the effective participation of small-scale artisanal fisheries and aquaculture in building and strengthening enabling policy environments

Pillar 5 – Gender equality and equity: Recognize that women and men in small-scale artisanal fisheries and aquaculture are equal

Pillar 6 – Food security and nutrition: Promoting the contribution to healthy diets of small-scale artisanal fisheries and aquaculture in sustainable food systems

Pillar 7 – Resilience: Increase the preparedness and adaptability of small-scale artisanal fisheries and aquaculture to environmental degradation, shocks, disasters and climate change.

5 FINAL CONSIDERATIONS

Sustainability has been one of the main concerns of today's society and linked to this, the fish processing industries, which currently generate significant amounts of waste, seek sustainable technological means that allow the use of this waste, adding value to this raw material through the generation of fish by-products of high nutritional value, used for various purposes.

Through these various initiatives, FAO recognizes the importance of aquatic food systems as engines of employment, economic growth, social development and environmental recovery, which underpin the Sustainable Development Goals. It also recognizes the need to support the 2030 Agenda for the evolution of actions, aiming to make aquatic food systems more efficient, inclusive, resilient and sustainable for better production, nutrition, environmental quality and life.

Sustainability is a topic of great importance for fish farming, since the sector can only evolve as long as there is a good availability of natural resources. This means that valuing environmental preservation is also a way to contribute to the profitability of aquaculture enterprises.

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