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SUSTENTABILIDADE NA PISCICULTURA: Análise dos Sistemas Integrados e Independentes em Nova Aurora-PR

SUSTAINABILITY IN PISCICULTURE: Analysis of Integrated and Independent Systems in Nova Aurora-PR

[TRADUÇÃO INGLESA]

LETICIA NATÂNIA PEREIRA BLANCO GERONA

CASCAVEL
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Dissertation Supervisor: Dra. Elizandra da Silva
Co-supervisor: Dr. Marcelo Roger Meneghatti

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RESUMO

Os avanços da piscicultura têm contribuído, mundialmente, não só para expansão da produção, mas também, como uma alternativa de abastecimento do mercado. Entretanto, este crescimento tem provocado a necessidade de os piscicultores buscarem medidas que possam reduzir os impactos no meio ambiente para se tornarem mais sustentáveis. Na cadeia produtiva da piscicultura do Brasil existem dois sistemas de cultivo predominantes: o sistema de cultivo integrado – que ocorre quando os diversos processos de produção passam a ser controlados por uma mesma empresa, como o fornecimento dos alevinos, ração, assistência técnica, no qual se firma contrato entre a empresa, chamada de integradora, e o produtor designado como integrado, que fornece a infraestrutura e mão de obra na produção – e o sistema independente, nesse o produtor adquire os alevinos e a ração de fornecedores, desenvolvendo o cultivo de forma independente, sendo responsável por todo o processo produtivo da piscicultura. Este estudo objetivou analisar a contribuição para a sustentabilidade de sistemas integrados e independentes da piscicultura em Nova Aurora-PR, considerando as dimensões econômicas, ambientais e sociais da sustentabilidade. A abordagem da pesquisa foi qualitativa e descritiva e, como instrumento de coleta dados, utilizou-se a entrevista semiestruturada realizada com dez piscicultores do sistema independente e dez piscicultores integrados. A análise e interpretação dos dados das entrevistas considerou se atendem ou não aos indicativos de sustentabilidade sugeridos na literatura. A partir deste indicativo, observou-se a proporção de produtores que indicaram práticas sustentáveis em cada item analisado, resultando, assim, em uma classificação em quatro diferentes níveis de contribuição para a sustentabilidade: não sustentável, pouco sustentável, parcialmente sustentável e sustentável. Com esta classificação dos itens, foi possível classificar um resultado proporcional para cada dimensão da sustentabilidade para fins de comparação entre os grupos de produtores integrados e independentes. Os resultados apontaram que o sistema integrado proporciona maior contribuição para a sustentabilidade na dimensão ambiental, principalmente nos itens relacionados ao tratamento de efluentes, manejo adequado dos recursos hídricos e qualidade da água. Na dimensão social, o sistema integrado apresentou maior contribuição para a sustentabilidade, devido ao item relacionado a treinamentos e capacitação. Já o sistema independente, vem favorecendo, em maior proporção, a dimensão econômica da piscicultura, contribuindo com a sustentabilidade especialmente para os itens relacionados ao crescimento econômico familiar. Embora as diferenças entre os grupos possam ser consideradas pequenas, foi possível concluir que o sistema integrado da piscicultura apresentou melhor contribuição para a sustentabilidade nas dimensões ambiental e social, enquanto o sistema independente contribuiu, em maior proporção, para a sustentabilidade na dimensão econômica, ainda que ambos contribuam para sustentabilidade da piscicultura em Nova Aurora-PR. Este estudo contribui para a conscientização dos piscicultores de Nova Aurora-PR sobre a necessidade de conciliar o crescimento econômico às dimensões sociais e ambientais da sustentabilidade. Além disso, contribui com um levantamento útil para fundamentar a formação de políticas públicas no município que promovam o crescimento da atividade, incentivando a capacitação dos piscicultores, em ambos os sistemas produtivos e, ainda, proporcionando maior sustentabilidade da atividade nas propriedades rurais.

Palavras-chave: Dimensões da Sustentabilidade. Piscicultura Familiar. Sistema Integrado e Independente.

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ABSTRACT

Advances in fish farming have contributed, worldwide, not only to the expansion of production, but also as an alternative to supply the market. However, this growth has led to the need for fish farmers to seek measures that can reduce impacts on the environment to become more sustainable. In the production chain of fish farming in Brazil there are two predominant cultivation systems: the integrated cultivation system – which occurs when the various production processes are controlled by the same company, such as the supply of fingerlings, feed, technical assistance, in which a contract is signed between the company, called an integrator, and the producer designated as integrated, which provides the infrastructure and labor in production – and the independent system, in this the producer acquires the fingerlings and the feed of suppliers, developing the crop independently, being responsible for the entire production process of fish farming. This study aimed to analyze the contribution to the sustainability of integrated and independent fish farming systems in Nova Aurora-PR, considering the economic, environmental and social dimensions of sustainability. The research approach was qualitative and descriptive and, as a data collection instrument, we used the semi-structured interview conducted with ten fish farmers from the independent system and ten integrated fish farmers. The analysis and interpretation of the data from the interviews considered whether or not they meet the sustainability indicators suggested in the literature. From this indicator, it was observed the proportion of producers who indicated sustainable practices in each item analyzed, thus resulting in a classification in four different levels of contribution to sustainability: unsustainable, unsustainable, partially sustainable and sustainable. With this classification of the items, it was possible to classify a proportional result for each dimension of sustainability for comparison between the groups of integrated and independent producers. The results showed that the integrated system provides a greater contribution to sustainability in the environmental dimension, especially in items related to effluent treatment, adequate management of water resources and water quality. In the social dimension, the integrated system presented a greater contribution to sustainability, due to the item related to training and training. On the other hand, the independent system has favored, to a greater extent, the economic dimension of fish farming, contributing to sustainability especially for items related to family economic growth. Although the differences between the groups can be considered small, it was possible to conclude that the integrated fish farming system made a better contribution to sustainability in the environmental and social dimensions, while the independent system contributed, to a greater extent, to sustainability in the economic dimension, even though both contribute to the sustainability of fish farming in Nova Aurora-PR. This study contributes the awareness of fish farmers in Nova Aurora-PR about the need to reconcile economic growth with the social and environmental dimensions of sustainability. In addition, it contributes with a useful survey to support the formation of public policies in the municipality that promote the growth of activity, encouraging the training of fish farmers, in both production systems and, further, providing greater sustainability of the activity in rural properties.

Keywords: Dimensions of Sustainability. Family Fish Farming. Integrated and Independent System.

SUMMARY

1 INTRODUCTION

According to Scorvo Filho *et al.* (2010) aquaculture has been an alternative to supply the market worldwide. With the cultivation of fish of various species, the activity is increasingly being sought by farmers and thus becomes a source of income, as well as for its own consumption. In addition, fish is a source of protein that provides numerous health benefits.

In 2014, the production of aquatic products reached 73.3 million tons, including finfish, mollusks, crustaceans and amphibians, thus making aquaculture the fastest growing sector in the world (Food and Agriculture Organization of the United Nations - FAO, 2016). In Brazil, according to Schulter &Vieira (2017), national production advanced in 1990, when the domestic market began to consume more fish, expanding imports. With this, the country began to enter international trade.

Five years later, in 2019, Brazilian fish farming grew 4.9% to 758,006 tons, being the highest index among all animal proteins in the country, in addition, Brazil is the 4th largest tilapia producer in the world, providing income generation for many families (Peixe Br, 2020). Due to the productive intensification, diversification of species, expansion to new areas and the introduction of innovative and more resource-efficient technologies, aquaculture production is expected to grow in the coming decades, thus surpassing the production of catch fishing by 2021 (FAO, 2017; Kobayashi, 2015; Organization for Economic Cooperation and Development - OECD & FAO, 2016). In contrast to all this growth in productivity, the environmental damage that is caused by the cultivation of the activity is significantly increased (Cardoso *et al.*, 2016).

This fact causes an alert to fish farmers and all who are directly related to fish farming, for the adoption of measures that can reduce the impacts on the environment in order to make the practice more sustainable. Therefore, it is important that producers associate the principles of sustainability with the use of water resources so that, in this way, there is the development of fish farming in the social, environmental and economic spheres, through actions that rationalize the use of water and waste generated, as well as in the supervision of the enterprises, in the occupation of the soil in the surroundings and in the reuse of water with the proper management in the process of the productive chain of the activity (Cardoso *et al.* , 2016; Kubitza, 1998; Nogueira *et al.*, 2011).

In the production chain of fish farming in Brazil there are two predominant cultivation systems, integrated and independent systems. In the integrated system, producers who work in

fish farming are linked to an association that provides technical support, development of fingerlings, feed for animals, slaughter and marketing through the structure, with the fish farmer, management and fattening. It is emphasized that the main cultivation methods are semi-extensive or intensive through excavated nurseries or net tanks (Brazilian Fish Farming Association - Peixe Br, 2020). On the other hand, the producers of the independent system seek to carry out the activity of fattening, acquiring fingerlings and the inputs of external suppliers, later selling the live animals for slaughter. It should be shown that the evolution and growth of independent fish farmers have been much smaller, when compared to the growth of integrated producers (Peixe Br, 2020).

Bocabello (2019), in his study on integrated producers, found that because they are linked to an association or cooperative, they do not recognize the need for improvements in the management process. Such impressions can occur because the cooperative provides a financial and technical support structure, ensuring them greater availability for the operation, as well as the low perception of risk, since the productive standards are made available by the cooperative without burden to the associate. Independent producers, on the other hand, suffer directly from the adverse conditions of production and are also exposed to the risks of loss of production, having to bear great financial losses, because they are not being re-managed by cooperatives.

Currently, the development of the productive activity of fish farming is intertwined with highly productive, sustainable and profitable systems that demand well-thought-out production strategies, such as the adjustment of fish stocking density and the use of balanced diets made with appropriate criteria of biological modeling (Cyrino *et al.*, 2010). In addition, management planning, the quality of the food used in the cultivation and the correct management of the residues and chemicals used are characteristic of sustainable practices that must be adopted in the production of fish, in order to contribute to the development of sustainability in the properties (Cardoso *et al.*, 2016).

And for aquaculture production to grow in a harmonized way, it will be necessary to improve the efficiency with which the inputs are transformed into products, as well as to prioritize the conservation of scarce natural resources and reduce waste (OECD & FAO, 2016; Troell *et al.*, 2014). Waite (2014) explains that the most efficient use of natural resources will depend not only on management practices, but also on local conditions and needs. Thus, in places with a large number of small family properties, it is necessary to promote innovation to develop productive and sustainable management.

About that, Valenti *et al.* (2010) discusses that fish farming is dependent on the ecosystems in which it is inserted, and it is impossible to produce without causing

environmental changes. However, the author advocates that in order not to reduce biodiversity, nor the extinction or contamination of natural resources and, especially, alteration of water resources that are related to the fish farming sector, it is necessary to raise awareness and actions to reduce the impact on the environment. So, in order to achieve sustainability in the rural environment, both in agriculture, fish farming and other existing agricultural activities, long-term productivity is required, with minimal adverse impacts on the environment, achieving the optimization of production with fewer external inputs and with an advantageous economic return, thus satisfying the human needs of food, income and the social needs of families and rural communities (Conjero *et al.*, 2009).

In both integrated and fish farming - independent systems there should be the integration of the performance of the dimensions of – sustainability. In addition to considering the environmental point of view, it is necessary to approach the social and economic perspective to achieve a balance of the preservation of the environment (Rocha *et al.*, 2013).

Thus, one should consider the environmental dimensions that involve the activity of fish farming evaluating, aspects of sustainable management in rural properties (Nascimento, 2012; Sarkar *et al.*, 2018; Silva *et al.*, 2018). It is worth pointing out that appropriate treatment of solid and liquid waste, care for water quality and water resources that are used during the process, the practice of integrating aquaculture with other agricultural crops, the use of organic techniques and the preservation of environmental biodiversity, are actions and techniques that can contribute to increasing the sustainability of fish farming (Cavalcanti, 2011; Stoffel, 2014; Sontag, 2016; Carneiro *et al.*, 2015).

About the economics dimensions of sustainability, Ferreira and De Souza (2019); Araujo (2015); Kimpara *et al.*, (2012) mention that fish farming activity can favor the reach of financial growth from income generation, increased jobs and infrastructure, thus contributing, to the sustainable and economic development of, family farming.

In the social dimension, of sustainability, the activity of fish farming needs to involve the set of aspects that promote the balance of society and its lifestyle, in order to bring improvement in the quality of life of in families and greater family subsistence, with ease to access to education, health services, sanitation, information, technology and training. In this way, it seeks to minimize the social exclusion of farmers with the possibility of spreading social sustainability in family farming (Silva *et al.*, 2016; Ahmad, 2015; Souza *et al.*, 2016).

Thus, the search for ways that can measure sustainability, covering all the economic, environmental and social dimensions of fish farming is important to increasingly disseminate sustainable development in rural areas (Aquino *et al.*, 2014).

1.1 SEARCH PROBLEM

Developing fish farming through sustainable production systems is not because it is far from an easy task, a reality of the adoption of. Like this it is needed practices and systems that consider the concepts of sustainability to walk a for this development. planned production, based solely on the market and financial opportunities leads to systems that are not sustained in the long term. These items are only part of the process because they do not consider environmental, economic and social issues, fundamental to develop the productivity of future generations (Valenti *et al.*, 2010).

The sustainability of fish farming can be influenced by environmental, social and economic dimensions (United Nations Development Program- UNDP, 2018). And still there may be differences in the forms of management and methods practiced in the production of fish farming, both in independent systems and in integrated systems. Thus, some sustainable practices should be adopted since the beginning of production in integrated and independent systems, such as the choice of the place of cultivation, the quality of water and the dilution capacity of nutrients in nurseries. All management and storage planning, the quality of food used in cultivation, correct management of waste and chemicals used, enable greater preservation of aquatic communities that are involved in the production of fish, ensuring sustainable development in properties in this way, (Cardoso *et al.*, 2016).

Appolo & Nishijima (2011) advise that inadequate management in both cultivation systems, without compliance with the environmental guidelines required for the cultivation of the activity and even, the scarcity of the use of technologies in the properties can cause imbalances and environmental impacts.

The municipality of Nova Aurora, in western Paraná, has been working in the fish farming sector specifically with the production of Tilapia, the production takes place by the independent and integrated system. The integrated producers have the aid for their production scale of the integrator located in the municipality that has an Industrial Unit of Fish, and maintains control of the entire still production process, it in this way, its opportunities, the associates, the practice of tilapia production activity, contributing to the fish farming is an alternative that adds to the rural producer greater income on their property. The management and use of technologies suitable for the activity by integrated producers, so that there is the development of a production chain with increasingly sustainable growth (Radar, 2019).

In addition to the integrated producers, independent producers who carry out the fattening activity, work in the city, acquire fingerlings from other producers and all the inputs most often from external, suppliers sell live animals for, slaughter companies that are not later integrators, as to well as deliver region, in, the local market, farmers' fairs and fish pay. These producers operate in a smaller amount compared to integrated producers according to data from the Municipality of Nova Aurora made available by the head of the Department of Agriculture – and environment.

In both systems, the elements of the dimensions of social, economic and environmental sustainability of fish farming must be present in order to achieve conditions that increasingly favor the sustainability of the activity. Otherwise, management and inadequate management may cause long-term impacts on both integrated and independent systems, so that fish such farmers increasingly commit themselves to the dimensions of sustainability in order to develop production strategies for the sustainable development of Need fish farming.

1.1.1 Research Question

In the integrated system, there is a potential productivity detractor factor, which is related to the support of the essential assets of this production system in the face of the environmental risk of its activities, due to the level of contamination of shared water bodies, in addition to seasonal climatic conditions that can affect, to a greater extent, the productive capacity. In independent systems, another determining factor is cultivation by net tanks or dams, which, although perceived as low risk of contamination, shows signs of environmental impacts on production development, requiring a change in methodologies and strategy for the allocation of producers' assets (Bocabello, 2019).

Thus, the research question of this study is: Is there a difference in the contributions to sustainability between integrated and independent fish farming systems in Nova Aurora-PR?

1.2 GOALS

1.2.1 General Objective

Analyze the contribution to the sustainability of integrated and independent systems of fish farming in Nova Aurora-PR.

1.2.2 Specific Objectives

a) To raise management methods Used and techniques in fish farming that contribute to sustainability;
b) Identify the characteristics of the environmental, economic and social dimensions of sustainability present in the activity of integrated and independent fish farmers in Nova Aurora-PR;
c) Compare the environmental, economic and social dimensions of the sustainability of integrated and independent systems in fish farming.

1.3 JUSTIFICATION AND CONTRIBUTION

Fish farming proves to be a profitable activity that depends on several factors, such as the technical efficiency of the production system, the quality of the feed, the variation of the sales price in the market, which are linked to the management of the activity, in which any variation that occurs in the profitability indexes, will interfere in the production chain and in the development of the activity. Therefore, the producer must be attentive to practice an efficient and sustainable management, with technological mastery in order to achieve the expected performance without considerably harming the environment (Da Costa *et al.*, 2018).

In fact, fish farming activity for years has also been associated with environmental impacts that are caused due to inadequate management that can compromise the quality of water resources, as well as local biodiversity due to the release of toxins from fish waste. For this reason, the fish farmer needs to adopt sustainable measures in the production process to ensure

the sustainability of the use of resources along with economic growth of the enterprise (Sobral *et al.*, 2006; Santos *et al.*, 2015).

In addition to the factors mentioned, the lack of information and knowledge of the dynamics of the fish farming market can harm the economic aspect for the identification of opportunities and alternatives of production and commercialization, both in the development of existing businesses, as for investments in new projects and enterprise in rural properties (Planello, 2015).

The development of fish farming activity in the Western region of Paraná now has the integrated cultivation system, also known as integration system, being adopted in Brazil by small producers, who are associated with some cooperative independent cultivation system, in which the fish farmer develops the activity on. In addition, there is his own, without being associated with any cooperative or association (Brum & Augusto, 2015).

However, the practice of fish farming also brings a lot of concern in the environmental issue, for example, the indiscriminate release of fish waste into rivers, lakes and streams that can cause impacts on the environment and the contamination of water and still other aquifer animals itself generating environmental pollution (Jana & Jana, 2003; Valentini *et al.*, 2002).

The availability of water in the areas producing fish farming and the generation of effluents in these areas can generate restrictive actions of government authorities, making it impossible to grow activity under geography, since the same water resources are shared by the producers located there (Bocabello, 2019; Donadio, Galbiatti & Paula, 2005). The studies of Rodrigues *et al.* (2012) demonstrated the technical aspects of the management of fish farming activity, the authors pointed out that in Brazil production techniques still need to evolve, directly criticizing, inadequate management, management problems that trigger environmental impacts and the lack of investment in the qualification of the labor force.

It is then necessary to find out if there are differences in the contribution to the sustainability of fish farming in integrated and independent systems. The perceived gaps concern both integrated system producers and producers of independent systems are related to. These gaps sustainability to dimensions that consider economic, social and environmental aspects, such as the environmental impacts caused by the composition of rations and feeding operations in the Addressed study by Dullah *et al.* (2020).

Based on this context, this study is justified from a practical point of view, since it aims to identify which of the fish farming systems, which are integrated and, independent, developed in Nova Aurora-PR, favor sustainability.

The theoretical justification of this research occurs from the study of integrated and independent cultivation systems of Nova Aurora-PR, focusing on the comparison between the two systems, trying to identify the differences in relation to environmental, economic and social dimensions of sustainability. In addition, the dissertation presents a theoretical study and deepening that contributed to the construction and formation of the categories of analysis of the environmental, economic and social dimensions of sustainability, which can be reproduced and applied in studies of fish farming systems from other regions. Thus, there is a theoretical contribution and an indication for new work that can be carried out on the same subject.

The practical justification of the study is given by identifying which of the cultivation systems provide the greatest contribution to the sustainability of fish farming in Nova Aurora-PR, aiming to add greater economic, social and environmental results, identifying sustainability measures that may be present in the activity. It also contributes to the awareness of fish farmers in the region about the need to reconcile economic growth to the preservation of the environment, so that they seek production technologies that generate greater sustainability of the enterprises in the properties.

1.4 STRUCTURE OF THE DISSERTATION

This dissertation includes six chapters: the introduction, theoretical and practical references, research methods and techniques, the context of fish farming in Nova Aurora-PR, analysis and discussion of data and final considerations.

The first chapter refers to the introduction that contextualizes aquaculture and the growth of fish farming in Brazil, in order to also expose the production chain of fish farming, the social and economic contributions of the activity, as environmental impacts that have been emerging and interfere in sustainability for fish, cultivation, besides presenting the general and specific objective, the problem of research, the justification and the structure of work.

The following Brings chapter, the theoretical and practical references related to the relevance of fish farming in the regional context, addressed the integrated and independent cultivation systems in fish farming, sustainability in fish farming and similar experiences in Brazil and in the world related to fish. To farming and the measures that are being used to reduce the environmental impact still of the activity.

In chapter three, the methods and techniques of research that were used to achieve the objective of this study are presented. This chapter is divided into research design, field of study, data collection procedures and categories of analysis.

In the fourth chapter, the context of fish farming in Nova Aurora-PR is discussed. The fifth chapter presents the analysis and discussion of the results found considering the profile of independent and integrated fish farmers, and their results for the environmental, economic and social dimension of fish farming, in the sixth chapter are the end considerations of this study.

2 THEORETICAL AND PRACTICAL REFERENCES

2.1 RELEVANCE OF PISCICULTURE IN THE REGIONAL CONTEXT

The contribution of fish farming in the fishing sector is growing more and more in countries and communities around the world, adding both to the rural and urban areas, in order to reduce poverty, being a source of income generation for local and international trade (Nomura. 2010).

Aquaculture, for Chuenpagdee *et al.* (2008), can be defined as the cultivation of aquatic animals (mainly crustaceans, bony fish and mollusks) and plants (macro and microalgae and freshwater macrophytes) from the 'seed' to a marketable size, usually in fixed areas of water and land. When fish cultivation occurs mainly, in fresh water, the activity is called Fish Farming, and was practiced 4000 years ago, at that time the Egyptians already created Nile Tilapia (Colpani Piscicultura, 2018). Fish farming is controlled by man with the objective of economic and financial productive exploitation. The production of fish that for many years originated from fishing, found in fish farming the way out for the continuity of sustainable growth (FAO, 2016).

Schulter and Vieira Filho (2017) affirm that the growth of the world's population, the concern with food security and the increasingly intense interest in environmental sustainability are among the main challenges to be faced by countries for decades to come. And, for the long-term sustainability of aquaculture, the conservation of aquatic resources with responsibility is essential, considering the economic, social and environmental dimensions that this activity provides (Lopes, 2018; Nomura, 2010).

When it comes to fish, production, China gains a prominent role as the main producer with special attention to tilapia (*Oreochromis niloticus*) which is one of the most produced species in the country due to good weather conditions and the great demand of the global market, for tilapia products (Yuan *et al.*, 2020).

In 2014, world fish production reached the mark of 167 million tons, with 73.8 million tons from aquaculture. In South America, Chile recorded a production of 1.2 million tons (being the seventh largest producer in the world), followed by Brazil, with 561,000 tons (occupying the 13th position in the overall ranking of the largest fish producers) (FAO, 2016).

And with the increase in the number of developing countries in, total fish production, production and supply is outsourced to international markets, reflecting the significant growth

of aquaculture, which through economies of scale and improved technology, can produce at low cost and offer production at a competitive, price, thus expanding, the global, market (Nomura, 2010).

In Brazil, the first fish farming initiatives emerged in the 1970s with the cultivation of Nile Tilapia *(Oreochromis niloticus)*, and today the main species produced in the country, was introduced together with Tilapia of Zanzibar *(Oreochromis hornorum)*. The expansion of production has placed the country among the largest tilapia producers in the world, because of the interest of domestic agroindustry and the increased demand for fish consumption in both domestic and foreign trade (Schulter & Vieira Filho, 2017).

According to the Brazilian Institute of Geography and Statistics-IBGE (2016), the Northeast contributed to the national production of fish with 26.8% of the total, followed by the North region with 25.7%, the Southern region with 24.2%, the Midwest region with 12.6% and the Southeast, with 10.7%. Within this context, the aquaculture sector showed the highest percentage increase in production between 2004 and 2014, with an average annual growth of almost 8%. Tilapia, the main aquaculture species cultivated in the country, showed an average production increase of 14.2% per year in the same period (Kubitza2015).

The growth of tilapia production in the country increased from 12,000 tons in 1995, to 219,000 tons in 2015, since the commercial activity of this type of fish has been consolidating and strengthening from decade to decade in Brazil if (FAO, 2016). According to IBGE data (2016), Brazilian fish grows gradually farming, reaching in 2016 the amount of 507.12 thousand tons, reflecting a production value of R$ 4.61 billion for Brazilian aquaculture, and 70.9% came from fish farming. Therefore, the fish industry in Brazil is expanding, mainly with the production of Tilapia, Tambaqui and shrimp (Fontes *et al.*, 2016).

For Schulter and Vieira Filho (2017) some regions of Brazil have become fish farms focused on tilapia production, with a production under development and growth, especially with the opening of new productive enterprises that are not restricted only to Poles fattening, but, also in the production of fingerlings and animal feed. With this growth and development, companies diversified the processing lines and others were created, specifically to produce Tilapia.

Tilapia has adapted to the conditions of cultivation in the State of Paraná, imbricated with cultivation being economic, technological and environmental factors, varying according to the conditions and expectation of each locality or production. It is emphasized that tilapia production has shown to be an economically viable alternative of strategic importance for the state's fish farming (Igarashi, 2018).

According to 2019, data collected by the Government of the State of Paraná (2019), the production of the species grew 7.96% in 2019 and represents 57% of the Brazilian production of fish, since Paraná maintains the lead with the production of 146,212 tons, ahead of São Paulo and Santa Catarina, which are in second and third place.

The main region of fish production (specifically Nile Tilapia) is in the industrial productive center of the State of Paraná, in the municipality of Toledo-PR, which is in the central region, in the west of the state with slaughter and industrialization around 55,000 kilos of fish (Schulter & Vieira Filho, 2017).

Between 2014 and 2015 in the West Paranaense region there were already 24 productions, stations for fingerlings in operation, among which, eight located in the municipality of Toledo, four in Marechal Cândido Rondon, three in Assis Chateaubriand, two in Nova Aurora and two Palotina, the municipalities of Cascavel, Guaíra and Tupãssi have one station, in this period all seasons together produced 143,000 thousand Tilapia fingerlings (Feiden *et al.*, 2018).

Two fish processing cooperatives are installed in western, Paraná, one in Cafelândia and the other in Toledo, who participate in the entire production process, both in the production of feed, fingerlings, fattening and slaughter of tilapia, as well as in the, commercialization and distribution of products to the region market has the support for the development of the activity coming from the Água Viva Institute, in the municipality of Toledo and the Foundation for Technological Scientific Development. the - Fundetec located in Cascavel, in addition to the Paraná Institute of Technical Assistance and Rural Extension - Emater (Feiden *et al.*, 2018).

Fish farming in Paraná stands out, in addition to the generation of direct and indirect employment, due to the comprehensive economic relationship with other activities, attracting producers and even agricultural entrepreneurs to various activities related to fish farming, such as the creation of fingerlings and fish fattening (Martins *et al.*, 2018).

In fish farming fish can be grown in fresh or saltwater, each species must undergo an adaptation process to develop in the environments in freshwater production, the most used crop is in nurseries and dug tanks, while in salt water the net tanks, (cages) predominates (Lopes, 2018; Schulter & Vieira Filho, 2017).

In fish farming there are several types of production systems that are used considering the site, management, species to be cultivated and market requirements. among the forms of production are extensive, semi-intensive, intensive and super intensive (Nunes *et al.*, 2015; Nascimento & Oliveira,2010). Fish farming is developed according to the type of production that the fish farmer wishes to work on. Crops can be classified by productivity; water use and

utilization at various trophic levels of water. Thus, the production in excavated nurseries is classified as: extensive, semi-intensive, intensive and super intensive production (Sebrae, 2016).

Extensive production is characterized by the little influence of man in the production process, being more used in properties where fish farming is not the main economic activity (Sebrae, 2016). Extensive production is considered a secondary activity, as it can be practiced in natural or artificial dams that were not built specifically for the cultivation of fish, as in reservoirs that serve as water fountains for animals and that are used for crop irrigation (Santos, 2005).

In extensive production fish depend on a natural development in the nursery, produced by hybrid mass to feed, with predominance of species polyculture (Sebrae, 2016; Lopes, 2018). In this way, the producer produces several species of fish that can be caught by seine, net or with the use of hook lines and does not care about costs. In extensive production there is no fertilization management, there are no controls on the parameters of supply, drainage, quality and physical-chemical parameters of water, no fertilization or carried is performed and the economic viability of extensive production is relative (Pereira and Silva, 2012).

The semi-intensive production system allows a higher density of fish storage than the extensive system and there is the complementation of artificial food, i.e., feed, in addition to the use of food produced naturally in the nursery system it is recommended to. This intercrop points several fish species or the polyculture of species, the system has occasional water renewals and production is for commercial purposes (Oliveira, Souza & Melo, 2015; Arana, 2004)

Intensive production, on the other hand, is practiced in excavated nurseries, is characterized by dependence on human intervention (management), high rates of water renewal, monitoring of water quality, and use of technologies in production such as aerators for water oxygenation. The production occurs with only one species, that is, by monoculture still and the feed is the food used for the cultivation of fish, with no use of the natural food of the nursery (Sebrae, 2016; Coldebella, 2018).

Nurseries need to be planned and built with. This is to use the specialized machinery excavations, since these structures require the runoff of water and the harvesting of cultivated organisms (Coldebella, 2018; Lopes, 2018). The construction of excavated nurseries requires a considerable cost to optimize the expenses with the movement of land and adequacy of the appropriate site for the execution of the work according to the relief of the properties, however it is the productive environment that has spread the most in Brazil. The type of net tanks (cages)

is made using federal and state public waters from hydroelectric plants for installation of tanks, composed of screen structures, fish are confined and fed feed, and cultivation is considered intensive due to the high volume of production (Schulter & Vieira Filho, 2017; Coldebella, 2018).

In the super intensive system, the tanks are small and are made of masonry with continuous water flow and total water renewal in a short period, in addition the fish storage occurs in high density being accounted for by biomass in, m3. (Nascimento and Oliveira, 2010).

2.2 CULTIVATION SYSTEM

In the fish farming production chain, integrated and independent cultivation systems are of great importance for the fish production, processing and marketing industry in Brazil (Bocabello, 2019).

The cultivation system integrated in fish farming occurs when the various production processes are controlled by the same company, in which signs a contract between the company called the integrator and the producer designated as the integrated, characterizing the process as integration like so (Stamm & Medeiros, 2012). As in the production of chickens and pigs, the production of fish with the integrated production system already consolidated greater value Brings aggregation, accompanied by control and monitoring of product quality and cost reduction (Brum & Augusto, 2015).

The integrated producers are those owners or tenants of rural properties, associated with a cooperative integration system, producing on riverbanks or dams, or in tanks excavated for the purpose of fish farming (Bocabello, 2019). In Brazil, integration occurs by medium and small farmers who join cooperatives close to the region they live in. The integration contracts provide an income stability to the integrated producers, in addition to the safety in the sale of products, a fact that has been making integrated fish farming as a production strategy of great economic importance for the country (Carvalho Filho, 2017).

In the integration system, the support for – production such as rations, vaccines and management inputs, development of genetic improvements of fingerlings, management techniques of creation and technical support in the stages of junior breeding and fattening – is at the behest of the integrator. The integrator cooperatives also have a structure for transporting and sending production to slaughterhouses for processing, and then making them available and delivered to supermarkets. With the productive activity coordinated by the integrative company,

there are also increases in operational efficiency, such as complete research and development structures, technical support, development of suppliers of ingredients and feed production. In this way, integrated production takes place at all stages of the development of fish farming (Bocabello, 2019).

Therefore, the integration in fish farming is a form of contract in which the cooperative provides the supplies and technologies, and the producer is responsible for the physical structures and the labor necessary for the cooperative activity like this obtains the standardized raw material and controls the process, remunerating producers according to the performance in the activity (Rodrigues *et al.*, 2012).

In the independent cultivation system, producers' own tenants or land on rural properties bordering rivers or dams, or those that have tanks excavated for fish farming, but grow independently. These producers make production in net tanks or excavated tanks. Net tanks are floating structures used to create fish in dams, lakes and rivers, while excavated tanks are lakes no more than two meters deep, which normally have control of water inlet and outlet, with food administration and forced water oxygenation (Bocabello, 2019).

In this independent system producers can acquire junior fish from producing companies and, these from producers and developers of fingerlings, initial phase of reproduction and development, being responsible for fattening the animal in its final phase before slaughter, or the super fattening for availability to fishing grounds. They acquire vaccines and management intake in specialized resales feed directly, from specialized producers. At the end of the production cycle, they hire carriers to send their production to fishing grounds or slaughterhouses and the latter perform the slaughter and processing of the animal for availability to supermarkets and restaurants (Bocabello, 2019).

2.3 SUSTAINABILITY IN FISH FARMING

The concept of sustainability in fish farming used in this study refers to the rational use of natural resources, without degrading the ecosystems that are inserted, in order to generate profitable production, generating employment for the local community, with harmonious interaction between ecosystems and local communities (Valenti, 2002; De Oliveira, 2015). The environmental, economic and social dimensions of sustainability chosen for this study are derived from the works of Rabelo and Lima (2007); Araujo, (2015); Sá (2013).

Sustainability to management corresponds to natural, financial, technological and institutional resources, aiming at meeting human needs in present generations and future generations (Valenti *et al.*, 2010; Kimpara, 2013). Valenti *et al.* (2010) conceptualize sustainability by referring to a combination of actions that together provide human well-being- and, also the well-being- of ecosystems. In this sense to develop a more sustainable way of life, it is necessary to consider the concerns related to environmental, economic and social dimensions of sustainability (Cunha, 2003).

The factors involving sustainability and sustainable development must be increasingly applied in aquaculture, so that it minimizes any future damage that may cause impacts to the environment through the industrial scale of aquaculture. In this way aquaculture systems need to be productive within the ecosystem transport capacity, environmentally sound, as well as economically and socially acceptable in the long term, (Jana & Jana, 2003; weber, 2009).

Fish farming occupies a prominent place in Brazil, so production systems should be more sustainable. Achieving sustainability is a difficult task, but it is necessary to consider practices and systems that consider the concepts of sustainability as good management practices (Valenti *et al.*, 2010; Amazonas, 2008; Banco Do Brasil, 2010; Gomes *et al.*, 2012; Santos *et al.*, 2014; Oliveira, 2018).

More and more information has been on sustainability and sustainable development worldwide and, in the fish farming sector the subject is also very pertinent, (FAO, 2014). Wilfart *et al.* (2013, p. 2) states that "it is necessary to guide aquaculture farmers to adopt Meat practices to this concept of sustainability to maximize productive efficiency, but also to reduce losses, costs and negative environmental impacts".

When it comes to fish farming and sustainability, it is a fact that for this activity it is extremely difficult to produce without causing impacts on the environment, it is possible to reduce environmental impacts meanwhile so as not to negatively compromise the natural resources and ecosystems involved in the production chain, without reducing biodiversity. This way must evaluate the environmental impacts caused by increased productivity, using technologies available in the market (Valentini *et al.*, 2002).

The increase in aquaculture production and the number of production units in the production model adopted by Brazil, in addition to the environmental impact, brings the growing risk of contamination of water bodies. The risks can, still, be imperceptible, but the effects on the sustainability of fish farming can be devastating (Kubitza, 2011; Poersch, *et al.*, 2012; Hundley *et al.*, 2013). In this context, the economic, environmental and social dimensions

of sustainable development must act in all sectors, including the development of fish farming (Veiga, 2010).

Fish farming makes use of natural resources for production, being considered potentially causing various interferences in the environment, especially in the aquatic environment, however the cultivation of fish in excavated tanks has contributed to sustainability, since it provides the possibility of reducing the use of feed in these nurseries, reducing the addition of phosphate and nitrogen compounds in the environment (Ministério da Pesca e Aquicultura - MPA, 2015).

The fact that fish farming is an activity that emerges from the water resource challenges in the environment points out the confrontation of issues that are increasingly relevant in the world and is necessary to adapt industry. Like this practice so that it does not harm the environment, shaping itself for the creation that involves the sustainability of fish production of resources (Eler & Millani, 2007), since the disordered development of this activity can have negative effects on the environment (Bronnman & Asche, 2017).

It is noted that the sustainability of fish farming is threatened by several risks involving the production process, such as alteration or destruction of habitat, excessive consumption of fresh water, organic pollution and chemical contamination with pesticides and unsustainable practicable (Leung & Dudgeon, 2008; Phillips & Subasinghe, 2008). Developing adequate means to assess sustainability in aquaculture remains a challenge, however these assessments help investors and policymakers to different projects in search of sustainable production validate (Valentini *et al.,* 2011).

Monitoring fish farming without an environmental management policy can become a useless tool for the development and sustainability of the activity and may in some cases become a trade barrier (FAO, 2009). Andreu-Sánchez *et al.*, (2012) highlight that it is extremely important to know the agricultural activities developed near the aquaculture production areas, as it is necessary to establish safety strategies to prevent the absorption of pesticides by fish, preventing the production of contamination, especially of chemicals used in crops.

Sustainable fish farming should be a value for profitable production, but with a conservation of natural resources in order to promote more and more social development (De Oliveira, 2015; Ayroza *et al.*, 2008; Pinheiro, 2004). And for the development of fish farming, in accordance with Law No. 12,651 of May 25, 2012 on the protection of native vegetation, the physical infrastructure of cultivation of the activity in the marginal ranges of any perennial and intermittent natural watercourse is admitted, as well as around the lakes and natural, lagoons, provided that they respect the range of 100 meters in rural areas, or 50 meters, for the body of

water with up to 20 hectares of surface, adopting sustainable practices of soil, water and water resources management, ensuring quality and quantity, according to the standards of the State Environmental Councils (Empresa Brasileira de Pesquisa Agropecuária - EMBRAPA, 2012; Brandão, 2018).

The fish farmer must provide the issuance of the water grant that is used to grant the right to use water, serving as a government instrument for qualitative and quantitative evaluation of the use, either by the capture or release of effluents, ensuring the right of access to water according to Federal Law No. 9,433/1997 (Da Silva *et al.*, 2015).

Thus, the fish farmer must adapt to the requirements of the Law to obtain its water grant, since in the development of fish, farming the quality of water is extremely important for the success, of production, being the main raw material of the activity (Leira *et al.*, 2017; Brandão 2018; Ayroza *et al.*, 2008). According to Morais *et al.* (2015) in the activity of fish farming there is a lack of information and acts on possible environmental impacts, since water supplies fishponds and is returned to the same watercourse, but with deteriorated quality.

Therefore, fish farming and its ecosystems involved in the activity must remain stable and balanced to enable the development of the production process. Producing without causing environmental change is a difficult task, it is possible to reduce the environmental impact in order not to compromise natural resources or cause significant changes in the structure and functioning of the ecosystem (Castellani & Barrella, 2018; Weber, 2009).

When it comes to sustainable development, there is already a growing global economic scenario that has been concerned with environmental issues, especially the reduction of environmental pollution and waste (Bolzan, 2014). The sustainability of any activity or system can be divided into three different and more accepted dimensions: environmental, social and economic, being essential for a perennial activity, such as fish farming (Valenti, 2002), which are treated below.

2.3.1 Environmental Dimension of Sustainability in Fish Farming

The idea of sustainability to be fostered must be how the citizen can use resources correctly, having as bias the ecologically correct, socially fair and economically viable (Rocha *et al.*, 2013). Sustainability from the point of view of the environmental dimension, consists in analyzing the interaction of processes with the environment without causing permanent damage, bringing balance between ecosystems (De Oliveira, 2015).

In order to achieve environmental sustainability in fish farming, one must consider the value of biodiversity and ecosystems inserted in this activity, so that there is harmony between production systems and nature. Using technologies that reduce the environmental impact of fish farming and conserve biodiversity and the functioning still structure of ecosystems can be the best way to achieve environmentally sustainable results in the fish farming production process (Valenti, 2008; Oliveira, 2009).

One of the items to measure the environmental sustainability of fish farming regarding the discharge of untreated effluents into water resources are sedimentation or decanting tanks (Born, 2007). The decanting tank serves as the destination site of the generated effluent and has good ability to remove suspended inorganic solids, but, inefficient in removing nitrogen and phosphorus (Nunes, 2002; Macedo & Sipaúba, 2018).

Effluents and waste are among the environmental impacts caused by fish farming and can generate contamination of water resources such as obstruction of water flows, eutrophication, discharge of effluents from nurseries and pollution by chemical waste used in the different stages of creation. The practice of fish farming produces organic and inorganic material that are poured into the water column, which compromises its quality and, consequently, will imply environmental impacts (Toledo *et al.*, 2003; Rabelo & Silva, 2018).

In, addition, the proper management of solid waste used in the properties contribute to the responsible management of waste in the rural environment – packaging of household products, pesticides used in agricultural activities, organic waste, and the proper disposal of solid waste derived from fish farming activity - (Silva *et al.*, 2008; Sá, 2013). The correct disposal of waste can reduce pollution and environmental sustainability of fish Contributes farming, besides interfering with human health and the environment (De Souza *et al.*, 2014; Boyd & Queiroz, 2004).

One way to minimize the impacts of effluents on water is the integration of aquaculture and agriculture, it presents itself as a sustainable means of production, because it uses the by-products and effluents of an activity to meet the needs of another productive activity (2018).Flowers The irrigated cultivation of lettuce and cucumber vegetables can be easily with fish integrated farming, where the effluent from fish can be destined to fertigation of these vegetables (Sátiro; Ramos Neto & Delprete, 2018; Rabelo & Silva, 2018; Pott, 2002).

To contribute to environmental, sustainability, water quality is of great importance for the success of production, in fish farming it is the main raw material of the activity, because, its characteristics can affect in some way the survival, reproduction, growth, production or even the management of fish (Leira, *et al.*, 2016; Figueiredo, 2018; Macedo & Sipaúba, 2018). Thus,

monitoring water quality in the management of aquaculture species is essential for fish to express their growth potential within water (Diniz & Honorato, 2012).

And, to assist in the water quality of the tanks the use of mechanical aeration is essential for the activity (Faria *et al.*, 2013). An aeration is important to compensate for the additional demand for oxygen favored by increased bacterial community and nitrification rates (conversion of ammonia into nitrate). The aeration allows organic matter (feces, unconsumed remains of feed and fertilizers) to be mineralized still in the water column, without sedimentation occurring in the cultivation environment (Medeiros, 2019; Dos Santos *et al.*, 2017; Lima *et al.*, 2013).

Water quality is extremely important for the development of fish farming activity. Thus, the reuse and preservation of water is essential both in agricultural activities and for the water supply on rural property either through well or treated water, (Leira *et al.*, 2016; Silva *et al.*, 2008; Silva & Carneiro, 2007).

Leira *et al.* (2016) and Pott (2002) complement that knowledge and monitoring of the quality of natural and water resources are made, not only to avoid sudden surprises, such as weakening and death of the organisms Indispensable created, but also aiming at an appropriate management of the rearing system, with better use of water itself, control of food and behavior of aquatic organisms.

Another important factor contributing to the environmental dimension of fish farming is forest cover and the preservation of biodiversity on the property. Producers must preserve the areas of legal reserves and springs, as they are fundamental for the survival of nature's fauna and biodiversity (Silva *et al.*, 2018). Therefore, compliance with the requirement of the legal reserve are sustainable practices that the producer must carry out in order to increase biodiversity in rural areas (Silva *et al.*, 2016).

The development of organic agriculture for food production is a practice that reduces environmental impacts on soil and water resources and can provide crop diversification and does not cause aggression to the environment, and the consumption of organic products is a particularly important component for human health (Sarkar *et al.*, 2020; Penteado, 2012). In addition, natural fertilizers derived from residues from activities such as fish farming provide organic compounds that can be used in crops for soil fertilization (Mengistu *et al.*, 2018; Ferreira, De Souza & Wizniesky, 2013; Sanes *et al.*, 2015).

The composting technique is an example of sustainable practice that helps in waste control (Kulikowska, 2015; Andreev *(et al.*, 2017), reducing the emission of polluting gases in the air, as well as reducing soil contamination, *(*Rakshit *et al.*, 2010; Sarkar *et al.*, 2018). Thus,

with the use of composting, residues can be reused as organic fertilizers that aid in soil treatment, allowing greater fertility for agricultural production (Radziemska & Mazur, 2015; Brogaard *(et al.*, 2015; Lalander *et al.*, 2018; Vidotti & Lopes (2016).

Environmental sustainability is at the balance that must be between ecosystems for the production and consumption process in such a way that inbred self-repair of the natural environment occurs (Nascimento, 2012; Oliveira, 2009), protection of the productive capacity of natural resources, ensuring the continuity of actions for the well-being of the population (Cavalcanti, 2011).

Like this seeks-if to reduce the consumption of external supplies and non-renewable resources (Stoffel, 2014; Sontag, 2016) and a sustainable managed management in the use of natural resources with reduction of environmental impact, through appropriate it is considered ecological practices, so that the use of non-renewable energy sources are reduced so that productive systems are ecologically sustainable, socially and economically sustainable (Abhilash *et al.*, 2016; Sarkar *et al.*, 2018; Altieri, 2012).

2.3.2 Economic Dimension of Sustainability in Fish Farming

The viability of economic sustainability involves sustainable development according to economic measures aimed at incorporating concerns about profitability and environmental and social concepts, thus creating an interconnection between the various sectors. In this case, development from the perspective of economic sustainability must occur in such a way that there is the distribution of economic and financial resources, as well as the allocation of the costs of the activity, efficiently within an appropriate, scale, reorienting the production process and creating so that models that measure the growth and performance of the economy, by categories that also incorporate the environmental and social, variables, (Van Bellen, 2010).

Werbach (2010) conceptualizes the economic sustainability of fish farming as a set of actions that meet human needs, ensuring that goods become profitable and continuous for all those involved in the activity. Already to Kimpara *et al.*, (2012) the economic sustainability of fish farming is, generally measured by, the profitability that the activity brings to the enterprise.

The economic growth of the rural producer is an aspect that reflects on the economic sustainability in fish farming. Soon, the practice of agricultural activities in rural areas, allows income generation, employment, marketing of diversified products and greater family financial development (Altafin, 2007; Schirmer, 2010), providing producers with the acquisition of

goods and the accumulation of capital in the long term, interfering in the expansion of their enterprise (Aquino *et al.*, 2014; Nascimento, 2012; Filipski & Belton, 2018).

Family income originated from agricultural activities such as fish farming, adds better living conditions for family members, as well as comfort and, better financial conditions that allow the development of rural properties and the achievement of the economic sustainability of the enterprise (Kimpara *et al.,* 2012; Sá, 2013; Barrett *et al.,* 2001; Ribeiro-Neto *et al.* 2016). The search for sustainable development in economic activities and resource exploitation is increasingly recurrent in fish farming. From there, the use of strategies for the proper planning and management of resources in, a more efficient manner should serve as the basis for the principles of the economic sustainability of fish farming (Cardoso *et al.*, 2016; Dantas Filho, 2017; Debus, Ribeiro Filho & Bertolini, 2016).

Among the components that lead to the generation of economic sustainability of a rural activity, the financial management stands out, in which rural producers must manage the enterprise, in order to succeed and increase economic growth with the activity produced in the property (Kubitza *et al.*, 2012; Andrade *et al.*, 2005). Financial management involves the set of practices that help the producer to manage their business, in the control of family expenses and revenues, as well as expenses related to agricultural activity, such as fish farming. This type of control can help the producer to achieve economic sustainability in rural areas (Stoffel, 2014; Rotta 2003).

The use of family labor enables a reduction in the costs of the activity, being a determining factor mainly in smaller fish farming, that is, those that have, the smallest amount of water in which slides, most of the labor is of family, members becoming cheap, bringing greater profitability and economic development in the family enterprise (Barros *et al.,* 2010; Paris, 2012; Silva *et al.,* 2018; Barbosa & Pantoja-Lima, 2016). However, outsourced labor costs are mainly needed in larger fish farms, in case producers need the manpower to assist in management and, also to provide service in the facilities of excavated tanks, materials and infrastructure (Barros et *al,* 2010; Dantas Filho, 2017).

When the farmer has easy access to credit or financing by banks, government agencies or partnerships with agricultural cooperatives, better economic sustainability of his enterprise is obtained, allowing the application of substantial resources for the development of production (Sontag, 2016; Emater, 2018). The financing lines to rural producers have reduced interest rates, with long payment terms, providing greater ease for farmers to access credit (De Faria & Santos, 2014). The association of producers with agricultural cooperatives in the regions can also contribute to the development and growth of producers and the community involved in fish

farming activity, influencing the economic sustainability of family farming (Ferreira & De Souza, 2019).

The costs of production and consumption in property interfere with the sustainability economics of fish farming and the rural producer needs to be aware of what is necessary for its cultivation (Araujo, 2015; Dantas Filho, 2017). The costs of feeding, during the fish production process are quite high in the activity, because the supply of adequate food in quantity and quality is important for the economic success of fish farming. Among the various related aspects, food represents about 70% of production costs in intensive production systems. In fish farming, protein requirements are higher when compared to other species, which further increases production costs (Honorato, 2019). Thus, having the knowledge of the number of inputs that will be consumed since the beginning of production, can ensure greater accuracy of the level of production expenditures, favoring the sustainability of agricultural activity (Araujo, 2015; Baldisseroto, 2013; Meante, 2020).

For the economic sustainability of fish farming activity to occur, it is necessary to understand production as a broad process, which involves a whole set of elements that interrelate forming a complex network, to what Valenti (2002) calls the production chain, since it involves elements from different areas. Thus, through economic efficiency in production and ecological prudence in the use of natural resources, environmental quality can be continued for future generations (Melo & Zozzoli, 2009).

Fish farming should generate a positive economic result; however, these results cannot compromise the dimensions of sustainability, especially environmental ecological quality, (Machado & Machado Filho, 2014). Caporal and Costabeber (2002) reinforce that positive economic results are key elements for sustainable rural development strategies.

In this context, in addition to the economic dimension, it is also necessary to worry about the social dimension, since fish farming only acquires meaning and relevance when the generated product can be equally appropriated and enjoyed by the various segments of society (Caporal & Costabeber,2002).

The economic dimension of sustainability involves a set of actions that meet human needs, ensuring that goods become profitable and continuous for all those involved in, according to the Werbach (2010) activity indicators that make it possible to verify the generation of. Like this form up income, labor, investment and profits from the production of an agricultural activity (Araujo, 2015). Also, from the perspective of the dimension of economic sustainability, economic measures are considered, those that address concerns with environmental and social issues, so that there is an interconnection between the various sectors.

If there is an efficient distribution of natural resources within an appropriate scale and with a good administration of the production process, so that there can be the allocation of the costs of the exploitation of agricultural activities, and consequently greater performance of the economy of a municipality (Van Bellen, 2010; Phillips & Subasinghe 2008).

2.3.3 Social Dimension of Sustainability in Fish Farming

Social sustainability is understood as the productive system capable of generating income and jobs to improve the quality of life of all people involved (Valenti, 2008). For Nascimento (2012), the social dimension of fish sustainability highlights the quality of life of the citizen with the reduction of poverty, distances from living standards and limits of access to material goods. Valenti (2002) stresses that for the development of social sustainability in fish farming to occur, there must be harmony with local communities.

According to Soares (2002) social sustainability focuses on balancing the socioeconomic development of society, promotes the reduction of inequalities and the equitable distribution of income and assets, as well as eliminates social injustices, reducing differences between social levels. In this way, the main concern is the human condition and the means used to increase quality of life, basic sanitation services, hospital medical services, safety and (Rabelo, 2007; Damasceno *et al.,* 2011).

Social sustainability in fish farming can act as a lever for social development (Nascimento, 2012; Torres *et al.,* 2017). Well-designed fish farming projects can generate income, direct, indirect and self-employment, distribute the wealth generated among the local population rather than confine it, harmonize the mode of production with the local culture and improve the quality of life of the population where it is inserted (Valenti, 2008; Sa, 2013).

The application of family labor in fish farming is predominant in Brazil (De Almeida *et al.*, 2016; Antonucci, 2016), being a factor that influences the quality of life of the producer, enables the generation of employment among the members of, contributing to the social sustainability of the activity family (Brazil, 2006; Silva *et al.*, 2008; De Almeida *et al.,* 2016; Antonucci, 2016; Debus, 2016; Leonel, 2016; Ferreira, 2017).

Fish farming is developed in Brazil mainly by small farmers and largely to supplement family income, (Ostrensky & Boeger, 1998; Ostrensky, Borghetti e Soto, 2008). The authors state that the perception of family fish farmers has changed about the activity, with some already

stopping making fish farming a secondary activity to transform it into a primary activity. Fish farming has been bringing greater family livelihoods, job creation and better living conditions in the countryside (Silva *et al.*, 2016; Araujo, 2015; Dutra, Bittencourt & Feiden, 2014). In addition, the ease of access to education, electricity, health services, leisure and information, enables the fish farmer to obtain a higher quality standard of living in the rural area, considered a determining factor of the social dimension that has been providing social integration and the economic development of those this involved in agricultural activities (Freitas & Silveira, 2015; Oliveira, Halmeman & Massochin, 2006).

Oliveira *et al.* (2012) emphasize that in addition to the generation of jobs and improvement in quality of life, fish farming can be an important strategy for establishing social and ecological standards of greater economic control and balance of ecosystems. According to Seuring and Müller (2008), the social dimension of sustainability is less studied, but is intended to evaluate the impact of strategies associated with working conditions, social commitment, human rights issues and working practices (Chardine-Baumann & Botta-Genoulaz, 2014). However, although most studies on social sustainability are directed working the conditions, Eskandarpour *et al.* (2015), in a literature review noted that no document was addressed to human rights and commercial practices. In the Social dimension, working conditions and the number of jobs created the healthy most used indicators (Devika *et al.*, 2014; Dehghanian & Mansour, 2009; Mota *et al.*, 2015).

It grows, like this, the implementation of training and training programs for fishermen and rural producers, including has positive effects on agricultural activities (Silva *et al.*, 2016). The training scares in the management of fish farmers in their activities, adding more knowledge that can be applied in fish farming, bringing new income alternatives and the social development of the activity (Souza *et al.*, 2016; Nascimento (2007), Rabelo (2007), Damasceno *et al.* (2011) e Silva (2011).

Access to technology, internet and media in properties is important for the social development of families in rural areas. The dissemination of technology can also increase producer productivity and contributes to the social development of fish farming (Silva *et al.*, 2016). However, Lima *et al.* (2012) states that difficulty in accessing production technologies can impair the fullness of activity in small properties. Small rural properties do not usually apply relevant technological increases during fish cultivation, generating a scenario in which the fish productivity of these properties contributes less than expected to the supply of the Brazilian market (Anjos *et al.*, 2018).

Sustainability in the social dimension is understood as the productive system capable of generating income and jobs to improve the quality of life of all people involved (Valenti, 2008). In agricultural activities, social sustainability involves the improvement of personal skills for food production with the intention of social inclusion of disadvantaged people for the development of appropriate tasks with responsibility in rural areas (Nicli, Elsen & Bernhard, 2020). Like this social sustainability in agriculture is the use of local resources and the creation of productive networks that favor the growth of regional economic Related cycles, leading rural properties to an increasingly sustainable development, generating jobs for the community with the production of regional products, and enabling the reduction of poverty, distances from living standards and limits of access to material goods. (Nicli, Elsen & Bernhard, 2020; Nascimento, 2012).

2.4 SIMILAR EXPERIENCES IN BRAZIL AND IN THE WORLD

In this topic we analyzed the studies related sustainability of fish farming and the measures being used to reduce the environmental impact of the activity.

In Indonesia, a study was made to evaluate how possible interventions and innovations can mitigate environmental impacts related to the growth of the aquaculture sector. The results demonstrated the need to create more conservative production targets and investments of more sustainable agricultural practices (Henriksson *et al.*, 2019). Carvalho Filho (2019), in his work noted that China, with enormous economic growth, is also criticized for the aggressiveness and exaggerated abuse of natural resources, being the leader in the world in the production of aquatic species in many regions, aquaculture activity is practiced in an unsustainable way, addressing that the path to growth must be rethought to pass through the sieve of sustainability.

Rodrigues *et al.* (2019) sought to understand whether the production of integrated tilapia-shrimp have the capacity to enhance the sustainability of aquaculture production when it is economically viable authors pointed out that the production of Tilapia and shrimp seems to be profitable, and evidenced that it is necessary to evaluate the economic compensations associated with different applications on a commercial scale to increase the similarity of the adoption of new technologies in the properties.

Marques *et al.* (2018) addressed in their study on the challenges of the sustainability of fish farming in the São Francisco River in northeastern Brazil, noting that there are problems in obtaining an environmental license due to bureaucracy and difficulties in multiple uses of

water by the release of tailings derived from the rations and inputs that cause the eutrophication of water, in addition to the increase in, productivity of algae has caused environmental impacts.

Moura *et al.* (2016) identified that the sustainability of Nile Tilapia cage production systems in a semiarid region proved economically viable, environmentally, speaking the system relies heavily on nutrient sedimentation in reservoirs. The social dimension of the system employs few workers, some enterprises still need to be modified to improve the sustainability of the enterprise.

Cardoso *et al.* (2016) analyzed fish farming based on the principles of sustainability through the case study of a fish farming of excavated tanks and it was possible to verify that the maintenance of the self-production of the system interferes in the aquaculture production chain in water bodies. So recommended the sustainable use of water resources with strategic planning to enable the development of the activity in the social, economic and environmental spheres.

From another perspective, Kist *et al.* (2016) in its study carried out to identify the physical, chemical and bacteriological characteristics of continuous effluents and Tilapia harvest and analyzing the impacts of these residues was obtained as a, result of a low level of eutrophication despite presenting considerable phosphorus levels. The alternative found to minimize the impacts is the use of wastewater in irrigation, with the rational use of water, so that water pollution reduction and lower fertilizer utilization rates occur. Rebouças and Gomes (2016) studied about organic aquaculture that, has been contributing to good food quality, the lack of adequate management can cause environmental meanwhile impacts, however, it has been pointed out as an alternative to conventional, differentiating itself in the use of economic, ecological and cultivation potential of organisms such as fish, shrimp and algae.

Hundley and Navarro (2013) state that sustainability is a necessity for food production, highlighting the aquaponics – technique refers to a type of integration between aquaculture and hydroponics in water and nutrient recirculation systems presents as a – this if less impactful alternative to the environment and is among the sustainability techniques for the production system of aquatic organisms, allowing plants to use the nutrients of water from fish cultivation, improving the quality of water bodies.

Brum and Augusto (2015) in their study dealt with strategies in the industrialization of tilapia through the integrated production system, it was found that. Like this in fish, farming the production of tilapia, even with obstacles to overcome, points to a growth of the integration model adopted for fish production, since it has achieved the objectives of finding space for expansion of the activity.

Bocabello (2019) sought to understand the trajectories and stages of evolution of the tilapia industry in Brazil, applying and testing a model of evolution of the industry, considering food production at the global and local level, the competitive scenario and value appropriation strategies of integrated and independent producers. The work sought to evaluate risks and opportunities to increase the competitiveness of this industry, within the Brazilian scenario. Special recommendation was, also, given for organizational alternatives to the independent producer's layer for the purpose of sustaining competitiveness.

Schulter and Vieira Filho (2017) noticed in their study that the performance of fish production fell short of expectations, with low insertion in the domestic and international markets. Even so, the national production of tilapia has increased since 2004 above 10%, emerging as an emerging activity in the production chain, but there are challenges to develop the production chain, in order to sustain growth.

It is estimated that fish farming will be the most growing food producing sector in the world, since it is a productive activity practiced in several countries, becoming an important source of income with a relevant role in food security (FAO, 2014).

2.5 CONSIDERATIONS ON THE CHAPTER

This chapter allowed the meeting of concepts about fish farming, and sustainability, pointed out the relevance of fish farming in the regional context and the importance of sustainability in fish farming activity. It also brought concepts about the farming systems of fish farming existing in Brazil, in which the integrated system and the independent system stood out. It was possible to verify the elements that characterize the two cultivation systems, such as the functioning of the production chain of the systems, predominance of the family labor. still force identified that an alternative of income and occupation for the rural fish farming constitutes population. The chapter also showed that there are environmental impacts that are being caused by inadequate management of activity in Brazil and worldwide, mainly interfering in water resources, soil and biodiversity of nature.

In addition, it made it possible to address sustainability in fish farming and the elements that compose it, being divided into three dimensions: environmental, social and economic, and which are essential for achieving the sustainable activity, dimensions that development served as the basis for computing the reference items for the analysis of sustainability categories of integrated and independent fish farming systems, allowing to identify the different

contributions of productive systems to sustainability. The chapter was broadly addressing the existing studies on sustainability in fish farming in Brazil and in the world and it is still an aspect. It was possible to verify measures and techniques that are being used to reduce the environmental impact of the activity.

It was found that the main way to measure sustainability in the most diverse rural enterprises is through components or characteristics that are present in the dimensions of sustainability, in that the characteristics existing in each dimension can show the paths for the evaluation of sustainability in fish farming, to achieve the objectives of the research.

Finally, for the achievement of the specific objective (A), all were considered in the chapter the studies of Henriksson *et. al.*, (2019); Moura *et al.* (2016), Cardoso *et al.* (2016), Kist *et al.* (2016), Rebouças and Gomes (2016), Hundley and Navarro (2013) among other authors, in which we addressed the methods and management techniques used in fish farming that contribute to sustainability.

3 RESEARCH METHODS AND TECHNIQUES

In this chapter, the methodological procedures of this research were detailed, starting with the design of the research, field of study, the procedure of data collection and analysis and the development of categories of analysis of the sustainability of fish farming to achieve the objectives.

3.1 RESEARCH DESIGN

The study is qualitative. Through qualitative methods, it is possible to explore and understand the problem analyzed from the information obtained with questionnaires and interviews, like this providing more subjective data about the phenomenon that is intended to be analyzed (Creswell, 2014). The qualitative approach is oriented based on the activities and expressions of people in their contexts or realities (Flick, 2009).

This study was classified as a descriptive study, which allows delimiting the characteristics related to the phenomenon among the variables of a given population, describing the information through the reports obtained (Raupp & Beuren, 2012). Thus, it is possible to describe the information obtained by the researcher, providing a coherent analysis referring to the object studied (Mezzaroba & Monteiro, 2009). This research is descriptive in that it is intended to delineate the perceptions of individuals regarding the integrated and independent cultivation systems existing in the municipality of Nova Aurora-PR, considering the economic, social and environmental dimensions that are involved in the activity of fish farming, with the purpose of identifying which of the systems favors for sustainability.

3.2 FIELD OF STUDY

The main scenario is the rural properties of Nova Aurora-PR that develop the activity of fish farming. The field of Includes studies the integrated and independent cultivation systems of fish farming existing in rural properties and the actors surveyed are the fish farmers of Nova Aurora-PR. The choice of this municipality for the research was due to its growth and

prominence in the production of tilapia species, surpassing neighboring cities such as Assis Chateaubriand, Palotina, Toledo and Maripá (SEAB/Deral, 2018). According to information provided by the head of the Department of the Department of Agriculture and Environment of the municipality of Nova Aurora, Tilapia production in 2019 was above 13,000 tons. According to data from the City Hall of Nova Aurora – that were made available by the head of the Department of Agriculture and Environment – in the municipality there are 101 small and medium-sized fish farmers who are integrated into some cooperative in the region, while 19 fish farmers work in the independent system in the activity.

The research was carried out with a sample of 20 fish farmers, 10 integrated and 10 independent fish farmers, both groups associated with a Credit Cooperative located in the municipality of Nova Aurora-PR. The selection criterion adopted for choosing the number of 20 interviewees in the research was that the cooperative has 50 members who carry out the activity of fish farming, thus the 20 producers who actively move their accounts in the cooperative to perform the selection of the sample, since the researcher had easy access to them, facilitating the contact to perform the interview. The amount of 10 integrated and 10 independent fish farmers was defined for the collection of research data.

3.3 DATA COLLECTION AND ANALYSIS PROCEDURES

Regarding the data collection procedure, a structured script (appendix) with open and closed questions was used. The questions addressed items related to the profile of fish farmers and issues involving the environmental, economic and social dimension of sustainability related to fish farming activity. Martins (2008) comments that the script used in an interview should be supported by the theoretical framework, as it will be related to the study and its objectives.

Regarding the type of questions, Marconi and Lakatos (2011) state that the questions can be opened or closed: the open ones are classified by the unlimited freedom of answers to the researcher, while the closed ones have specific alternatives with several answers for the choice of an alternative. The questions were organized according to the target audience to facilitate the understanding of the interviewees.

An open interview was conducted with the head of the Department of Agriculture and Environment of the municipality to identify the total number of independent and integrated fish farmers working in Nova Aurora-PR, the data served as the. In this way, basis for surveying the

context of fish farming in Nova Aurora-PR. According to Duarte (2005), open interviews are characterized by their flexibility and by exploring to the maximum a certain theme and are usually conducted without itinerary from a central theme.

After the preparation of the structured script (appendix) the interviews were conducted, Gil (1999) points out that the preparation of the interview script is a fundamental point and depends on the type of interview that will be adopted. The purpose of the interview is to obtain information about a particular subject or problem. Thus, the structured interview is one that the questions and the order in which they attend are the same for all respondents (Gil, 2010).

A structured interview, as in the case of an opinion survey, is composed of a set of questions previously elaborated and chained sequentially in which it allows the fluidity and direction of the subjects (Edwards & Holland, 2013; Yin (2010). In this study, data collection through interviews aimed to extract practices performed in the fish farming activity of the participants, regarding the presence of environmental, economic and social aspects of sustainability in integrated and independent systems of Nova Aurora-PR.

The procedure for conducting the interview was initially done by scheduling via telephone, to know what the availability of time would be, and day indicated by the fish farmers. Ten integrated fish farmers and ten independent fish farmers were interviewed individually. Due to the pandemic period, it was not possible to conduct the interviews in, person, so the interview took place initially via WhatsApp by audio addressing the issues of the structured script (appendix), but because the interview lasted, approximately 2 hours, it became tiring and a certain deviation from the focus of the interview was observed in this way. After the second interview, it was identified the need to conduct the other interviews via call to optimize the time and clarify the questions to the interviewees if they had doubts during the interview. It is worth mentioning that the first two interviews are part of the total analyzed, because there was no harm in obtaining the necessary information.

There was the use of a call recorder application, with the authorization of the interviewees and notes were made, throughout the interview, according to the authors Martins (2008) and Yin (2010) guide to the procedure of data collection of an interview. The period of interviews took place between 17/11/2020 and 09/01/2021, with an average duration of 01:20 hours each.

After the completion of the interviews, the transcription of each one was performed, allowing to observe in detail the course and content of the interview, the transcriptions were organized and categorized with the use of a spreadsheet. In addition, the notes referring to the items addressed in the interviews were reviewed later, from the listening of the recordings and,

when necessary, the notes for later analysis of the data were complemented together with the complete transcription of the interview.

Data analysis occurred in a comparative way, based on a previous field-led structure, developed according to the structured script (appendix) with the categories of sustainability analysis composed of environmental, economic and social dimensions, made it possible where if to compare the results with the literature and perform the interpretation of the information obtained. Yin (2015) mentions that a data analysis process with comparative composition structure repeats the same study two or more times, comparing the alternative descriptions or explanations of the same case. The broad objective of the analysis is to seek meaning and understanding in the collected data (Gil, 2009), since a qualitative analysis has the comparison as the main intellectual tool, in turn the data obtained can be compared with models already, defined, with the data themselves and, also with data from other, studies (Tesch, 2013).

The practices reported in the interview were analyzed considering whether they meet the sustainability indicators suggested in the literature. From this indicator, it was observed the proportion of producers who indicated sustainable practices in each item analyzed, thus, resulting in a classification in four different levels of contribution to sustainability: unsustainable, unsustainable, partially sustainable and sustainable. With this classification of the items, it was possible to classify a proportional result for each dimension of sustainability for the purpose of comparison between the groups of integrated and independent producers.

The study had some limitations regarding data collection, due to the pandemic period by Covid-19. Among the difficulties encountered for the elaboration of this dissertation are: (i) the difficulty in applying the interview to all fish farmers in the city of Nova Aurora-PR, due to the fact that they do not have everyone's contact to make the calls and answer the questions of the research; (ii) the pandemic prevented the interview from taking place in person, and it was not possible to make the field observation, because there was no possibility of reaching these rural properties.

3.4 ANALYSIS CATEGORIES

The categories of research analysis were defined considering the environmental, social and economic dimensions of sustainability that are essential for the ecosystem balance of natural resources and sustainable development. Each category has its components and the

description of these components. From the selection of the components, the category framework was developed to conduct data collection and analysis.

Initially, the characterization of existing production systems in fish farming activity was developed. Table 1 demonstrates this characterization.

Table 1 - Characterization of Fish Farming Production Systems

CHARACTERIZATION OF FISH FARMING PRODUCTION SYSTEMS	
In fish farming there are several types of production systems that are used considering the site, management, species to be cultivated and market requirements, among the forms of production are the extensive, semi-intensive, intensive and super intensive system (Nunes *et al.*, 2015).	
Items	**Features**
Extensive system	− Characterized by the number of fish per unit area and production. − The food is restricted to the natural food produced by the hybrid mass existing in the dams. − Little influence of man in the production process. − There is no fertilization management and water supply and quality controls (Nascimento & Oliveira, 2010).
Semi-intensive system	− Nurseries built specifically for fish farming. − Daily water exchange occurs from 1% to 10% of the volume. − Feeding from the intake of organic fertilizers, chemicals or feed. − Handling is done with or without water renewal (Nascimento & Oliveira, 2010).
Intensive system	− High density of fish (Oliveira, 2009). − Chemical treatment of water, mechanization of some processes (Oliveira, 2009). − Use of balanced feed (Oliveira, 2009). − The harvest and fish storage are 1 to 10 fish per m2, with controlled water flow (Nascimento & Oliveira, 2010). − Nurseries are planned, have slope to facilitate the flow of water (Nascimento & Oliveira, 2010).
Super-intensive system	− It is used as small tanks. − Tanks are masonry, with continuous water flow and total water renewal in a short period. − High storage density accounted for by biomass in m3 (Nascimento & Oliveira, 2010).

Source: Elaborated by the author from the literature (2020)

The characteristics of the two integrated and independent cultivation systems were defined, considering the literature consulted in this study, so that the profile of fish farmers from Nova Aurora-PR can be classified. Table 2 demonstrates the characteristics present in both systems.

Table 2 - Characterization of Integrated and Independent Fish Farming Systems

1 - INTEGRATED CULTIVATION SYSTEM OF FISH FARMING	
The integrated cultivation system occurs when different production processes are controlled by the same company, receiving the integration name, the company is called integrator and the producer of integrated in this process(Stam and Medeiros, 2012), the integration works in such a way that the company, or cooperative to the cooperated fingerlings with genetic origin, feed and technical assistance, in contrast the producer delivers all production to the cooperative, without transport costs provide (Brum & Augusto, 2015; Sidonio et. al., 2012).	
Items	**Features**
Integrative company.	− Responsible for making available the necessary supplies for the producer to develop the activity of fish farming Sidonio *(et al.*, 2012; Peixe Br, 2020). − A production contract is made in partnership between the producer and the cooperative (Copacol, 2016) − The fish farmer enters with the infrastructure (the water slide), the manpower and the fulfillment of the requirements and recommendations of the integrator (Copacol, 2016).
Tanks or nurseries excavated.	− Excavated nurseries are required in the integrated system). (Copacol,2016 − They have reservoirs built on natural land, equipped with water supply and drainage systems (Lopes, 2018). − They are excavated in land suitable for fish farming (Bocabello, 2019).
Aerators and water pumps.	− Aerators are used for water renewal in nurseries during the production period (Coldebella, 2018). − It is an equipment that is part of the infrastructure required by the integrator and assists the incorporation of oxygen into water (Copacol, 2016). − The pumps play the role of returning to treated and reoxygenated water for the breeding tanks (Kubitza, 2006).
Environmental license and water concession.	− It is mandatory that the fish farmer has an environmental license and the granting of the current right of use of water (Copacol, 2016).
Support and technical interventions.	− The integrator's support occurs throughout the production process (Kubitza, 2009). − It is offered technical assistance from fishing engineers to the fish farmer frequently (Nervis, 2019). − The integrator offers technical training for the associate (Nervis, 2019).
Monoculture of the species Tilapia.	− In the integrated system there is the monoculture of tilapia and total density for excavated nurseries of approximately 8 t/ago (Hermes, 2009).
Intensive production system.	− Production occurs intensively due to fertilization and catheter, feeding with balanced feed and water renewal (Guimarães, 2012). − Use of organic or inorganic fertilizers and high density of fish storage per m² (Faria *et al.* 2013; *(*Cyrino *et al.*, 2010).
2 - INDEPENDENT CULTIVATION SYSTEM OF FISH FARMING	
In the independent cultivation system, fish farmers carry out the activity of fattening, acquiring their fingerlings and/or juniors from other producers and all the inputs of external suppliers, later selling the live animals for slaughter (Peixe Br, 2020).	
Items	**Features**
Tanks dug.	− Use of excavated tanks for fish rearing with water inlet and outlet, with food administration and forced water oxygenation (Bocabello, 2019).

Purchase of feed and inputs on behest the producer.	– Producers go in search of external suppliers to purchase the necessary food, vaccines and management supplies during the fattening phase (Bocabello, 2019).
Hiring a company for the transport of fish	– Fish farmers hire carriers to send their production to fishing grounds or slaughterhouses that slaughter and distribute fish to supermarkets (Bocabello, 2019; Sidonio *(et al.*, 2012). – Fish carriers, fish makers and fish wholesalers act as intermediaries in this chain (Kubitza, 2011).
Environmental license and water concession.	– In this system the producer must submit to the licensing process, and grant water (Brandão, 2018).
Intensive production system.	– The intensive production system occurs with the use of feed, housing high densities of fish per m², and water renewals during the management of fish farming (Lopes, 2018; Cyrino *(et al.*, 2010).

Source: Elaborated by the author from the literature (2020)

With the characterization of production systems and the definition of the characteristics of the integrated and independent cultivation system, aspects that have relevance for the sustainability of fish farming were raised. From these aspects, the categories of sustainability analysis were developed based on the environmental, social and economic dimensions, which served to evaluate the sustainability of independent and integrated cultivation systems in the municipality of Nova Aurora-PR.

Table 3 was elaborated from studies such as Cavalcanti (2011); Sontag (2016); Nascimento, (2007); Nascimento (2012); Faria *et al.*, (2013); Medeiros (2019); Sarkar *et al.*, (2018), in which it was possible to build the categories of analysis of the environmental dimension focused on fish farming.

Table 3 - Environmental Dimension Analysis Categories

ENVIRONMENTAL DIMENSION	
The environmental dimension is tied to the balance that must be between ecosystems for the production and consumption process in such a way that self-repair of the natural environment occurs (Nascimento, 2012), protection of the productive capacity of natural resources, ensuring the continuity of actions for the well-being of the population (Cavalcanti, 2011). Taking into account the search for a decrease in the consumption of external and non-renewable resources (Stoffel, 2014; Sontag, 2016) and considering a management managed in a sustainable way in the use of natural resources with reduction of environmental impact, through appropriate ecological practices, so that the use of non-renewable energy sources are reduced so that production systems are ecologically sustainable, socially and economically sustainable (Abhilash *et al.*, 2016; Sarkar*et al.*, 2018).	
Items	**Features**
Treatment of liquid effluents in fish farming activity.	– Sedimentation or decanting tanks help with the dumping of effluents into water (De Queiroz & Silveira, 2006). – This practice causes the fish effluents generated by the activity to be decanted and sedimented, easing the eutrophication and pollution of water (Nascimento, 2007).

	– The decanting tank facilitates handling and reduces possible environmental damage (Macedo & Sipaúba, 2018).
Disposal of solid waste in rural properties.	– Responsible waste management (Dantas Filho, 2017). – Correct destination of the packaging of household products, pesticides used in rural properties, through municipal collection (Silva *et al.*, 2008; Sá, 2013). – Care should be for both household waste and organic and inorganic waste from agricultural activities (De Souza, *et al.*, 2014).
Integration between Aquaculture and Agriculture.	– Irrigated cultivation of vegetables such as lettuce and cucumber can be easily cultivated with fish farming integrated. – The integration between aquaculture and agriculture causes fish effluents to be destined for fertigation of vegetables (Sátiro, Ramos Neto & Delprete, 2018).
Adequate management of rural activities in the management of water resources through mechanical aeration.	– The use of mechanical aeration in tanks contributes to water quality with higher water renewal rate (Faria *et al.*, 2013). – Proper management increases water oxygenation and generates less impact of contamination water resources (Dos Santos, *et al.*, 2017).
Water quality: reuse and preservation of water.	– The reuse and preservation of water is of great importance for agricultural activities. – Water supply on the rural property can occur by means of well or treated water (Leira *et al.*, 2016; Silva *et al.*, 2008).
Forest cover on the property.	– Federal legislation must be commendable in the area of forest cover for rural properties that have bodies of water. – Preservation of margins and springs that are covered with dense riparian forests. – Care is needed with soil quality reducing environmental impacts on water resources (Silva *et al.*, 2018).
Preservation of biodiversity on the property.	– The existence of protected areas on the property and compliance with the requirement of the legal reserve are sustainable practices. – The growth of animal and forest biodiversity in the properties should be preserved (Silva *et al.*, 2016).
Organic activity practices.	– The practice of organic agriculture for food production causes low environmental impact in the rural environment (Sarkar *et al.*, 2020). – It provides greater crop diversification (Sarkar *et al.*, 2020). – The use of green management, natural fertilizers and composting techniques help in the control of residues and reduction of soil contamination (Rakshit, *et al.*, 2010; Sarkar *et al.*, 2018).

Source: Elaborated by the author from the literature (2020)

For the identification of aspects related to the economic dimension authors, such as Werbach (2010); Araujo (2015); Van Bellen, (2010); Kimpara *et al.* (2012); Nascimento (2012); Aquino *et al.* (2014) stood out for the construction of the categories of sustainability analysis of the economic dimension of fish farming. In which, based on the work of these authors, it was possible to propose categories adapted to the reality of fish farming activity in

Nova Aurora-PR. The categories of the economic dimension can be verified in Table 4, just below.

Table 4 - Economic Dimension Analysis Categories

ECONOMIC DIMENSION	
The economic dimension of sustainability involves a set of actions that meet human needs, ensuring that goods become profitable and continuous for all those involved in the activity Werbach (2010). Form indicators that make it possible to verify the generation of income, labor, investment and profits from the production of an agricultural activity (Araujo, 2015). Economic measures are considered those that address concerns with environmental and social issues, so that there is an interconnection between the various sectors. If there is an efficient distribution of natural resources within an appropriate scale, and with a good administration of the production process, so that there can be the allocation of the costs of the exploitation of agricultural activities, and consequently greater performance of the economy of a municipality (Van Bellen, 2010).	
Items	**Features**
Economic Growth.	– Agricultural activities that use family work generate income in the marketing of their products (Nascimento, 2012). – Economic growth can provide farmers with the acquisition of goods (Nascimento, 2012). – Long-term capital accumulation (Aquino *et al.*, 2014; Nascimento, 2012).
household income.	– The family income from agricultural activity in rural areas allows improvements in the quality of life of families. – The producer may have more than one source of income (fish farming, aviculture, pig farming) (Kimpara *et al.*, 2012; Sá, 2013).
financial management.	– It allows the diversification of production and gives investment capacity to the property (Stoffel, 2014). – This type of control helps identify expenses and revenues and can assist the producer in his family financial management still (Stoffel, 2014; Rotta, 2003).
Labor costs.	– Labor costs are higher in larger fish farms. – These expenses are necessary if the producer needs to hire outsourced labor for the management, and for service services in the facilities of excavated tanks, materials and infrastructure (Barros *et al*, 2010). – The use of family labor in fish farming can reduce costs with outsourced labor (Silva *et al.*, 2018).
Access to credit or financing by government agencies and/or partnerships with agricultural cooperatives.	– Partnerships between technical assistance organizations and rural extension, financial agents, unions and municipal governments have allowed access to the financing of agricultural activities (Sontag, 2016). – Access to credit contributes to improving the quality of life of rural families (Emater, 2018; Sontag, 2016). – The association of rural producers with agricultural cooperatives in the regions that provide services and technical support to the producer in the management of their activities contribute to the economic development of the producer (Ferreira & De Souza, 2019).
Production and consumption.	– The farmer should be aware of what is necessary for their cultivation. – It is important to be aware of the required number of materials for the cultivation period in order to ensure greater accuracy of the level of production expenditures (Araujo, 2015).

Source: Elaborated by the author from the literature (2020)

Authors such as Valenti (2008); Nicli, Elsen and Bernhard (2020); Stoffel (2014); Silva *et al.* (2016); Souza *et al.* (2016) were highlights for the elaboration of components for the

construction of the categories of analysis of the social dimension, verified in Table 5, in which items could be listed for categories of the social dimension adapted to the activity of fish farming.

Table 5 - Social Dimension Analysis Categories

SOCIAL DIMENSION	
The social dimension of sustainability involves the productive system capable of generating income and jobs to improve the quality of life of all people involved (Valenti, 2008). In agricultural activities, the improvement of personal skills for food production is being enhanced with the intention of social inclusion of disadvantaged people for the development of appropriate tasks with responsibility in rural areas, (Nicli, Elsen & Bernhard, 2020). Considering the use of local resources and the creation of productive networks that favor the growth of regional economic cycles, in which rural properties can have an increasingly sustainable development, generating jobs for the community with the production of regional products, and enabling the reduction of poverty, distances from living standards and limits of access to material goods. (Nicli, Elsen & Bernhard, 2020; Nascimento, 2012).	
Items	**Features**
Employment and Income.	– Agricultural activities that generate employment and income function as a lever for social development in rural properties (Nascimento, 2012). – Provides job creation for the community (Ostrensky, Borghetti & Soto, 2008). – It enables the expansion of the practice of growing other crops in family farming (Stoffel, 2014).
Manpower.	– In agriculture, the use of family labor is predominant. – Family and/or outsourced labor on rural property are factors that interfere in the quality of life of the producer (Silva *et al.*, 2008).
Family livelihood.	– It is related to the contribution of agricultural activity to the generation of employment in relation to the area used for the practice of agricultural purposes (Silva *et al.*, 2016). – Family work favors the subsistence of producers in food production in rural properties, ensuring better living conditions for families in the countryside (Araújo, 2015; Silva *et al.*, 2016).
Quality of life.	– The quality of life of rural producers is linked to issues related to access to education. – It also refers to the infrastructure of housing in rural properties. – It is considered the access of families to electricity, health services, basic sanitation, leisure and income (Araújo, 2015; Silva *(et al.*, 2016).
Training and Training.	– The development of training can assist the producer in the management of his activities (Silva *et al.*, 2016). – The participation of rural families in training programs can contribute to the practice of fish farming activity, bringing new alternatives for income generation and reduction of social (Dotti *et al.*, 2012; Souza *et al.*, 2016).
Access to technology.	– Easy access to the internet in rural properties is important for social development in rural areas (Silva *et al.*, 2018). – Access to rural telephony, media and technology are aspects that help in the performance of family farming (Silva *et al.*, 2016).

Source: Elaborated by the author from the literature (2020)

The construction of the tables of the categories of analysis was carried out through a survey of the aspects that have relevance for the sustainability of fish farming. From these aspects, the categories of sustainability analysis were developed as an evaluation tool, which can favor and contribute to the sustainability of the activity. Thus, the main components related to the environmental, economic and social dimensions in fish farming were identified.

4 CONTEXT OF FISH FARMING IN NOVA AURORA - PR.

The city of Nova Aurora has significant results, placing first in tilapia production in Paraná in 2018. Nova Aurora's figures for gross production value (VBP) in 2018 Were of R$753 million, with a VBP of 63,000 per inhabitant, and tilapia production had a 9% share of these totals in the municipality (SEAB/DERAL, 2018).

The beginning of the production of tilapia in Nova Aurora was driven by a cooperative installed in the region that is Copacol, a pioneer in agricultural activities in western Paraná, and in 2008 invested R$ 15 million in an area of 2,300 m², a land of 55,000 m² given by the Municipality of Nova Aurora to 17 km from Cafelândia – headquarters of Copacol, for the implementation of an exclusive refrigerator for fish production. With this, the cooperative expanded the diversification of production by investing heavily in the activity (Brum & Augusto (2015).

Since the implementation of the refrigerator, fish farming has expanded more and more in the city of Nova Aurora. The Cooperative envisioned forms of gains throughout the process, also considering, as, a determining factor the analysis of the price/cost ratio, because this is what determines the profitability and performance of the company in the activity (Horn, Shikida & Staduto, 2009).

The creation of Copacol's fish integration system was a driving force for the expansion of fish cultivation in the city, generating more than 1,000 jobs, bringing opportunities for 220 rural families in Nova Aurora and the region who bet on the integration project and explore an area of 530 hectares of water slide (O Novo Oeste, 2018).

According to data provided by the head of the Department of Agriculture and Environment of the Municipality, 81 fish farmers are already integrated into Copacol. There are also independent producers who produce the fish for sale on their own, many sell the fish to companies that are not integrators, such as private refrigerators, or even sell in local trade and in the region, this public total 19 independent fish farmers in Nova Aurora-PR.

The 81 fish farmers integrated to Copacol currently have a total of 2,411.00m² of water slides distributed in the properties of Nova Aurora-PR and according to, data provided by the head of the Department of Agriculture and Environment of the Municipality, the production of these fish farmers in 2019, resulted in around 11,600 tons of fish of the species Tilapia. Independent producers produced an amount of 586 tons in 2019.

The results have pointed to an increasing advance of activity especially for tilapia cultivation. And in December 2019 the municipality received the title of Paraná Capital of Tilapia, the bill 8532/17 was approved by the House and Senate, in which the city became even more recognized by the State Government (Radar, 2019).

In addition to the high results in tilapia production, with the activity of fish farming, the municipality has been promoting local development accompanied by the generation of employment and income, a fact that helps to further achieve the sustainable human development of the producing families and the entire community involved, contributing to the reduction of social vulnerability (PUND, 2018). In this context, 20 fish farmers from Nova Aurora-PR were selected, 10 producers integrated with Copacol and 10 independent producers, that is, who are not integrated into any cooperative, for the interviews.

5 ANALYSIS AND DISCUSSION

This chapter presents the analysis and discussion of the data found in the research regarding the environmental, economic and social dimensions of sustainability in fish farming activity in Nova Aurora-PR. To this end, it initially discusses the general profile of the interviewees, information on the infrastructure of the property and data on the production of integrated and independent fish farmers.

Table 6 presents the characteristics of the profile of independent and integrated fish farmers.

Table 6 - Profile of Fish Growers

sex	**independent**	**integrated**
male	10	10
female	0	0
age	**independent**	**integrated**
From 20 - 30 years	1	2
From 31 - 40 years old	3	1
From 41 - 50 years old	5	2
From 61 - 60 years old	1	3
From 61 - 70 years old	0	2
marital status	**independent**	**integrated**
married	8	9
single	2	0
other	0	1
Number of Children	**independent**	**integrated**
0 children	2	1
1 son	2	1
2 children	2	6
3 children	4	1
4 children	0	0
5 children	0	1
Education Level	**independent**	**integrated**
Ens. Fund, fund. incomplete	0	1
Ens. Fund, fund. complete	2	3
Ens. Incomplete Medium	1	0
Ens. Full Medium	4	4
Incomplete superior	1	0
Full top	1	2
Time in Activity	**independent**	**integrated**
From 0 - 5 years	6	7
From 6 - 10 years	1	0
From 11 - 15 years old	1	1
From 16 - 20 years	0	2
From 21 - 25 years old	2	0

Source: Data from the Interview with Fish Farmers (2020)

Analyzing the identification of the profile of the interviewees, the survey shows that all 20 interviewees are male. The age of integrated and independent fish farmers ranges from 20 to 70 years, it is worth noting that the largest number is among the 41 to 60 years of age for

both profiles. Similar results were evidenced in the study by Nakauth *et al.* (2015) showing great similarity due to the activity being predominantly male and aged around 55 years. It was noticed that integrated and independent producers over the age of 40 have longer time in the fish farming sector.

As for the marital status of independent and integrated producers most of them are married and similar results were found at the Mato Grosso Institute of Agricultural Economics-IMEA (2014), where the majority, 73.34% of Mato Grosso fish farmers are married, Nakauth *et al.* (2015). Araújo (2015) in his studies highlights the predominance of married fish farmers. This is probably due to the frequency of age they present, also, observing in the fish farming activity of Nova Aurora, which is practiced by heads of families.

Regarding the number of children, it was observed that independent producers have mostly 1 to 3 children, the most integrated fish farmers have 1 to 2 children, this fact points to the same tendency to reduce the size of families observed in urban areas (Leone *et al.*, 2010).

Regarding education, it is observed that most independent and integrated producers have completed high school, however it was observed that the level of education of the integrated producers was higher, due to the presence of producers who have complete higher education. Schooling can become a barrier to restricting the growth of activities in rural areas if there is a low level in rural, communities (Nascimento, 2007; Rabelo, 2007; Damasceno e*t al.*, 2011), thus, schooling is a fundamental factor for the success of development in rural areas, as it helps in the interpretation of information pertinent to practices of economic activities and adoption of technologies (Sá, 2013). It was found in the research that the predominant schooling was complete, high school, such results indicate that the activity of fish farming is performed by fish farmers with. According to data from IBGE (2018) the rural producer with complete elementary school and complete or incomplete high school, is classified in the middle schooling range.

Regarding the time of activity in fish farming, it was noticed that two independent fish farmers and two integrated fish farmers have been working in fish farming for more than 25 years. The fact that drew attention in the interview was in relation to the number of producers who have been working for only 5 years in the activity, totaling six independent fish farmers and seven integrated fish farmers, who are beginners in the fish farming activity. Contrasting with the data found in this research, Torres *et al.*, (2017) obtained a higher percentage of producers working in fish farming over 5 years, portraying that this fact is due to the time they reside in the properties and the producers have the main economic activity in Dourados-MS.

Table 7 shows information on the production infrastructure of independent and integrated fish farmers.

Table 7 - Property Production Infrastructure

Property Size	**independent**	**integrated**
01 -12.1 hectares	6	2
12.1 - 24.2 hectares	1	3
26.62 - 36.3 hectares	2	2
28.72- 48.4 hectares	1	1
50.82 - 60.5 hectares	0	1
60.92 - 72.6 hectares	0	0
75.02 - 84.7 hectares	0	0
87.12 - 96.8 hectares	0	1
Property Residents	**independent**	**integrated**
1 person	0	0
2 people	2	1
3 people	3	2
4 people	1	3
5 people	2	2
6 people	1	1
7 people	0	1
10 people	1	0
Own Area	**independent**	**integrated**
yes	9	10
No	1	0
Water Slide	**independent**	**integrated**
From 1 - 20 thousand m2	7	5
From 21 - 40 thousand m2	1	2
From 41 - 60,000 m2	1	3
From 61 - 80,000 m2	0	0
From 81 - 100,000 m2	0	0
From 101 - 120,000 m2	1	0

Source: Data from the Interview with Fish Farmers (2020)

Regarding the production infrastructure of fish farming, regarding the size of the property, a significant number of responses were obtained for the number of independent producers who have up to 12.1 hectares of area and with respect to integrated producers, most of, which have a property of 12.1 hectares to 36.3 hectares of area. According to a study published by the Brazilian Service of Support to Micro and Small Enterprises (Sebrae, 2012), based on the Agricultural Census conducted by the Brazilian Institute of Geography and Statistics (IBGE), it was, found that in Brazil producers with an area of less than, 100 hectares, indicate the predominance of small rural properties. Therefore, of the fish farmers interviewed, all have small rural properties that do not exceed 100 hectares.

With regard to the size of the area of occupation of fish farming in the enterprise, most of the integrated and independent fish farmers have 1 to 20,000 m² of water slide, that is, the equivalent of up to 2 hectares of water slide, which are the beginners in the activity, however the number of fish farmers, who exploit from 41 to 60 thousand m² of water slide was also relevant, highlighting this amount possibly for producers with more time of operation in fish

farming. According to Conama Resolution No. 413 of June 26, 2009, fish farmers who exploit an area of no more than 5 hectares of water slide are considered small producers, those who have 5 to 50 hectares of water slide, medium producers and above 50 hectares of water slide, large producers. From this classification, it was observed that integrated and independent fish farmers are mostly small, and medium-sized farmers.

It was identified that most of the interviewees, both independent and integrated, reside in the property with up to 5 people in the family and only one independent producer has 10 people residing on the property. Therefore, the families of integrated and independent fish farmers are mostly small, and the result demonstrates the decrease in the population in rural areas. This reduction in the number of people living in rural areas is understood by De Mera and Netto (2014) because family members seek opportunities for better living conditions in cities.

It was observed that most of the integrated and independent producers have their own area, only an independent producer indicated that he owns a lease of his father's area. What can be concluded is that most farmers do not have to bear the rental costs, because they own the land, noting that the producers practice family farming. According to Brazil (2006) and Altafin (2007) family farming occurs when producers, predominantly use their own family's labor in the economic activities of their, enterprise, have family income desist almost from the economic activities linked to the enterprise still and the enterprise is directed in the family, occurring a family management of the productive unit.

Table 8 sets out the production data of the fish farming activity of the integrated and independent producers of Nova Aurora-PR.

Table 8 - Production Data

Fish per m2	**independent**	**integrated**
5 fish m2	1	1
6.5 m2 fish	0	9
7 m2 fish	1	0
8 fish m2	3	0
9 fish m2	4	0
50 fish m2	1	0
Species produced	**independent**	**integrated**
tilapia	10	10
Tank Structure	**independent**	**integrated**
Excavated Nursery	10	10
Net Tank	0	0
Legal Reserve Area	**independent**	**integrated**
From 1 - 10 m from the margin	3	1
From 11 - 20 m from the margin	1	3
From 21 - 30 m from the margin	2	1
From 31 - 40 m from the margin	2	2

(+ 40 m from the margin)	0	3
Environmental License and Water Grant	**independent**	**integrated**
yes	10	10
No	0	0
Middleweight	**independent**	**integrated**
50 grams	1	0
800 grams	2	7
850 grams	1	1
From 750 to 800 grams	2	1
From 750 to 850 grams	1	0
From 850 to 900 grams	3	1
Fish Farming Goal	**independent**	**integrated**
fattening	9	10
juvenile	1	0

Source: Data from the Interview with Fish Farmers (2020)

In the analysis of production data, it was identified that all the fish farmers interviewed produce the tilapia species in the structure of excavated tanks. Furthermore, the cultivation of fish in the fattening phase is predominant in both producer profiles, except for 1 independent producer who makes the cultivation in the rearing phase of juveniles, subsequently reselling them to fattening phase producers. It was observed that the number of fish per m² housed in the tank ranges from 8 to 9 fish per m² for independent producers, except for the independent juvenile producer that houses 50 juveniles per m². The integrated producers host 5 to 6.5 fish per m² in the tanks, following the guidelines and recommendations of the integrator.

By means of the production characteristics identified in the interview with the integrated and independent producers and considering the amount of fish per m² housed to be of high density, the management for fish feeding occurs entirely with the use of balanced rations both in the integrated system and in the independent system, in addition to the nurseries being ,all excavated with the monoculture of tilapia, as well as because the chemical treatment of the water of the tanks and the mechanization of some processes occur through aerators and pumps during production), it was found that all the producers interviewed make use of the intensive production system in the fish farm (Coldebella, 2018; Schulter & Vieira Filho, 2017; Oliveira, 2009; Nascimento & Oliveira, 2010; Lopes, 2018; Sebrae, 2016).

Regarding the average weight of fish withdrawal from independent fish farmers, they range from 750 to 900 grams and, for the fish farmer who produces juvenile-rated fish the withdrawal weight is around 40 to 50 grams.

The integrated fish farmers remove the fish mostly with average weight ranging from 750 to 900 grams, depending on the integrator needing fish for slaughter and can be removed up to 1 kilo. Therefore, it was observed that there are no major differences between the two groups of fish farmers in relation to the average weight of fish withdrawal.

Regarding the environmental license and water concession, it was found that all independent and integrated fish farmers have the grant of water and environmental license for the practice of the activity, as they are mandatory for the activity of fish farming, as highlighted by Ayroza *et al.*, (2008); Brandão (2018).

Regarding the legal reserve area, it was noticed that all respondents also have a part of the legal reserve property that ranges from 10 meters to more than 40 meters from the margin depending on the location of the tanks. Thus, it was noted that fish farmers are meeting the technical requirements of joint resolution IBAMA/SEMA/IAP No. 002/08 respecting a marginal range of up to 10 meters between the waterline and the reforested strip for circulation and management of the production nursery, with preservation vegetation around fish farming and possible areas of compensation of the surrounding vegetation.

According to the data of fish farmers, it is noteworthy that the two profiles produce tilapia in excavated tanks, are small and medium-sized farmers who respect legal requirements and have active environmental licenses to produce fish farming, with no differences in the two groups. Most producers are operating in the activity less than 5 years in both profiles. The cultivation is usually done in the fattening phase, only 1 independent producer does the cultivation in the breeding phase of juveniles and there were no significant differences in relation to the average weight of fish withdrawal for the two producer profiles. The main difference between the two profiles was in relation to the number of fish housed per m², and the integrated producers host less fish per m² compared to independent producers.

5.1 ENVIRONMENTAL DIMENSION ANALYSIS

The results found in the environmental dimension in the aspects of liquid effluent treatment produced in the fish farming activity showed that 9 of the 10 integrated producers have decanting tanks for the treatment of liquid effluents, only 1 fish farmer of the integrated system does not have a decanting tank. This fish farmer pointed out that due to the location of the tank being near the river, it is not possible to dig the decanting tank, on the other hand the fish farmer planted grams near the water outlet of the tank, have the function of filtering the water that is because, before descending into the river, according to the excerpt of the transcript of the interview of E.Integr.7:

> I do not have the decanting, but I have planted a grass-like plant at the water outlet of the tank, the water comes out of the dam passes through the grass that gives a filter in the waste and goes to the river, the grass also helps holding the clay that comes out of the tanks

> preventing the dirty mud from reaching the river, causing the silting of sediments , and helps filter the water before it is dumped into the river.

Rabelo e Silva (2018) in their study comment on the importance of plants in the processes of filtration and elimination of bacteria and pathogens from the waters of rivers and lakes, and Aguapé (*Eichhornia crassipes*) is one of the main species used in this process, results pointed out that the aguapé presented filter potential, because there was improvement in all physical parameters -chemicals of the analyzed water. Therefore, the use of aquatic plants can be an alternative that aids in the purification of water, in which chemical compounds are absorbed eliminating only water filtered. (Pott, 2002; Rabelo & Silva, 2018, Figueiredo, 2018) It can then be said that the use of the plant by the integrated fish farmer is a sustainable alternative that assists in the filtration of sediments, as well as decanting tanks.

Of the independent fish farmers, 2 of them do not have a decanting tank due to the lack of space on the property, such as the excerpt from the transcript of the interview of E. Indep.7:

> when I built I didn't have much room to make a decanting tank, my dam is small and because of the lack of area space on the property I can't even expand more in water slide, when low the water level of the dam the water goes straight to the river, because I don't have the decanting the main challenge is in the fishing so that there is no water so dirty to the river , I take care and treat the water inside the tank with probiotics.

The other 8 independent producers have decanting tanks and the literature highlights the use of decanting tank as an important aspect of sustainability in fish farming to avoid the dumping of untreated effluents interviewed into resources, which is used by most of the fish farmers Water (Macedo & Sipaúba, 2018; Nascimento, 2007). The results showed that the integrated producers stood out in relation to the independent ones, because 9 out of 10 integrated fish farmers have decanting tanks, while 8 out of 10 independent producers have decanting tanks, since the 2 producers who do not have the decanting throw the water directly into the river and do not use any method, to replace the decanting tanks. Although the difference is not so significant, the method developed by the integrated producer that does not have the, decanting tank, making the use of aquatic plants that filter organic materials is an alternative to reduce pollution in, water, reinforcing what Pott (2002) says, about tanks with aquatic plants as well as swamps act with, pollutant filters, helping to return clean water to the springs giving favorable conditions for the food base in aquatic, ecosystems.

It has stood, out in the use of a product interview that assists in reducing fish waste and in the treatment of liquid effluents, is the probiotic 7 of like this the 10 independent fish farmers do the treatment of effluents with probiotics in water, like the excerpt transcribed from the E.Indep.2 interview: "I use probiotic, buy gallon and set in water the liquid to reduce ammonia and nitrite from tanks and increase good bacteria from water, making the water get cleaner." Or

even the excerpt transcribed from the interview E. Indep.4: "I treat effluents with probiotics, which is a natural product that I buy in gallons, i play at least once a week in the dam they help dilute the bad bacteria and the fish waste". Integrated producers do not use probiotics.

Products known as bio remediators use living microorganisms in polluted environments to accelerate the removal and biodegradation of undesirable contaminants such as ammonia, nitrite and nitrate. In fish farming it is known by producers as probiotic, being a biotechnological solution that does not harm the environment, degrading the excess of organic matter and eliminating excess nitrogen in the tanks (Mouriño, 2016; Freitas, 2010). The use of probiotics has been one of the techniques developed to assist in the management processes of fish farming, contributing to food management, load densities, reduction of water temperature, being a way to treat and restrict effluents in water (Ramirez *et al.*, 2013; Diniz e Honorato, 2012; Pandiyan *et al.*, 2013), and it was noted that this product has been used only by independent fish farmers in management.

In addition to indicating the use of decanting, tanks for all integrated fish farmers, they described as part of the care of management in fish farming in the treatment of effluents, the use of hydrated and virgin lime and salt in still dams, such as the transcribed excerpt from the interview. E.Integr 10:

> I use hydrated lime directly in the tank, I play about 20 grams per m², it helps to increase the alkalinity of water and improves the PH of water and salt is also a product that the technicians of the cooperative guide us to use, around 50 grams per m², it helps in the treatment of fattening the fish because sometimes the fish ends up eating , we play salt to relieve stress and improve the defensive system of fish, it is very important to improve the health of fish.

Virgin and hydrated lime are also management products for fish farming that, in addition to helping in the disinfection of nurseries to eliminate pathogens and unwanted organisms, are used for water quality control (Leira *et. al.*, 2016; Massago & Da Silva, 2020) and salt assists in the prevention of diseases in fish, stress, relief related to expenses and acts as a softener of adverse environmental conditions, such as nitrite toxicity and fungal control (Kubitza, 2007). The independent producers, on the other year, make use of these products in the management of tanks.

Of the interviewees, it was observed that the 10 integrated fish farmers use lime to treat liquid effluents because it is recommended by the cooperative technicians to help in the elimination of bacteria and water quality control and only 4 of the 10 independent producers make use of hydrated or virgin lime. It is noted that integrated fish farmers have been adopting good management practices in fish farming, using inputs such as hydrated or virgin lime, as well as independent producers using probiotics has also been an important measure in fish

management, since probiotics can act beneficially in increasing pressure on microorganisms, promoting increased bacterial resistance, constituting an alternative in disease control (Nikoskelainen, *et al.*, 2001; Gram *et al.*, 1999; Ribeiro, Costa & Logato, 2008).

Regarding the components identified for the treatment of liquid effluents, it was observed that the producers of the integrated system have a significant contribution to the dimension of environmental sustainability, since they have a greater number of decanting tanks than independent producers, since the decanting tanks main means healthy the used by producers to ensure the environmental sustainability of the activity and , also use products such as lime and salt to assist in the management, of tanks. Independent producers, on the other hand, contribute partially to environmental sustainability, as it has been identified that they are not all that have the decanting tank, however they use probiotics in the, excavated tanks, and the use of probiotics is among the preventive sanitary practices, which helps in increasing the zootechnical parameters and immunological capacity of fish to reduce waste in water, according to Diniz and Honorato, (2012), Pandiyan *et al.*, (2013).

As for the disposal of solid waste on the property (household waste, packaging of pesticides and inputs, organic waste) half of the independent fish farmers make the correct destination, as in the excerpt transcribed from the interview of E. Indep.5: "here at home we gather the household waste and take in the landfill of the city, and the organic game in the vegetable garden, and the packaging of pesticides we separate and return in the company that buys the products, at the collection point of packaging." The other fish farmers burn household waste, while organic waste is destined by the 10 fish farmers for fertilization of the garden and in the crop.

Most of them are integrated fish farmers, they recycle household waste, such as the excerpt from the transcript of the E.Integr interview.3:

> everything that is packaging of poison or pesticide comes back to recycling at the collection point of the city, and the organic waste I throw right here on the property to become fertilizer, the household waste I gather and put in a large bag and take to dump in the garbage of the city.

However,, it was noted that some fish farmers of both the integrated and independent systems still burn, the garbage on the property as the excerpt from the transcript of the interview, of E. Indep.1: "it is not always that I go in the city, so the garbage here from home we end up burning everything, only the poison packaging that I'm seeking and when I go to the city I return to the company that collects these packages." It is noteworthy that most integrated and independent producers are doing the correct disposal of waste for recycling.

Waste management responsibly is essential so as not to impact environmental and human health issues (Silva *et al.*, 2008; Sá, 2013; De Souza *et al.*, 2014). Dantas Filho (2017) adds that the implementation of good practices in fish management increases productivity. Regarding solid residues of fish farming, all fish farmers make use of composting for the disposal of dead fish in tanks, and composting acts on the decomposition of solid materials and the organic matter available in the initial materials tends to stabilize over time, forming unique substances and increasing their potential for agronomic use (Kulikowska, 2015; Andreev *et. al.*, 2017; Mengistu *et al.*, 2018). It is evidenced, that in this item, both independent producers and integrated producers contribute to the dimension of environmental sustainability, giving an adequate destination for solid waste, since waste management in a responsible manner is essential not to impact environmental and human health issues.

Regarding the practice of integration between agriculture and aquaculture, the producers of the integrated system do not have the adoption, as well as independent producers, although all interviewees are farmers of grain cultivation, work individually in each activity. Therefore, in this item none of the integrated and independent producers contribute to the dimension of environmental sustainability since the integration of aquaculture and agriculture presents itself as a means of sustainable production (Sátiro, Ramos Neto & Delprete, (2018) because it uses the by-products and effluents of an activity to meet the needs of another productive activity, since the integration of agriculture and aquaculture can contribute to the sustainability of the planet (Carneiro *et al.*, 2015).

In the aspect related to the management of water resources in fish farming activity, all 20 fish farmers have aerators in the tanks, such as the excerpt transcribed from the E.Integr interview.8:

> the aerator in fish farming is essential to generate oxygen in the water and avoid the mortality of fish, I always take care of the level of oxygen in the tanks is an important management that needs to do every day, I take the oximeter and when it is missing the oxygen, I already turn on the aerators.

The excerpt of the interview is consistent with what the literature reports on the role of the aerator that is fundamental for the incorporation of oxygen from water, and the non-accumulation of toxic gases at the bottom of excavated tanks, being an equipment that helps to ensure sustainable management practices in fish farming (Dos Santos *et al.*, 2017; Faria *et al.*, 2013; Medeiros, 2019).

The results showed that both fish farmers of the integrated system and fish farmers of the independent system use aerators for water oxygenation, evidence that both also contribute

to the dimension of environmental sustainability by adding sustainable management in the productive environment of fish farming.

As identified in, the interviews to know how the oxygen level of water is used, an equipment called oximeter, all integrated fish farmers have the oximeter as a tool for water analysis, since, like the excerpt from the transcript of the interview E.Integr.3: "the oximeter is a mandatory equipment that you need to have when you enter the integration, they require you to buy because the equipment helps us to know when you need to connect the aerators in the dams to generate oxygen for the fish".

On the other hand, independent fish farmers, only 3 have the oximeter and the main reason for not using it is due to the high cost of the equipment, such as the excerpt transcribed from the interview of E. Indep.5:

> I do not have the oximeter because it is an expensive device, and because I do not have such a large area of fish farming, I can see if the fish are pointing up the water, I know I need to turn on the aerator, or when it's cloudy during the day I also need to turn on, I'm controlling and tracking if the fish need oxygen in the water that way.

Some of the independent fish farmers have reinforced that they observe the oxygenation of water by their experience with the activity, through the behavior of fish and the coloration of the water of the tank, so they already know if it is necessary to connect the aerations to increase the oxygen of the water. Dissolved oxygen in water is a fundamental parameter in fish farming (Lima *et al.*, 2013; Silva & Carneiro, 2007) and daily monitoring of these values help predict the occurrence of critical levels of dissolved oxygen in tanks and sudden variations in water temperature (Kubitza, 1998; Macedo & Sipaúba, (2018).

It was noted that integrated fish farmers use the oximeter in greater quantity to measure oxygen in fish farming, compared to independent fish farmers, so, it can be said that the producers of the system integrated in this item have a greater, contribution to the dimension of environmental sustainability than independent producers, since monitoring of water quality is associated with the health of fish, which need ideal development conditions, to obtain better productivity of fish crop.

Also, regarding the management of water resources, it was identified that most integrated and independent producers capture water for tanks through pumps, which use the water from nearby rivers, streams and springs Pumps help to return to treated and to the property reoxygenated water for excavated tanks (Kubitza, 2006). It was identified that most independent and integrated producers need the pumps to capture water from rivers to tanks, except for 3 integrated producers who obtain water by gravity, such as the transcribed excerpt from the E.Integr interview.2:

> by the location that was made the excavation of the tanks in the site and the location of the river that is above the level of the tank, the water comes down everything by gravity to supply the tanks, I have no cost to pump the water, but in times of drought or drought ends up decreasing the volume of water and this is a problem that happened and has already interfered in my productivity in the lots of fish.

The water supply of fish farming can be done by gravity or pumping, and sometimes, combining these two forms, with gravity supply, can reduce the operational cost (electricity or fuel) during the management of tanks and reduce the risk of failures with the breakdown of pumps or lack of, energy (National Rural Learning Service - SENAR, 2018). Therefore, it is noted that the supply of tanks for water collection for both fish farmers of the integrated system and for fish farmers of the independent, system, occurs, mostly through pumps to meet the needs of tanks in the production of fish, since the water of rivers and streams are below the level of tanks, thus it is not possible to supply water by, gravity.

In the related to quality aspect of tank water, most integrated and independent fish farmers use reagent kits to perform tests to measure the amount of nitrite, nitrate, ammonia, PH and water alkalinity, such as the transcribed excerpt from E. Indep.6's interview:

> I do the tests by the chemical reagents I buy to measure the quality of the water, at least once a week I take a sample of the water from the tank to do the test, and even by the color of the water I already realize if it is too strong nitrite and take care in the management play the probiotics in the water to improve the quality.

Or the excerpt transcribed from the interview of E. Integr.7:

> with the test by the reagent kits I can see the result by the coloration of the water, if it is good quality or not, comes a table together in the kit that I buy and according to the color of the water, know if the water is too high nitrite, ammonia the Ph of water, I control weekly, and reduce the treatment of fish to decrease the excess organic matter in the tank and also set the lime to make the water more alkaline.

Of the 20, interviewees, only 1 independent and 1 integrated fish farmer do not use the reagent kits and what stood out in their speech is, like the transcribed excerpt from interview E. Indep.8: "I've been working with the fish farm for over 10 years, I know how the water is by the smell of it and the color, if I notice that the smell of ammonia is strong, I already control the tract and i put lime in the water to reduce toxicity and kill the bad bacteria from the water." It was evidenced that the minority of fish farmers do not use reagent kits to control the quality of water in tanks due to the time they have experience working in the field of fish farming. Water availability and quality are essential factors in a fish farm (Rodrigues *et al.*, 2013) and the use of reagent products helps in the measurement of water quality parameters, in order to ensure favorable conditions of the fish to reproduce, feed and grow (Cardoso, 2017) and thus, achieve success in the productive activity.

In this perspective, one of the most important aspects of fish farming involves maintaining water quality under adequate conditions for fish rearing, requiring effective management and ensuring sustainability literature highlights that (Macedo & Sipaúba, 2018). Like this a treatment of water adequately in tanks, has a direct influence on water quality and the process of fattening fish (Nogueira et. *al.*, 2011; Silva & Carneiro, 2007). With the use of reagent kits by most fish farmers to measure water quality, it is evidenced that with this form of management, both integrated and independent fish farmers also contribute to the dimension of environmental sustainability, since water is an essential component for the activity throughout the production process.

Also on water quality, it was identified that all integrated producers make use of inputs such as virgin lime and hydrated lime frequently to control water quality in production tanks, while independent producers, some use these intakes less frequently. Therefore, the producers of the integrated system obtained greater relevance in this aspect, since virgin and hydrated Lime are important management products, since they help in the disinfection of nurseries with the elimination of pathogens and unwanted organisms these methods used by integrated fish farmers that have been contributing to the dimension of environmental sustainability in fish so farming.

Another finding found in the research was about the management of tanks through water renewal, it was identified that 7 independent producers do the water renewal when they realize that the water is too loaded with organic matter, lower the level of the tank and replenish with clean water from the rivers, the other do not renew water, as the excerpt from the transcript of the interview E.Indep.2: "I'm not doing water renewal at the moment because of the drought, the river water that fills the tanks is little and I stopped doing in these last batches because I do not have enough water for renewal".

Among the integrated, producers 4 practice the renewal of water, but do less often than the independent, stated that they are instructed by the technicians of the cooperative to make the lower in of the water limit if necessary, the others do not do the renewal of water in the tanks. Therefore, it is observed that independent producers are practicing water renewal more frequently than integrated ones. Water renewal is a key factor in environmental issues present in fish farming, it is possible to reduce impacts on the environment by reducing water renewal rates in tanks (De Faria *et al.*, 2013; Sousa; Brito Neto & Leite, 2016).

The renewal and discharge of water practiced constantly interferes in the increase of pollution and generation of waste in the environment, if there is too much concentration of effluent in the tanks the discharge of water can affect aquatic communities and reduce the

quality of water intended for other beneficial uses (Boyd & Queiroz, 2004; Silapajarn & Boyd, 2005). Thus, the practice of water renewal in tanks that is frequently done during the lot by most independent fish farmers can mainly aggravate the quality of the region's water resources, negatively affecting the environmental sustainability of fish farming.

During the interview, an integrated producer commented that he has knowledge through the Internet of a technology used in the management of fish farming that helps reduce water renewals, such as the transcribed excerpt from E. Integr.1:

> I read reports on the Internet that in Brazil producers are already using bio flakes that are various bacteria that help to eat the organic matter of fish and clean the water, not needing to do the renewal of water, but it is not in dug tanks, the tanks are inside greenhouses, I found it very interesting and in the future I think it would be very good if we used this management technology here in the region.

The cultivation during the Bioflakes of English *(Biofloc* Technology - BFT), is a technology still little widespread in Brazil, but meets the new concepts of a responsible and environmentally correct aquaculture, since they are carried out practically without water *renewal* and with the use of microorganisms as a natural food, which reduces the use of feed, allowing less environmental impact. The BFT system, in addition to improving productivity rates, when compared to traditional cultivation systems, has greater biosecurity, because it reduces water changes and thus avoids diseases (Sampaio et. al., 2010; Zimmermann, 2017; Zimmermann & Fitzsimmons, 2004).

Regarding the forest cover item on the property, it was identified that all fish farmers, both independent and integrated, have legal reserve area according to environmental requirements, the legal reserve area varies between 10 meters to 100 meters wide on the riverbank. The literature reinforces that the lack of vegetation can cause negative influences on the habitat of living beings, compromising the environment regarding aquatic and terrestrial systems (Magalhães & Cunha, 2007; Pinheiro, 2004). So, the vegetation acts protecting the soil, influencing the water quality of a hydrographic basin. Thus, these areas are essential to maintain good quality water supply (Silva *et al.*, 2018; Donadio, Galbiatti & Paula, 2005).

On the aspect of biodiversity preservation, the 20 producers interviewed care and take care of nature, such as the excerpt transcribed from the interview of E. Indep.9: "I try to plant trees in the place whenever necessary and not deforestation in any way, zeal for property." The results show that the integrated and independent producers are aware and helpful in the care of nature, do their best within their realities to avoid aggression to the environment, because they depend on natural resources to produce fish farming activity. The literature portrays that vegetation and riparian forest areas around the water body improve water quality, conserve soil,

biodiversity and regulate the processes of exchange between terrestrial and aquatic ecosystems (Weber, 2009; Appolo, 2010; Pinheiro, 2004), so people involved in fish farming should be aware of these implications to seek the sustainability of the activity.

In the item of organic activity practices in the properties, of the 10 independent producers, only 2 produce organic vegetables, and 1 of them also emphasized that it produces organic beans for their own consumption, the other do not do any organic activity on the property. Of the integrated interviewees, only 2 of them have organic vegetable production for their own consumption, and it is noted that organic production in rural areas is little widespread. It is important that the rural producer increasingly reduces the use of agrochemicals, giving preference to organic sources of nutrients and changes in management techniques in food production, in order to protect the environment, using natural resources in an appropriate and sustainable way (Altieri, 2012; Penteado, 2012). The results show that only 4 producers, 2 independent and 2 integrated, make organic food production, the other integrated and independent producers do not perform organic food production practices on the farms.

However, it was identified that producers use organic management techniques that are related to sustainability practices in fish farming activity, composting is a technique widely used in solid waste management by all independent fish farmers and integrated in the process of disposal of dead fish from the tank. The literature reinforces that aquatic animal residues have high organic loads and significant amounts of plant nutrients, which can be used when effectively managed (Radziemska & Mazur, 2015). Like this composting stands out as a simple and low-cost method (Brogaard *et al.*, 2015; Lalander e*t al.*, 2018), which allows the production of nutrient-rich organic fertilizers that can be used in agriculture, bringing several benefits for soil fertility and for the recovery of degraded areas (Illera-Vives *et al.*, 2015; Sreesai *et al.*, 2013). Vidotti and Lopes (2016) add that the formation of organic composting from production residues makes the activity sustainable and viable, so that organic compounds can be applied to agricultural crops on the property, as well as being transformed into silage for commercialization.

It was identified that some producers use the residues (organic compounds) taken from the bottom of the tanks in the fishing as natural fertilizer to throw into the soil in the crop. Of the interviewees, 8 independent producers use the waste in the crop, the other 2 independent fish farmers did not have the need to play in the crop at the moment because the tanks are newly made and have not yet generated enough waste accumulation at the bottom of the tank. It was observed that 7 integrated producers also use the waste removed in the fishing as a natural fertilizer in the crop, but it was identified in the research that 3 producers make a ditch (hole)

in an area of the property to perform the disposal of the waste, and later cover the ditch with land.

The literature states that the correct disposal of waste should be planned from the beginning of the production chain of fish farming avoiding future problems with the disposal of these, (Vidotti & Lopes, 2016). The use of natural fertilizer as agricultural input provides the increase of nutrients, improvement in the physical, chemical and biological aspects of the soil, adding greater fertility to the land (Ferreira, De Souza & Wizniesky, 2013; Sanes et. al., 2015; Dos Santos *et al.*, *2018*).

The result shows that the practice of composting technique and natural fertilizer is widely used in both cultivation systems and as, discussed in the literature the method of composting animal residues is composed of organic matter and can serve as a natural fertilizer and reused in crops by producers (Radziemska & Mazur, 2015; Brogaard *(et al.*, 2015; Lalander *et al.*, 2018). Abbreviation of do this form was evidenced, that with the adoption of these management techniques, the two integrated and independent cultivation systems present practices that favor the dimension of environmental sustainability in fish farming, because they are doing the reuse and the correct disposal of fish compounds.

A relevant aspect found in, the research when addressing the environmental impacts that fish farming activity could cause was that the integrated and independent producers, mostly do not consider fish farming, a polluting activity, such as the excerpt transcribed from the e.Integr interview.9:

> in my point of view if we do the correct management does not pollute so much the water and the environment, the sewers of the cities I believe that pollute much more than fish farming, we treat the water in the tank, have the decanting and we did all the fish farming according to environmental laws and with the guidelines of the integrator in a correct way, I think that agriculture with the use of poisons in crops pollutes much more than fish farming.

In most of the, interviews, statements were obtained from the point of view that fish farming with correct management helps in the quality of water, because it is continuously treated in tanks and also contributes to the diversification and reproduction of more fish species in rivers, like the excerpt transcribed from the interview of E.Indep.8: "today I see that in rivers there are more fish than a while ago for me fish farming even helps in this part to increase species in rivers", this fact contradicts what some authors say about the environmental impacts of fish farming that has been causing the pollution of water resources by the excess organic matter of the nurseries, may cause mutations in the environment, and the contamination of other aquifer animals itself generating environmental pollution (Jana & Jana, 2003; Valentini

et al., 2002; Leung & Dudgeon, 2008; Phillips & Subasinghe 2008; Sobral *et al.*, 2006; Santos *et al.*, 2015; Dullah *et al.* , 2020).

However, because they are small areas of water slides identified in, most of the interviewees, Schirmer (2010) mentions that when there is a small-scale production, large, impacts caused to the environment are not visible, thus it was noted that the profiles of small and medium producers interviewed have the perception that the activity of fish farming does not significantly pollute the environment. A summary of the results of the environmental dimension is shown in Table 9.

Table 9 - Environmental Dimension - Main Results

Items analyzed	independent	integrated
Treatment of liquid effluents in fish farming activity.	Decanting tanks (8). Aquatic plants (0). Use of Probiotics (7). Use of hydrated and virgin lime and salt (4). Classification: Partially Sustainable	Decanting tanks (9). Aquatic plants (1). Use of Probiotics (0). Use of hydrated and virgin lime and salt (10). Classification: Sustainable
Disposal of solid waste in rural properties.	Recycling of solid waste (5). Burning garbage (5). Organic waste (10). Composting (10). Classification: Partially Sustainable	Recycling of solid waste (7). Burning garbage (3). Organic waste (10). Composting (10). Classification: Partially Sustainable
Aquaculture and Agriculture Integration.	integration between agriculture and aquaculture (0). Rating: Unsustainable	integration between agriculture and aquaculture (0). Rating: Unsustainable
Adequate management of rural activities in the management of water resources through mechanical action.	They have aerators (10). Use of the oximeter (3). Use of Pumps (10). Classification: Partially sustainable	They have aerators (10). Use of the oximeter (10). Use of Pumps (7). Classification: Sustainable
Water quality: reuse and preservation of water	Use of reagent kits (9) Use of virgin lime and hydrated lime (4). It does water renewal (7), Rating: Unsustainable	Use of reagent kits (9) Use of virgin lime and hydrated lime (10). It does water renewal (4). Classification: Sustainable
Forest cover on the property.	Forest cover on the property (10). Classification: Sustainable	Forest cover on the property (10). Classification: Sustainable
Preservation of biodiversity on the property.	Preservation of biodiversity in the property (10).	Preservation of biodiversity in the property (10).

	Classification: Sustainable	Classification: Sustainable
Organic activity practices.	Organic production (2). Composting technique (10). Classification: Partially Sustainable	Organic production (2). Composting technique (10). Classification: Partially Sustainable
Completion of the Environmental Dimension	Partially Sustainable	sustainable

Source: Data from the Interview with Fish Farmers (2020)
Note: the numbers in parentheses indicate the number of respondents who indicated the characteristic

The framework demonstrates the differences found in the integrated and independent system in the environmental dimension of sustainability. From the classification of the items, it was possible to compare the differences in the two groups. It is concluded that , in the item related to the treatment of liquid effluents , the independent system is partially sustainable, due to the fact that not all have decanting tanks, however, they make use of probiotics that aid in the treatment, while in the integrated system it was considered sustainable due to the number of integrated fish farmers that have a decanting tank being larger, while the fish farmer who does not have, the decanting, practices a method considered sustainable that is the use of aquatic plants to perform the filtration of water, from the tanks, in addition to using natural lime sums for the treatment of effluents. Regarding the disposal of solid waste, the two systems were considered partially sustainable due to the proportion of fish farmers not recycling properly and burning the waste on the property, despite performing the disposal of organic waste and using the composting technique in the fish farming activity, correctly.

About the practice of integration between aquaculture and agriculture, the independent and integrated system were classified as not sustainable, because they make use of this practice. Regarding the proper management of rural activities in the management of water resources, it can be concluded that the independent system is partially sustainable, because the minority has an oximeter to measure the oxygen of the water of the tanks, despite using pumps and aerators in the management. On the other hand, integrated fish farmers were considered sustainable by most to use oximeters, pumps and aerators in which they contribute to a good management of water resources. As for water quality, fish farmers in the independent system are, unsustainable, mainly because the majority do constant water renewal in tanks and do not use inputs such as virgin and hydrated lime frequently to improve the quality of water s integrated fish farmers are sustainable to the extent that, all use virgin and hydrated lime in management for water quality and do not do water renewal of frequently.

As for forest cover, the two groups are considered sustainable because they have a preservation area in the properties, as well as, preserving the biodiversity of the rural area. As for the practice of organic activities, fish farmers of the independent and integrated system are considered partially sustainable, by the minority of producers producing organic food on the property, however all perform the composting technique in the fish farming activity.

5.2 ECONOMIC DIMENSION ANALYSIS

In the dimension of the economic sustainability of fish farming, issues related to family economic growth were addressed. It was observed that independent fish farmers have been achieving, more and more, economic growth that the fish farmers of the independent system were satisfied with. The profitability and the results obtained in the activity, such as the transcribed excerpt from the interview of E. Indep.5:

> With the activity I achieved a growth that I did not expect, even though there is little amount of water slide that I have here in the site, my economic growth has increased a lot, brought more income and I, want to expand my fish farming area in the future.

In the view of Castellani and Barrela (2018) the activity of fish farming needs basic planning to produce satisfactory results and can be leveraged in the perspective of social and economic development, the effective use of local natural resources and the creation of. This is because it makes it possible to do jobs. It was noted that the economic return of the activity caused independent producers to have better financial conditions and fish farming added the possibility of like this new achievements and acquisition of goods for the family, like the excerpt transcribed from the interview of E.Indep.1: "fish farming brought me greater opportunity for growth, I was able to change cars, with the profit of the last batch of fish I invested in the construction of my aedicula, and we have more comfort here at home, it brings me a good profitability".

In this way, it is emphasized that all independent fish farmers stated that they have greater economic independence after starting the activity of fish farming. This result reinforces what the literature approaches, since fish farming has, been one of the most growing food-producing sectors in the world, becoming an important source of income for fish farmers, with a relevant role for economic development in Brazil and the achievement of economic sustainability by all rural families involved still in the activity (FAO, 2011; Aquino *et. al*, 2014; Nascimento, 2012).

Regarding the economic growth of integrated fish farmers, the interviewees are partially satisfied with the results and profits obtained in production, some of them reinforced that they have not yet achieved the return they expected, due to the investment having been high and long-term, being compromised a part of the results they receive from the lots, because the money is being used to liquidate the portions of financing in the banks, as the excerpt transcribed from the interview E.Integr.4:

> I still could not get a good financial return, because the investment I made to make the whole structure of the tanks, I am still paying, so I have installments in the banks and expenses that I need to pay when a lot of fish comes out, not much left for me.

Or the example of the excerpt transcribed from the interview E. Integ.2:

> the lots did not work as good as we expected and for now, we are just paying for the investment, and the integrator is always demanding some improvement that needs to do on the property, want us to surround the tanks, also put sanitary arch in the access to the tanks, then it ends up not leaving a good profit as we would like.

The results indicate that independent fish farmers are more satisfied with the economic growth achieved with the activity in relation to integrated fish farmers thereby and it was observed that the main aspects are due to the price of them kilo of , the fish that has been increasing and also because they are not obliged to meet, the requirements of integrators that generate extra costs for the fish farmer in the fish lot, that's because, in the independent system the fish farmers themselves manage, their business. Possibly the economic growth of independent fish farmers is being higher compared to integrated fish farmers. Like the excerpt transcribed from the interview of E. Indep.8:

> working independently, I have a higher profit per kilo, and I have the power to buy food for a better price and sell the fish to whom I want, I think in the integration the producer ends up being an employee of the integrator instead of owner of the business, and yet the integrator is demanding many improvements in the property that are unnecessary sometimes, and I do not depend on anyone to make my decisions.

The interviewees were interested in expanding their areas of water slides to further improve the economic development familiar with the activity. Along the same lines regarding the expansion and implementation of new technologies in fish farming, most integrated and independent fish farmers intend to expand the number of dams on the property and make investments in new technologies. Only 1 integrated and 1 independent fish farmer do not intend to expand, because the maximum production capacity has already been reached in the property, with no more conditions for expansion. The information found affirms what Andrade *et al.* (2005) mention about the rise of fish farming within the agricultural sector of the State of Paraná, since the activity is an important alternative source of income and growth for small property.

Among the investments, most cited by the interviewees, 14 of the 20 producers answered that they intend to implement technologies such as solar energy in the future on, the property, since the use of energy produced by the sun, besides being a long-term available source, is clean, free and renewable (Corrêa, 2013). Sousa (2017) in his study of the technical and economic feasibility of a Photovoltaic System Connected to the Network in the fish farming enterprise located in Tocantins, obtained satisfactory results and identified that the implementation is advantageous, and that the investment would have its return in approximately seven months. Thus, it is important to highlight the interest discovered in the research of fish farmers in adhering to this technology, as it can bring greater environmental and economic sustainability to the activity of fish farming, in addition to the reduction of energy costs during the lot, derived mainly from aerators and pumps that are connected daily in tanks.

In addition to solar energy, some integrated and independent producers have expressed interest in investing in the acquisition of automatic handlers and aerators for dams. The literature shows that the correct use of technologies in the production of fish farming contributes to the generation of income at satisfactory levels and still favors the use of available natural resources, minimizing the environmental impacts of the activity (Araujo, 2015). The adoption of technologies by fish farmers leads to increased production of quality fish and. Like this the sustainable rural development of fish farming (De Almeida *et al.*, 2017; Muñoz, Mataveli & Faveri, 2019). Because of this, economic growth can trigger greater purchasing power and acquisition of technologies, which reflect the increase in gains in productivity of integrated and independent producers.

About family income, all 20 interviewees have monthly income above 6 minimum wages, being an expressive value, considering the monthly income of rural producers in Brazil released by IBGE, (2018) The according to data from the first quarter of 2018, 82.6% of them receive a maximum of 2 minimum wages (MS) per month, 12% receive between 2 and 5 MS and only 5% receive more than 5 MS. The literature points out that the remuneration to the fish farmer is based on productivity, having a profit margin over the kilo of the product in question (Peixe BR, 2018; Confederation of Agriculture and Livestock of Brazil - CNA, 2019) and, among the socioeconomic benefits of aquaculture can be, highlighted: food, employment and resources through methods, cultivation systems and species created, since the activity provides economic and social development, considering the jobs generated in the producing property, in the rural extension, in the equipment industry, of the products, processing and in the commercialization of the product (Muñoz, Mataveli & Faveri, 2019).

Of the interviewees, 2 independent fish farmers have fish farming as their only source of income, the other 6 producers have secondary income from agriculture with the cultivation of, grains, cattle and aviculture, and 1 of the independent fish farmers has extra income from truck freight during the harvest seasons and 1 producer is a partner of a company in the construction business that also obtains source of income. Related to the integrated producers, the 10 interviewees have other sources of income besides fish farming, and 6 of them have income from agriculture with the cultivation of soybeans, corn and wheat, 1 producer has extra income with vegetables, and 3 integrated producers have the complementary income of the agricultural activity. Thus, it was noted that, generally, both integrated producers and independent producers have another alternative source of income besides fish farming and work with other, diversified activities.

The literature stresses that diversification of agricultural production allows producers to have the option of more crops on their property, enabling increased income and new alternatives for food production for families, reducing risks in production (Barrett *et al.*, 2001; Liu *et al.*, 2008; Babatunde & Qaim, 2010; Bezu *et al.*, 2012; Hoang *et al.*, 2014). It was noticed that both integrated and independent fish farmers are presenting good financial stability and diversification of rural production that reflect in the increase in family income results. Thus, the obtained for this item presuppose that the development of fish farms can supply much of the needs of families working in this activity, and that the diversification of crops in rural areas is a positive point for complementing family income through alternative activities.

Batista (2013), Dutra, Bittencourt and Feiden (2014), Vieira Filho (2009) showed in his studies how aquaculture activity can be an important source of income for small and medium-sized properties. Even as an extensive or subsistence activity, typically familiar in nature, fish farming can promote food and nutritional security, besides representing extra income, with low maintenance cost (Ribeiro-Neto *et al.*, 2016).

Fish farming is a possibility of diversification of small family property, bringing greater productivity to families, helping to reduce poverty and promoting social and economic development, even in places that have water restrictions (Lima *et al.*, 2018). Authors state that aquaculture generates more income than agriculture per hectare because it has a more complex production chain and with greater social impact on its industrialization. With this, it is noteworthy that the repercussions of small property chains are more relevant when compared to large networks in this sector, (Filipski & Belton, 2018).

Regarding the component related to financial management, the results showed that most of the interviewees partially control financial planning, of the 10 independent producers 4 of

them make notes of their, expenses, expenses and, of the profits obtained in notebooks, agendas or Excel spreadsheets, as in the excerpt transcribed from the interview of E. Indep.8:

> I take everything noted in a booklet my expenses and the profits I managed to take in, the lot since I started with the activity and I also, have a spreadsheet in the notebook that I, anoint all the expenses with juices and feed, this control helps me a lot because I know how much I am profiting from the fish and do not work in the dark.

The other 6 producers do not have the habit of writing down and have knowledge of the costs, through the previously removed lots of fish, family expenses and fish farming are calculated only head-on, do not use any tool to assist in the control and family financial management, as in the transcribed excerpt of the interview E.Indep.6: "we do not have the habit of noting , comes out lot and enters lot and I know the amounts of my expenses only head, but I do not write down to know how much I spent, even the expenses of the house I have nothing controlled", or even, as the transcribed excerpt of the interview E.Indep.3: "I do not have the habit of writing things down, I do not make the right control of my expenses here on the site".

In relation to the integrated producers, it was observed that the minority controls the planning and spending on fish farming, of the 10 interviewees, only 2 integrated producers take control their expenses and revenues in excel spreadsheet, the remaining 8 do not make notes and awareness of the expenses and profits obtained Have only head, based on experience with the activity, but do not have the routine habit of making notes, as the excerpt transcribed from the interview, E. Integ.6:

> I do not take anything noted here at home, in fish farming I have no control of food and fingerlings because the cooperative that is bringing gradually and then at the end of the lot, is de estimated the amount that was consumed to remain a net value for me, always was head my control of spending and the basis of the experience of time I work with fish farming , but I think I can manage my recipes well.

Like the excerpt transcribed from the interview E. Integ.8: "I don't take notes of my expenses, I need to have more control and annotate everything that comes in and comes out with fish farming and indoors too, but I end up not doing it." The literature portrays that the processes of management and financial control of small and medium-sized rural producers are of high informality, and this is not different in the area of fish farming (Pimenta, 2012), in question of the management of the enterprise, Kubitza *et al.*, (2012) observed in a survey conducted with more than 350 fish farmers that most producers do not control the production and costs of the enterprise.

It was noted that both integrated and independent producers, possibly due to the lack of time and willingness to do family financial planning, do not carry out financial management practices in daily life, for the better control of their money. It was found that the public of independent producers is concerned with making a control of two expenses, due to inputs,

fingerlings, and other expenses that they need to afford throughout the lot so as not to come to a loss at the end of the production cycle. The integrated producers, on the other hand, because feed costs, fingerlings are already embedded in the final value of the lot by the integrator, they do not take these expenses so controlled, but they are aware that it is necessary to save and have, control with energy expenditures, inputs such as lime during the lot, because , they have benefits of fish farming investments to pay in financial institutions, they need to reduce expenses for the lot of fish to be profitable and productive and it is also important to highlight that the integrated producers noticed less financial results with the activity of fish farming compared to the, independent ones.

Rotta (2003) adds that the lack of financial control in the activity of fish farming is a worrying reality, because losses can occur in the enterprise during the production process, leading the producer to be discouraged by the creation and abandon the activity. According to Debus, Ribeiro Filho and Bertolini (2016) there are few studies dealing with financial management related to family fish farming in micro and small enterprises, especially in cost control.

About labor costs on the property, the 7 independent producers have family labor, in which wives and children also help in the activity of fish farming, except for 3 independent producers who have outsourced labor in fish farming due to the amount of water slides being higher, and employees are paid a monthly salary ranging from R$ 1,000.00 to R$ 3,000.00 reais. In the group of integrated producers, 8 of them have family labor to work in the activity, while 2 of the fish farmers hire outsourced labor to assist in the management of the reinforced producing tanks that participate in the management of fish farming, but they have the help of a person responsible for taking care of the lots from the beginning to the end of the management, and 1 of them points out that they need to hire outsourced labor, due to the amount of water slide being high and the tanks are in two properties distant from each other, the salary paid to employees is in the range of R $ 1,500.00 to R $ 2,500.00 per month.

It was observed that most of the independent and integrated interviewees have the family workforce to take care of the fish farming activity on the property, not having frequent costs of hiring employees. The literature highlights that the family labor in fish farming becomes cheap, because it employs only the family in the whole activity, being an activity of easy management, does not require much physical effort and the enterprise can be operationalized by one or two people, consequently the family can have a higher income and a better quality of life (Paris, 2012; Barbosa & Pantoja-Lima, 2016).

Another point identified is that all 20 interviewees need to bear expenses to maintain the activity and if they need to make, improvements in the property, hire outsourced services to throw gravel in the dam, dams, clean the tanks and then be the only often, usually every, 3 lots they have expenses with outsourced labor to make these repairs. Dantas Filho (2017) in, his, study investigated the management of implementation costs and family fish production in the municipality of Presidente Médici-RO, in which it was found that the guarantee of the quality of the fish produced increases profitability and that the highest production costs were in cleaning the tanks and with the labor of third-party services.

On the ease of access to credit or financing by government agencies and credit unions, or partnerships with agricultural cooperatives, it was identified that all 20 interviewees have easy access, with good conditions to take investment credits and agricultural costs, also, reinforced that the interest rate per year is relatively low for rural producers and the payment period is long, providing opportunities to be able to finance and pay off, the installments annually with the result of the production of fish lots, as the excerpt transcribed from the interview E.Integ.6:

> most of the resources I used are from banks, because the investment for fish farming costs expensive and did not have all the capital to make the tanks when I started the activity, from my pocket I even invested only a little resource of my own.

De Faria and Santos (2014) mention that banks and credit institutions provide different lines of financing to rural producers with subsidized interest, and, in some cases, there is an economic subsidy, which allows producers to access credit to cover the expenses with the activity and make investments in the property. Therefore, it was noticed that the 20 fish farmers have already taken credit, using resources from banks and cooperatives to make investments in tank excavations and expansions, not least because investments are high and producers do not have enough equity for investments, leaving to use their own resources only with lower expenses that they may have during the production of fish farming.

Regarding consumption to fish farming, it was observed that the 10 independent producers have spent on consumption since the purchase of fingerlings, feed and inputs such as lime, salt, probiotics, electricity and other items that are funded by fish farmers. Feed consumption is high, because since the beginning of the lot it is already necessary to use powder feed to feed the fingerlings. Noted it is that the feed demands are from also 10.5 tons to 350 tons spent per lot, according to the size of the water slide found, which ranges from 20 to 120 thousand square meters. It was identified that independent producers produce 8 to 600 tons of

fish per batch, and the prices that are selling the kilo of fish have been high in recent years, as in the excerpt transcribed from the interview of E.Indep.3:

> today I think it pays a lot to work on account, a couple of years ago I sold the kilo of tilapia at R $ 4.20 for refrigerators, from 2020 here rose enough already delivered fish to R $ 7,15 a kilo, then valued a lot, and if continue at this good price so, I will manage to have a big profit with the fish.

According to data from Embrapa (2021), the average price of the kilo of tilapia in 2013 was R$4.39, in December 2020 the price of tilapia reached R$8.50 a kilo, showing a high growth in 7 years. All independent producers indicated that the value of fish they are selling is in the range of R$7.10 to R$7.30 a kilo and stated that they were satisfied with the way they work, and the profit obtained, despite the risks that are exposed during the lot, such as the transcribed excerpt from the interview E. Indep.6:

> If the price of fish continues to rise, with little amount of water slide, I can have good financial results, but I can also run the risk of some disease in fish that generates mortality in the lot, which I cannot sell even the price being high I end up getting loss in the lot.

For the integrated fish farmers, the expenses with the consumption of feed, fingerlings and inputs such as (salt, lime) are borne by the integrator throughout the lot, producers only need to bear the costs of energy consumption, medicines, and improvements in tanks and property if necessary. As in the excerpt transcribed from the E.Integr.9 interview:

> the cooperative brings everything here for me the fingerlings, the ration and inputs, I have to afford the electricity, maintenance costs and if she has to improve on something on the property I have to arrange according to what she asks, at the end of the batch they make the settlement of the production, based on feed consumption and feed conversion, make the reduction of the value of the fingerlings and feed that they sent during the batch, and then reach the final liquid value of the kilo of the fish, the last batch came out to R $ 1.16 the kilo of tilapia. The profit is a little lower that if I worked on account, but I have more security, guarantee of sale and the support of a cooperative like Copacol, and at the end of the year has the leftovers That I get referring to the amount of fish I produce, it is an extra that already helps a lot in my budget.

It was identified that in the integration system the reduction of expenses borne by the integrator during the batch if the fish farmer obtained lower. thereby feed consumption and higher meat production during the lot, the better the remuneration that the producer will receive. The average price liquid of the kilo of the fish sold in the integration is coming out, to R$ 1.16, the integrated producer has the advantage of participating in the financial results of the cooperative, because it provides the benefit of the distribution of the profits of the activity, called "leftovers" to producers at the end of the year of the year.

As for fish production, integrated fish farmers have been producing from 27 tons to 350 tons of fish per lot, according to the amount of water depths highlighted in the interviews ranging from 20 to 60 thousand square meters, while the production of independent producers is above 350 tons of fish per lot. Fish farming, like any other cultivation activity, aims at

maximum fish production to obtain greater profitability possible and the organization of the producer regarding the management of his enterprise is one of the most important factors to achieve the desired goal (Baldisseroto, 2013; Meante, 2020).

As identified in, the interview, the profitability of independent producers is being higher than the integrated producers, the production of independent producers has been quite high, with the amount obtained from production of up to 600 tons of fish per lot, compared to the production of up to 350 tons of fish per batch of the integrated producers. Thus, it was noticed that in the item production and consumption the independent producers have been outperforming and having greater prominence in the results in relation to the integrated producers. Thus, a brief synthesis of the economic dimension is demonstrated in Table 10.

Table 10 - Economic Dimension - Main Results

Items analyzed	independent	integrated
Economic Growth.	Economic Growth (10). Expansion and acquisition of new technologies (9). Classification: Sustainable	Economic Growth (6). Expansion and acquisition of new technologies (9). Classification: Partially Sustainable
household income.	Income greater than 6 minimum wages (10). Complementary source of income (8). Classification: Sustainable	Income greater than 6 minimum wages (10). Complementary source of income (10). Classification: Sustainable
financial management.	Financial management (4) Rating: Unsustainable	Financial management (2). Rating: Unsustainable
Labor costs.	Family labor (7). Classification: Partially sustainable	Family labor (8). Classification: Partially sustainable
Access to credit or financing.	Access to Credit (10). Classification: Sustainable	Access to Credit (10). Classification: Sustainable
Production and consumption.	Higher profitability (10). Classification: Sustainable	Higher Profitability (5). Classification: Partially sustainable
Completion of the Economic Dimension	Classification: Sustainable	Classification: Partially Sustainable

Source: Data from the Interview with Fish Farmers (2020)
Note: The numbers in parentheses Point the number of respondents who indicated the characteristic

On the related economic to the dimension aspects, Chart 10 demonstrates the differences found in the integrated and independent system. It was identified that in the item economic growth, independent producers are considered sustainable because they achieved the growth they expected in the system, while the producers of the integrated system were considered partially sustainable due to not yet achieving the growth desired by having high spending on integration, which are paying for the investments. As for family income, the results were similar, the two systems are sustainable because they can have a monthly income, above 6 minimum wages. Beyond this has a complementary source of income from activities of other agricultural activities, diversifying production on the property, enabling an increase in family income.

In the financial related to management item, the producers of integrated and independent systems are few sustainable, due to the lack of family financial control that is remarkable in both systems. As for labor costs, both independent systems and integrated systems are partially sustainable, although they have family labor to work in the activity, some need to hire outsourced labor, having expenses with salaries that interfere with their family income and economic development. Regarding access to credit or financing by banks and financial institutions, producers of the integrated and independent system are sustainable, as all producers have already taken credit to invest in fish farming, with ease to access rural financing. As for production and consumption in fish farming, the producers of the independent system are sustainable, since they have consumption expenses during the period of fish fattening, but productivity is significant, resulting in greater profitability, when compared to producers of the integrated system that have a lower, profitability, therefore are classified as partially sustainable.

5.3 SOCIAL DIMENSION ANALYSIS

In the dimension of social sustainability in the activity of fish farming, the aspect related to employment and income was addressed, it was identified that all integrated and independent fish farmers obtain a very considerable family income from fish farming and the activity also provides the generation of employment to family members. In the labor item, it was mostly, highlighted, that the family members themselves work with fish farming. Of the independent producers, 5 producers have 2 family members working in fish farming and 2 producers have 3 to 4 family members who assist in the management of fish farming, only 3 of them work

alone, without the help of family members. Regarding the integrated producers, the results obtained were like the previous public, and 2 producers work individually, 5 producers have 2 family members working with fish farming, and 3 producers have 3 to 4 family members who work ensuring income and support for fish farming coming from activity.

The literature states that the application of family labor in fish farming is predominant in Brazil (De Almeida *et al.*, 2016; Antonucci, 2016; Debus, 2016; Leonel, 2016; Ferreira, 2017). Therefore, it was observed that 7 independent producers and 8 integrated producers have a family workforce with more than two family members, working in the activity, thus reducing costs with the hiring of outsourced labor in the enterprise. The results affirm that Ostrensky, Borghetti and Soto (2008) reinforce family fish farming as a form, for these authors it of production which predominates the interaction between self-management and work, the members of the local community themselves use the family in the workforce.

Regarding the family subsistence , item, it was observed that all producers achieved family subsistence through fish farming, supplying family needs ensuring a good stability of life, as the excerpt transcribed from the, interview E.Indep.5: "fish farming brought more subsistence yes, helped in income, brought improvements in the revenue of my family, bought a better car and even for leisure improved we left more eat out in restaurants, we were able to travel last year, contributed a lot", or even the excerpt of the interview of E.Integr.9:

> it allowed us to have more comfort indoors, it is our livelihood today, and working in fish farming we think it decreased the stress because before we worked with dairy cows and it was much more laborious and now the service is lighter, and it is tasty to take care of fish, fish farming contributed a lot to our quality of life.

All 20 producers have electricity at home and easy access for the education of children, because the State Municipal Education network provides and buses for the transportation of children, buses pass at the entrances of the properties, not having any difficulty for logistics children attend to school. Like the excerpt transcribed from the interview of E. Integ.6: "there were changes for the better in our life, because we were slowly growing financially, bought land in thick bush to raise cattle, and in my house, there is nothing missing, we have a good stability thanks to fish farming", another excerpt transcribed from the interview of E.Indep.1:

> It certainly helped a lot to have a better family livelihood, after I started working with fish farming, our life changed and it brought me greater opportunity for growth, I was able to change cars and we have greater comfort and leisure for our family, it greatly improved our conditions here on the site.

The literature shows that the implementation of fish farms in each region provides significant gains and wealth for the regional and national economy, in addition, generates direct

and indirect jobs, improves the quality of life of the local population that reflects studies such as greater family subsistence (Valenti,2002). The start, Nascimento (2007), Rabelo (2007), Damasceno et al., (2011) and Silva (2011) reinforce that access to education is a fundamental factor for the success of any regional development policy, especially when it comes to the rural environment. Education is an aspect of the social dimension identified that all integrated and independent producers have and thus access. It is remarkable that fish farming has contributed to the two profiles of producers ensuring greater family subsistence in the municipality of Nova Aurora-PR.

Addressing the quality of life of the families of fish farmers, with regard to health, it was observed, that 5 independent producers have health insurance for the family and the integrated, producers 6 of them also have health plans for the family, the others do not have any family, health plan, however they stated that access to the Unified Health System, (SUS) is very agile in the city of Nova Aurora, if they need surgeries or have exams and consultations.

Thus, it was noted that integrated and independent producers have good conditions for access in the health area. According to IBGE (2012), the analysis of the living conditions of Brazilians is possible through the measurement of the housing conditions of each family, this involves parameters that are distributed from access to their home, electricity, public services such as sanitation and, also access to, health services, water availability and, even the comfort of, the home. Like the excerpt transcribed from the interview of E. Indep.5:

> in my house we have electricity, drinking water and a good housing structure, we put internet, I think our quality of life is even better than in the city, because here on the site I do what I want, and it is better to raise children and we can eat fruits and vegetables that we plant the food ourselves.

Regarding the improvements in the quality of life of families, it was highlighted that many producers were able to carry out renovations in their homes after starting with the activity of fish farming, 7 independent producers were able to make renovation in the house, and even expansion and construction of aediculas for better comfort of the home of the other families 3 have not yet been able to carry out. The renovations at home. Of the integrated producers, 3 of them managed to make renovations in the house, 4 of them answered that they are not yet needing to make new reforms and another 3 have not been able to make reforms because they are paying for the investments of fish, farming. It was noted that mainly independent producers were able to make more improvements in their homes compared to integrated ones.

Related to quality of life, only 1 integrated producer answered that there were no changes in quality of life, as in the transcribed excerpt from the E.Integr.1 interview:

> here at home continued the same thing, never missed anything indoors, but I have not yet had many differences in my quality of life because I am paying for the investment of fish farming, but it is paying itself, only the return is time consuming.

The other interviewees stressed that they had improvements in quality of life, leisure, greater comfort, possibilities for financial growth, as in the excerpt transcribed from the interview of E.Integr.5: "decreased stress and life is quieter today for me, I do my job I know what I need to do, and I am having a better remuneration and more profitability than agriculture when I was moving with crops". Another excerpt also portrays the satisfaction of working with fish farming, E. Indep.9: "it has certainly greatly improved our quality of life, we survive mainly from fish farming and it has been bringing good profitability and does not need to leave home if you work close to the family."

The literature shows that the success of the practice of fish farming activity can provide the rural producer with safe economic conditions with significant income, causing better living conditions, if it is sustainable (Prochmann & Tredezini, 2003). Thus, 9 integrated producers and 10 independent producers stated that after starting with the activity of fish farming, they obtained improvements in the quality of life of their families and, highlighting that they like to work with the activity, because it does not require much physical and psychological effort to produce. About that, that fish farming is a therapy and helps to relieve stress, others said that with the income obtained from fish farming they have achieved everything that is essential for the well-being of the family.

Regarding the question related to training and training, only 4 independent producers stated that they had already participated in training by Emater regarding management in fish farming and 6 integrated producers have also done training provided by the integrator on fish management and environmental issues that helped to obtain more information with day-to-day care in fish farming. The 20 interviewees pointed out that they have already been in agricultural events such as field, day that takes place in Nova Aurora, and Cafelândia, attended lectures in the area of fish farming with the care of the environment and participate in the Rural Show, in Cascavel-PR that allows the knowledge of the technology novelties existing in the market, adding more knowledge about the management in fish farming and information for agricultural activity in general.

The literature highlights that because fish farming is not considered the only activity developed in rural properties, producers have difficulties of time to participate in offered training (Dotti *et al.*, 2012). The low technical knowledge of the producer in the control of his enterprise, leads to deficiencies and failures in the use of resources in the production process,

generating a lack of organization and management, and even difficulty in the proper use of production technologies, *(*Rotta, 2003; Barros et. al., 2010; Araujo, 2015; Loose *et al.*, 2014; Oliveira, 2017).

In fact, an important highlight found in, the research on training is in the excerpt transcribed from the interview E.Integr.9:

> we always participate in the events and meetings on fish farming and now with the pandemic is having *the lives*, we attended a l*ive* of a congress of fish farming that Copacol made available for fish farmers to participate, which added a lot of new information for us.

It was noticed that the number of integrated producers who did training was higher compared to independent producers and this may be since integrators invest in courses for producers to frequently participate in events and training that are offered free of charge online, in order to enable them to achieve greater productivity in fish farming. Emater de Nova Aurora, on the other hand, has not been offering online training as cited by independent producers.

About the receipt of technical management guidelines for care in the activity of fish farming, all integrated producers have technical assistance from the integrative cooperative, the technicians and fisheries engineers pass information on the use of the appropriate products, indications of management, new technologies to be used, solving doubts that fish farmers may have during the plot. Visits to the properties take place every 15 days, the technicians follow the growth of the fish with the fish farmer until the phase of removal and fishing of the lot.

Independent producers do not receive technical assistance, but if they have any doubts in the management area, assisted by suppliers and professionals who sell feed and other fish-related inputs, it was observed that Emater has not been providing technical assistance to independent producers. According to the literature, fish farming is considered one of the activities in which the rural producer needs technical support to develop the correct management of the (Rotta, 2003; Ramos, Silva & Barros, 2013 rearing and production environment). Specialized advice is a key investment component to maintain the good progress of the fish farming enterprise, especially for small producers (Amazonas, 2008; Banco Do Brasil, 2010; Gomes *et al.*, 2012; Santos *et al.*, 2014; Oliveira, 2018), since it is a factor considered determinant for the adoption of techniques and procedures appropriate to the conduct of the activity (Araújo, 2006; Antonucci, 2016).

Technical assistance services should contribute to the adoption of appropriate technologies, consequently, the better development of agricultural activities and the training of family farmers for innovation (De Souza Filho *et al.*, 2011). Emphasizing, in the literature the importance of having support and technical, assistance for the control of the production process,

such as efficient monitoring of the water quality of nurseries, correct calculation in stocking density and supply of feed to animals, formulation of diets that meet the needs of fish, prevention of diseases in the breeding environment (Tavares- Dias, 2011; Dotti *et al.*, 2012; Rodrigues *et al.*, 2012; Pimenta, 2012; Rodrigues, 2016). It was noted that of the 20 interviewees, only the 10 integrated producers have continuous technical assistance for the management of fish farming.

Access to technology is an essential requirement for the advancement of fish farming, the 20 producers interviewed have access to the Internet and telephony, even being in the rural area, have no difficulty receiving information, interact in with other fish farmers, 15 of them have a WhatsApp group to exchange ide and information among fish farmers in this region, friends and neighbors. The interviewees are always looking for knowledge to add greater results in the activity, as in the excerpt transcribed from the interview of E. Indep.2: "I have participated in some training of Emater and research a lot on the Internet on YouTube when I have some doubts, I see management videos, and I stay on top of the new things that create for fish farming, this information helps me on a daily life."

It was identified that a part of the integrated and independent producers makes use of YouTube frequently to learn more about fish. Noticed farming - it was found that by the time of, pandemic producers are not meeting frequently, but the phone is a working tool that they use to communicate with other producers, technicians and suppliers. The involvement of farmers with the community is a fundamental factor to achieve the sustainability of fish farming activity and to improve the quality of life of producers (Oliveira, 2011) generation of technologies has allowed the fish farmer greater productivity, opportunities to generate income under sustainable conditions, so that management is adequate according to the available resources, without having. Thus, to expand the production area, which reduces the pressure on natural resources (Silva *et al.*, 2018). The synthesis of the social dimension is shown in Table 11.

Table 11 - Social Dimension - Summary of Key Results

Items analyzed	independent	integrated
Employment and Income.	Family income (10). Classification: Sustainable	Family income (10). Classification: Sustainable
Manpower.	Family labor (7). Outsourced labor (3). Classification: Partially sustainable.	Family labor (8). Outsourced labor (2). Classification: Partially sustainable.
Family livelihood.	Family subsistence (10).	Family subsistence (10).

	Classification: Sustainable	Classification: Sustainable
Quality of life.	Health Plan (5). Housing renovations (7). Access to energy (10) Access to education (10). Drinking water (10) Leisure and comfort (10) Improvements in Quality of Life (10). Classification: Sustainable	Health Plan (6). Housing renovations (3). Access to energy (10) Access to education (10) Drinking water (10) Leisure and comfort (9) Improvements in Quality of Life (9). Classification: Partially Sustainable
Training and Training.	Training and Training (4). Events and lectures (10). Technical Assistance (0). Rating: Unsustainable.	Training and Training (6). Events and lectures (10). Technical Assistance (10) Classification: Sustainable
Access to technology.	Internet (10). Telephony (10). Classification: Sustainable	Internet (10). Telephony (10). Classification: Sustainable
Completion of the Social Dimension	Classification: Partially Sustainable	Classification: Partially Sustainable

Source: Data from the Interview with Fish Farmers (2020)
Note: The numbers in parentheses Point the number of respondents who indicated the characteristic

Based on the results of the research, related to the category of the dimension of social sustainability, for the item employment and income the producers of the independent and integrated system were classified as sustainable, since the activity of fish farming provides generation of family employment and ensures the increase of income of families. As for the item labor, both systems are partially sustainable, because the total labor is not familiar to the activity of fish farming, with costs with outsourced labor in the enterprise. In the aspect related to family subsistence, there are no differences in the systems, and both are sustainable, since the activity of fish farming contributes to the supply of family needs.

As for the quality of life, the producers of the independent system classified themselves as sustainable, due to their good, living conditions, fish farming provided better infrastructure for their homes, comfort and family social well-being, while the results for the integrated system producers proved to be partially sustainable, since some producers still do not notice changes in their lifestyle, and some have failed to carry out construction and renovations in their homes.

In the item related to training and training, the fish farmers of the independent system classified themselves as unsustainable due to the lower number of participations in training and,

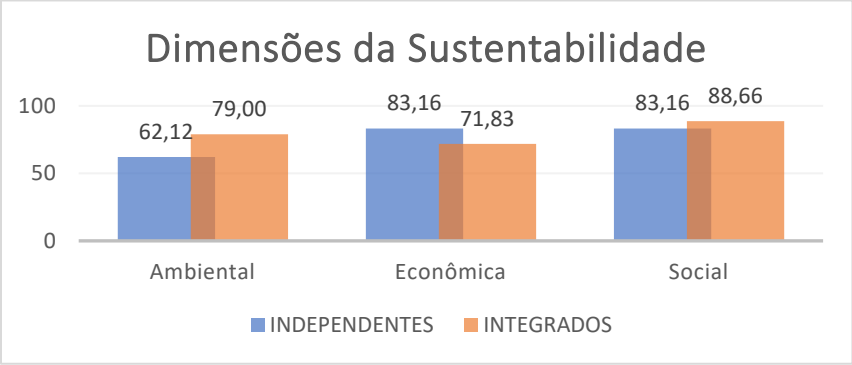
also because they do not receive technical assistance in, the activity, since the training scans can often assist the fish farmer in their activity, enabling the exchange of information and greater social interaction. already the integrated producers were considered as sustainable due to greater participation in events, as well as the receipt of technical, assistance, lectures and training by the integrator, that promotes greater generation of knowledge and social participation. As for access to technology, both systems are sustainable, because producers have internet in rural properties, cell phones that enable better communication and social interaction in rural areas.

5.4 CONCLUSIONS OF THE ANALYSIS

The results of the analyses made it possible to answer the research question of this study, and it was possible to identify the differences in contributions to sustainability between the integrated and independent cultivation systems of fish farming in Nova Aurora-PR.

Figure 1 shows the comparison of the results found. In the environmental dimension, it was concluded that the integrated system has a greater contribution to the sustainability of fish farming, and this is mainly, due to items related to, effluent treatment, adequate management of water resources and water quality, when compared to independent systems. As for items involving the disposal of solid waste, integration between aquaculture and agriculture, forest cover, preservation of biodiversity and the practice of organic activities in the properties, the results were similar, with no significant differences between the two systems.

Figure 1: Dimensions of sustainability.



Source: Prepared by the author (2020).

Note: The values indicate percentage of items served in each dimension analyzed

When the dimension was economic, it was concluded that the independent system has a greater contribution to the sustainability of fish farming, with greater relevance, especially for

items related to family, economic growth, production and consumption has been providing greater. So, this system, profitability to producers than the integrated system. For the items related to family income, access to credit, labor cost and financial management, it was observed that the difference in sustainability between the two systems is not relevant.

In the social dimension, the, system that obtained a greater contribution to the sustainability of fish farming was the integrated system, with emphasis on the item related to training and training since the producers participate in training and lectures that assist in the activity of fish, farming, however the differences in sustainability for the social dimension are small between the two, systems.

Therefore, it is possible to affirm that the integrated fish farming system presented a better contribution to sustainability in the environmental and social dimensions, while the independent system contributed in greater proportion to sustainability in the economic dimension.

6 FINAL CONSIDERATIONS

The research achieved the proposed objectives, whose general objective was to analyze the contribution to the sustainability of integrated and independent systems of fish farming in Nova Aurora-PR. The specific objectives of this study proposed to raise management methods and techniques, used in fish farming that contribute to sustainability, identify the characteristics of environmental, economic and social sustainability present in the activity of integrated and independent fish farmers in Nova Aurora-PR and compare environmental sustainability, economic and social systems of integrated and independent fish farming systems were still fulfilled, because as could be seen in, Chapter 2, a search was carried out in the literature upon measures considered sustainable, used in Brazil and in the world that contribute to the sustainability of, fish farming, discovering the elements that make up the dimensions of sustainability present in fish farming, making it possible to perform a like this comparative analysis of the dimensions of sustainability and independent and integrated cultivation systems.

In Chapter, 3, the main aspects of the environmental, economic and social dimensions were considered, and the construction of categories of, in this way, analysis, adapted to fish farming was carried out to evaluate the existing characteristics in the integrated and independent cultivation systems of fish farming in Nova Aurora-PR. And in Chapter 5, a comparison was made between the two cultivation systems, demonstrating their differences for environmental, economic and social sustainability.

The result of this research identified which of the integrated and independent systems has been bringing greater, economic, social and environmental contributions to fish farming. In fact, it was possible to identify that the integrated system has been providing a greater contribution to sustainability in the environmental and social dimension of fish farming. On the other, the independent system has been favoring greater sustainability in the economic dimension of fish farming. Although the differences between the groups are considered small, it is also concluded that both contribute to the sustainability of fish farming in Nova Aurora-PR.

It can be considered that the integrated and independent fish farming systems like this of Nova Aurora-PR, require adjustments such as the adoptive sums of management measures and management techniques in their enterprises, in order to become fully sustainable in the environmental, economic and social dimensions of sustainability.

The study brought contributions to this because practice provided the awareness of fish farmers in the region about the need to reconcile economic growth to the preservation of the environment, so that they seek technologies that increasingly provide the sustainability of rural activities in properties. The study contributes to assist in the formation of public policies that can promote the growth of the activity, such as more opportunities for financing projects and credit lines, incentives and support for the training of fish farmers, these so that they achieve the results they expect and, become increasingly sustainable in their systems, of operation, providing greater social inclusion and sustainable development.

The practice of fish farming in Nova Aurora-PR is an activity that brings economic development to the municipality, generating income for families. This allows social integration, contributing to the economic, social, and environmental dimensions, requiring special monitoring, especially of environmental and technological aspects, so that the activity continues to develop in a sustainable way.

Future studies are recommended that can contribute to the sustainability performance of fish farming, in a way that meets the dimensions of sustainability. It is suggested studies of implementation of increasingly sustainable methods for the management of fish farming, especially for the issue of the quality of water resources, it is essential to care and preserve water for the activity of fish because farming studies aimed at the elaboration of public policies for the implementation of selective collection in. In addition, rural properties. Furthermore, studies focused on family financial planning are suggested, since management in rural properties is still quite informal. Studies related to the training of fish farmers also in the management process of the activity are indicated, in order to achieve greater productivity and profitability in fish farming.

REFERENCES

Abhilash, P.C., Tripathi, V., Edrisi, S.A., Dubey, R.K., Bakshi, M., Dubey, P.K., Singh, H.B., Ebbs, S.D., (2016). Sustainability of agricultural production from pollutedland. Energy Ecol. Environ. 1 (1), 54-65.

Altieri, M. A. (2012). Agroecology: the scientific basis for sustainable agriculture. Sao Paulo. Rio de Janeiro: Popular Expression, AS-PTA.

Altafin, I. (2007). Reflections on the concept of family farming. Brasilia: CDS/UnB, 1-23.

Amazonas (2008). Preliminary Development Plan - APL of Fish Production: City Polo Tabatinga. State Center of Local Productive Arrangements of Amazonas - neapl/ AM. Secretary of State for Planning and Economic Development - seplan/am. 75p. Amazonas. Manaus: UFAM. 365p.

Andrade, R. L.B. D., Wagner, R. L., Mahl, I., & Martins, R. S. (2005). Production costs of tilapia (Oreochromis niloticus) in a model owned by the western region of the State of Paraná, Brazil. Ciência Rural, 35(1), 198-203.

Andreev, N., Ronteltap,M., Boincean, B., & Lens, P. N. (2017). Treatment of source-separated human feces via lactic acid fermentation combined with thermophilic composting. Compost Science & Utilization, 25(4), 220-230.

Andreu-Sánchez, O., Paraíba, L.C., Jonsson, C.M., & Carrasco, J.M. (2012). Acute toxicity and bioconcentration of fungicide tebuconazole in zebrafish (Danio rerio). Environmental toxicology, 27(2), 109-116.

Anjos O. A.M. A. dos, Martins, J.C., Soeiro, W.B., Freire, T.B., dos Santos, R. P., & de Oliveira Silva, C. (2018). Production, management and commercialization in the breeding of fish from family farming in the municipality of Santo Amaro do Maranhão. practices in extension, 2(1), 71-81.

Antonucci, M.C. (2016) Characterization of fish production and consumption of the Northern Pioneer region of Paraná. 61p. Dissertation (Master in Agronomy) - State University of Northern Paraná, Luiz Meneghel Campus, Bandeirantes, 2016.

Appolo, C.B. (2010). Environmental education aimed at fish farming practiced by small farmers.

Appolo, C.B.; Nishijima, T. (2011). Environmental education focused on fish farming practiced by small farmers. Electronic Journal in Management, Education and Environmental Technology. REGET-CT/UFSM, v. 2, n. 2, p. 214-224.

Aquino, A. R., Almeida, J. R., Senna, M. L. G. S., Dutra, V.C., & Martins, T. P. (2014). Indicators of sustainable development: an academic vision (1st ed). Rio de Janeiro: Sirius Network. Available in: http://www.rsirius.uerj.br/pdfs/indicadores_desenvolvimento_sustentavel.pdf. Access on 01 Oct. 2020.

Arana, L. V. (2004). Aquaculture fundamentals. Editor of UFSC.

Araujo, L. D. S. (2015). Study of fish farming sustainability in the municipality of Coremas PB.

Brazilian Fish Farming Association (Peixe BR) (2019). Fish BR Yearbook of FishFarming. São Paulo, SP: PeixeBR Brazilian Fish Farming Association.

Brazilian Fish Farming Association (Peixe BR) (2020). Fish BR Yearbook of Fish Farming. São Paulo, SP: PeixeBR Brazilian Fish Farming Association.

Brazilian Fish Farming Association (Peixe BR) (2018). Fish Br yearbook of Fish Farming. São Paulo: Peixe Br, 2018. Available in: < https://www.peixebr.com.br/anuario2018>. Accessed: 27 Jan. 2021.

Ayroza, D.M.M. R., Furlaneto,F. P.B., & Ayroza, L.M. D. S. (2008). Regularization of fish farming projects in the state of São Paulo. Revista Tecnologia & Inovação Agropecuária, 1(1), 33-41.

Babatunde, R. O., & Qaim, M. (2010). Impact of off-farm income on food security and nutrition in Nigeria. Food policy, 35(4), 303-311.

Baldisserotto, B. Physiology applied to fish production. Ed. 3. UFSM Publishing House. 2013. 352p.

Banco do Brasil. (2010). Sustainable Regional Development: Aquaculture and Fisheries. Series of proposals for performance in production chains. Brasilia: Banco do Brasil, vol. 6, 56p.

Barbosa, H. T.B., & Pantoja-Lima, J. (2016). Characteristics of fish farming in Presidente Figueiredo, Amazonas. IGAPÓ JOURNAL-Journal of Education Science and Technology of IFAM, 10(1), 103-113.

Barrett, C.B., Bezuneh, M., & Aboud, A. (2001). Income diversification, poverty traps and policy shocks in Côte d'Ivoire and Kenya. Food policy, 26(4), 367-384.

Barros, A.F.; Martins, M.I.E.G.; Abreu, J.S. and Amaral, C.M.C. (2010). Total cost of production and economic indicators. In: Investment with implementation and cost of production in fish farms in the State of Mato Grosso. 1. Ed. Ed. UNEMAT. Cáceres. 55 pp.

Batista, A. (2013). The contribution of fish farming to small rural properties in Dourados-MS. 2013. 93f. Dissertation (Master's degree in Agribusiness) - Federal University of Grande Dourados, Dourados. Available in:< http://repositorio.ufgd.edu.br/jspui/handle/prefix/675>. Accessed Jan 12, 2021

Bezu, S., Barrett, C.B., & Holden, S. T. (2012). Does the nonfarm economy offer pathways for upward mobility Evidence from a panel data study in Ethiopia. World Development, 40(8), 1634-1646.

Bocabello, F. Z. (2019). Evolutions in the animal protein industry: the paths for the tilapia industry in Brazil (Doctoral dissertation).

Bolzan, J. F.M., & Herrera, V. É. (2014). Sustainability in organizations: A question of competitiveness. REGRAD-Electronic Journal of Graduation of UNIVEM-ISSN 1984-7866, 6(1). Available in:< https://revista.univem.edu.br/REGRAD/article/view/438>. Access in 13. It's a set. 2020

Boyd, C. E., & Queiroz, J. D. (2004). Management of bottom sediment conditions and quality of water and effluents from nurseries. Special topics in intensive tropical freshwater fish farming. Jaboticabal: Brazilian Society of Aquaculture and Aquatic Biology, 25-43.

Brandão, C. D. S. (2018). Perspectives of the development of fish farming in Brazil: a focus on tilapia production in the last ten years. Available in: https://repositorio.ufba.br/ri/handle/ri/25945. Access on Oct. 1. 2020.

Brasil. (2006) Law 11,326 of 24 July 2006. It establishes the guidelines for the formulation of the National Policy of Family Agriculture and Rural Family Enterprises. Official Gazette of the Union, 25/07/2006.

Brogaard, L. K., Petersen, P. H., Nielsen, P. D., & Christensen, T. H. (2015). Quantifying capital goods for biological treatment of organic waste. Waste Management & Research, 33(2), 96-106.

Bronnmann, J., & Asche, F. (2017). Sustainable seafood from aquaculture and wild fisheries: insights from a discrete choice experiment in Germany. Ecological Economics, 142, 113-119.

Brum, S. A., & Augusto, P. O.M. (2015). Task environment: Copacol Strategies (PR) in the Production of Tilapia in Industrial Scale by the Integrated Vertical System. Scientific electronic journal of cra-pr-recc, 2(1), 19-34.

Caporal, F. R., & Costabeber, J. A. (2002). Multidimensional sustainability analysis. Agroecological and sustainable rural development, 3(3), 70-85.

Cardoso, A. S., El-Deir, S. G., & Cunha, M.C.C. (2016). Sustainability bases for fish farming activity in the semi-arid region of Pernambuco. Interactions, 17(4), 645-653.

Cardoso, G. L. S. (2017). Good management practices in production, applied to fish farming.

Carneiro, P.C. F., Morais, C. A. R. S., Nunes, M. U.C., Maria, A. N., & Fujimoto, R. Y. (2015). Integrated production of fish and vegetables in aquaponics. Embrapa Coastal Boards-Documents–Aracaju.

Carvalho F., J. (Editor) (2019). Pirarucu in high density systems - Panorama da Aquicultura, Rio de Janeiro, n. 171, v. 29, Jan/Feb.- Available in: <https://panoramadaaquicultura.com.br/edicoes/edicao-171/> Access on April 22, 2020.
Carvalho F., J. Panorama of Aquaculture (2017). System in the production of tilapia in western Paraná – Available in:<https://panoramadaaquicultura.com.br/a-integracao-chegou-para-ficar-c-vale-segue-os-passos-da-copacol-e-consolidates-o-sucesso-do-sistema-na-producao-de-tilapias-no-oeste-do-parana/>. Accessed May 18, 2020.

Castellani, D., & Barrella, W. (2018). Impacts of fish farming activity in the Ribeira de Iguape River Basin, SP-Brazil. Bulletin of the Fisheries Institute, 32(2), 161-171.

Cavalcanti, A. P.B. (2011). Environmental sustainability as a development perspective. International Interdisciplinary Journal INTERthesis, 8(1), 219-237.

Chardine-Baumann, E., & Botta-Genoulaz, V. (2014). A framework for sustainable performance assessment of supply chain management practices. Computers & Industrial Engineering. 76:138–147.

Chuenpagdee, R., Kooiman, J., & Pullin, R. (2008). Assessing governability in capture fisheries, aquaculture and coastal zones. The Journal of Transdisciplinary Environmental Studies, 7(1), 1-20.

Clough, S., Mamo, J., Hoevenaars, K., Bardocz, T., Petersen, P., Rosendorf, P., & Hoinkis, J. (2020). Innovative technologies to promote sustainable recirculating aquaculture in Eastern Africa–a case study of a Nile Tilapia (Oreochromis niloticus) hatchery in Kisumu, Kenya. Integrated Environmental Assessment and Management.

Coldebella, A. (2018). Effluents from intensive fish farming in excavated nurseries: characterization and dynamics of nutrients.

Colpani Fish Farming (2018). What is Fish Farming? Advantages of Fish Farming in Brazil. Available in:< https://www.grupoaguasclaras.com.br/o-que-e-piscicultura>. Accessed April 28, 2020.

Confederation of Agriculture and Livestock of Brazil - CNA. (2019). Impact of fuel price on the cost of tilapia production in Palotina/PR and Toledo/PR. Brasilia. Available in: https://www.cnabrasil.org.br/boletins/impacto-do-preco-dos-combustiveis-no-custo-de-producao-de-tilapia-em-palotina-pr-e-toledo-pr. Accessed: 27 Jan. 2021.

Conjero, M. A.; Tavares, L.S.; Neves, M. F. (2009) Organic Products: what it is, dimensions and how to qualify. In: NEVES, M. F. (Coord.). Agribusiness and Sustainable Development: an agenda for the world's leadership in food production and bioenergy. - 1. ed. - 3. reimpr. – São Paulo: Atlas, 2009.

Copacol (2016). Agribusiness portal. Integration of new fish farmers is carried out. Available in: https://www.copacol.com.br/agronegocio/noticia/2618/integracao-de-novos-piscicultores-e-realizada. Accessed 15 Sep 2020.

Corrêa, D. P. (2013). Study of the use of solar radiation captured by photovoltaic panels as generation of electricity in buildings in the municipality of Cuiabá-MT. Available in:< https://ri.ufmt.br/handle/1/1648>. Accessed Jan 10, 2021

Creswell, JW (2014). A concise introduction to the search for mixed methods. Sage Publications.

Cunha, F. L. S. J. (2003). The use of environmental sustainability indicators in monitoring agricultural development. Brasília: Master's Thesis. UNB/CDS.

Cyrino, J. E. P., Bicudo, A. J. D. A., Sado, R. Y., Borghesi, R., & Dairik, J. K. (2010). Fish farming and the environment: the use of environmentally friendly foods in fish farming. Revista Brasileira de Zootecnia, 39, 68-87.

Cyrino, J.E.; Conte, L. Tilapiculture in cages: production and economy. In: José Américo Possebon Cyrino and Elizabeth Criscuolo Urbinati (Eds.). 2006. Aquascience, 2004. Special Topics in Aquatic Biology and Aquaculture. Jaboticabal: Brazilian Society of Aquaculture and Aquatic Biology, cap.12, p.151-171, 2006.

Da Costa, J. I., Sabbag, O. J., & Espagnoli G.M. (2018). Economic evaluation of tilapia production in cages in the middle Paranapanema-SP. Costs and Agribusiness On Line,14(4), 259-281.

Da Cruz, A.C. R., de Moraes Fayal, J., & Soares, J. L. F. (2020). Evaluation of the sustainability of a fish farm through the mesmis method: a casestudy, in the municipality of Abaetetuba, Eastern Amazonia. Brazilian Journal of Development, 6(2), 5559-5570. Available in: https://www.brazilianjournals.com/index.php/BRJD/article/view/6619. Access on 02 Oct. 2020.

Damasceno, N. P., Khan, A. S., & Lima, P. V. P. S. (2011). The impact of Pronaf on the sustainability of family farming, job creation and income in the State of Ceará. Journal of Economics and Rural Sociology, 49(1), 129-156.

Da Silva, D.B., & de Queiroz C. S.M. (2015). Sustainable Agricultural Production: analysis of a vegetable production system in Mato Grosso doSul. Qualitas Electronic Magazine, 16(1).

Da Silva, G. F., Maciel, L.M., Dalmass, M. V., & Gonçalves, M. T. (2015). Nile tilapia: breedingand cultivation innurseries in the State of Paraná. Available in: <https://gia.org.br/portal/livro-tilapia-students/>. Access on May 5, 2020.

Dantas Filho, J. V. (2017). Cost management in fish farming in the municipality of Presidente Medici-Rondônia-Brazil. ABCosts, 12(2).

De Almeida Kato, H.C., Evangelista, D. K. R., de Sousa, D. N., & Mataveli, M. (2017). Technology transfer in freshwater fishfarming. Revista Em Extensão, 16(2), 129-146.

De Almeida, I. F., Fischer, J., de Soares, J.M. F., Hellebrandt, L.M., de Anello, L. D. F. S., & Walter, T. (2016). The production chain of fish farming in São Lourenço do Sul/rs. sinergia-Journal of the Institute ofEconomic, Administrative and Accounting Sciences, 20(2), 111-126.

Debus, D. (2016). Diagnosis of fish farming in family farming in the municipalities of Toledo-PR and Maripá-PR. Available in:< http://tede.unioeste.br/handle/tede/1522>. Access in 05. It's a set. 2020.

Debus, D., Ribeiro Filho, G. V., & Bertolini, G. R. F. (2016). Analysis of studies on financial management in fish farm family. Costs and @gronegócio, 12 (Special Edition),215-230.

De Faria, R.B., & Santos, D. F. L. (2014). Rural credit in Brazil: the profile of academic research. Management and Development Magazine, 11(2).

De Faria, R. H. S., Morais, M., De Souza Soranna, M. R. G., & Sallum, W.B. (2013). Fish farming in nurseries. Brasilia. Codevasf,54-65. Available in:<http://www.agriverdes.com.br/biblioteca/biblioteca/Agroecologia/Cartilhas%20%20Agroecology/Manual%20%20Creates%C3%A7%C3%A3o%20%20Pfish%20em%20Nurseries.pdf>. Accessed Nov 1, 2020.

Dehghanian, F., & Mansour, S. (2009). Designing sustainable recovery network of end-of-life products using genetic algorithm. Resources, Conservation and Recycling. 53(10):559–570.

De Mera, C.M. P., & Netto, C. G.M. (2014). The decrease in the rural population in the Region of Alto Jacuí/RS: analysis from the perspective of rural segments. Development in question, 12(27), 216-263.

De Oliveira, R.C. (2015). The aquaculture landscape in Brazil: the practice focused on sustainability. INTERTOX Toxicology, Environmental Risk and Society Journal, 2(1), 71-89.

De Queiroz, J. F., & Silveira, M. (2006). Practical recommendations to improve the quality of water and effluents from aquaculture nurseries. Embrapa Environment-Circular Technique (INFOTECA-E). Available in:<https://www.infoteca.cnptia.embrapa.br/infoteca/handle/doc/83145>. Accessed 13 Oct 2020.

De Souza Filho, H.M., Buainain, A.M., da Silveira, J.M. F. J., & Vinholis, M. D.M.B. (2011). Conditions of the adoption of technological innovations in agriculture. Science & Technology Notebooks, 28(1), 223-255.

De Souza Mazza, V.M., Madruga, L. R. D. R. G., Ávila, L. V., Perlin, A. P., Machado, E.C., & Duarte, T. L. (2014). Solid waste management in rural properties of municipalities in the interior of the state of Rio Grande do Sul. Magazine in Agribusiness and Environment, 7(3). Available in: https://periodicos.unicesumar.edu.br/index.php/rama/article/view/2986. Accessed 29 Sep. 2020.

Devika, K., Jafarian, A., & Nourbakhsh, V. (2014) Designing a sustainable closed-loop supply chain network based on triple bottom line approach: a comparison of metaheuristics hybridization techniques. European Journal of Operational Research. 235(3):594–615.

Diniz, N.M., & Honorato, C. A. (2012). Some alternatives to decrease the effects of stress on fish-cultivation review. Archives of veterinary sciences and zoology of UNIPAR, 15(2).

Donadio, N.M., Galbiatti, J. A., & Paula, R.C. D. (2005). Water quality of springs with different land uses in the Córrego Rico watershed, São Paulo, Brazil. Agricultural Engineering, 25(1), 115-125.

Dos Santos Nascimento, M., Pereira, S. J.B., dos Santos, R. F., & Vieira, A.M. (2018). Evaluation and characterization of the process of composting fishresidues. PUBVET, 12, 133.

Dos Santos, C. V., de Sá, C.B., Antunes, W. L., de Freitas, F.B., Silva, O. P., & Santos, H. S. (2017). Construction and Evaluation of an Aerator Made with Low-Cost Material. Engineering Journal of salesian college n.6.pp. 35-46.

Dotti, A., Poliano Valejo, P. A., & Russo, M. R. (2012). Environmental licensing in fish farming with a focus on small property: an environmental management tool. Ibero-American Journal of Environmental Sciences, 3(1).

Duarte, J. (2005). In-depth interview. Methods and techniques of research in communication. São Paulo: Atlas, 1, 62-83.

Dullah, H., Malek, M. A., & Hanafiah, M.M. (2020). Life Cycle Assessment of Nile Tilapia (Oreochromis niloticus) Farming in Kenyir Lake, Terengganu. Sustainability, 12(6), 2268.

Dutra, F.M., Bittencourt, F., & Feiden, A. (2014). Aquicola Profile of Small Border Properties of Southwest Paraná/Brazil. Extension: Electronic ExtensionMagazine, 11(17), 180-189.

Edwards, R., & Holland, J. (2013). What is qualitative interviewing? London: Bloomsbury.

Eler, M. N., & Millani, T. J. (2007). Methods of sustainability studies applied to aquaculture. Revista Brasileira de Zootecnia, 36, 33-44.

Embrapa - Brazilian Agricultural Research Company (2012). Law 12,651 of May 25, 2012 - Forest Code.
Available from: < https://www.embrapa.br/codigo-florestal/entenda-o-codigo-florestal> Access on 19 Feb. 2021.

Embrapa- Brazilian Agricultural Research Company (2021). Quotes on Ceagesp. Available in:< https://www.embrapa.br/cim-centro-de-inteligencia-e-mercado-em-aquicultura/cotacao-pescado-ceagesp/tilapia>. Access on 05 Mar.2021.

Eskandarpour, M., Dejax, P., Miemczyk, J., & Péton, O. (2015). Sustainable supply chain network design: An optimization-oriented review. Omega, 54:11-32.

Fao – Food and Agriculture Organization of the United Nations (2016). The state of world fisheries and aquaculture: opportunities and challenges. Rome: FAO, 243 p.

Fao – Food and Agriculture Organization of the United Nations (2017). The Future of Food and Agriculture - Trends and Challenges. Rome: UN. Food and Agriculture Organization.

Fao - Food and Agriculture Organization of the United Nations. (2010). The State of World Fisheries and Aquaculture, Rome.

Fao – Food and Agriculture Organization of the United Nations. (2009). Fisheries and Aquaculture Department Statistics. Rome

Fao – Food and Agriculture Organization of the United Nations. (2014). The State of World Fisheries and Aquaculture: Opportunities and Challenges. Fao, Rome.

Fao - Food and Agriculture Organization. Global aquaculture production statistics. Rome: FAO, 256 p.

Feiden, A., Ramos, M. J., Chidichima, A.C., Schmidt, C.M., Fiorese, M. L., & Coldebella, A. (2018). The tilapia production chain in western Paraná: an analysis on the formation of a local productive arrangement. Redes (St. Cruz Sul, Online), 23(2), 238-263.

Ferreira, A. G., De Souza Borba, S. N., & Wizniewsky, J. G. (2013). The practice of composting for organic fertilization by family farmers in Santa Rosa/RS. Electronic Journal of the Ufsm Law Course, 8, 307-317.

Ferreira, M. V. (2017) Power Structure and Fish Farming in Benjamin Constant, Amazon. Manaus: UFAM. 365p.

Ferreira, P. R., & de Sousa, D. N. (2019). Cooperative education: deepening the concept. Embrapa Fisheries and Aquaculture-Article in an indexed journal (ALICE).

Figueiredo, S.A. D. (2018). Analysis of the phytomediator and energy potential of the biomass of the species Eichhornia crassipes (aguapé) and Pistia stratiotes (water lettuce). Available in:< https://repositorio.ufpb.br/jspui/handle/123456789/13497>. Access on 02. Jan.2021.

Filipski, M., & Belton, B. (2018). Give a man a fishpond: modeling the impacts of aquaculture in the rural economy. World Development, 110, 205-223.

Flick, U. (2009). Introduction to qualitative research. Artmed (3rd ed, Vol. 3). Porto Alegre: Artmed.

Fontes, A., Nikolik, G., Rasmussen, R., Ikeda, V., & Souza, I. (2016). Feeding nemo. Turning Brazil's economic turmoil into seafood business opportunities. Rabobank Industry Note, 564, 1-8.

Freitas, F. V. D. (2010). Bioremediation in fish farming effluents using aquatic macrophytes Eichhornia crassipes (Pontederiaceae)and probiotics. Available in:< http://tede.bc.uepb.edu.br/jspui/handle/tede/1725>. Access on 03 Feb.2021

Freitas, G. de, & Silveira, S. D. F. R. (2015). Light For All Program: a representation of program theory through the logical model. Planning and Public Policies, (45).

Gil, A.C. (1999). Methods and techniques of social research. 5.ed. São Paulo: Atlas, 1999. 202 p.ISBN: 8522422702.

Gil, A.C. (2009). Case study. Atlas, i'm sorry.

Gil, A.C. (2010). How to Develop Research Projects. Atlas Publishing House (5th). Sao Paulo.

Gomes, R. N., Jordão Filho, J., & Mendes, G. O. (2012). Technical analysis of tilapia production in the municipality of banana trees-pb. Green Notebook of Agroecology and Sustainable Development, 2(1).

Governo do Estado do Paraná (2019). Paraná expands leadership in farm farming. Available from:http://www.aen.pr.gov.br/modules/noticias/article.php?storyid=105826&tit=Parana-amplia-lideranca-em-piscicultura-de-cultivo. Access on 20 August.2020.

Guimarães, A. F. (2012). Fish farming. Islanders. Ceplac. Islanders, Ceplac. 28p.

Gram, L., Melchiorsen, J., Spanggaard, B., Huber, I., & Nielsen, TF (1999). Inhibition of vibrio anguillarum by pseudomonas fluorescens AH2, a possible probiotic treatment of fish. Applied and environmental microbiology, 65 (3), 969-973.

Henriksson, P. J. G., Banks, L. K., Suri, S. K., Pratiwi, T. Y., Fatan, N. A., & Troell, M. (2019). Indonesian aquaculture futures—identifying interventions for reducing environmental impacts. Environmental Research Letters, 14(12), 124062.

Hermes, C. A. (2009). Agro-industrial tilapia system in the Toledo-PR region and cost and revenue behavior. Available in:< https://repositorio.unesp.br/handle/11449/100243>. Accessed 08.jan. 2021.

Hoang, T. X., Pham, C. S., & Ulubaşoğlu, M. A. (2014). Non-farm activity, household expenditure, and poverty reduction in rural Vietnam: 2002–2008. World Development, 64, 554-568.

Honorato, C. A. (2019). Measures to expand sanity in fish farming–the importance of quality food. Performance, 6(11), 34-43.

Horn, C. L., Shikida, P. F. A., & Staduto, J. A. R. (2009). The competitive environment and the strategies of copacol (Pr): The case of tilapia production. Rural Extension, (17), 5-24.

Hundley, G.C., & Navarro, R. D. (2013). Aquaponics: the integration between fish farming and hydroponics. Brazilian Journal of Sustainable Agriculture.

Hundley, G.M.C., Navarro, R. D., Figueiredo, C.M. G., Navarro, F. K. S. P., Pereira, M.M., Ribeiro Filho, O. P., & Seixas Filho, J. T. (2013). Utilization of the effluent from the production of Nile tilapia for the growth ofbasil(Origanum basilicum)andmarjoram (Origanum majorana)inaquaponics systems. Brazilian Journal of Sustainable Agriculture.

Igarashi, M. A. (2018). Economic Aspects of Tilapia Cultivation and Perspectives for The Development of Activity in Brazil, Especially in the State of Paraná (Literature Review). Unimar Ciências Magazine, 27(1-2).

Illera-Vives, M., Labandeira, S. S., Brito, L.M., López-Fabal, A., & López-Mosquera, M. E. (2015). Evaluation of compost from seaweed and fish waste as a fertilizer for horticultural use. Scientia Horticulturae, 186, 101-107.

Instituto Brasileiro de Geografa e Estatística-IBGE (2012) Studies and Research Demographic and Socioeconomic Information, number 29: Synthesis of Social Indicators An analysis of the living conditions of the Brazilian population.293 pages. Rio de Janeiro.

Instituto Brasileiro de Geografa e Estatística-IBGE. (2016). Municipal Livestock Production. v. 44. Available in:

<https://www.ibge.gov.br/media/com_materialdeapoio/arquivos/ea77821e06cad1457f9b35c1abe2137f.pdf>. Accessed March 13, 2020.

Instituto Brasileiro de Geografa e Estatística-IBGE. (2018). National Survey by Continuous Household Sample (Continuous PNAD), Rural Producer Profile. Available in:<https://datasebrae.com.br/perfil-do-produtor-rural/#indice>. Access on March 5, 2021.

Instituto Mato-Grossense de Economia Agropecuária-IMEA. (2014). Diagnosis of Fish Farming in Mato Grosso. Federation of Agriculture and Livestock of the State of Mato Grosso, CUIABÁ,2014,103f.

Instituto Paranaense de Assistência Técnica e Extensão Rural - Emater. (2018). Project 166 Family Agroindustry of Paraná - Farmer's Factory - Emater. Available in: http://www.emater.pr.gov.br/modules/conteudo/conteudo.php?conteudo=81. Accessed Sep 16, 2020.

ISO- International Organization for Standardization 14044 (2006). Environmental Life Cycle Assessment- Requirements and Guidelines (Geneva, Switzerland).

Jana, B.B and Jana, S. (2003). The potential and sustainability of aquaculture in India. Journal of Applied Aquaculture, 13 (3-4), 283-316.

Kimpara, J. (2013). Aquaculture in Brazil today and the role of the researcher. Agribusiness portal.

Kimpara, J.M., Zadjband, A. D., & Valenti, W.C. (2012). Methods for measuring sustainability in aquaculture. Embrapa Half-North-Documents (INFOTECA-E).

Kist, L. T., Porciuncula, A., & Machado, E. L. (2016). Evaluation of the environmental impacts of tilapia grown in a semi-intensive system. Journal Environmental Monographs, 15(1), 53-60.

Kobayashi, M., Msangi, S., Batka, M., Vannuccini, S., Dey, M. M., & Anderson, J. L. (2015). Fish to 2030: the role and opportunity for aquaculture. Aquaculture economics & management, 19(3), 282-300.

Kubitza, F. (1998). Water quality in fish production-Part III (final). Panorama Aquicult, 8, 35-43.

Kubitza, F. (2006). Recirculation Systems: Closed systems with water treatment and reuse. Aquaculture panorama, 16(95),15-22.

Kubitza, F. (2007). The versatility of salt in fish farming. Aquaculture panorama, 17(103), 14-23.
Kubitza, F. (2009). Management in fish production. Aquaculture panorama, 19(111), 14-27.

Kubitza, F. (2011). Creation of tilapia in a system with bioflakes without water renewal. Aquaculture Panorama, 21(125), 14-23.

Kubitza, F. (2011). The current status and trends of tilapiculture in Brazil. Aquaculture Panorama Magazine. Rio de Janeiro, n. 124, Apr. 2011.

Kubitza, F. (2015). Aquaculture in Brazil. Aquaculture Panorama, 25, 10-23.

Kubitza, F., Campos, J. L., Ono, E. A., & Istchuk, P. I. (2012). Panorama of Fish Farming in Brazil: regional particularities of fish farming-Part II. Aquaculture Panorama, 22, 16-31.

Kulikowska, D., Gusiatin, Z.M., Bułkowska, K., & Kierklo, K. (2015). Humic substances from sewage sludge compost as washing agent effectively removes Cu and Cd from soil. Chemosphere, 136, 42-49.

Lalander, C., Nordberg, Å., & Vinnerås, B. (2018). A comparison in product-value potential in four treatment strategies for food waste and faeces–assessing composting, fly larvae composting and anaerobic digestion. GCB Bioenergy, 10(2), 84-91.

Leira, M. H., da Cunha, L. T., Braz, M. S., Melo, C.C. V., Botelho, H. A., & Reghim, L. S. (2016). Water quality and its use in fish farms. Pubvet,11, 1-102.

Leira, M. H., Reghim, L. S., Da Silva C. L., Da Cunha, L. T., Botelho, H. A., Braz, M. S., & Melo, C.C. V. (2017). Sanitary problems of Brazilian fish farms. Pubvet, 11, 538-645.

Leone, E. T., Maia, A. G., & Baltar, P. E. (2010). Changes in the composition of families and impacts on poverty reduction in Brazil. Economics and Society, 19(1), 59-77.

Leonel, A. P. D. S. (2016). Economic viability of tilapia-based products for school feeding in the municipalities of Toledo-PR and Marechal Cândido Rondon-PR. Available in:< https://repositorio.unesp.br/handle/11449/148648>. Access on 09 Feb.2021.

Leung, K.M., & Dudgeon, D. (2008). Ecological risk assessment and management of exotic organisms associated with aquaculture activities. Understanding and applying risk analysis in aquaculture.

Lima, A. F., Prysthon, A., Bergamin, G. T., & Pedroza Filho, M. X. (2012). Family fish farming first looks and opportunities for action in Tocantins. In Embrapa Fishing and Aquaculture-Abstract in congress anais (Alice). In: Congress of the Brazilian Society of Aquaculture and Aquatic Biology, 5., 2012, Palmas. Unite, consolidate and advance: the annais. Palms: Aquabio, 2012.

Lima, A. F., Da Silva, A. P., Rodrigues, A., Bergamin, G., Torati, L., Pedroza Filho, M. X., & Maciel, P. (2013). Water quality: family fish farming. Embrapa Fisheries and Aquaculture-Fôlder/Brochure/Booklet (INFOTECA-E).

Lima, A. F., Rodrigues, A. P. O., Oliveira-Maciel, P., Prysthon, A., Valladão-Flores, R.M., & Araújo-Bezerra, T. (2018). Small-scale fish farming in seasonal ponds in Brazil: technical and economic characterization. Latin American journal of aquatic research, 46(2), 314-329.

Liu, C., Golding, D., & Gong, G. (2008). Farmers' coping response to the low flows in the lower Yellow River: a case study of temporal dimensions of vulnerability. Global Environmental Change, 18(4), 543-553.

Loose, C. E., da Silva Sato, S. A., Aleixo, N. D., Aleixo, A. D., Freitas, C. O., & Souza, D. F. D. S. (2014). Costs in the creation of tambaqui(Colossoma Macropomum Couvier,1818) in the properties participating in the Forte Fish Program in Cacoal (RO). In Anais of the Brazilian Congress of Costs-ABC.

Lopes, J.C. O. (2018). fish farming. Available in: http://www.proedu.rnp.br/bitstream/handle/123456789/1460/Piscicultura_Z_WEB.pdf?sequence=1&isAllowed=y. Accessed 13 Oct 2020.

Macedo, C. F., & Sipaúba-Tavares, L. H. (2018). Eutrophication and water quality in fish farming: consequences and recommendations. Bulletin of the Fisheries Institute, 36(2), 149-163.

Machado, L.C. P., & Machado Filho, L.C. P. (2014). Dialectics of agroecology. Popular Expression Publishing House.

Magalhães, V. L., & da Cunha, J. E. (2007). Land use and degradation in the valley bottom of Sanga Creoula, Margarida District, Municipality of Marechal Cândido Rondon-PR. Geography (Londrina), 16(2), 49-62.

Marconi, M. D. A.; Lakatos, E.M. (2011). Methodology of scientific work: basic procedures, bibliographic research, project and report, publications and scientific papers. 7. Ed. 6.reimpr. São Paulo: Atlas.

Marques, E. A. T., de Oliveira, C. R., da Silva, G.M. N., Cardoso, A. S., & do Carmo Sobral, m. (2018). Challenges for the sustainability of fish farming in the São FranciscoRiverbasin. 2(3), 14-29.

Martins, C. V.B., Oliveira, D. P., Martins, R. S., Hermes, C. A., Oliveira, L. G., Vaz, S. K., ... & Zacarkin, C. E. (2018). Evaluation of fish farming in the western region of the state of Paraná. Bulletin of the Fisheries Institute, 27(1), 77-84.

Martins, G. A. (2008). Case study: A research strategy. São Paulo: Atlas.

Massago, H., & da Silva, B.C. (2020). Use of chlorinated products in the disinfection of fish farms. Agricultural Santa Catarina, 33(2), 26-28.

Meante, R. E. X. (2020). Technical and economic analysis of tambaqui production (Colossoma macropomum) in the region of Ariquemes-RO, Brazil.

Medeiros, S.B. D. (2019). Evaluation of physical-chemical and zootechnical parameters in the cultivation of litopenaeus vannamei sea shrimp in greenhouse nurseries.
Melo, C. S.; Zozzoli, J. C. J. (2009). Brand, Public Relations and Sustainable Development. Available in: <http://www.intercom.org.br/papers/nacionais/2009/resumos/R4-3585-2.pdf>. Accessed Jun 30, 2020.

Mengistu, T., Gebrekidan, H., Kibret, K., Woldetsadik, K., Shimelis, B., & Yadav, H. (2018). Comparative effectiveness of different composting methods on the stabilization, maturation

and sanitization of municipal organic solid wastes and dried faecal sludge mixtures. Environmental Systems Research, 6(1), 1-16.

Mezzaroba, O., Monteiro, C. S. (2009). Manual of research methodology in law. São Paulo: Saraiva.

Ministério da Pesca e Aquicultura – MPA (2015). Brazilian Aquaculture Development Plan - 2015/2020. Brasilia. Brazil. Available in: <https://www.seafoodbrasil.com.br/wpcontent/uploads/2015/09/Plano_de_Desenvolvimento_da_Aquicultura-2015-2020.pdf>. Access in 15. Aug. 2020.

Morais, J.P.; Ribeiro, D. K.; Coutinho, F.C.; Oliveira, K.M. (2015). Water quality in fish farming: a case study in rural communities of the municipality of Formiga - Mg. In: Anais Symposium Brazilian of Water Resources, 21.

Mota, B., Gomes, M.I., Carvalho, A., & Barbosa-Povoa, A.P. (2015). Towards supply chain sustainability: economic, environmental and social design and planning. Journal of Cleaner Production. 105:14-27.

Moura, R.S.T., Valenti, W.C. & Henry-Silva, G.G. (2016). Sustainability of the nile tilapia network culture in a reservoir in a semi-arid region. Ecological Indicators, 66, 574-582.

Mouriño, J. (2016). The Importance of Bioremediation in Aquaculture. Panorama of Aquaculture.

Muñoz, A., Mataveli, M., & de Fáveri, A. P. (2019). Economic benefits of the adoption of good management practices in fish farming in the state of Tocantins. In Embrapa Fisheries and Aquaculture-Article in congress annais (Alice). In: congress of the Brazilian society of economics, administration and rural sociology, 57., 2019, Ilhéus. Agriculture, food and development. Islanders: Sober, 2019.

Nakauth, A.C. S. S., Nakauth, R. F., & Nóvoa, N. A.C.B. (2015). Characterization of fish farming in the municipality of Tabatinga-AM. IGAPÓ JOURNAL-Journal of Education Science and Technology of IFAM, 9(2), 54-64.

Nascimento, E. P. do. (2012). Trajectory of sustainability: from environmental to social, from social to economic. Advanced Studies, 26(74), 14. Available in: http://www.scielo.br/pdf/ea/v26n74/a05v26n74.pdf. Access on 25 Sep. 2020.

Nascimento, F. L., & Oliveira, M. D. (2010). Basics on fish farming and cultivation in net tanks in the Pantanal. Embrapa Pantanal. Corumbá, 28.

Nascimento, S.C. O. D. (2007). Evaluation of the sustainability of the Curupatifish farming project in castanhão dam, Jaguaribara-CE.

Nervis J. A.L. (2019). Integration system in Brazilian fish farming with examples of tilapia creation in excavated tank (2029). Available in: https://abccam.com.br/wp-content/uploads/2019/11/5-Sistema-de-integra%C3%A7%C3%A3o-na-piscicultura-brasileira-com-examples-de-cria%C3%A7%C3%A3o-de-til%C3%A1pia-em-tanque-escavado-Juliana-Nervis-COPACOL.pdf. Accessed 15 Sep 2020.

Nicli, S., Elsen, S. U., & Bernhard, A. (2020). Eco-social agriculture for social transformation and environmental sustainability: A case study of the UPAS-project. Sustainability, 12(14), 5510.

Niederle, P. A., & Grisa, C. (2008). Diversification of livelihoods and access to actors and assets: an approach on the dynamics of local development of family farming. Cuadernos de Desarrollo Rural, 5(61), 28-28.

Nikoskelainen, S., Salminen, S., Bylund, G., & Ouwehand, AC (2001). Characterization of the properties of human and dairyderived probiotics for the prevention of infectious diseases in fish. Applied and Environmental Microbiology, 67 (6), 2430-2435.

Nogueira, E. da C. *et al.* (2011) Monitoring the Water Quality of a Nursery Nile Tilapia Cultivation. In: Latin American meeting of scientific initiation, 15, 2011, São José dos Campos. annals. São José dos Campos: Ed. University of the Paraíba Valley.

Nomura, I. (2010). The future of marine fishing and aquaculture in theworld. Science and Culture, 62(3), 28-32.

Nunes, A. J. P. (2002). Effluent treatment and water recirculation in marine shrimp fattening. Panorama of Aquaculture ,71, 27-39.

Nunes, J. S., Remor, E., Amorin, D. G., Muelbert, B., & Borba, M. R. D. (2015). Agroecological fish farming: utopia or necessity? In V Congreso Latinoamericano de Agroecología-SOCLA (7 to 9 October 2015, La Plata).

Organization for Economic Cooperation and Development- OECD & FAO. (2016). OECD-FAO Agricultural Outlook 2016–2025. Paris, OECD

Oliveira, A. S. (2011). Socio-environmental characterization of fish farming in net tanks in the municipality of Guapé.

Oliveira, A. S., de Souza, R. A. L., & de Melo, N. F. A.C. (2015). State of the Art of Fish Farming in the Southwestern Mesoregion of Pará-Eastern Amazon. Cepnor Scientific Technical Bulletin, 14(1), 33-38.

Oliveira, L. R. D., Medeiros, R.M., Terra, P. D.B., & Quelhas, O. L. G. (2012). Sustainability: from the evolution of concepts to implementation as a strategy in organizations. Production, 22(1), 70-82.

Oliveira, C., Halmeman, M., & Massochin, A. (2006). Rural Electrification Program "Clic Rural" its effects and implications in the western region of Paraná 20 years later. In Brazilian energy congress (Vol. 1, pp. 55-66).

Oliveira, N. I. D. S., & Florentino, A.C. (2018). Socioeconomic evaluation of fish farmers in the municipality of Porto Grande, Amapá, Brazil. Science and Natura, 40, and 31.

Oliveira, R.C. (2009). The aquaculture landscape in Brazil: the practice focused onsustainability. Intertox Journal of Toxicology, Environmental Risk and Society, v. 2, n. 1, p. 7-89, Feb.2009.

O Novo Oeste. (2018). After 10 years Copacol's fish slaughterhouse is the largest in slaughter volume in South America. Available in: http://www.onovooeste.com.br/noticia/2739/apos-10-anos-abatedouro-de-peixes-da-copacol-e-o-maior-em-volume-de-abate-da-america-do-sul. Access on May 5, 2020.

Osmundsen, TC, Amundsen, VS, Alexander, KA, Asche, F., Bailey, J., Finstad, B., & Salgado, H. (2020). The operationalization of sustainability: Sustainable aquaculture production as defined by certification schemes. Global Environmental Change, 60, 102025.

Ostrensky, A., Borghetti, J., & Soto, D. (2008). Aquaculture in Brazil: the challenge is to grow. Brasilia, 2007. 276 p.

Ostrensky, A., & Boeger, W. A. (1998). Fish farming: foundations and management techniques.

Pandiyan, P., Balaraman, D., Thirunavkarakarasu, R., George, E. G. J., Subaramaniyan, K., Manikkam, S., & Sadayappan, B. (2013). Probiotics in aquaculture. Drug invention today, 5(1), 55-59.

Paris, V.M. W. (2012). Fish farming, income alternative to small property. Available in:< http://repositorio.utfpr.edu.br/jspui/handle/1/21529>. Access on Dec 10, 2020.

Penteado, S. R. (2012). Implementation of organic cultivation: planning and planting. 2. Ed. Campinas, SP: Organic Way.

Pereira, A.C. & Silva, R.F. (2012). Tilapia production / Rio Rural Program. Technical Manual 31. Niterói: Rio Rural Program, 2012.52 p.; 30cm. Available in:<http://docplayer.com.br/14177948-Manual-tecnico-31-issn-1983-5671-producao-de-tilapias-augusto-costa-pereira-rodrigo-froes-silva.html> Access on 03 Apr. 2020.

Phillips, MJ and Subasinghe, RP (2008). Application of risk analysis to environmental issues in aquaculture. Understanding and application of risk analysis in aquaculture, 101.

Pimenta, P. (2012). The viability of fish farming for the small producer of Dourados. Communication & Market, 1(1), 36.

Pinheiro, L. (2004). From ichthyology to ethnoknowledge:popular knowledge, environmental perception and sense of conservation in a riverside community of the Piraí River, Joinville, State of Santa Catarina. Acta scientiarum. Biological Sciences, 26(3), 325-334.

Planello, D. R. F. (2015). Exploratory study of the tilapia market in the state of SãoPaulo. (dissertation Doctoral, University of São Paulo).

Pnud - Programa das Nações Unidas para o Desenvolvimento (2018) - Panorama Ods: Nova Aurora in numbers - Available in:<https://oestepr2030.org.br/wp-content/uploads/2019/04/Nova-Aurora-web.pdf>. Accessed On 21 Apr. 2020.

Poersch, L., Almeida, M., Gaona, C., Furtado, P., Fóes, G., & Wasielesky, W. (2012). Bioflakes: viable economic alternative for shrimp producers in nurseries. Aquaculture panorama, 22(131), 36-43. Publishing.

Pott, V. J. (2002). Potential use of aquatic plants in water depollution. Embrapa Cattle-Cut Documents (INFOTECA-E).

Prochmann, A.M., & Tredezini, C. A. O. (2003). Fish farming in Mato Grosso do Sul as an instrument for generating employment and income on the small property. In CONGRESS OF THE BRAZILIAN SOCIETY OF ECONOMICS AND RURAL SOCIOLOGY (Vol. 42).

Rabelo, L. S., & Lima, P. V. P. S. (2007). Sustainability indicators: the possibility of measuring sustainable development. Available in:< http://repositorio.ufc.br/handle/riufc/3630>. Accessed: 05 Dec.2020

Rabelo, D. S., & da Silva Salvi, J. (2018). Viabiability of Eichhornia Crassipes (aguapé) as an alternative for water filtration in Ji-Paraná/Ro. South American Journal of Basic Education, Technical and Technological, 5(1).

Radar Agrojornalismo em Tempo Real. (2019). City of Nova Aurora (PR) receives the title of National Capital of Tilapia. Available in: https://www.canalrural.com.br/radar/cidade-de-nova-aurora-pr-recebe-o-titulo-de-capital-nacional-da-tilapia/. Access on 06. Mar.2020.

Radziemska, M., & Mazur, Z. (2015). Effect of compost from by-product of the fishing industry on crop yield and microelement content in maize. Journal of Ecological Engineering, 16(4).

Rakshit, A., Sarkar, N.C., Maiti, R.K., (2010). Basics of conversion to organic agriculture. Int. J. Agric. Mr. Environ. biotechnology. 3 (2), 253-256.

Ramírez-Duarte, W. F., Pineda-Quiroga, C., Martínez-Rueda, N., & Eslava-Mocha, P. R. (2013). Evaluation of the use of sodium chloride, eugenol, and zeolite in confinement of Ancistrus triradiatus. Orinochia ,17(1), 84-95.

Ramos, G. D. L., Silva, A. P. G., & Barros, A. A. F. (2013). Manual of rural extension methodology. Recife: Agronomic Institute of Pernambuco-IPA.

Raupp, F.M.; Beuren, I.M. (2012). Research methodology applicable to social sciences. In: Beuren, I.M. (Org.). How to elaborate monographic works in accounting: theory and practice. 3. Ed. São Paulo: Atlas, p. 76-97.

Rebouças, L. D. O. S., & Gomes, R.B. (2016). Organic aquaculture: an overview. Brazilian Journal of Fisheries Engineering, 9(2), 135-151.

Resolução Conama nº 413 of June 26, 2009. Available in: <https://www.icmbio.gov.br/cepsul/images/stories/legislacao/Resolucao/2009/RES_CONAMA_N413_2009.pdf>. Accessed Feb 25, 2021.

Resolução Conjunta IBAMA/SEMA/IAP - n° 002/08. Available in: <https://docplayer.com.br/46948800-Resolucao-conjunta-n-002-08-ibama-sema-iap.html>. Accessed Feb. 27. 2021

Ribeiro, P. A. P., Costa, L. S., & Logato, P. V. R. (2008). Probiotics in aquaculture. Rev. Nutritime, 6(1), 837-846.

Ribeiro-Neto, T. F., da Silva, A. H. G., Guimarães, I.M., & Gomes, M. V. T. (2016). Extensive family fish farming in lower São Francisco, Sergipe State, Brazil/Extensive fish farming in Lower São Francisco River Basin in Sergipe State, Brazil. Minutes of Fisheries and Aquatic Resources, 4(1), 62-69.

Rocha, C.M.C. da; Resende, E. K. de; Routledge, E.A.B.; Lundsted, L.M. (2013). Advances in the research and development of Brazilian aquaculture. Revista Pesquisa Agropecuária Brasileira, Brasília, v.48, n.8, p.iv-vi, Aug.

Rodrigues, C. G., Engle, C., Garcia Neto, B. F., Amorim, R. V., & Valenti, W.C. (2019). The effect of choice of targeted market, production scale, and land tenure on the economics of integrated tilapia-prawn production. Aquaculture Economics & Management, 23(2), 204-217.

Rodrigues, L. S., Cavalcanti, I.M., Capanema, L. X. D. L., Morch, R.B., Magalhães, G., Lima, J. F., & Mungioli, R. P. (2012). Aquaculture panorama in Brazil: challenges and opportunities. BNDES Setorial, n. 35, Mar. 2012, p. 421-463.

Rotta, M. A. (2003). Diagnosis of fish farming in the Upper Taquari-MS Basin. Embrapa Pantanal-Bulletin of Research and Development (Infoteca-E).

Sá, G. G. (2013). Evaluation of the sustainability of the family fish farming project: the case of the community of Malhada-Pentecoste-Ceará.

Sampaio, L. A. N. D., Tesser, M.B., & Wasielesky Junior, W. F.B. (2010). Advances in mariculture in the first decade of the 21st century: fish farming and marine carcinoculture.

Sanes, F. S.M., Strassburger, A. S., Araújo, F.B., & Medeiros, C. A.B. (2015). Composting and fermentation of fish residues for the production of organic fertilizers. Semina: Agrarian Sciences, 36(3), 1241-1251.

Santos, A. A. O., Aubin, J., Corson, M. S., Valenti, W.C., & Camargo, A. F.M. (2015). Comparing environmental impacts of native and introduced freshwater prawn farming in Brazil and the influence of better effluent management using LCA. Aquaculture, 444, 151-159.

Santos, M. L., Carvalho, R., Alencar, R., Rocha, I., Fonseca, C., Peregrino, L. H., & Rodrigues, J. (2005). Biosafety program on the marine shrimp farm. Brazilian Association of Shrimp Breeders, Recife, Brazil.

Sarkar, D., Ganguly, S., Shikha (2018). Organic agriculture for sustainable environment. Kurukshetra 66 (6), 27-30.

Sarkar, D., Kar, S. K., & Chattopadhyay, A.; Shikha; Rakshit, A.; Tripathi, VK; Dubey, PK; Abhilash, PC. Low input sustainable agriculture: A viable climate-smart option for boosting food production in a warming world. Et al. Indic. Secur,115, 106412.

Stamm, F.O., & Medeiros, H.A.S. (2012). Fish farming, in the wave of integration. Available in:< https://gia.org.br/portal/wp-content/uploads/2013/11/Texto-Integracao-na-Piscicultura.pdf>. Accessed Nov 5, 2020.

Sátiro, T.M.; Neto, K. X.C. R.; & Delprete, S. E. (2018). Aquaponics: System that integrates fish production with vegetable production in a sustainable way. Brazilian Journal of Fisheries Engineering, 11(1), 38-54.

Schirmer, G. J., & Cardoso, E. S. (2010). Fish farming in the socioeconomic dynamics of the municipality of Agudo-RS. Bulletin Gaucho Geography, 36(1).

Schulter, E. P., & Vieira Filho, J. E. R. (2017). Evolution of fish farming in Brazil: Diagnosis and development of the tilapia production chain (No. 2328). Text for Discussion.

Scorvo Filho, J. D., Frascá-Scorvo, C.M. D., Alves, J.M.C., & Souza, F. R. A. D. (2010). Tilapiculture and its insums, economic relations. Revista Brasileira de Zootecnia, 39, 112-118.

Seab/Deral -Secretary of Agriculture and Supply Government of the State of Paraná / Department of Rural Economy (2018). Municipal Graphs referring to the Gross Value of Rural Production (2018). Available in: http://www.agricultura.pr.gov.br/sites/default/arquivos_restritos/files/documento/2019-10/graficosmunicipaisvbp2018r_0.pdf. Access on April 19. 2020.

Sebrae -Brazilian Support Service for Micro and Small Enterprises (2012). "Profile of the farmer." Series Studies and Research 44. Available from:< https://bibliotecas.sebrae.com.br/chronus/ARQUIVOS_CHRONUS/bds/bds.nsf/74018fad8be70a4c727626c2d9bbc4c4/$File/4806.pdf>. Accessed Feb. 27. 2021.

Sebrae - Brazilian Support Service for Micro and Small Enterprises. (2016). Creation of tilapia in excavated nurseries. Technical guide to undertake in the creation of tilapia in nurseries. Brasília-DF. Available from: <https://bibliotecas.sebrae.com.br/chronus/arquivos_chronus/bds/bds.nsf/3fdeb1a972ee85108b5b8a2ee264063b/$File/7703.pdf>. Access on May 5, 2020.

Serviço Nacional de Aprendizagem Rural – Senar (2018). Fish farming: construction of excavated nurseries. Brasilia: Senar, 2018.72 p, il. - (Senar Collection, 209). Available in: < https://www.cnabrasil.org.br/assets/arquivos/209-VIVEIROS-ESCAVADOS.pdf>. Accessed March 21, 2021

Secretaria da Agricultura e Meio Ambiente (2020). Nova Aurora City. Available in:< http://novaaurora.pr.gov.br/index.php?sessao=b054603368svb0&id=1520>. Access in 10 Oct 2020.

Seuring S.; Müller, M. (2008). From a literature review to a conceptual framework for sustainable supply chain management. Journal of Cleaner Production, 16(15):1699–1710.

Sidonio, L.; Cavalcanti, I.; Capanema, L.; Morch, R.; Magellan, G.; Lima, J.; Burns, V.; Alves Junior, J. Mungioli, R. (2012). Aquaculture panorama in Brazil: challenges and opportunities. BNDES Sector. p. 421-463.

Silapajarn, O., & Boyd, CE (2005). Effects of channel catfish farming on water quality and flow in an Alabama Stream. Reviews in Fisheries Science, 13 (2), 109-140.

Silva, C. A., & Carneiro, P.C. F. (2007). Water quality in tambaqui fattening in nurseries without water renewal.

Silva, D. F., de Araújo, L. E., & de Sousa, F. D. A. S. (2008). Indicators for Some Dimensions of Sustainability Applied to Rural Properties within Small and Medium Hydrographic Basins. Qualitas Electronic Magazine, 7(1).

Silva, L. F., Russo, R. D. F. S.M., & de Oliveira, P. S. G. (2018). Quantitative or qualitative? an alignment between research, researcher and findings in social research. Pretexto Magazine, 19(4), 30-45.

Silva, W. L.M., Frozzi, J.C., Fonseca, J. S., Souza, A. L., Salvador, J. S. P., Ribeiro, P. N. T., & Campos, M.C.C. (2018). Sustainability in aquaculture: social, economic and environmental dimensions–a literature review. Education, Society and Environment, 20(1, Jan-Jun),87-108.

Silva, M. R., Lingnau, R., Godoy, W. I., & Bortoluzzi, S.C. (2016). Indicators proposed in the national literature for sustainability assessment in family agriculture. Journal Environmental Monographs, 15(1), 37-52.

Soares, A.C. (2002). Opportunity for improvement for the sustainable development of fish farming in the municipality of Pato Branco-PR. Available in: < https://repositorio.ufsc.br/handle/123456789/83794>. Access on 04 Feb.2021

Sobral, M. D.C.M., Carvalho, R.M.C.M. O., SILVA, M.M. D., & Melo, G. L. D. (2006). Land use and occupation around reservoirs in the Brazilian semi-arid region as a determining factor in water quality. In XXX Inter-American Congreso de Ingeniería Sanitaria Y Ambiental. Punta del Este, Uruguay (Vol. 26).

Sontag, A. G. (2016). Sustainability index: A study applied in the municipality of Marechal Cândido RondonPR. State University of West Parana, Cascavel. Available in: https://bdtd.ibict.br/vufind/Record/UNIOESTE-1_672d13a42fd946982fa1f4eea8954752. Accessed Sep 16, 2020.

Sousa, A. S.C.; Neto, E.B.; & Leite, M. A. (2016). Fish farming and the cost of producing round fish in excavatedtank. qualia: science in motion, 2(1), 1-25.

Sousa, I. L.M. D. (2017). Solar power system for fish farming-TO. Available in:< https://bdm.unb.br/handle/10483/20033>. Accessed Jan 10, 2021

Souza, S.B. de, Doula, S.M., & Carmo, P.M. (2016). Rural Youth of the Mining Forest Area and professional life projects. Redes (St. Cruz Sul, Online), 21(1), 233-249.

Sreesai, S., Peapueng, P., Tippayamongkonkun, T., & Sthiannopkao, S. (2013). Assessment of a potential agricultural application of Bangkok-digested sewage sludge and finished compost products. Waste Management & Research, 31(9), 925-936.

Stoffel, J. A. (2014). Construction and evaluation of sustainability indicators for family farming: a multidimensionalanalysis. State University of Western Paraná, Toledo. Available in: https://bdtd.ibict.br/vufind/Record/UNIOESTE1_8729ff78d64dfa7f371cbaaa5e61d22f. Access on 12 Sep. 2020.

Tavares-Dias, M. (2011). Continental fish farming in the state of Amapá: diagnosis and perspectives. Embrapa Amapá-Bulletin of Research and Development (Infoteca-E).

Tavares, T. G. (2016). Limiters and opportunities of the fish farming production chain in southeastern Tocantins.

Tesch, R. (2013). Qualitative research: Analysis types and software. Routledge.

Toledo, J. J., Castro, J. G. D., Santos, K. F., Farias, R. A., Hacon, S., & Smermann, W. (2003). Evaluation of the environmental impact caused by effluents from nurseries of the High Forest Fish Farm Station-MT. Journal of the Agro-Environmental Sciences Program,Alta Floresta, 2, 13-31.

Torres, S., Pereira, F. D. A. R., Souza, C.C., & Ferreira, M.B. (2017). Analysis of the efficiency of fish farming production in the Region of Dourados-MS. Espacios Magazine, 38(52).

Troell, M., Naylor, R. L., Metian, M., Beveridge, M., Tyedmers, P. H., Folke, C., & De Zeeuw, A. (2014). Does aquaculture add resilience to the global food system?. Proceedings of the National Academy of Sciences,111(37), 13257-13263.

Valenti, W.C. (2002). Sustainable aquaculture. In Congress of Animal Science (Vol. 12, pp. 111-118).

Valenti, W.C. (2008). Brazilian aquaculture is sustainable. Lecture presented during the IV International Seminar on Aquaculture, Mariculture and Fisheries, Aquafair,13-15.

Valenti, W.C., Kimpara, J.M., & de L Black, B. (2011). Measuring aquaculture sustainability. World aquaculture, 42(3), 26.

Valenti, W.C., Kimpara, J.M., & Zajdband, A. D. (2010). Methods for measuring sustainability in aquaculture, n.119, p.28-33.

Valentini, H., D'Incao, F., & Rodrigues, L. F. (2002). Evaluation of shrimp fishing in the Southeast and South regions of Brazil (1965-1999).

Van Bellen, H.M. (2010). The Dimensions of Development: an exploratory study from the perspective of evaluation tools. Journal of Management Sciences, 12(27), 143-168.

Veiga, J. E. D. (2010). Sustainability indicators. Advanced studies, 24(68), 39-52.

Vidotti, R.M., & Lopes, I. G. (2016). Organic waste generated in fish farming. Research & Technology, 13(2), 1-6.

Vieira Filho, D. D. (2009). Fish farming as an alternative for local development in the Dourados-MS region. Graduate Program in Local Development -UCDB, Campo Grande-MS/2009, 95p. Master's thesis.

Waite, R., Beveridge, M., Brummett, R., Castine, S., Chaiyawannakarn, N., Kaushik, S., & Phillips, M. (2014). Improving productivity and environmental performance of aquaculture. Worldfish.

Werbach, A. D. A.M. (2010). Sustainability strategy: a new way to plan your business strategy. Rio de Janeiro: Campus.

Weber, L. S. (conteudist). (2009). Ecosystems and Flora. Santa Maria, ETIC-EAD/USFM/UAB.

Wilfart, A., Prudhomme, J., Blancheton, J., Aubin, J., (2013). LCA and emerged AC-counting aquaculture systems: for ecological intensification. Mr. J. Environ. Manag, manag. 121, 96—109. https://doi.org/10.1016/j.jenvman.2013.01.03 sorry.

Yin, R. K. (2010). Case study: planning andmethods. Four, four, four. Ed. Porto Alegre: Bookman.

Yin, R. K. (2015). Case Study-: Planning and methods. Bookman editor.

Yuan, Y., Yuan, Y., Dai, Y., Zhang, Z., Gong, Y., & Yuan, Y. (2020). Technical efficiency of different farm sizes for tilapia farming inChina. Aquaculture Research, 51(1), 307-315.

Zimmermann, Sergio (2017). Optimizing feed conversion factor (FCA) in tilapia by growing bioflakes with specific genetic lineage. Stilo Publishing House. Sao Paulo, 2017. Available in:< https://www.editorastilo.com.br/otimizando-o-fator-de-conversao-alimentar-fca-em-tilapias-pelo-cultivo-em-bioflocos-com-linhagem-genetica-especifica/>. Access in 01. March, march. 2021.

Zimmermann, S., & Fitzsimmons, K. (2004). Intensive tilbeculture. Special topics in tropical freshwater fish farming. São Paulo, SP: TecArt, 1, 239-266.

APPENDIX - APPLIED RESEARCH ROADMAP

Semi-structured interview script applied to fish farmers in the city of Nova Aurora-PR.

Script No.:_____ Date: _____ from _____from 2020.

1 PRODUCER PROFILE DATA

1.1 AGE: _____ SEX: ( ) MALE ( ) FEMALE

1.2 Marital status

( ) - single

( ) - married

( ) - others

1.3 Schooling

( ) - Incomplete elementary school (1st grade)

( ) - Complete elementary school (1st grade)

( ) - Incomplete high school (2nd grade)

( ) - High school (2nd grade)

( ) - Incomplete higher education (graduation)

( ) - Complete higher education (undergraduate)

1.4 Number of children: _____

1.5 How long have you been working in fish farming?

2 Property data

2.1 How big is the property?

_____

2.2 How many people reside on the property?

_____

2.3 Is the area its own?

_____

2.4 How many meters of water slide do you have?

_____

2.5 How much fish per square metre are housed in nurseries?

_____

2.6 Type of fish it produces.

( ) - Tilapia

( ) - Pacu

( ) - Dourado

( ) - Tambaqui - tambacu

( ) - Carpas(capim, cabeçudas, prateada, húngara)

( ) – Other

2.7 Do you use tank structure (nurseries) excavated to produce?

_____

2.8 Do you have a legal reserve area in the rivers and springs near the property?

_____

2.9 How many meters wide on the margin:

_____

2.10 Is there an environmental license for the development of fish farming?

_____

2.11 Do you have a water grant for fish farming?

_____

3 PRODUCTION DATA

3.1 What is the purpose of production?

( ) resale to private refrigerators (slaughterhouses)

( ) resale for refrigerators (slaughterhouses) integration

( ) fish-pay

( ) Small restaurants or retail

( ) own consumption

3.2 What is the average weight for the delivery of fish for slaughter?

_____

3.3 Fish feeding is by means of natural food in nurseries,
or use balanced feed?

_____

3.4 On your property which of the productive systems of fish farming you use:
Extensive system
Semi-intensive system
Intensive system
Super-intensive system
Why is that? _____

3.5 It has a system for the flow of water from nurseries and the management and renewal of water? which?

_____

3.6 How do you control water quality in nurseries?

_____

3.7 The cultivation system you have chosen to work with is:
( ) - integrated into a cooperative
( ) - works independently.

3.8 If integrated, which cooperative: _____

3.9 What motivated you to choose the integrated fish farming system?

_____

3.10 What is the main characteristic of your cultivation system being integrated?

_____

3.11 What differentiates your integrated cultivation system from a cultivation system independent?

_____

3.12 In addition to the manpower and infrastructure, the fish farmer is responsible for Which obligations in the integrated cultivation system?

_____

3.13 And in the independent cultivation system how management control works, up to the marketing phase of the fish? (inputs, fingerlings, transportation, industrialization)

_____

3.14 In fish farming you take proper care not to assault environment and generate pollution in rivers? In what way?

_____

3.15 What requirements need to be met for the cultivation system integrated?

_____

3.16 What about the independent cultivation system?

_____

3.17 What problems have you encountered with the integrated system or independent?

_____

3.18 Does it make polyculture fish farming? (more than one species of fish in the nursery)

_____

3.19 Do you have technical assistance that can assist in the management of your activity?

_____

3.20 Do you reuse fish waste? In what way?
(composting, other)

_____

3.21 Uses waste as a natural fertilizer for soil (annual crops, vegetables, fruit growing, pastures)

_____

3.22 Do you grow fish only in the fattening phase? Or does the (juvenile up to 50 grams in separate nurseries)?

_____

3.23 How is water collection carried out for fish farming? (by gravity, pumping. (electric pumps)

_____

3.24 Where does the water catchment for fish farming come from? (rivers, streams, streams, springs and water sources, artesian wells, well)

_____

4 RELATED ASPECTS THE SOCIAL DIMENSION OF SUSTAINABILITY

4.1 FAMILY SOCIAL SUSTAINABILITY

4.1.1 How many family members work in fish farming (labor family)?

_____

4.1.2 In addition to family members, hires others to work in the activity fish farming? If so, how many?

_____

4.1.3 Presence of electricity in the residence?

( ) Yes ( ) No.

Which: _____(Copel example)

Other: _____ (photovoltaic)

4.1.4 Do you have internet access and telephony?

( ) Yes ( ) No.

Fixed: _____

Mobile: _____

4.1.5 He did some sort of renovation in his house after he went to work at fish farming?

_____

4.1.6 Do you have easy access to the education of children?

_____

4.1.7 Do you have a health plan for the family?

_____

4.1.8 With the activity of fish farming there have been changes in the quality of their health and your family?

_____

4.2 SOCIAL SUSTAINABILITY IN FISH FARMING

4.2.1 Fish farming brings subsistence and contributes to a better quality of life for your family?

_____

In what way?

_____

4.2.2 It makes another type of commercial production or subsistence of rearing (bovine milk, pig-cutting chicken and others) or cultivation of annual crops (soybeans, corn, wheat, vegetables, fruit growing and others on the property, such as vegetables?

_____

4.2.3 Receives some technical guidance for the development of the company's fish farming? whose?

_____

4.2.4 You have already done some environmental education, aquaculture-fish farming or fish farming training to assist you in the day-to-day activity of fish farming?

_____

4.2.5 Participates in events on Fish Farming (field day, meetings, seminars, events)?

_____

4.2.6 Do you usually meet with other fish farmers to exchange information?

_____

5 RELATED ASPECTS THE ECONOMIC DIMENSION OF SUSTAINABILITY

5.1 FAMILY ECONOMIC SUSTAINABILITY

5.1.1 What income/profit has been paid on a monthly basis?

( ) - Less than 1 minimum wage

( ) - Between 1 and 3 minimum wages

( ) - Between 3 and 6 minimum wages

( ) - Above 6 minimum wages

5.1.2 Do you have another source of family income?

_____

5.1.3 Does it take financial control of household expenses?

_____

5.1.4 Do you have outsourced labor expenses? How much?

_____

5.1.5 Are the resources invested in the property their own? Or need to search for Resource in the banks for costs and investments in property?

_____

5.1.6 Has access to credit and growth opportunities through partnerships government agencies, cooperatives, financial agents and other partnerships?

_____

5.2 ECONOMIC SUSTAINABILITY IN FISH FARMING

5.2.1 With fish farming activity you have achieved the economic growth that desired?

_____

5.2.2 Do you intend to make new investments in fish farming or expansion?

_____

5.2.3 Acquired some equipment to achieve greater production growth in the fish farming?

_____

5.2.4 Do you have labor costs in the production process of fish farming? It has expenditure on inputs (fertilizers, salt, lime, medicines) during the process of fish fattening?

_____

5.2.5 Do you have expenses with improvements in the infrastructure (installation) of nurseries?
How often?

_____

5.2.6 Do you have financial control over your spending on fish farming?
What is the required number of materials for the growing period? What materials are needed?

_____

5.2.7 Are you aware of the amount (in Reais) of feed and inputs spent on each batch of fish by tanks (nurseries)?

_____

5.2.8 The way you do financial control has been helping you to ensure accuracy of the level of production spending as well as your revenue generated?

_____

5.2.9 Are you aware of how much you produce from fish farming?

_____

5.2.10 Do you want to expand the amount of water slide on your property?

_____

5.2.11 Would invest in more technologies in fish farming for the activity to become More sustainable? What?

_____

6 RELATED ASPECTS THE ENVIRONMENTAL DIMENSION OF SUSTAINABILITY:

6.1 FAMILY ENVIRONMENTAL SUSTAINABILITY

6.1.1 Is the residence connected to a sewer age?

_____

6.1.2 Do you have treated water or well water?

( ) Artesian well.

( ) Springs or protected source

( ) Water treated public network

6.1.3 The disposal of solid waste (household waste, fertilizer packaging, pesticides) is done in what way?

( ) Selective collection

( ) Burned

6.1.4 Does water treatment and preservation on the property?

_____

In what way?

_____

6.1.5 You care about the preservation of biodiversity fauna and flora in your property?

_____

6.1.6 Do you have organic production on the property?

_____

6.1.7 Do you make use of organic activity practices on the property? Which of these practices the producer makes on the property:

( ) Natural fertilizer

( ) Composting technique

( ) Waste control

( ) Others:_____

6.2 ENVIRONMENTAL SUSTAINABILITY IN FISH FARMING

6.2.1 What are the main challenges or difficulties you encounter in so that the fish farming does not so much put the environment?

_____

6.2.2 How water management works in tanks (nurseries)
Dug? (It has mechanical aeration; It has water pumps).

_____

6.2.3 How is the quality of water used in fish farming measured? It makes any water quality analysis? How much in how long?

_____

6.2.4 Makes use of some input/(Salt, fertilizer) or product to assist in the management fish inside the excavated ponds? Quantity per m2 of blade water: _____

6.2.5 Uses hydrated lime, virgin lime or limestone for ph control in water and improving the water quality of excavated tanks?

_____

6.2.6 Uses hydrated lime, virgin lime disinfection of tanks (nurseries) after fishing?

_____

6.2.7 Do you have an oxygen meter for measuring oxygen in excavated tanks (nurseries)

_____

6.2.8 What care do you take to reduce eutrophication (excess matter organic) in the water of excavated tanks (nurseries)? Do you use any management techniques?

_____

6.2.9 Do you practice agriculture integrated with fish farming?

( ) Irrigated cultivation for the production of vegetables,

( ) Irrigated fruit growing

( ) Other crops

( ) Aquaponics (cultivation of vegetables with hydroponics)

6.2.10 Do you consider it important to take measures to make fish production have less impact on the environment? In what way?

_____

6.2.11 Technology is available for the treatment of effluents generated from production fish farming? Can you name which one?

_____

6.2.12 Do you treat liquid effluents in tanks?

_____

6.2.13 Do you have decanting tanks? In what way are they?

_____

6.2.14 Do you use another effluent treatment technique?

_____

6.2.15 Is it necessary to clean the tanks after the fish have been removed?

_____

6.2.16 How is organic matter cleaned at the bottom of the nursery? What is it used for cleaning?

_____