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THE SUSTAINABILITY OF PISICULTURE IN THE MUNICIPALITY OF PATO BRAGADO ASSESSED BY THE MESMIS: "WILL IT BE FOR FISH?"

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Abstract: This work aims to use indicators that make up the MESMIS method in order to assess whether the pisiculture activity in the municipality of Pato Bragado/PR is sustainable and promotes local development, constituting a tool for consultation by municipal managers. When prioritizing the qualitative analysis in the study, the inter-complementary knowledge of pisiculturists was considered to problematize it, making it possible to apply the method that helped to quantify the sustainability of the pisiculture activity. Critical factors were pointed out by indicators, based on the relationship between environmental, social and economic processes to be rethought, however it is concluded that there is intention towards sustainability due to the relationship to be activated between social actors who understand pisiculture as a ascending activity in Pato Bragado because it plays an economic and social role if organized in a productive arrangement, however, because it uses natural resources, it needs attention from the factors involved in local development through the territorial bias to articulate the challenge for a municipal plan of rural development with identity, socially cohesive and environmentally cared.
Keywords: Sustainability, MESMIS, Pisciculture, rural development plan, Pato Bragado.

INTRODUCTION

The world production of fish reached the mark of 179 million tons in 2018, with 46% coming from aquaculture. The FAO report "State of Fisheries and Aquaculture 2020" estimated that production must increase to 204 million tons in 2030, an increase of 15% compared to 2018 (FAO, 2020).

In 2020, Brazil increased its production by 4.3% compared to 2019, in turn, stands out as one of the largest producers, reaching the mark of 551.9 thousand tons. The southern region accounts for 48.2% of the country's total. In

this context, the State of Paraná, with 166,000 tons, stands out as the largest tilapia producer in Brazil, with an increase of 14% compared to 2019 (IBGE - Brazilian Institute of Geography and Statistics, 2020, Anuário Peixebr, 2021). The western region of Paraná is a pioneer in pisiculture in excavated ponds, being an important source of income in small rural properties (FEIDEN et al 2018; SCHULTER and VIEIRA FILHO, 2017; BOSCOLO and FEIDEN, 2007; SPEELMAN et al, 2007).

A survey carried out by Welter et al, (2021) points out the Maripá Municipality, 57 km from Pato Bragado of the studied location, as a regional and national reference in pisiculture and mentions the investments made in the activity and articulation of different actors as determining factors for the success of the productive arrangement, greatly contributing to the economic development, in a sustainable way, of the region.

Data from SEAB (2020) show that Pato Bragado produced 890 thousand kg of tilapia, reaching a gross production value of R$ 4,957,300.00.

This way, it corroborates the thesis that the production of tilapia, notably in the Pato Bragado Municipality, is also one of the determining economic forces for the sustainable development of rural producers by allowing diversification, producing food, contributing to the formation of networks and productive arrangements and provide income generation, extending to the region.

Sustainable development is understood as that which "meets the needs of the present without compromising the capacity of future generations to also meet theirs" (CMMAD, 1991, p.9). It is characterized by being multidimensional, involving at least the social, economic and environmental dimensions. Development in fact only occurs when it is economically viable, socially fair and environmentally sustainable over time (SACHS, 2008).

Based on these concepts and the premise that it is necessary to assess sustainability, and corroborating Zeni, (2019) in order to guide the decision of municipal managers in decision-making to improve issues involving the social, economic and environmental aspects of pisiculturists, it is proposed to use indicators that determine the process of interpreting the results and allow the assessment of development under previously defined aspects.

This way, the research on screen consists of the analysis of indicators, through the MESMIS methodology (Marco de Evaluación de Management Systems Incorporating Sustainability Indicators) applied to seven tilapia producers located in the municipality of Pato Bragado/PR, with the purpose of evaluating the interrelationships between the results of the environmental, social and economic dimensions for a future participation in a productive arrangement based on a Municipal Plan for Sustainable Rural Development.

The adoption of the MESMIS Methodology is justified because it is an action-assessment used to assess the sustainability of systems, which has already been validated in various regions of the world and in different areas of agricultural sciences (SOUZA et al, 2014). It was also chosen because of its scope and applicability in family productive units and because it provides broad and, at the same time, specific indicators under different evaluation approaches of the productive activity.

The article is divided into sections: introduction, theoretical foundation that contextualizes sustainable development within the reality of pisiculture developed in the municipality of Pato Bragado /PR. Then, the methodological procedures are described, as well as the characterization of the sample and then the results arising from

the application of the MESMIS Methodology and the final considerations are presented.

THEORETICAL FOUNDATION

With the release of the report called *Brundtland*, published by the *World Commission on Environment and Development* (WCED), the expression "sustainable development" appears, being conceptualized as "the development that meets present needs without compromising the ability of future generations to meet their own needs" (GIBBERD, 2015; MATTHEW and HAMMILL, 2009; WCED, 1987).

Sustainable development is based on three important pillars: "social relevance, ecological prudence and economic viability" (SACHS, 2005). Thus, the promotion of economic growth needs to be linked with positive impacts in social and environmental terms (SACHS, 2008). Although it has been criticized "for being an oxymoron, redundant or vague", the concept has been widely adopted by the most varied actors from different cultures and social classes (MATTHEW and HAMMILL, 2009).

Sustainable development strives for the preservation of the ecosystem, combined with the socioeconomic needs of communities through economic development. A rural sustainable development process is complex and involves many relationships of cause and effect (HEIN and SILVA, 2019; GLOWKA et al, 2018; CHAVES; RODRIGUES, 2006).

A topic in the midst of discussion in the social, economic and academic spheres, sustainability has a variety of conceptions and over the last fifty years, it has been refined by leading researchers and has fostered stricter demands on the part of society and more responsible attitudes on the part of of corporations (CIOFI, 2010).

Sustainability reflects the possibility of enjoying a good quality of life without damaging or altering ecosystems, that is, within the aspect of resilience, or they are ways and means to face the environmental, social and economic challenges that the future presents (WILLIS, 2012; SANTOS, SEHNEM and FREITAS, 2015; GIBBERD, 2015).

In this line, Engel, (2012) refers sustainability to geographic conservation and to finding the balance of ecosystems, this being promoted in parallel with the eradication of poverty, overcoming social and economic exclusion, observing human rights and seeking social integration.

Sustainability must be analyzed under three dimensions: environmental, social and economic, with the aim of achieving a balance in the preservation of the environment. Dealing with pisiculture, Gerona, (2021) cites sustainable management, treatment of solid waste, care with the quality of water and water resources, use of organic techniques to preserve biodiversity and the environment, in addition to financial growth from the generation of income, increase in jobs and infrastructure as examples of aspects to be observed when analyzing sustainability.

Likewise, sustainability needs to be measured. For this, indicators are used, which consist of an assessment instrument and translate into measures whose interpretation evidences the condition of a system as sustainable or not, according to the standards established for the analyzed context (CANDIDO et al, 2015).

Sustainability indicators can contribute to decision-making processes and must allow: measuring different dimensions in order to apprehend the complexity of social phenomena; enable society's participation in the process of defining development; communicate trends; and relate variables, as reality is neither linear nor one-dimensional (CANDIDO et al, 2015; GUIMARÃES and FEICHAS, 2009). In this sense, the work

uses indicators that make up the MESMIS methodology in order to assess whether the pisiculture activity in the municipality of Pato Bragado/PR is sustainable and promotes local development.

For Schulter and Vieira Filho (2017), when compared to agricultural activity, fish production is divided between aquaculture and extractive fishing. Aquaculture is cultivation, which commonly occurs in confined and controlled spaces, whereas fishing is the activity based on the removal of fishery resources from the natural environment.

In aquaculture, the species produced in each region of Brazil are: i) tilapia, pacu and painted in the Southeast; ii) tambaqui, pacu and painted in the Midwest; iii) tilapia and marine shrimp in the Northeast; iv) tambaqui, pirarucu and pirapitinga in the North region; and v) carp, tilapia, silver catfish, oyster and mussel in the southern region (EMBRAPA, 2017).

In Brazil, tilapia culture started in 1971 and, although it is not a native species, the Nile tilapia (Oreochromis niloticus), the main species produced in Brazil, was introduced, with the Zanzibar tilapia (Oreochromis hornorum), by the National Department of Works Against Droughts (DNOCS). DNOCS introduced the first specimens with the intention of providing the production of fingerlings for fish stocking in public reservoirs (KUBITZA, 2003).

According to Figueiredo Junior and Valente Junior (2008), the species was quickly introduced in several properties and water bodies in the Southeast and Northeast, then in the South region. Also in that decade, there was a transition in which tilapia culture changed from an activity focused on to the repopulation and income supplement to small producers for an activity exploited commercially, giving rise to the first ventures aimed at tilapia culture.

According to Pedroza Filho; et al (2020), there are seven main centers of tilapia production in Brazil: West Paraná, North Paraná and Vale do Itajaí (SC), in the South region; Sub-middle São Francisco (BA, PE and AL) and Boa Esperança Reservoir (PI), in the Northeast region; Ilha Solteira (SP), in the Southeast region, dividing itself with the Midwest; and Serra da Mesa and Cana Brava (GO) Reservoirs, considered together due to their physical proximity, in the Midwest.

In terms of exports of Brazilian pisiculture totaled US$ 5.7 million in the 3rd quarter of 2021, which represents an increase of 71% compared to the same period in 2020, Paraná appears in second place, with US$ 1.7 million, after Mato Grosso do Sul, with a total of US$ 1.9 million (EMBRAPA, 2021).

MATERIAL AND METHOD

The research was carried out in the municipality of Pato Bragado, represented in a total area of 135,286 km², with an estimated population of 5,610 inhabitants (IBGE, 2019). Located in West Paraná, Figure 1, a prominent region in pisiculture for playing an economic and social role when organized in a productive arrangement, according to Feiden et al, (2017).

The municipality's delimitation took into account its participation in the Council of Lindeiros do Lago de Itaipu Municipalities, based on a voluntary manifestation of social actors at a meeting on governance of the Lindeiros territories and the motivation to use sustainability indicators as a diagnosis to direct a start for a pilot Municipal Sustainable Rural Development Plan.

The sample interviewed was for convenience, based on registration at the municipal agriculture department of Pato Bragado, consisting of 70 people involved in the activity, but with two selection criteria: having pisiculture as an activity on the property

Figure 1 – Location of Pato Bragado in Paraná.

Source: Wikipédia, (2021)

for at least three years and having production for marketing purposes. Seven responses returned, representing 47% of the selected population of 15 pisiculturists. This sample was chosen for better monitoring in order to apply the method to more families in the future. At the beginning of the questionnaire, all agreed with the Informed Consent Form (FICF).

Data collection took place in September 2021, when questionnaires with closed questions were made available, considering the dimensions of sustainability, environmental, social and economic according to variables raised with the participation of pisiculturists (Figure 2). The submission was in the online Google Form format, as it was during the Covid-19 pandemic, providing pisiculturists with opportunities, through a structured script, to participate safely in action research, collaborating with their knowledge about the pisiculture agroecosystem, in order to characterize the activity profile through the perception of the subjects involved in it, beyond facts and material data (FREIRE, 2006).

When prioritizing the qualitative analysis in the study, the inter-complementary knowledge of pisiculturists was considered to problematize the study and develop indicators and apply the MESMIS method that helps to quantify sustainability and is based on the relationship between environmental, social and economic processes.

With a participatory approach, MESMIS promotes discussion and re-discussion of the evaluators and evaluated, starting from an interdisciplinary view to fully understand the limits and potential for the sustainability of the agroecosystem, in this case providing a systemic monitoring of a productive unit (DEPONTI, 2014 ; NUNES, 2016).

A method that guarantees the participation and involvement of families is a sine qua non condition for assessing the perception and monitoring of changes in attitudes of these pisiculturists in relation to sustainable practices (SOUZA et al, 2014).

In Figure 2, the survey of critical points in the three dimensions of pisiculture was considered in order to reach the application of MESMIS.

Figure 3 shows the variables raised in line with pisiculturists, bibliographies and researchers with the bias of interdisciplinarity, which originated the indicators to be analyzed by MESMIS. According to Proença (2014), the following steps were developed: I) determination of the study environment; II) determination of critical points in the

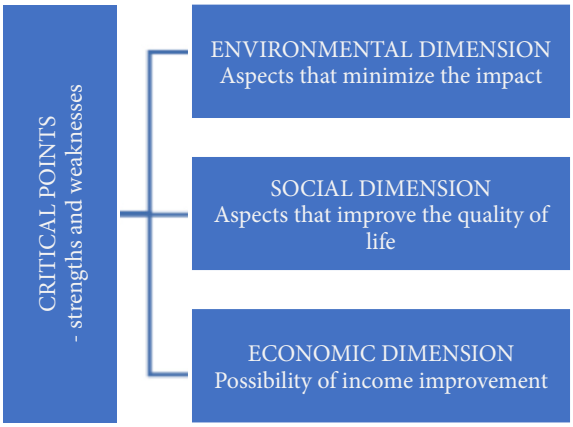

Figure 2 – Critical points detected to raise sustainability indicators

Source: The authors, (2021)

Dimension	Composite Sustainability Indicators - ISC	Indicators
Enviromental	ISCRH - Water resources	Origin of water
		Permanent protection area
		Destination of pisiculture
		Regularization with supervisor bodies
	ISCA - Agricultural	Fish species
		Grazing animals on the mudflats
		Importance of pisiculture on the property
		Destination of solid waste
Social	ISCT - Technology	Solar power generation
		Emergency generator for aerators
		Technical assistance
		Technical assistance service
	ISCMO - Labor	Labor
		Production management
	ISCD - Diversity	Road access
		House on the property
		Participation unions, associations, cooperatives, councils
		Municipal sustainable rural development plan
Economic	ISCDE - Economic dependency	Resources to subsidize production
	ISCRF - Financial feedback	Profitability
		Has another source of income in addition to agricultural
		Forms of commercialization
		Future of activity

Figure 3 - Indicators selected to compose the MESMIS method

Source: Authors, (2021)

system; III) determination of indicators; IV) measurement of parameters; V) presentation of results; VI) conclusion and recommendations.

In the measurement parameters of the indicators, the following scores were assigned: 1.00 (one) represents a critical condition with difficulties in achieving good results in terms of sustainability; 2.00 (two) regular condition; 3.00 (three) condition close to the ideal sustainable. Finally, the data were analyzed in electronic spreadsheets and presented in tables and in the radar chart.

RESULTS AND DISCUSSIONS

The results, with primary data, characterize the participation of family culture in pisiculture in the municipality of Pato Bragado in 71.4% of the seven properties, in addition to presenting a relevant percentage of 42.9% arising from family succession, with the others being purchased and leased. It also configures in 42.9% of the properties the effective participation of women in the family, in the management and management of pisiculture. They act as entrepreneurs (FAO, 2020; SCHREIBER, 2021). In 85.7% of the properties, the family workforce is the main productive factor, with one of them employing hired labor.

The intensification of activity focused on the use of family labor is a need for Brazilian agriculture, as well as the diversification of its agricultural production using best-practice technologies, contribute to local sustainable development (WELTER, 2021). Sometimes, developed as an income supplement, it is an alternative for family culture as it adds value to the budget, reconciling with other rural activities, allowing the permanence of producers in the field (SCHREIBER, 2021; COTA, SCCOTI and CARAMELO, 2021).

In terms of time working with pisiculture, producers in West Paraná had the longest average time, with 13 years. The experience of selected pisiculturists from Pato Bragado varies from 3 to 11 years and together they add up to 188,550 m² of water, seen in Figure 4, producing approximately 500,540 kg of fish annually, a productivity of 2.65 kg/m², approaching the density in an excavated nursery system in West Paraná with productivity above 2.8 kg/m².

It is interesting to know the reality to share experiences and technologies such as high performance aerators, improved strains, bulk feed storage silos and management focused on sustainability.

After a brief characterization of pisiculture, the process follows, using the MESMIS method that, according to Freitag (2020), results are obtained to support owners and other social actors to make decisions regarding the improvement of factors that influence the degree of unsustainability of agroecosystems.

Figure 5 shows the indicators covered in the survey, through the 23 results declared and scored by the questionnaires obtained. From reality, the critical points can be highlighted when applying the MESMIS to demonstrate a way to diagnose and monitor pisiculture, in order to raise plans and goals for a more sustainable territorial development.

After characterizing the pisiculturists' statements, in Tables 2, 3 and 4, scores were calculated according to each alternative chosen by the respondents: from 1 (one) to 3 (three) arriving, by means of a simple average, to the critical factors, both strong: with regular conditions (2.00-2.50) until close to the sustainable ideal (2.51-3.00), such as weak factors: (<2.00) in critical conditions to achieve good results in terms of sustainability.

For Masera et al. (2008), the critical points are the factors that limit or strengthen the systems' capacity to be more sustainable. When checking attributes to measure sustainability, it is essential to consider aspects such as

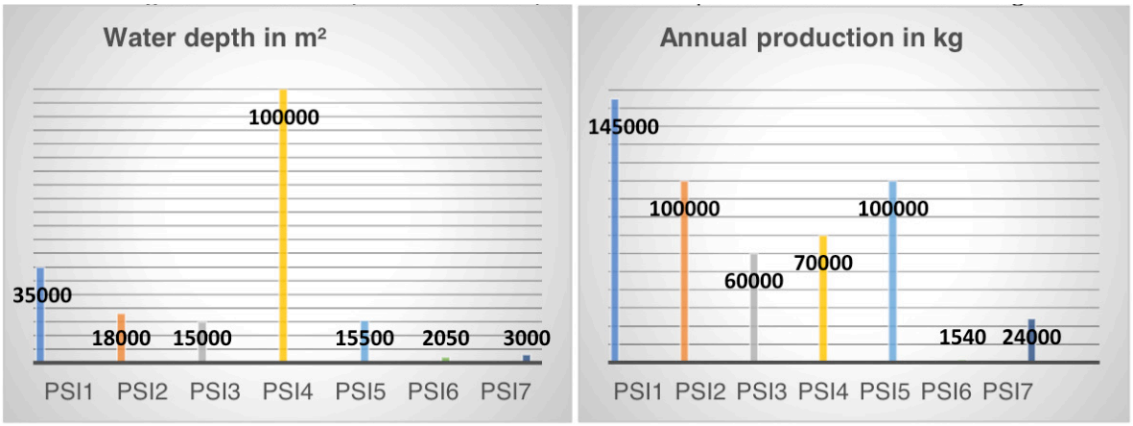

Figure 4 - Water depth and annual production of pisiculturists from Pato Bragado

Source: Survey data, (2021)

	Contextualized Indicators	Interpretation of responses obtained from highlighted pisiculturists		
		1 – Critical condition	**2 - Regular condition**	**3 – Ideal condition**
1	Origin of water	River	Watershed and River	Watershed
2	Permanent protection area - APP	Nonexistent	Inappropriate	Proper
3	Destination of pisiculture waters	Straight to the river	Other producer	Settling
4	Regularization with supervisory bodies	It does not have	Project in progress	Regularized
5	Fish species	Diversification	Monoculture	Monoculture with predators
6	Grazing on the mudflats	It does not have	One species	Various species
7	Solid waste disposal	Not intended	Separate and sell	Compost
8	Importance of pisiculture on the property	Small participation	Partially dependent	Financially self-sustaining
9	Solar power generation	It does not have	Want to install	It has
10	Emergency generator for aerators	It does not have	It partially attends	It attends
11	Technical assistance	Private	Cooperative	Public
12	Technical assistance service	Unssatisfied	Partially satisfied	Satisfied
13	Manpower	Not enough	Partially enough	Adequate to demand
14	Production management	Outsourced	Owner and employee	Family and employee
15	Road access	Inappropriate	Partially	Adequate
16	House on the property	Employee only	Employee and Owner	Owner
17	Participation in unions, associations, cooperatives, councils.	It does not participate	Sporadically	Assiduously
18	Resources to subsidize production	Banking Cost	Partially funded	Private
19	Profitability	It does not cover direct costs. Losses	It covers direct costs, not indirect ones.	Covers all costs and surplus

20	Has another source of income in addition to farming	Yes	Home people who share the costs	No
21	Forms of commercialization	Long circuits (refrigerators)	Long Circuits and Short Circuits	Short circuits (direct sales)
22	Future of activity	To stop	To keep	To increase
23	Importance of a municipal sustainable rural development plan	Low	Indifferent	High

Figure 5 – Indicators contextualized by the results of the survey with pisiculturists

Source: Survey data, (2021)

productivity, stability, resilience, reliability, adaptability, equity and self-management of agroecosystems.

In Figure 6, the environmental dimension measured by the sustainability indicators composed of water resources signaled sustainable, unlike the agricultural indicators, given the importance of pisiculture among the others and the lack of grazing on the mudflats, resulting in 2.41 in regular condition of sustainability.

It is important to point out that for pisiculture, the National Water Resources Policy, Federal Law No. 9433, of 01/08/1997 (BRASIL, 1997) must be observed. Water needs to be managed rationally, thinking about multiple uses.

The measurement of the percentage of APP is possible with resources from satellite images and also data from the Rural Environmental Registry - (CAR).

In Figura 7, due to indicators of technical assistance, production management, electricity and non-participation with other social actors, the social dimension was impaired, but access to roads, labor and the importance given to structuring a municipal plan sustainable rural development (PMDRS) made the social dimension into regular conditions of sustainability.

A PMDRS depends on the capacity of individuals and their organizations to promote the best use of the region's attributes, including ending the rural-urban divide and taking advantage of the links between them (FAVERO and ROESLER, 2006; DEPONTI, 2021).

The teaching, research and extension institutions meet the needs of training the workforce in the region, with four federal institutions: Federal University of Latin American Integration - Unila, Federal Technological University of Paraná - UTFPR, Federal University of Paraná - UFPR and the Federal Institute of Paraná - IFPR. At the state level, the State University of West Paraná - Unioeste, the UFPR and about 30 private educational institutions that offer training courses in related areas, according to Feiden, et al, (2018), in addition to other agents such as the Rural Development Institute of Paraná IAPAR/EMATER– IDR Pr.

Figure 8 showed that pisiculture is profitable, but there are some obstacles to subsidies and forms of marketing. The high financial investment, the difficulty in obtaining environmental licenses, water scarcity, low prices, lack of buyers, labor for fishing, transport of live fish, followed by default are bottlenecks also pointed out in the studies by Pedroza Filho; et al (2020) and Scheiber, Zucatto and Lazzari (2021). Signaling the PMDRS to municipal managers to raise funds with their policies and purchase

Critical Factors: Enviroment		Grade
STRENGTHS	Origin of water	2,70
	Permanent Preservation Area APP	3,00
	Water Destination	2,60
	Regulating regulatory bodies	3,00
	Waste Disposal	3,00
	Fish Species	2,30
WEAKSESS	Importance to pisiculture on the property	1,30
	Grazing on the mudflats	1,40
	Environmental Dimension	**2,41**

Figure 6 – Critical points of the environmental dimension

Source: Survey data, (2021)

Critical Factors: Social		Grade
STRENGTHS	Manpower	2,90
	Road Access	3,00
	Technical assistance service	2,30
	Importance of a PMDRS	2,90
	Emergency generator for aerators	2,70
WEAKNESESS	Private technical assistance	1,70
	Production management	2,00
	Houses on the property	2,00
	Participation of unions/associations/cooperatives/councils	1,40
	Solar power generation	1,90
	Social Dimension	**2,28**

Figure 7 – Critical points of the social dimension

Source: Survey data, (2021)

Critical Factors: Economic		Grade
STRENGTHS	Profitability	2,60
	Future of activity	2,40
WEAKNESESS	Resources to subsidize production	2,00
	Another source of income in addition to farming	1,60
	Forms of commercialization	1,40
	Economic Dimension	**2,00**

Figure 8 – Critical points of the economic dimension

Source: Survey data, (2021)

programs and required infrastructure.

Also, the West of Paraná has cooperatives with integration systems, in which the impact of investment can be minimized, in addition to credit financial institutions: Brazilian Credit Cooperative System - Sicoob, Credit Cooperatives - Sicredi, BB Aquicultura Program and Fisheries from Banco do Brasil, Paraná Productive Program and Regional Bank of the Extreme South – BRDE (FEIDEN et al, 2018). In addition to the programs Coopera Paraná, Banco do Agricultor Paranaense, Paraná Energia Rural Renovável.

In the municipalities of the Pato Bragado region there are 24 slaughterhouses that slaughter and process around 170 tons of tilapia/day. 14 feed suppliers were identified, six companies related to the sale of machinery and equipment related to the activity and 24 fingerling production stations, the synergy with all generates beneficial externalities to the entire local, regional and surrounding community (FEIDEN et al, 2018).

The results stand out for the multidimensionality of the indicators raised by the MESMIS method that characterized pisiculture in Pato Bragado with an integrated index of 2.23 under regular conditions (environmental dimension: 2.41; social dimension: 2.28; economic dimension: 2.00) with critical limiting factors, however, considering aspects such as productivity, stability, resilience, reliability, adaptability, equity and self-management, this indicates a municipal plan that directs the activity towards an ideal of sustainability, contributing to the identity of pisiculture in the municipality.

All the dynamism of Figure 9 imposes the need to understand how tilapia cultivation has been presented in Pato Bragado. The closer to

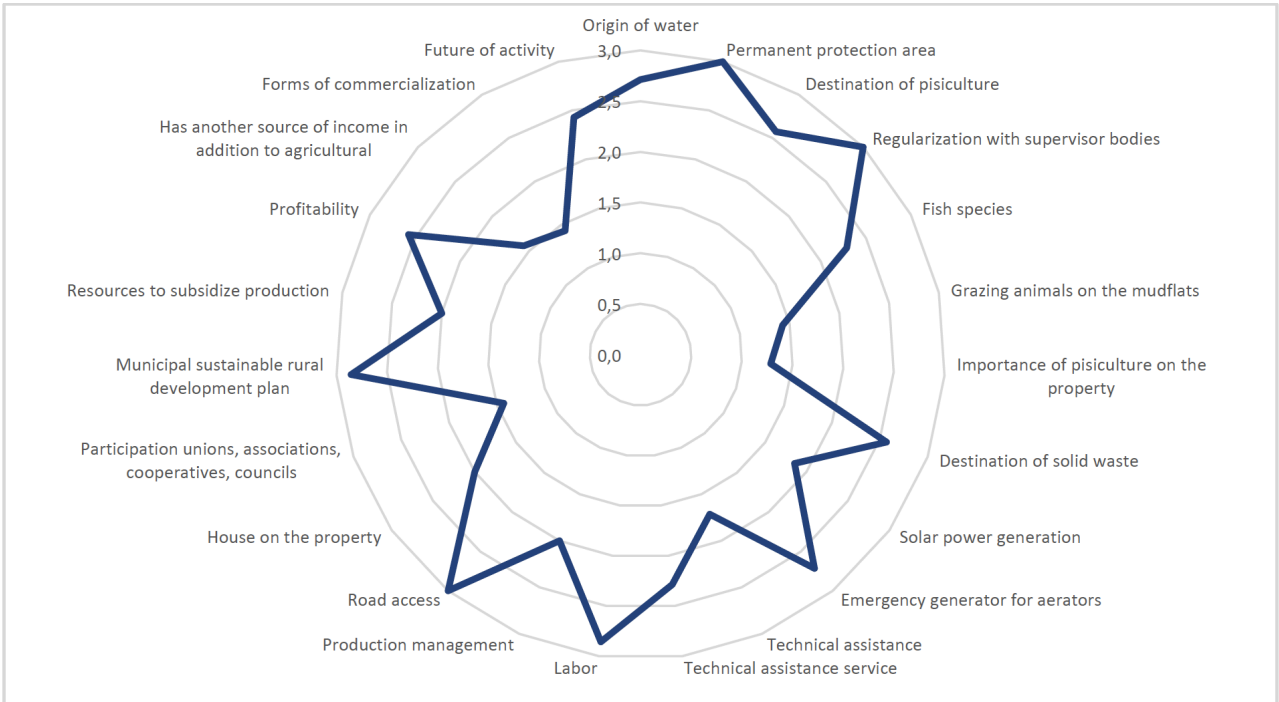

Figure 9 Radar of the pisiculture sustainability indicators in Pato Bragado

Source: Survey data, (2021)

the center of the radar, the more critical the sustainability indicator and the closer to the edge the better.

What is known is that the use of indicators, if properly applied, can contribute to advances in the construction of the sustainability ideal and in the planning of sustainable development via PMDRS. Even though I have to test, correct and study, because a consensus on the "sustainability ideal" has not yet been reached. We are still in a process that seeks to understand and characterize sustainability (PROENÇA, 2014).

When analyzing each indicator, an analysis tool is offered so that, when applied by municipal managers, they can be an instrument to improve the condition of Sustainable Development in the municipality through plans with effective programs, laws and actions oriented to demands (MORAES, 2016).

FINAL CONSIDERATIONS

The sustainability indicators that make up the MESMIS method evaluated the pisiculture activity in the Municipality of Pato Bragado/PR as promising for a sustainable local productive arrangement with possibilities for synergy with a wide network of social actors that would result in an appreciation of the space for dialogue for construction of a municipal sustainable development plan with a view to subsidizing the effectiveness of public policies.

Municipal management supported by sustainability indicators emanates a direction that can reduce social inequalities, environmental risks and expand the economic paths that would place the municipality on a higher level compared to the current level, with regular sustainability conditions.

In this sense, with the creation of mechanisms that favor the growing mobilization and social participation with the availability of live indicators for the recognition of the potential and challenges of pisiculturists, together with governance, a PMDRS can be structured.

According to Nicacio and Roesler, (2021) through the governance, innovation and intelligence program for the development of productive arrangements in municipalities bordering Lake Itaipu: articulate, integrate, converge and subsidize actions for development with actions that articulate the competencies of leaders and managers of public and private organizations, contributing to the sustainability of pisiculture, both economically and socially and environmentally, also contributing to the goals of sustainable development.

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