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Understanding the Abandonment of Aquaculturists: A Case in the Amazon (North of Brazil)

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Abstract: Despite the huge potential of aquaculture in the Amazon, several producers have abandoned the activity due to a lack of assistance, technology, and innovation. Thus, the objective of this study was to identify factors that have contributed to the withdrawal of aquaculturists from the municipality of 'Vigia de Nazaré', state of Pará (Northern Region of Brazil). This case study took place in 2022 through a quanti-qualitative survey, applying structured questionnaires to former aquaculturists. A total of 30 fish farms were investigated, with 11 of them being abandoned. They are distributed across 10 rural communities that have developed fish farming, with 'Vila de Itapuá' (18.2%) being the most representative. When active, fish farming was practiced by men (100%) aged between 51 to 60 years (54.5%) with an incomplete primary education (100%), who carried out the activity for an average of 5 years (81.8%), quitting fish farming between the years 2019 and 2020 (72.7%). All former aquaculturists owned small properties, with excavated ponds in an extensive system and used family labor. The absence of technical assistance and the high cost of feed were pointed out as the main problems in the production chain. It is worth noting that the monoculture of Tambaqui (*Colossoma macropomum*) accounted for 63.6% of the species produced in rural communities. In conclusion, former aquaculturists express the desire to return to fish farming due to its socioeconomic importance. For this, government actions supporting technical assistance and advanced studies in fish nutrition by educational, research, and extension institutions are necessary.

Keywords: *Colossoma macropomum*; extension; resumption

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1. Introduction

For many years, global fishery production was based on extraction. However, this activity is stagnating, primarily due to the disorganized exploitation of the main fishery stocks [1]. Given the increasing market demand for animal protein derived from aquatic organisms, aquaculture emerges as a solution to the production of high-protein fish for human consumption [2].

In this context, continental fish farming has established itself as one of the most promising branches of aquaculture in Brazil [3–5]. It generates socioeconomic development opportunities for small and medium entrepreneurs, contributing to job and income creation, as well as improving the quality of life of the Amazon population [6].

In the state of Pará (Brazil), the cultivation of freshwater fish, especially native species, is the main aquaculture activity [7–9]. In the municipality of 'Vigia' (state of Pará), both artisanal and industrial fishing are intensely practiced, while fish farming is slowly taking place in various rural communities. Thus, there are incentive projects aimed at stimulating local fish farming. It is worth noting that this activity is becoming an alternative source of protein compared to local fishing, emerging with a strong potential and growing consumer market.

Despite the evolution of fish farming in the Amazon, the production chain is still poorly structured and faces numerous challenges [10]. The most reported obstacles include low genetic quality, the irregular supply of young fish, high price of commercial feed, and lack of technical assistance for producers [11,12].

Such limitations observed in the Amazon region are quite common in other countries and have led small fish farmers to sell their farms or abandon their activity around the world, as evidenced in studies carried out on the Asian continent ([13] in China, [14] in India, [15] in Bangladesh, and [16] in Nepal), on the African continent ([17] in Egypt, [18] in Nigeria, and [19,20] in Ghana), and in countries in Latin America [21].

From this perspective, socioeconomic studies of producers, research on returning to fish farming, and the characteristics of fish farming are of utmost importance [7,22–26]. In this context, diagnosing and understanding former aquaculturists can contribute to the formulation of public policies and actions for rural development, as well as the return to local fish farming practices. Therefore, understanding the reasons for abandoning this activity enables its revitalization, as it represents a unique opportunity to ensure safe food, social inclusion, and the valuation of available resources for sustainability in the Amazon.

Thus, the objective of this study was to analyze the main factors that contributed to the dropout of fish farmers in Vigia (state of Pará, Brazil).

2. Materials and Methods

2.1. Study Area Description

The case study was conducted on properties that had fish farming practices (inactive fish farms) in the municipality of Vigia de Nazaré (Latitude 00°51′28″ S and Longitude 48°08′31″ W) (Figure 1). Vigia is located in the northeastern mesoregion of Pará, in the Salgado Paraense microregion, bordered to the west by Colares Island, to the south by the municipalities of Castanhal and Santo Antônio do Tauá, to the east by the municipality of São Caetano de Odivelas, and to the north by the Atlantic Ocean. The municipality includes urban and rural areas, covers an area of 401.589 km^2, and has a population of 50,832 inhabitants [27]. Vigia is 77 km away from the capital, Belém, with access to the municipality provided by highway BR 316 to the municipality of Santa Izabel do Pará and then by PA 140.

2.2. Data Collection

Data collection occurred in three distinct phases: pre-field, field, and post-field (Table 1). The current research is considered a case study, aiming to explore, describe, or explain current phenomena within their own context [7]. The methodological procedures initially involved conducting an exploratory bibliographic and documentary study of the obstacles in fish farming.

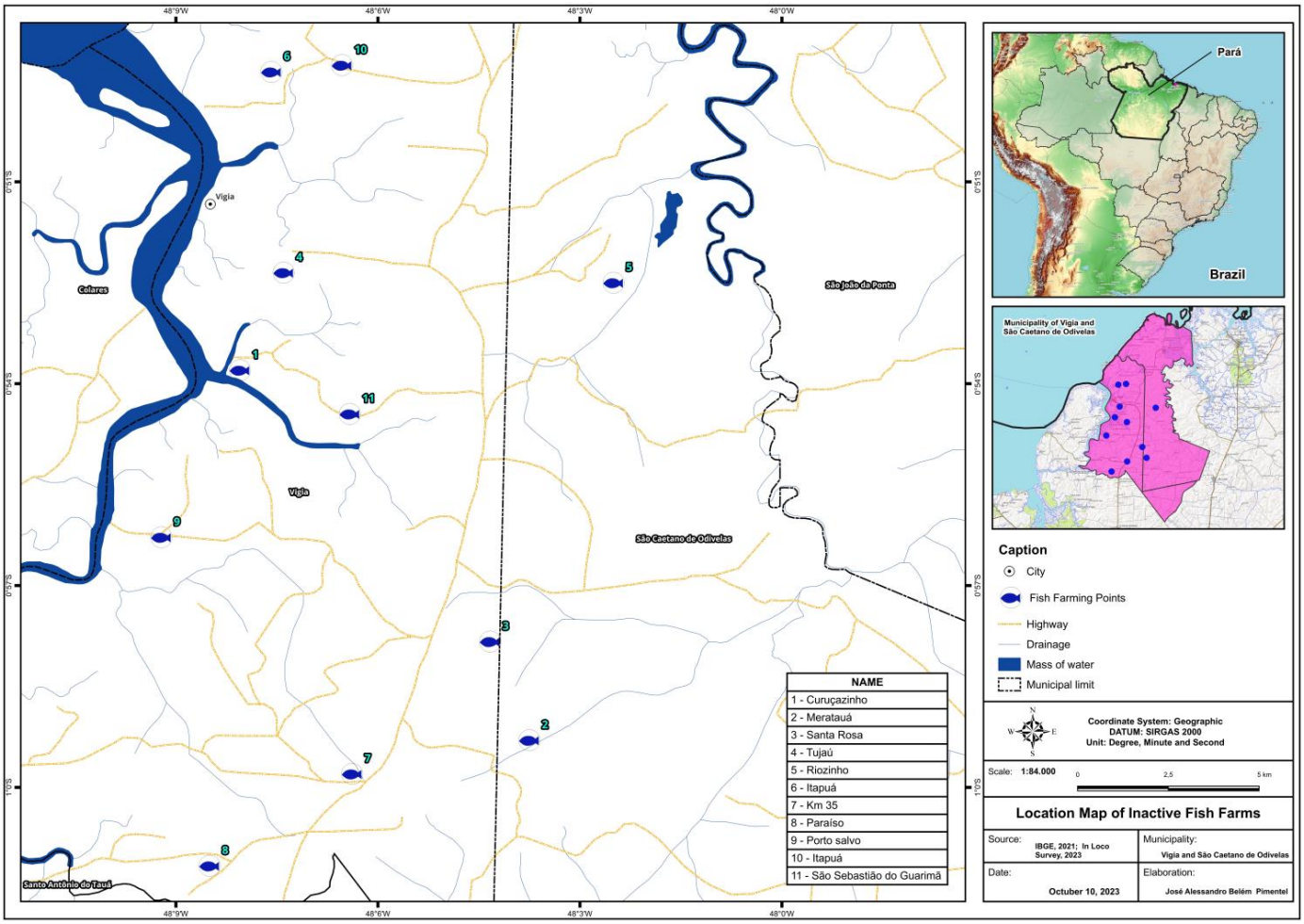

Figure 1. Geographic location of the inactive fish farms in the municipality of Vigia (Pará, Brazil).

Table 1. Methodological path of the research.

Pre-Field	Field	Post-Field
Review of the scientific literature	Identification of fish farms in the municipality	Tabulation of collected information
Determination of the target audience (former aquaculturists)	Selection of abandoned fish farms	Grouping of the achieved results
Development of guiding questions	Visits to properties that had fish farms	Analysis and discussion of the results
Design of structured questionnaire	Clarification to the target audience about the research	-
-	Application of interviews to former aquaculturists	-
-	Transect walks on the properties	-

Subsequently, a mixed-methods approach was employed to interpret qualitative information using numerical symbols and quantitative data. Qualitative data were collected during the year 2022 through individual interviews, using a semi-structured questionnaire with open and closed questions. For this purpose, an interview script was developed and applied to former aquaculturists (Table 2). The development of the script was based on data gathered from the scientific literature [28–30], focusing on personal information, data about the activity, and entry/re-entry into fish farming, in alignment with the objectives of the study.

Table 2. Information collected from former aquaculturists.

Personal Information	Activity Data	Entry/Re-Entry
Gender	Water area	Reasons for discontinuation of the activity
Age	Cultivation structures	Duration of abandonment of the activity
Education level	Cultivation system	Main difficulties faced
Time of experience in aquaculture	Cultivation modality	Limiting factors of the activity
-	Cultivated species	Importance of the activity in the community
-	-	Future prospects and recommendations

Through data collection, the research identified a total of thirty (30) aquaculture enterprises (fish farming), representing 100% of the sample universe. It is worth noting that eleven (11) enterprises were declared inactive, having been operational between the years 2005 and 2021. To identify the producers, the snowball method, also known as snowball sampling, a non-probabilistic tool, was used [31]. This methodology is widely used in social parameter research, where initial participants suggest new participants until the point of saturation, i.e., when the participant starts to provide information already obtained in previous questionnaires.

At the end of the interviews, participants were asked to sign an informed consent form, acknowledging their awareness of the research. The identities of the participants were kept confidential, ensuring their anonymity and the confidentiality of the information.

2.3. Data Analysis

The collected data were analyzed using descriptive statistics [32]. The Excel program was utilized for the production of tables and charts.

3. Results

Figure 2 displays a total of ten (10) rural communities and locations that developed fish farming in Vigia between the years 2005 and 2021. In the current study, the majority of former producers who practiced fish farming belonged to the 'Itapuá' community.

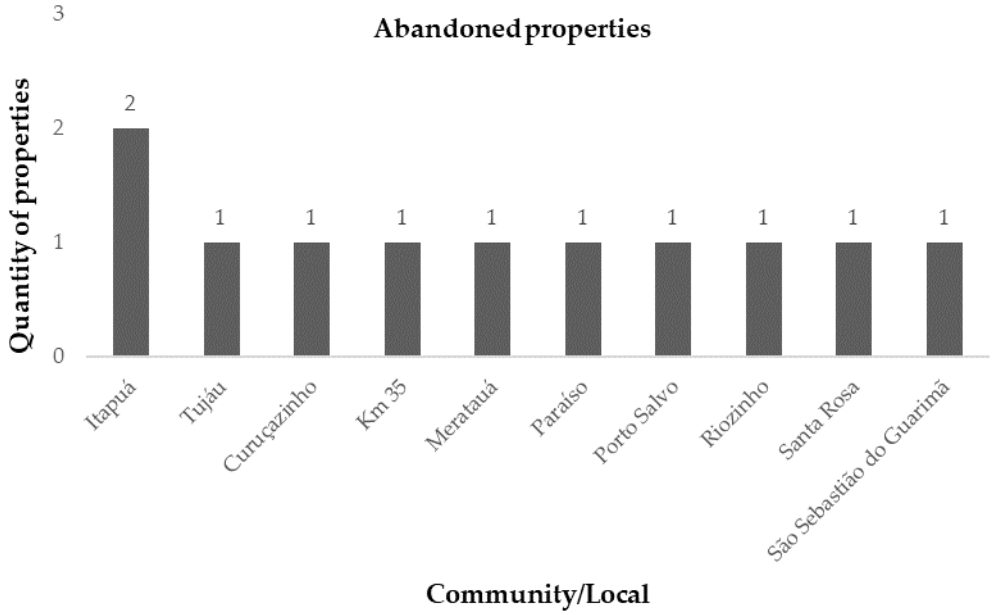

Figure 2. Localities and quantities of abandoned fish farms.

It was identified that all visited enterprises were managed by male rural producers (Table 3). The age of these interviewees ranged from 42 to 79 years, with an average age of 59 years.

Table 3. Social profile at the time that the aquaculturist was active.

Category	Total Sample	
	Absolute Frequency (N)	**Relative Frequency (%)**
Gender		
Male	11	100
Female	00	00
Age Group		
Between 40 and 50 Years	3	27.3
Between 51 and 60 Years	6	54.5
Over 60 years old	2	18.2
Education level		
Incomplete Elementary Education	11	100
Complete Elementary Education	00	00
Secondary Education	00	00
College Education	00	00
Time spent in fish farming		
From 1 to 5 Years	9	81.8
From 10 to 15 Years	2	18.2
Year of activity abandonment		
(2017–2018)	3	27.3
(2019–2020)	8	72.7

Thus, a total of 54.5% of the respondents were aged between 51 to 60 years. Regarding the education level of the producers, 100% of them did not complete elementary education.

Concerning the duration of activity, 81.8% of the producers had been involved in fish farming for at least 5 years. They claimed to have given up their farming in the last 3 years (72.7%).

The cases of producers withdrawing from fish farming activity are a recent event in the visited communities and became more prominent in the last 3 years (Table 4). The reasons and factors reported by the fish farmers are varied. However, the lack of financial resources, the high cost of inputs, the difficulty of accessing rural credit for financing, maintenance, and the expansion of businesses due to bureaucratic issues were the predominant factors for the evasion of most interviewees.

Regarding cultivation structures, fish farming in the northeastern region of Pará does not differ from the rest of the state, with a predominance of fish breeding in excavated ponds and small- to medium-scale production. The facilities are, therefore, extremely rustic, built by the producers themselves, in most cases without any technical monitoring since the producers have limited financial resources. This, in turn, can lead to technical and structural problems, reported by the fish farmers themselves, mainly related to infiltration. Due to the excavation of ponds in places where the soil characteristics are not conducive to fish farming, water loss occurs in infiltration, which must be corrected by soil waterproofing using geomembranes, leading to an increase in the producer's production costs. Figure 3 depicts the abandoned fish farms in the region.

Regarding the aspect of productivity, the presence of extensive systems was diagnosed, accounting for 100% (Table 5). They reported that the labor used was exclusively family-based (100% of cases). It was detected that the inactive aquaculturists only practiced monocultures with the purpose of fattening the species. Concerning cultivated fish, a total of three species were identified, with the native species Tambaqui (*Colossoma macropomum*) being the most widespread (63.6%), followed by the Nile Tilapia (*Oreochromis niloticus*) and the Pirarucu (*Arapaima gigas*) to a lesser extent.

Figure 3. Extensive and abandoned fish farming systems and their respective locations: (**1**) Merataué, (**2**) Santa Rosa, (**3**) Tujaú, (**4**) Riozinho, (**5**) Itapuá, (**6**) Itapuá, (**7**) Curuçazinho, (**8**) Km 35, (**9**) Paraíso, (**10**) Porto Salvo, and (**11**,**12**) São Sebastião do Guarimã.

Table 4. Abandoned fish farms listed by local community.

Local Community	Absolute Frequency (N)	Year of Implementation	Cultivation System	Cultivated Species	Year of Abandonment	Annual Gross Income	Rural Credit	Compliance Status	Sales Location	Technical Assistance
Itapuá	2	2012	Extensive	Tambaqui	2017	Not provided	Yes	Yes	Property	No
Tujáu	1	2015	Extensive	Tambaqui	2020	Not provided	No	-	Property	No
Curuçazinho	1	2005	Extensive	Tambaqui	2020	Not provided	No	-	Markets	No
Km 35	1	2015	Extensive	Tambaqui and Tilápia	2018	Not provided	No	-	Property	No
Meratauá	1	2015	Extensive	Tambaqui	2021	Not provided	No	-	Property	No
Paraíso	1	2017	Extensive	Tilápia	2020	Not provided	No	-	-	No
Porto Salvo	1	2018	Extensive	Pirarucu	2020	Not provided	No	-	-	No
Riozinho	1	2009	Extensive	Tilápia	2019	Not provided	No	-	Property	No
Santa Rosa	1	2016	Extensive	Tambaqui	2020	Not provided	No	-	Property	No
São Sebastião do Guarimã	1	2018	Extensive	Tambaqui	2021	Not provided	No	-	Property	No

Source: Created by the authors.

Table 5. Productive profile at the time of practicing fish farming.

Category	Total Sample	
	Absolute Frequency (N)	**Relative Frequency (%)**
Cultivation system		
Extensive	11	100
Labor		
Family	11	100
Cultivated species		
Tilápia	3	27.3
Tambaqui	7	63.6
Pirarucu	1	9.1

Like any agricultural or livestock activity, fish farming presents certain production constraints. Therefore, the main reported difficulties and limitations that negatively influence the development of the activity were specialized technical assistance and the cost of feed, accounting for 100% of the respondents (Figures 4 and 5).

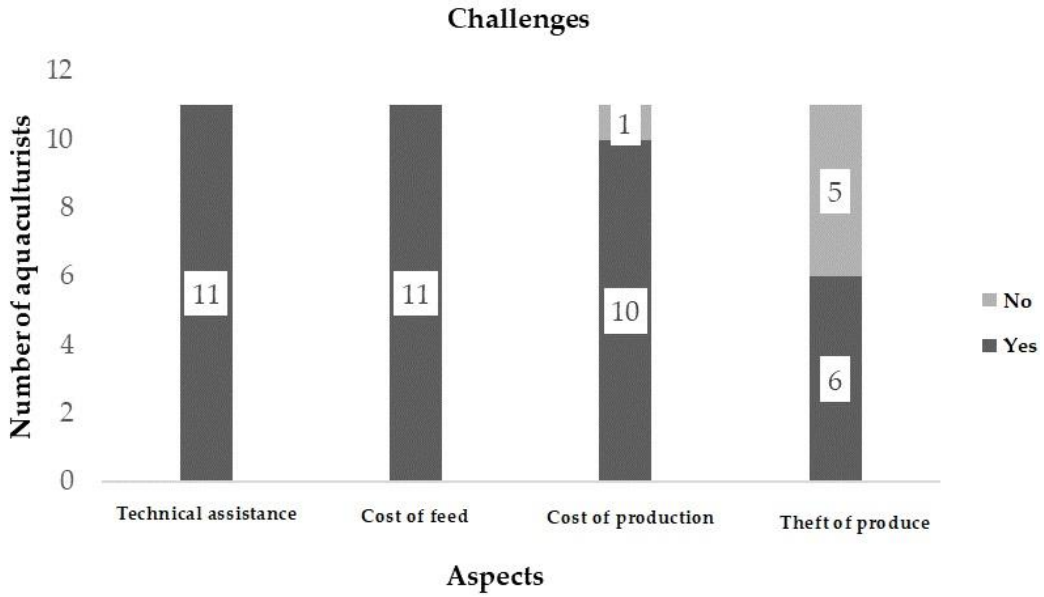

Figure 4. Challenges in the activity mentioned by aquaculturists.

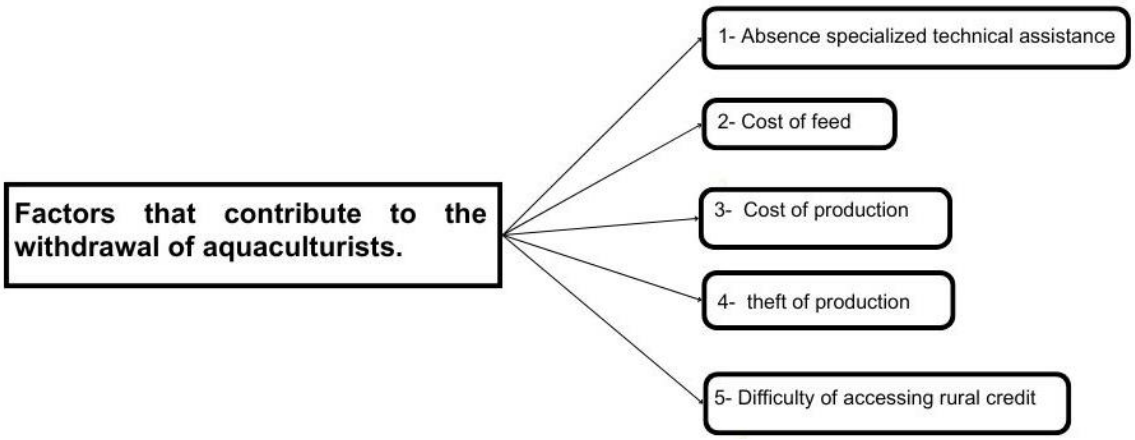

Figure 5. The main limitations that contribute to the withdrawal of aquaculturists.

The fish farmers were asked about the possibility of re-entering the activity, where 73% of the respondents answered that they would be willing to resume their farming at an opportune moment (Figure 6), motivated by the economic growth that the activity has experienced. However, this return is approached with great caution by the producers, as to avoid repeating past mistakes, they must adopt planning strategies from the initial implementation phase to commercialization. In order for aquaculturists to successfully return to this activity, we recommend that a series of actions be developed by governmental agencies according to the following criteria (Figure 7).

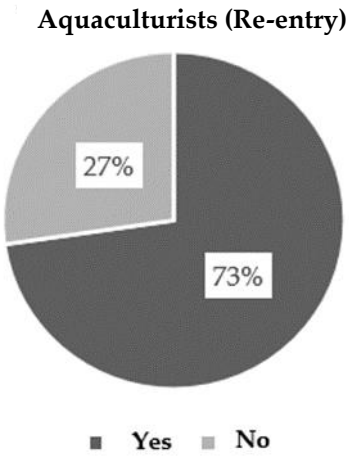

Figure 6. Producers' perspectives on re-entry into aquaculture.

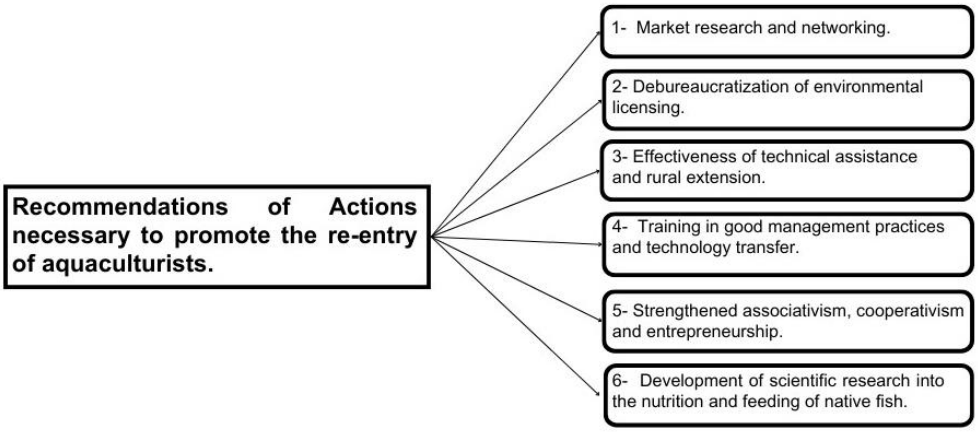

Figure 7. Recommendations to promote the re-entry of aquaculturists.

4. Discussion

The male dominance in the management of aquaculture enterprises identified in this study is a common reality in various parts of the world [33,34]. The majority participation of men in aquaculture production activities may be related to the gender division of labor. In rural communities, it is common for men to be in charge of production tasks that may require greater physical effort, while women are responsible for household chores and family care [12].

Despite the disparity and invisibility of female participation in aquaculture activities, it is worth highlighting that this scenario has been gradually changing [35,36] and the protagonism of women in aquaculture has, over time, gained notable recognition thanks to the empowerment, engagement, and promotion of public policies for women. These strategic actions aim to train and provide greater autonomy and decision-making power through professional courses, influencing aquaculturists to socioeconomically develop

through increased education, a transformative factor that enables access to knowledge, decisively contributing to the promotion of gender equality [37–39].

The low level of education observed among the interviewed fish farmers, according to reports, is a combined consequence of the difficulty of accessing schools in rural areas or the premature abandonment of studies in order to work and contribute to family support. A similar reality occurs for fish farmers in the coastal cities of Pará, who have low levels of education [40].

The labor used in the ventures in this study was of familial origin. This reinforces that the activity is seen as a "family" endeavor by the local fish farmer, and qualified labor is virtually nonexistent, as described by [41], working in the western regions of Pará with aquaculturists. It is worth noting that, although rare, there were records of temporary hires for specific activities over short periods.

Fish farming, despite being considered a relatively recent activity for most producers in Vigia, has been practiced for at least 15 years. However, our findings show that fish farmers are still inexperienced in fish farming. It is observed that they are gradually acquiring knowledge to develop the activity as a source of subsistence and with the perspective of supplementing family income. In fact, no producer had fish farming as their only and main source of income, which characterizes the activity as complementary and secondary. Other sectors such as livestock and agriculture, with the raising of other animals (poultry, pig farming, and fruit growing), stand out as the main sources of income for property owners. This reality diverges from that recorded for rural producers in the southeast microregion of Pará, where 75% of fish farmers earn their main income from fish farming [42].

The cases of producers withdrawing from fish farming activity are a recent event in the visited communities and became more evident in the last 3 years. The reasons and factors reported by the fish farmers are varied. However, the lack of financial resources; the high cost of inputs; and the difficulty of accessing rural credit for the financing, maintenance, and the expansion of businesses due to bureaucratic issues were the predominant factors for the evasion of most interviewees.

In various studies carried out around the world with the aim of investigating the difficulties faced and factors that motivate producers to give up aquaculture, the researchers proved that the absence of good management protocols and poor administration, a lack of technical support, and subsidies from government agencies, were the main factors [13,15–20].

The absence of or non-compliance with good management protocols as well as poor administration decisively contributed to the emergence of outbreaks and diseases in large aquaculture areas in Southern India and Latin American countries, that decimated a large part of the production, causing serious losses and with them the abandonment of aquaculture production [14,21].

The extensive production system prevailed in all the visited inactive enterprises, where aquaculturists used few or no management practices, such as: preparation and maintenance of cultivation structures, fertilization or liming, control of stocking density, monitoring of fish growth through biometric measurements, and monitoring of water's physicochemical parameters. In the Marajó archipelago in Pará, a predominance of the extensive system was also observed [43].

The greater use of the extensive system in communities, despite its lower productivity, is likely due to the fact that the implementation cost is lower, making it compatible with the economic and social conditions of the studied communities. Regarding the species cultivated in the visited inactive fish farms, Tambaqui prevailed as the most produced, corroborating that fish farming, especially of native species, constitutes the main aquaculture activity in the state of Pará [44].

Generally, producers started their projects with empirical knowledge and report that information was acquired through informal conversations with friends or technicians from public agencies. The lack of training, qualifications, and technical assistance in the production chain became one of the main problems for the success of aquaculture

enterprises [20]. This reality leads to a discrediting of the activity or even abandonment by the producers, as inadequate management, without proper planning and zootechnical and/or economic control, results in errors such as low productivity and production losses, causing serious losses to the producer [18].

The difficulty in accessing financing and credit lines for obtaining financial subsidies is considered a "barrier" for most respondents, as they claim that there are several documents necessary to enable financing, which is challenging because not all interviewees can gather all these documents.

One of the significant difficulties faced by fish farmers in the region is related to the fact that, to increase the biomass of the fish, the correct supply of balanced feed with a high nutritional value that meets the animals' needs is necessary. In this sense, commercial feed is seen as one of the highest costs for production, becoming a problem for the activity's development. The expense of acquiring industrialized feed can reach up to 70% of the total production costs [45]. This difficulty with feed costs was also observed by [46] in the states of Amazonas, Rondônia, and Roraima (Brazil).

Inactive local producers who wish to return to the activity are calling for effective participation from the public sector to gain more support related to technical/productive aspects. For this to be possible, and for this activity to establish itself and move beyond a supporting role in rural areas to decisively contribute to food security, job creation, employment, and local income, we recommend the adoption of a series of integrated measures by government bodies aimed at addressing the difficulties faced by fish farmers (Table 6).

Table 6. Recommendations for integrated actions by governmental bodies necessary for the development of the aquaculture sector.

Governmental Agencies	Actions
Technical assistance and rural extension company of the state of Pará. (EMATER/PA)	Promote the regular provision of free and high-quality technical assistance aimed at guiding and training producers in fish farming production techniques.
Federal Institute of Education, Science, and Technology of Pará (IFPA)	Develop technological innovations in aquaculture aimed at creating products and services that will be incorporated into the production chain. For example, the development of feeds with alternative ingredients to reduce aquaculturists' production costs.
Brazilian Service of Support for Micro and Small Enterprises (SEBRAE)	Offer regular courses in entrepreneurship and business plan development, providing aquaculturists with knowledge that will enable them to manage their business more professionally.
Municipal Secretariat of Fisheries and Rural Development.	Promote the commercialization of the product through periodic public events, such as live fish fairs, with appropriate infrastructure for fish marketing.

Regarding the actions of the public sector aimed at supporting the development of the fish farming chain, which can decisively contribute to the re-entry of the producer, there is the effective participation of the Federal Institute of Education, Science, and Technology of Pará (IFPA), Campus Anaçado Vigia, which has been developing projects in the areas of teaching, research, and extension, as shown in (Table 7). This institution has been working towards the development of the local fish farming productive chain, promoting and implementing a series of activities in the realms of teaching, research, and extension. These include offering FIC courses (Initial and Continued Education) in the area of aquaculture, developing applied research and technologies to support the activity, as well as extension actions aimed at sharing knowledge with the community and its social actors. All this research in the region is the result of a collective effort that aims to promote the re-entry of inactive local fish farmers, as well as professionalizing producers, thus forming critical citizens capable of transforming the socioeconomic reality of these communities.

Table 7. Actions carried out in the scope of teaching, research, and extension for the re-entry of aquaculturists.

Teaching Actions		Research Actions		Extension Actions	
Description	**Institution**	**Description**	**Institution**	**Description**	**Institution**
Offering of Continuing Education Course (FIC) in Fish Processor	IFPA Campus Vigia	Creation of an application for selling fish from the Amazon region	IFPA Campus Vigia	1st Aquaculturists Meeting	IFPA Campus Vigia
Offering of Continuing Education Course (FIC) in Fish Farming	IFPA Campus Vigia	Efficacy of board games for fishing, aquaculture, and environment in teaching biology in public schools	IFPA Campus Vigia	Business Plan: Market Analysis of Fish by the Population of the Microregion of Salgado Paraense in the Post-Pandemic Period	IFPA Campus Vigia
Offering of Technical Course in Fisheries Resources	IFPA Campus Vigia	Pacaxi oil in Tambaqui diet	IFPA Campus Vigia	Aqua Entrepreneurship: Diagnostics, Trainings, and Social Technologies	IFPA Campus Vigia
Offering of Technical Course in Fishing	IFPA Campus Vigia	"Effects of the pandemic on fish marketing in Vigia de Nazaré, Pará, Brazil"	IFPA Campus Vigia	Digital Marketing in Fish Commerce in the Salgado Microregion, Pará, Brazil: A Strategy to Counteract the Negative Impacts of the COVID-19 Pandemic	IFPA Campus Vigia
Offering of Technical Course in Aquaculture	IFPA Campus Vigia	Business Opportunities in Aquaculture: Perspectives from Fishermen in the Salgado Microregion, Pará, Brazil	IFPA Campus Vigia	Fishing, Aquaculture, and Environment in Rural Education During the Pandemic (COVID-19)	IFPA Campus Vigia

5. Conclusions

The aquaculture practiced by the producers who abandoned the activity in Vigia was carried out by fish farmers with an average age of 59 and a low level of education. The vast majority of producers reported having at least 5 years' experience and had given up fish farming in the last 3 years. In terms of farming structures, fish farms were characterized as small and relied on family labor. However, they often lacked good management practices, compromising quality and causing negative impacts throughout the production chain.

With regard to the aspect of production, the presence of an extensive system was diagnosed, in which the farmers practiced a monoculture for the purpose of fattening three species, especially the native species, Tambaqui (Colossoma macropomum). The lack of technical knowledge, limited access to technical assistance services, high input costs, and the need for financing to expand production, together with the absence of government support, played a significant role in demotivating fish farmers, resulting in them abandoning the activity. Inactive local producers are eager to return to the activity at an opportune moment, but for this to be possible, integrated actions by government agencies will be of fundamental importance for the development of the aquaculture sector, among which we can highlight the regular provision of technical assistance, the development of technological innovations, and vocational courses. The adoption of these measures will help to train fish farmers, thus

leading to educated citizens capable of transforming the socio-economic reality of these communities and making a decisive contribution to food security, generating occupation, employment, and income for the local population.

Author Contributions: Conceptualization, F.N.L.d.S. and A.P.H.; methodology, F.N.L.d.S. and A.P.H.; software, A.P.H.; validation, F.N.L.d.S., L.V.B., R.C.M., A.R.G.M. and O.L.L.S.; formal analysis, F.N.L.d.S.; investigation, F.N.L.d.S., A.P.H. and M.D.P.; resources, F.N.L.d.S. and A.P.H.; data curation, A.P.H.; writing—original draft preparation, F.N.L.d.S. and A.P.H.; writing—review and editing, F.N.L.d.S., A.P.H. and L.A.d.A.O.; visualization, all authors; supervision, F.N.L.d.S.; project administration, F.N.L.d.S.; funding acquisition, F.N.L.d.S. and A.P.H. All authors have read and agreed to the published version of the manuscript.

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Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: Data from the study is available from the corresponding authors upon reasonable request.

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Conflicts of Interest: The authors declare that there are no conflicts of interest.

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