

Characterization of Fish Farming in San Pedro, Côte d'Ivoire

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Abstract

Original Research Article

A survey was conducted from April to July 2024 in the departments of San Pedro and Tabou, among thirty (30) fish farmers. This survey was conducted in order to analyze the characteristics of the farms and the socioeconomic profile of the actors, as well as to assess their production potential and the difficulties encountered. The results show an uneven distribution of fish farming activities: 90% of farms are located in San Pedro compared to 10% in Tabou. The majority of fish farmers are farmers (66.7%), mostly men (93.3), aged 40 to 60 years (80%). Most farms are less than 10 years old. Water supply is mainly based on rivers and streams (93.3%), but 46.7% of stakeholders report periods of water shortages. Furthermore, 83.3% of fish farmers have never received specialized training. Nile tilapia (*Oreochromis niloticus*) is farmed by all fish farmers (100%). Fish feed is mainly based on local products (63.3%). The extensive system is the most widespread (66.7%), with a low diversity of farming infrastructure. Just over half of the stakeholders (53.3%) practice controlled fishing and 63.3% regularly distribute feed. However, 50% of farms produce less than 1000kg. The development of fish farming in this region therefore requires the promotion of intensive production techniques among employees and economic operators in order to increase the productivity and sustainability of farms.

Keywords: fish farming, fry, production system, San Pedro, Côte d'Ivoire.

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INTRODUCTION

Côte d'Ivoire, thanks to its vast hydrographic network, has significant fishing potential. This sector, which includes aquaculture in particular, plays a vital role in the national economy. According to PONADEPA [1], it generates nearly 14,000 jobs, including more than 6,000 direct jobs and 8,000 indirect jobs [2]. Aquaculture, based primarily on fish farming, contributes significantly to the food security of the population. Fish is indeed the main source of animal protein for Ivorian consumers with an average estimate of 24 kg/year/inhabitant for a population of more than 29 million inhabitants [3, 4]. This means that almost 600,000 tonnes of fish are needed to meet the population's needs. However, national fish production only covers around 20% of this demand, forcing the State to import nearly 500,000 tonnes of fish per year. However, Côte d'Ivoire has significant natural assets (four major rivers, numerous streams, around 150,000 ha of lagoons, 350,000 ha of lakes as well as low-lying banks) that are favorable to the development of aquaculture. In addition, the Ivorian government has

implemented a National Policy for the Development of Livestock, Fisheries and Aquaculture [1] with the aim of reviving the animal and fisheries resources sector. Within this framework, a specific strategy has been developed for the development of aquaculture: the National Aquaculture Development Strategy (SNDA). This has given rise to several major programs and projects, including the Strategic Program for the Transformation of Aquaculture in Côte d'Ivoire (PSTACI), the Commercial Fish Farming Revival Project (PREPICO 2) and the Project for the Improvement of the Production of Fish Inputs and Products (PRO-Aquacole). Despite these efforts, national aquaculture production remained limited to 8,467 tonnes in 2023, or barely 4% of total fish production [5]. Côte d'Ivoire remains far from its target of producing 250,000 to 300,000 tonnes of fish by 2030. In light of the above, what constraints explain this poor performance and how can fish farming potential be developed, particularly in the Bas Sassandra region, to contribute to achieving national objectives? Much research has been carried out in the field of fish farming,

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particularly on the biology of species and feeding methods, such as the PASRES project No. 97 (2012) entitled "the identification of performance indicators for feeding farmed fish in fish farming areas of Côte d'Ivoire" [6]. However, the San Pedro region is not among the fifteen (15) fish farming regions with high potential, even though it is full of important natural assets for the development of aquaculture. It is in this context that this study aims to characterize fish farming in the Bas Sassandra region in order to assess its fish farming potential, identify the constraints that hinder its growth and highlight the prospects likely to contribute to reducing dependence on imports.

MATERIALS AND METHODS

Study areas

The San Pedro region, comprising the departments of San Pedro and Tabou, is a coastal port city located in southwest Côte d'Ivoire. It is bordered by Liberia to the west, the Gulf of Guinea to the south, and the Nawa region to the east. The region is crossed by at least six coastal rivers, the largest of which is the San Pedro River, covering 3,310 km² [7]. The regional economy is dominated by the agricultural sector. An integral component of the Bas-Sassandra district, the population is estimated at 1,060,724 inhabitants [4].

Study survey

The objective of this study is to assess the fish productivity of stakeholders in the San Pedro region. Therefore, a survey was carried out in this region among fish farming stakeholders of the Simplified Cooperative Society of Fish Farmers of Bas Sassandra (SCSPBS) from June to August 2024. It consisted of visiting fish farming sites to collect qualitative and quantitative information on breeding practices, species raised, feeding strategies, production systems, infrastructure used, production data and challenges encountered by fish farmers. Thus, 30 fish farmers were selected in six (6) localities based on information received from the Regional Directorate of the Ministry of Animal and Fisheries Resources of San Pedro and the Simplified Cooperative Society of Fish Farmers of Bas Sassandra. These are San Pedro, Gabiadji, Doba, Grand Béréby, Tabou and Grabo. The survey was conducted using a questionnaire developed with Sphinx 4.5 software. The data collected related to the socioeconomic profiles of the stakeholders, production systems, livestock species, feed used, farm characteristics, and yields. The production systems were classified according to the descriptions of La Croix [8, 9].

Statistical analysis

The information collected on the forms was processed using Sphinx 4.5 software and presented as percentages.

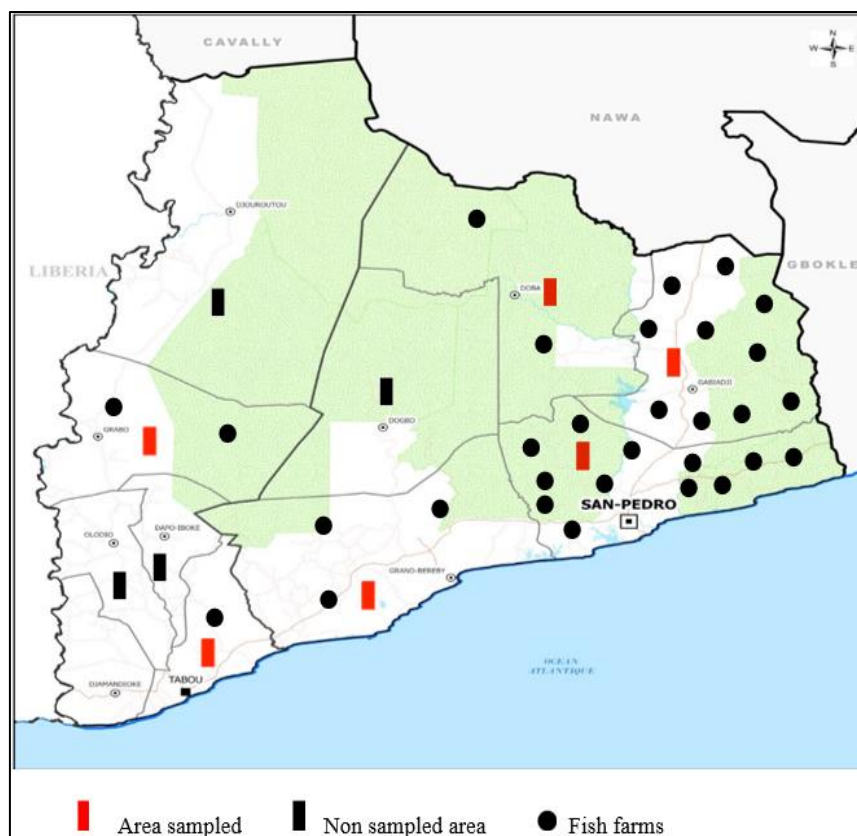


Figure 1: Location of study sites

RESULTS

Farm mapping

The survey results show that fish farming is more prevalent in the San Pedro department (90%) than in Tabou (10%). In the San Pedro department, a total of twelve (12) fish farms were registered in the San Pedro sub-prefecture, eight (10) farms in the Gabiadjì sub-prefecture, three (3) farms in the Grand-Béréby sub-prefecture, and two (2) in the Doba sub-prefecture. In the Tabou department, only three farms were registered, including one (1) in the Tabou sub-prefecture and two (2) in the Grabo sub-prefecture. (Figure 1).

Characterization of the fish farms surveyed

The characteristics of the fish farms surveyed are shown in Table I. The majority of the farms visited are located in the sub-prefectures of San Pedro (40%) and Gabiadjì (33.3%). Forty percent of the farms have been in operation for less than 10 years. Of the farms visited, 36.7% are located in urban and peri-urban areas,

and 63.3% are in rural areas. Almost all of these farms are managed by the developers themselves (96.7%). Of the thirty (30) fish farmers surveyed, 46.7% face a water shortage, compared to 53.3%. Most of the farms are managed by the promoters themselves (96.7%), only 3.3% are run by managers. The results reveal that 16.7% of the fish farmers surveyed have received training and 83.3% have received no training. Half of the fish farms have only one worker compared to 3.3% of the farms that employ more than 4 workers. Regarding water sources, the data reveal that the main sources are rivers and streams representing 93.3% of the total. On the other hand, dams constitute only 3.3% of the water source.

Socioeconomic aspects of the developers

The socioeconomic profile of the developers is shown in Table II. Analysis of the results reveals notable variations in the developers' socioeconomic characteristics. The majority of fish farmers in San Pedro are farmers

Table I: Characterization of the fish farms surveyed

Settings	Effective	Percentage %	Cumulative percentage %
Sub-Prefecture			
San Pedro	12	40	40
Gabiadjì	10	33,3	73,3
Doba	2	6,7	80
Grand Béréby	3	10	90
Tabou	1	3,3	93,3
Grabo	2	6,7	100
Number of years of existence			
Under 10 years old	12	40	40
10-20 years	11	36,66	76
20-30 years	5	16,66	92,66
Over 30 years	2	6,66	100
Do you benefit from supervision ?			
Yes	5	16,7	16,7
No	25	83,3	100
Farm Locations			
Urban and Peri-Urban	11	36,7	36,70
Rural	19	63,3	100
Number of workers			
1	15	50,00	50,00
2-4	14	46,7	96,70
More than 4	1	3,3	100
Is the developer the manager of his farm ?			
Yes	29	96,7	96,7
No	1	3,3	100
Water source			
River or stream	28	93,3	93,3
Dam	1	3,3	96,6
Other	1	3,3	100
Water shortage			
Yes	14	46,7	46,7
No	16	53,3	100

Table II: Socio-economic profile of promoters

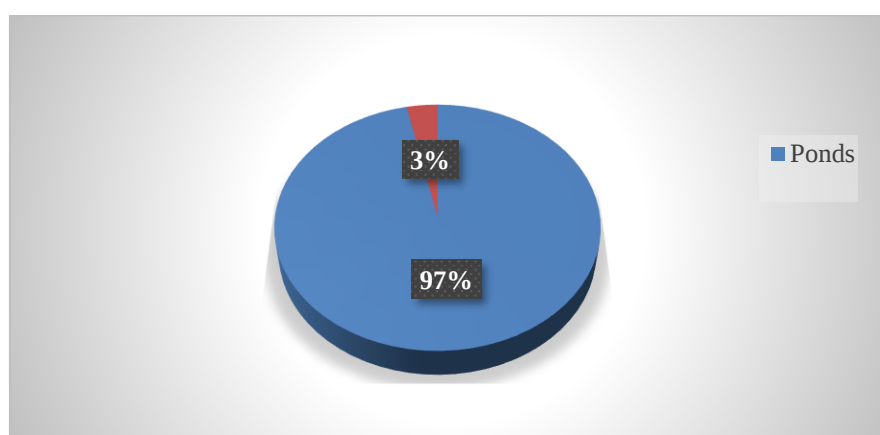
Settings	Effective	Percentage %	Cumulative percentage %
Origin of the promoter			
Indigenous	5	17	17
Non-Indigenous	22	73	90
Non-Indigenous	3	10	100
Promoter's gender			
Male	28	93,30	93,30
Female	2	6,70	100
Age of the promoter			
20-30 years	1	3,3	3,3
30-40 years	5	16,70	20,0
40-50 years	12	40,0	60,0
50-60 years	12	40,0	100
Other posiiion			
Economic operator	8	26,7	26,7
Employee	1	3,3	30
Farmer	20	66,7	96,7
Breeder	1	3,3	100
Education Level			
None	5	16,70	16,70
Koranic School	6	20,00	36,70
Primary	11	36,70	73,40
Secondary	7	23,30	96,7
Higher Education	1	3,30	100
Do you belong to an association ?			
Yes	30	100	100
No	0	0	

(66.7%), followed by economic operators (26.7%). Only 3.3% of fish farmers are employed. Fish farming is dominated by men (93.3%) and by fish farmers aged 40 to 60. Most developers are non-natives (73.3%). The largest number of fish farmers have a primary education (36.70%), followed by secondary education (23.30%). Only 3.3% of fish farmers have a higher education level.

Fish farming techniques

Farm Structure

An analysis of the fish farming structures used by fish farmers reveals a strong predominance of ponds, which represent 96.7% of the facilities (Figure 2). In contrast, tanks represent only 3.3% of the structures surveyed.

**Figure 2: Breeding structures used on farms**

Farmed Species

The results of the survey on fish species farming are presented in Figure 3. Tilapia (*Oreochromis niloticus*) is farmed by all fish farms (100%). However, the catfish (*Heterobranchus longifilis*) is found on

30.00% of farms. *Heterotis* (*Heterotis niloticus*) is farmed on 6.7% of farms. Only 3.3% of fish farmers farm the catfish (*Chrysichthys nigrodigitatus*). Tilapia is farmed in mixed farming with other species at 33.3%. Monoculture is found on 66.7% of farms.

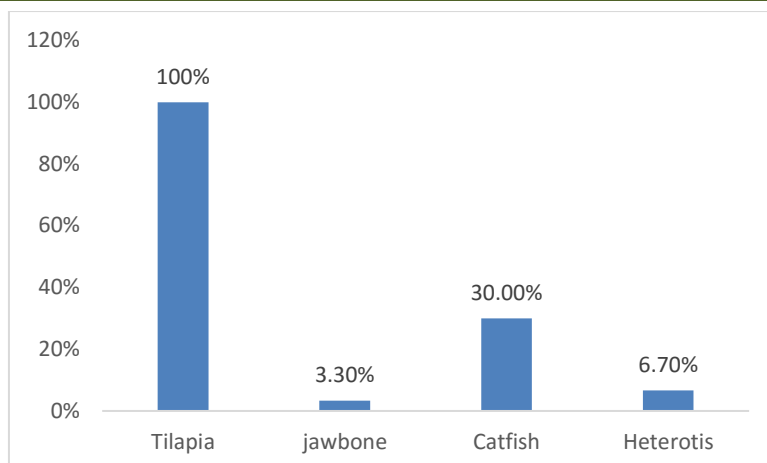


Figure 3: Farming frequencies of different fish species on farms

Production System

The farming systems used on fish farms are represented in Figure 4. These are the intensive, semi-intensive and extensive systems. The results show a

predominance of the extensive production system with 66.7% of farms. The semi-intensive system represents 20% of the farms surveyed. The intensive system is the least represented.

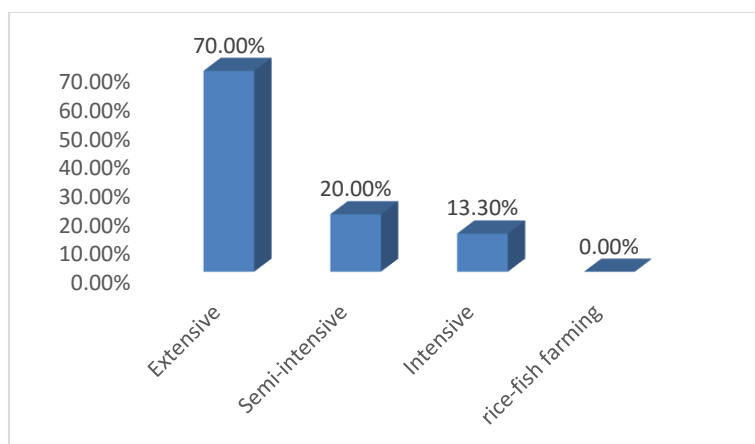


Figure 4: Frequency of use of different production systems

Fish Feed

Analysis of data on the various feeds used on farms shows a dominance of locally produced feeds (63.30%). Commercial feeds are used at 23.3%. By-

products are used by 20.0% of stakeholders to feed the fish. Only 3.3% of the stakeholders use commercial feeds + by-products.

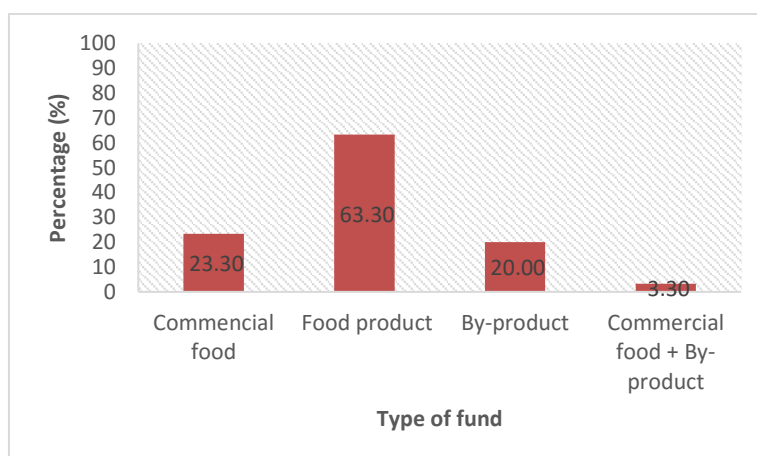


Figure 5: Frequency of use of different types of food

Fish Farming practices

Table III : Fish farming practices encountered on farms

	Effective	Percentage (%)	Pourcentage cumulée (%)
Do you have a logbook?			
Yes	7	23,33	23,33
No	23	76,66	100
Fish farmer carries out control fishing			
Yes	16	53,3	53,3
No	14	46,7	100
Fish farmer sorts fish			
Yes	16	53,3	53,3
No	14	46,7	46,7
Production cycle practiced			
Single cycle	12	40,0	40,0
Normal cycle	1	3,3	43,3
Pre-enlargement and enlargement	17	56,7	100
Food Availability			
Year-Round	25	83,3	83,3
Occasional	4	13,3	96,6
Rare	1	3,3	100
Feeding Frequency			
Regular	19	63,3	63,3
Occasional	11	36,7	100
Food presentation method			
Flour	24	80	
Granulated-floating	9	30	

Surveys conducted among fish farmers revealed that 23.33% of them have a monitoring logbook, while 76.66% do not keep any formal records. In this study, 53.3% of the stakeholders conduct control fishing and sort their fish stock during farming, while 46.7% do not. The production cycle of commercial fish is limited to the pre-growing and grow-out stages for the majority of farms surveyed (56.7%). Feed is regularly distributed by 63.3% of the fish farmers surveyed, while 36.7% do not comply with the defined frequency. Analysis of data

relating to feed presentation methods reveals that 80% of fish farmers use feed in meal form, compared to 30% (Table III).

Fish farming production

The results reveal that 50% of fish farmers produce less than 1,000 kg per year. Furthermore, 46.7% of producers record a production between 1,000 and 10,000 kg. Only 3.3% produce more than 10,000 kg.

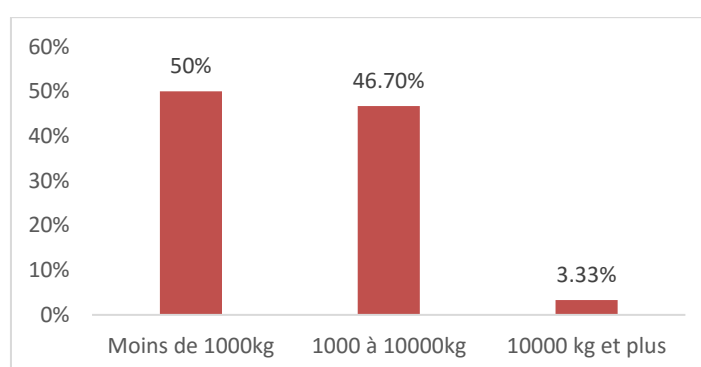


Figure 6: Fish production of farms

DISCUSSION

Fish farming is unevenly distributed in the departments of San Pedro and Tabou. The predominance of this activity in the sub-prefectures of San Pedro and Gabiadji is likely due to consumer markets, proximity to the port area, and fish farming input supply centers. Furthermore, the low proportion of fish farming practices

in the sub-prefectures of Tabou and Grabo could be explained by logistical difficulties, geographic isolation, or a lack of awareness among local populations about the opportunities associated with fish farming.

Data analysis reveals that 63.7% of fish farms are located in rural areas, compared to 36.7% in urban

and peri-urban areas. This finding could be reflected in the proximity of water sources (rivers and streams), land availability, and low investment costs in rural areas. This situation is consistent with the research work of other authors [10].

The fact that 40% of farms are less than 10 years old is due to a context of innovation, professional retraining, or institutional support. This demonstrates a certain dynamism in the fish farming sector. The results reveal that 50% of farms employ at least one worker. Indeed, this observation shows that the majority of fish farms are small, family-run or individual operations, often managed by the owner and their family members. These farms rarely have permanent, qualified staff, which limits the sector's capacity for expansion and professionalization [11].

The results indicate that nearly half of the fish farming stakeholders visited highlight an increasing vulnerability due to water variations in the aquaculture sector. Indeed, climate change and anthropogenic pressure on water resources are the main factors of water scarcity [3]. Water availability is a potential indicator for the sustainability of fish production systems. Moreover, a water shortage can lead to a significant decline in water quality, an increase in stress in fish, and therefore reduce production [12]. The use of rivers or streams by the majority of stakeholders indicates a dependence on natural surface resources for water supply. This can be both an advantage in terms of availability, accessibility and relatively low operating cost and a risk in the event of drought or pollution [13-15]. The dam represents only 3.3%, which reflects limited hydraulic infrastructure for water resource management [16]. Similarly, the low use of groundwater reflects a low diversification of water supply sources [17].

The majority of fish farming stakeholders are non-natives (73%) compared to 17% of indigenous people and 10% non-natives. This distribution can be explained by internal economic mobility and better access to fishery resources [18] (Kawarazuka *et al.*, 2010). Fish farming activity is almost exclusively male (93.30%), only 6.7% of stakeholders are promoters. This finding reflects the persistent sociocultural constraints to which women are exposed [19, 20, 3]. Farmers are the main actors in fish farming (66.7%), followed by economic operators (26.7%). Employees (3.3%) and breeders (3.3%) show a low level of salaried employment or specialization in the field [21]. If farmers are in the majority, this reflects the strong diversification of activities, the valorization of by-products and the security of income [22].

The most used breeding structures are ponds. This traditional method remains widely favored by fish farmers, probably due to its simplicity of implementation, its relatively low cost and its good adaptation to local conditions. However, the use of 3.3%

tarpaulin tanks could be explained by the higher initial cost, the need for a constant supply of clean water as well as more demanding technical mastery. This situation is consistent with the observations reported by several authors [10, 23, 24]. Indeed, ponds offer several advantages for fish farmers. They promote natural feeding with plankton, limit dependence on industrial inputs and provide a certain degree of autonomy. On the other hand, tanks represent only 3.3% of the structures surveyed. The low proportion of tanks could be reflected in their high initial cost and the lack of technical training of fish farmers. However, the use of tanks has advantages in terms of water quality control, stocking density, and productivity [25].

The survey results show a predominance of Nile tilapia (*Oreochromis niloticus*) farming. This species is raised by 100% of the fish farmers surveyed. It remains the main species farmed in San Pedro. This trend confirms the observations made by [9] Lazard (2009), similar to those in African, Asian, and South American countries. Tilapia is considered the most important species in inland aquaculture due to its hardiness, rapid growth, and good adaptation to diverse environmental conditions [3, 26]. In Côte d'Ivoire, Cameroon, and Benin, similar studies have shown a high rate of tilapia farming in fish production systems [27, 28]. In contrast, the relatively low proportion of farmed wels catfish (*Heterobranchius longifilis*) (30%) is explained by the complexity of its captive breeding and the high costs associated with feeding it, as it requires a higher protein diet [29, 30]. However, this species is of significant economic interest due to its high market value and the quality of its flesh. The low farming rates observed for Nile catfish (*Heterotis niloticus*) (6.7%) and black catfish (*Chrysichthys nigrodigitatus*) can be explained by the lack of available fry, insufficient mastery of breeding techniques, and limited market demand for these species [31, 32].

The predominance of the extensive production system with 66.7% of farms reflects a low population density and minimal use of inputs and relies essentially on the natural resources of the environment [3]. Although it presents a low level of investment, it remains limited in terms of yield [33, 34, 10]. The semi-intensive system represents 20% of the farms surveyed. It is an intermediate system, practiced in contexts of transition towards productive aquaculture [35]. The low proportion of the observed intensive system can be attributed to the high cost of infrastructure and the complexity of management [36].

The high use of locally produced feed (63%) to feed fish can be explained by a preferential use of locally available resources, therefore may be linked to economic considerations, in particular the reduction of production costs [37]. Commercial feed constitutes 23.3% of the inputs, although significant but insufficient. These feeds are formulated to meet the specific nutritional needs of

species. They are recognized for their efficiency in terms of growth and feed conversion [38]. The use of by-products reflects a desire to valorize residues in order to reduce losses and optimize resources. This practice, although favorable from the point of view of the circular economy, however, it can present limitations in terms of nutritional quality [39, 40].

Among fish farmers, 76.66% do not keep any formal records compared to 23.33%. This observation could be explained by the lack of training or information among fish farmers on the usefulness of this tool. While it constitutes an essential element for the rational management of farms. It allows for the systematic recording of data relating to feeding, fish growth, prophylactic treatments, and mortalities. Control fishing and sorting are essential in intensive or semi-intensive fish farming systems. They allow monitoring fish growth, adjusting stocking density and optimizing feeding based on the average stock weight [41, 42, 43]. The production cycle of commercial fish is often restricted to the pre-growing and grow-out stages. This situation may reflect partial specialization, whereas adopting a complete cycle including reproduction could enable stakeholders to improve their income [3]. Regular feed distribution is a determining factor for growth, health and performance. Studies have shown that feeding frequencies ranging from 3 to 5 times per day, with adjustment of rations according to biomass, significantly improve growth performance [44]. The preference for using meal as a feed method in fish farming can be explained by the local availability of the raw material and its relatively low cost. Indeed, this method presents food losses due to the dispersion of meal in the water, degrading water quality [45]. Floating pellets, although still a minority, have advantages in terms of feed yield and loss reduction [46].

Half of fish farmers produce less than 1000 kg per year. This result shows that fish farming activity is dominated by low-yield, family-type production units, often characterized by limited technical and financial resources [3]. Only 3.3% of actors produce more than 10,000 kg. This highlights the scarcity of large-capacity farms.

CONCLUSION

Fish farming in the San Pedro region is unevenly distributed. It remains dominated by low-intensity production systems. This reflects not only the socio-economic constraints faced by producers but also the need for technical support. These results show only partial adoption of good fish farming practices, with significant room for improvement in feed management. It is necessary to adopt development strategies that include promoting intensive production techniques among employees and economic operators. It is also essential to strengthen the capacity of fish farmers through targeted training and facilitate access to quality inputs such as fingerlings and feed.

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