SUSTAINABILITY ANALYSIS AND DEVELOPMENT STRATEGY FOR CATFISH CULTIVATION IN TULUNGAGUNG, EAST JAVA

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Abstract

Tulungagung Regency, located in East Java Province, is a region with significant fisheries potential, encompassing both marine capture and aquaculture. With 12,220 cultivators actively engaged in aquaculture, Tulungagung stands out as a key area for freshwater fish farming, particularly for species such as catfish, gourami, and tilapia. However, for these cultivators to succeed, it is crucial to assess the sustainability of their operations and develop effective business strategies. This research focuses on identifying the gaps in current cultivation practices and offering solutions to ensure both sustainability and profitability, especially in the catfish farming sector. Using a quantitative approach, the study surveyed 71 catfish cultivators across five prominent sub-districts in Tulungagung Regency. Data were gathered through observations and questionnaires distributed to the respondents in the January – April 2024 range. The sustainability of the catfish farming business was evaluated using a Likert scale, which assessed four key dimensions: technological, ecological, economic, and social. Additionally, a SWOT analysis was conducted to determine the most appropriate strategies for business development. The findings revealed that the combined index for the four sustainability dimensions was 72.78%, indicating that the catfish farming industry in Tulungagung Regency is relatively sustainable. The SWOT analysis positioned the business development strategy in quadrant II, suggesting a diversification approach that leverages the business's internal strengths to mitigate external threats.

Keywords: Catfish Cultivation, Fisheries Business Development, Sustainability Index, SWOT Analysis

INTRODUCTION

Fisheries in Indonesia are an important sector in national development, and they not only contribute to food security but act as a main driver of the economy [1]. According to the Ministry of Maritime Affairs and Fisheries of the Republic of Indonesia, Indonesia's territorial waters, which reach 5.8 million square kilometers, provide great potential for developing the fisheries sector. As stated by Kurniawan [2], the development of the fisheries sector is expected to contribute to regional income, employment, and overall national development.

In the context of regional development, Tulungagung Regency in East Java is known to have great potential in fisheries, both capture and aquaculture. Specifically for aquaculture, Tulungagung Regency is divided into two sub-sectors, namely brackish water cultivation (ponds) and freshwater cultivation. Freshwater cultivation is divided into two commodities: ornamental fish and consumption fish [3]. Among the food fish cultivators in Tulungagung, whose number reaches 12,220 people and is spread across 12 sub-districts, one of the leading commodities is the cultivation of catfish (*Pangasius sp*) [4].

Catfish has become one of the leading export commodities, and its cultivation in Indonesia continues to grow[5]. The government has supported this development by campaigning to develop catfish cultivation villages in potential areas and providing assistance with facilities and infrastructure for catfish cultivation[5], [6]. This effort is also supported by investment from several investors in the catfish filleting industry around Tulungagung Regency [7]. However, even though Tulungagung Regency is one of the centers for catfish cultivation, overproduction

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has become a significant problem for farmers in the past years [8]. Partnerships usually obtained from fish suppliers or catfish fillet companies are decreasing, especially due to marketing constraints fillet companies face after the COVID-19 pandemic [4]. As a result, farmers have to bear production costs independently, especially the cost of catfish feed which continues to increase without being offset by the increase in market prices for catfish [9].

Wahid et. al. [5] emphasized the importance of developing alternative strategies to ensure the sustainability of catfish farming businesses, considering that a profitable industry in this sector can significantly impact other economic sectors, which ultimately contributes to increasing regional economic stability. In this context, Yulisti [10] explained that strategy is a sustainable response to the dynamics of the business environment, which includes an analysis of the internal environment (strengths and weaknesses) and the external environment (opportunities and threats).

Tulungagung Regency, which has long been known as one of the catfish production centers in East Java, has several advantages supporting this fishing industry's development. Among these are excellent water quality and easy access to high-quality catfish seeds. These conditions have made Tulungagung an ideal location for catfish cultivation, with production that has great potential to meet domestic and international market demand. However, as time goes by, catfish farmers in this region are starting to face increasingly complex and significant challenges, threatening their businesses' sustainability [11].

One of the biggest challenges farmers face is increasing production costs, especially the cost of fish feed which continues to increase. This increase in feed prices is not matched by an increase in the selling price of catfish on the market, so that profit margins for farmers are increasingly eroded. Additionally, partnerships established with suppliers or catfish fillet companies, which usually help ease the production burden by providing facilities and marketing support, are now increasingly difficult to obtain. This condition has been exacerbated by the decline in the price of catfish in the past year, making it difficult for cultivators to find business partners who can accommodate their harvest. As a result, the harvest process is often delayed, which causes production costs to continue to increase and profit margins to become thinner.

In facing these challenges, it is very important to formulate a comprehensive and sustainable strategy to ensure the sustainability of the catfish cultivation business in Tulungagung Regency. This strategy must include an in-depth analysis of all factors that influence this industry, both in terms of cultivation technology, economic aspects, ecological impacts, and related social dimensions. With a holistic approach, it is hoped that the strategy formulated will not only be able to overcome existing challenges but can also increase the competitiveness and sustainability of the catfish cultivation industry in Tulungagung Regency, as well as make a greater contribution to the regional economy and the welfare of the farmers.

Based on the various challenges faced by catfish farmers in Tulungagung Regency, this research was conducted with the aim of (1) Analyzing the sustainability status of catfish cultivation businesses by considering various dimensions, such as the technology used, ecological impacts, economic conditions and social aspects those involved in the cultivation process; and (2) Formulate strategies that can be implemented for the development of catfish cultivation businesses, with the main aim of increasing production efficiency, expanding markets, and ensuring business sustainability for cultivators in Tulungagung Regency.

METHOD

This research used a quantitative approach to systematically assess the sustainability and development strategies of the catfish cultivation business in Tulungagung Regency by utilizing SWOT analysis. SWOT analysis can be useful for identifying the internal and external factors related to catfish cultivation [12]. The quantitative method was chosen because it allows for the collection and analysis of numerical data, providing a clear and objective evaluation of the various factors influencing the sustainability of the catfish farming sector [13].

Research Location and Time

This research was conducted in Tulungagung Regency, East Java Province. To be precise, this was carried out in five sub-districts as research samples, namely Boyolangu, Sumbergempol, Ngunut, Rejotangan, and Kedungwaru sub-districts because these five sub-districts are centers for catfish cultivation in Tulungagung Regency [8].

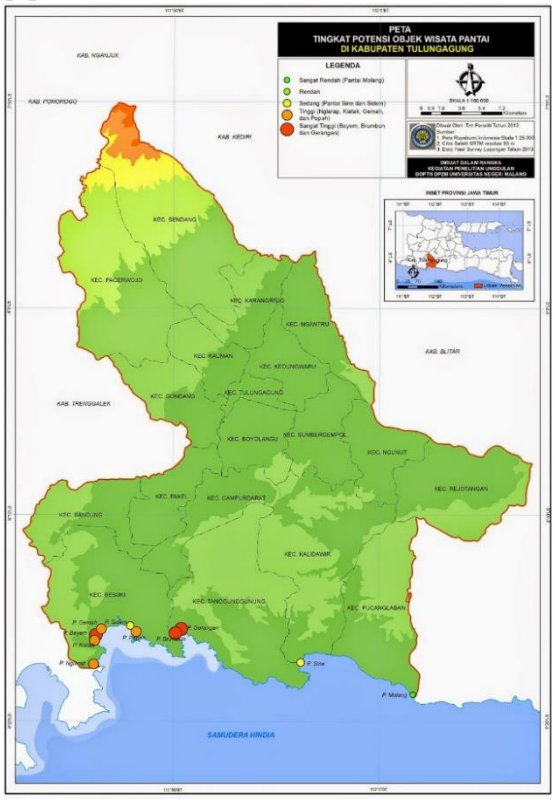

Figure 1. Research Location Map

The research began by observing the problems in catfish cultivation in Tulungaung Regency. This was followed by preparing proposals in January – February, then going to the field in March – April, and producing research reports from May – July 2024.

Population and Sample

The population of this study consisted of all catfish cultivators in Tulungagung Regency. The research samples were taken from five sub-districts with the greatest catfish cultivation potential, namely Boyolangu, Sumbergempol, Ngunut, Kedungwaru and Rejotangan sub-districts. The author used a purposive sampling method, namely selecting a group of farmers who consistently cultivated catfish without switching to other fish commodities.

In Ngunut, Kedungwaru and Rejotangan subdistricts, 1 group of cultivators were taken each, while in Boyolangu and Sumbergempol subdistricts, 2 groups of cultivators were taken because there were more groups. The number of group members in Ngunut, Kedungwaru and Rejotangan subdistricts is 10 people each. Meanwhile, in Boyolangu District there are 21 people, and in Sumbergempol there are 20 people. Overall, the total samples taken were 71 farmers who were actively cultivating catfish in Tulungagung Regency [13].

Data Type

Primary data in this research was obtained directly from the research location in Tulungagung Regency through observation and documentation. This data was collected from a sample of individuals with in-depth knowledge of catfish farming. Primary data includes sustainability dimension values (technological, ecological, economic and social), as well as the results of SWOT analysis (EFAS and IFAS) to determine sustainability strategies. Apart from that, observations also produce data about the facilities and infrastructure for catfish cultivation.

Secondary data was obtained from literature studies and population data that support this research. Population data was taken from the Tulungagung Central Statistics Agency (BPS), while literature was used to build a theoretical basis and strengthen the analysis. This secondary data functions to complement and strengthen research findings. In more detail, the types and data sources in this research can be seen in the following table.

Table 1. Types of Data Used in the Research

No	Data Type	
	Primary	**Secondary**
1	Indicators of the sustainability of catfish cultivation	Population statistical data
2	Value of internal and external factors of catfish cultivation	Literature Study

Source: Author (2024)

Data Collection

Data collection in this research was conducted using a structured questionnaire

[13]. The questionnaire was distributed to selected respondents, specifically a group of catfish cultivators who have consistently focused on catfish farming without switching to other commodities.

The first section of the questionnaire aimed to assess the sustainability dimensions of catfish farming. This was measured using a Likert scale ranging from 1 to 5. The dimensions evaluated included technological, ecological, economic, and social aspects, each with specific attributes [14]:

- Technological Dimension (5 Attributes):
    1. Ease of access to technology for learning farming techniques has led to a yearly increase in the number of Patin fish cultivators.
    2. Production in modern farming systems is higher, but the risks are also greater compared to semi-intensive or traditional systems.
    3. Availability of seeds and feed at expected prices is easily accessible.
    4. There is a match between the stocking density and harvest yield in the cultivated fish.
    5. The harvest yield of Patin fish aligns with the amount of feed used.
- **E**cological Dimension (6 Attributes):
    1. The cultivation land has been designed according to CBIB (Cara Budidaya Ikan yang Baik) standards and has been used for a long period (>5 years).
    2. Water quality (pH, temperature, Dissolved Oxygen, and clarity) at your site is suitable for Patin fish farming.
    3. You have mastery over disease prevention and control in Patin fish.
    4. Feed and water treatment directly impact the survival rate of the fish.
    5. Current climate and weather conditions are favorable for Patin fish farming.
    6. The water source (well) can sustain >5 years with consistent flow and quality.
- Economic Dimension (6 Attributes):
    1. The availability of fish and market demand are balanced, leading to stable fish prices.
    2. The production costs (feed, seeds, electricity, etc.) for Patin fish farming are relatively low.
    3. Patin fish prices are generally stable.
    4. The difference between harvest income and expenses is sufficiently profitable.
    5. Market access during harvest time is relatively easy.
    6. Patin fish farming is a viable business.
- Social Dimension (7 Attributes):
    1. The experience of cultivators significantly impacts the continuity of Patin fish farming.
    2. Higher education levels correlate with better management of Patin fish farming.
    3. The age of cultivators significantly affects the farming process.
    4. Independence and self-reliance are crucial for running the business.
    5. Family involvement in the farming business is essential.
    6. All fish are sold fresh and alive.
    7. The majority of people in Tulungagung prefer consuming Patin fish.

The second section of the questionnaire was designed to gather data on the internal and external factors influencing catfish cultivation. Internal factors include strengths and weaknesses in farming practices, such as technical skills, resource availability, and supporting infrastructure. External factors involve opportunities and threats faced by cultivators, such as market conditions, policy changes, and environmental factors.

The evaluation in this section utilized a scoring system ranging from 1 to 4 (scores: 4 = very important, 3 = important, 2 = somewhat important, 1 = less important). These scores were then used to calculate the weights in the IFAS (Internal Factors Analysis Summary) and EFAS (External Factors Analysis Summary) matrices.

Table 2. Research Questionnaire for SWOT

No	Influence factors	Score			
		1	2	3	4
Influence variable I					
1	Variable a				
2	Variable b				
3	Variable c				
Influence Variable II					
1	Variable a				
2	Variable b				
3	Variable c				

Source: Rangkuti (2014)

Data Analysis

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1. Sustainability Status of Catfish Cultivation Fisheries

The sustainability status in this research was analyzed using sustainability indicator scoring using the Likert scale. Scoring indicators for the sustainability of catfish farming businesses is carried out by calculating sustainability aspects which are formulated as follows

$$Sustainability\ Index = \left(\frac{Obtained\ score}{Maximum\ score}\right) x\ 100\%$$

The sustainability value index obtained is then adjusted according to the range of sustainability indices referenced by [15]. The sustainability status is categorized into four types: a) Not Sustainable: 0-25%; b) Less Sustainable: 26-50%; c) Quite Sustainable: 51-75%; d) Sustainable: 76-100%.

2. Analysis of Catfish Cultivation Fisheries Development Strategy

In this research, determining the sustainability strategy for catfish cultivation was carried out using the SWOT analysis method. SWOT analysis is the systematic identification of various factors to formulate a strategy. SWOT analysis is carried out by maximizing strengths and opportunities, as well as minimizing weaknesses and threats [12].

1) The way to determine internal strategy factors is as follows:
   a) Researchers determine what factors are the strengths and weaknesses of the development strategy.
   b) Give a value or weight to each factor that has been determined. The total weight must be 1.00
   c) Calculate the rating (column 4) for each factor according to the influence of these factors on the strategy for developing superior commodities in the aquaculture subsector in Tulungagung Regency
   d) Calculate the scoring (column 5) by multiplying the weight (column 3) by the branch (column 4). The results obtained from this multiplication are in the form of weighting scores for each factor, which can be seen in the following table:
2) The method of determining external strategic factors is as follows:
   a) Search for and then determine factors that can be used as opportunity and threat factors for development strategies.
   b) Give weight to each of these factors according to their level of importance. The total weight should be 1.00.
   c) In the 4th column (Rank) are the calculation results for each factor based on the influence/response of these factors on the strategy for developing fisheries cultivation which is a superior commodity in the district. Tulungagung.
   d) The 5th column (score) is the calculation result of multiplying the 3rd column (Weight) with the 4th column (Rating)
3) Matrix Arrangement

In the next stage of SWOT analysis, after the internal strategy factor matrix and external strategy factors have been completed and the results are known, the next step is to connect the internal and external elements to a matrix to obtain several possible alternative strategies. This matrix shows that there are 4 possible strategies which can be seen in the following table:

Table 3. SWOT Matrix Preparation

EFAS IFAS	**Strengths (S)**	**Weaknesses (W)**
Opportunities (O)	SO, Strategy A strategy that uses	WO, Strategy Strategy to minimize

	strengths to take advantage of opportunities	weaknesses to take advantage of opportunities
Threats (T)	ST, Strategy The strategy of using force to resolve threats	TW, Strategy Strategy to minimize weaknesses to avoid threats

Source: Rangkuti (2014)

4) Grand Strategy Matrix

The grand strategy matrix can later determine two central variables in the determination process to develop fish cultivation in the district.

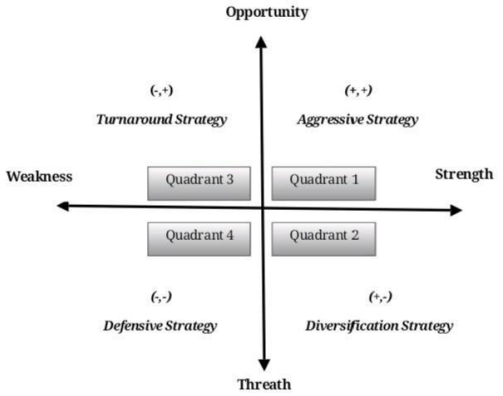

Figure 2. Matrix Grand Strategy
Source: Rangkuti (2014)

- Quadrant 1 Indicates a profitable situation. This business has opportunities and strengths, so business development can take advantage of existing opportunities. The strategy used in this condition is to support aggressive growth policies.
- Quadrant 2: There are various threats, but the business still has strength from an internal perspective. The strategy that needs to be implemented is to use strengths to take advantage of opportunities in the long-term using a diversification strategy (product/market).
- Quadrant 3: A business has a fairly large market opportunity, but on the other hand, the business experiences obstacles. Business conditions in quadrant 3 are almost the same as those in Question Mark (where a business condition is in a developing market but has a low market share) in the BCG (Boston Consulting Group) matrix. This business strategy focuses on minimizing the internal problems that exist in the business to regain better market opportunities.
- Quadrant 4: This is a very unfavorable situation; the company is facing various internal threats and weaknesses.

RESULT AND DISCUSSION

Tulungagung Regency is recognized as a significant hub for freshwater fish cultivation in East Java. The freshwater fisheries sector in Tulungagung can be broadly categorized into two main types: the cultivation of freshwater ornamental fish and freshwater consumption fish [8], [16]. Among the consumption fish, the primary commodities include Catfish, Gourami, and Catfish. While Banyuwangi and Lamongan are often regarded as the leading catfish producers in East Java, the data tells a different story. In 2021, Banyuwangi's catfish production reached only 25 tons, and Lamongan's output was approximately 21 tons. In contrast, Tulungagung's catfish production is significantly higher, positioning it as a major producer in the region. Within Tulungagung Regency, five key sub-districts are identified as the largest producers of catfish: Boyolangu District, Sumbergempol District, Ngunut District, Kedungwaru District, and Rejotangan District. The trends in catfish production from 2018 to 2022 in these sub-districts are illustrated in Figure 3.

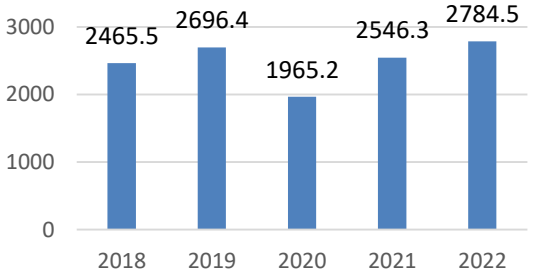

Figure 3. Tulungagung Regency Catfish Production 2018-2022

The graph above shows catfish production in Tulungagung Regency from 2018 to 2022. Based on the data displayed, it can be seen that catfish production experienced fluctuations during this period. In 2018, catfish production was around 2,500 tons, and increased in 2019,

reaching 2,700 tons. However, in 2020, there was a significant decline in production, dropping to around 1,800 tonnes. This decline is likely caused by various factors, including the COVID-19 pandemic which has affected many sectors, including fisheries. Entering 2021, catfish production increased again, reaching around 2,400 tons, approaching production levels before the decline in 2020 [4]. This increasing trend continued until 2022, where production rose again and reached around 2,700 tons, showing significant recovery and increase in production capacity.

Sustainability Status of Catfish Cultivation Fisheries

a. Technological Dimension

The technology dimension assessment includes five attributes: ease of access to technology, production using modern cultivation systems, availability of seeds and feed, suitability of stocking quantities with harvest yields, and feed efficiency (Table 4).

The ease of access to technology for learning farming techniques has a moderate sustainability index of 54.93%, indicating that while technology is accessible to some extent, there is still a significant opportunity to enhance its availability and usage. Improving access to technology could lead to a more substantial increase in the number of catfish cultivators each year [9].

In contrast, the attribute related to production in modern farming systems has a high sustainability index of 83.10%. This suggests that modern systems are widely adopted and effective in increasing production. However, the higher risks associated with these systems compared to semi-intensive and traditional methods must be carefully managed to maintain this level of sustainability [17].

The ease of obtaining seeds and feed at expected prices shows a sustainability index of 64.51%. While this is a relatively positive result, it suggests that there are still challenges related to pricing or the availability of these critical inputs. Addressing these issues could further enhance the sustainability of catfish cultivation.

The alignment between stocking density and harvest yield is strong, with a sustainability index of 80.00%. This indicates that most cultivators have optimized their practices to ensure that the number of fish stocked correlates well with the harvest yield, reflecting efficient management. Similarly, the sustainability index for the alignment of harvest yield with the amount of feed used is 81.13%, suggesting that feed usage is well-optimized, with minimal waste, contributing to the overall efficiency and sustainability of the farming practices.

b. Ecological Dimension

The ecological dimension includes six attributes related to land design, water quality, disease control, feed and water treatment influence, climate and weather, and the resilience of water sources (Table 5). The attribute related to cultivation land design and longevity has a sustainability index of 73.52%, indicating that while most respondents follow CBIB standards and have cultivated their land for over five years, there is still room for improvement in these practices. Water quality, which includes factors such as pH, temperature, dissolved oxygen, and brightness, has a sustainability index of 79.44%. This suggests that water conditions are generally good and suitable for cultivation, though there is still a need to maintain and possibly improve these conditions further [18].

Prevention and management of diseases in catfish show a relatively high sustainability index of 82.54%, reflecting that most cultivators have adequate knowledge and practices in place to manage diseases effectively. The attribute concerning the impact of feed and water treatment on the fish's survival rate has the highest sustainability index at 99.44%, indicating that these practices are nearly optimal, with very few issues reported.

The suitability of the current climate and weather for catfish cultivation, however, has a lower sustainability index of 70.42%, suggesting that while conditions are generally favorable, there may be challenges related to seasonal changes or climate variability that affect sustainability. Lastly, the attribute assessing the longevity of water sources, specifically wells, in terms of maintaining consistent water flow and quality, has a sustainability index of 79.44%. This reflects that most water sources are reliable, but there

may be concerns about their long-term sustainability.

c. Economic Dimension

The economic dimension includes six attributes: balance of supply and demand, production costs, price stability, harvest profits, market access, and business feasibility (Table 6). The attribute concerning the balance between fish availability and market demand has a relatively low sustainability index of 43.66%. This suggests that there is a significant challenge in maintaining this balance, which in turn affects the stability of fish prices. A balanced market is crucial for ensuring consistent profitability, and this score highlights an area where improvements are needed [19].

The production costs, including expenses for feed, seeds, and electricity, have an even lower sustainability index of 40.56%. This indicates that the costs associated with catfish farming are relatively high, which can pose a significant barrier to achieving higher sustainability in the economic dimension. Reducing these costs through better resource management or technological innovations could greatly enhance the overall sustainability of the business [19].

The price stability of catfish is reflected in a moderate sustainability index of 56.62%. While the price of catfish is relatively stable, there are still fluctuations that could impact profitability. Ensuring more consistent pricing could provide greater economic security for cultivators.

A more positive result is seen in the attribute measuring the profitability of catfish farming, which has a sustainability index of 76.34%. This suggests that, despite the challenges in cost management and price stability, the difference between harvest yields and costs is generally profitable, making catfish farming a viable economic activity [19].

Market access during harvest time scores a sustainability index of 69.58%, indicating that while access to markets is relatively easy, there are still some barriers that could be addressed to improve the ease of selling the harvested fish. Finally, the overall feasibility of the catfish farming business is rated with a sustainability index of 79.44%, showing that, on the whole, catfish farming is a sustainable and viable economic activity.

d. Social Dimension

The social dimension includes seven attributes related to experience, education, age, independence, family role, fish sales conditions, and people's preferences for catfish consumption (Table 7). The attribute regarding the farmer's experience has the highest sustainability index at 96.34%, underscoring the critical role of experienced farmers in sustaining operations. Education, with a 74.93% index, positively influences farming efficiency but suggests the need for further targeted training to enhance sustainability.

The age of the cultivator, scoring 66.48%, indicates challenges across different age groups, highlighting the need for age-specific support such as mentorship for younger farmers and accessible technology for older ones. Independence and self-reliance, with an index of 74.08%, emphasize the importance of autonomy, suggesting that fostering self-sufficiency could strengthen sustainability.

Family involvement, with a 77.46% index, is crucial for providing support and continuity in farming operations, indicating the need to consider family dynamics in sustainability strategies. The practice of selling fish fresh and alive, at 75.49%, is essential for maintaining product quality and market demand, underscoring the importance of high standards in product handling. Lastly, local preference for catfish, reflected in a 70.99% index, drives sustainability but also points to the potential benefits of expanding and diversifying the market to reduce reliance on local demand alone.

Table 4. Sustainability Status Score of Technological Dimension

No	Attribute	Total score	Maximum Total Score	Sustainability Index (%)
1	Ease of access to technology for learning farming techniques has led to a yearly increase in the number of catfish cultivators	195	355	54.93
2	Production in modern farming systems is higher, but the risks are also greater compared to semi-intensive and traditional systems	259	355	83.10
3	Seeds and feed are easily obtained at expected prices	229	355	64.51
4	The fish you cultivate show a match between stocking density and harvest yield	284	355	80.00
5	The harvest yield of catfish aligns with the amount of feed used	288	355	81.13

Table 5. Sustainability Status Score of Ecological Dimension

No	Attribute	Total score	Maximum Total Score	Sustainability Index (%)
1	Your cultivation land has been designed according to CBIB and is cultivated for a long period of time (> 5 years)	261	355	73.52
2	Your place's water quality (pH, temperature, Dissolved Oxygen, and brightness) is good and suitable for cultivating catfish.	282	355	79.44
3	You have mastered the prevention and management of diseases in catfish	293	355	82.54
4	Feed and water treatment influence the fish's ability to survive (survival rate)	353	355	99.44
5	The current climate and weather are suitable for cultivating catfish	250	355	70.42
6	Water sources (wells) can last >5 years with maintained water flow and quality	282	355	79.44

Table 6. Sustainability Status Score of Economic Dimension

No	Attribute	Total score	Maximum Total Score	Sustainability Index (%)
1	The availability of fish and market demand are always in balance so that fish prices are relatively stable	155	355	43.66
2	Production costs (feed, seeds, electricity, etc.) for catfish farming are quite low	144	355	40.56
3	The price of catfish is relatively stable	201	355	56.62
4	The difference between harvest yields and costs incurred is quite profitable	271	355	76.34
5	Market access when fish is harvested tends to be easy	247	355	69.58
6	The catfish farming business is feasible	282	355	79.44

Table 7. Sustainability Status Score of Social Dimension

No	Attribute	Total score	Maximum Total Score	Sustainability Index (%)
1	The farmer's experience greatly influences the continuity of the catfish cultivation business	342	355	96.34
2	The higher the level of education, the better you will be at cultivating catfish	266	355	74.93
3	The age of the cultivator has a significant influence on the cultivation process	236	355	66.48
4	Independence and not depending on other people is very necessary to run a business	263	355	74.08
5	The role of the family which plays a role in the cultivation business is very necessary	275	355	77.46
6	All fish are sold fresh and alive	268	355	75.49
7	The majority of people in Tulungagung like to eat catfish	252	355	70.99

The results for each dimension of the sustainability index—technological, ecological, economic, and social—then was categorized according to the sustainability status framework proposed by Fauzi and Anna (2005). The result is as follows:

Table 8. Sustainability Status

No.	Dimensions	Sustainability Index (%)	Sustainability Status
1	Technology	72.73	Quite Sustainable
2	Ecology	80.8	Sustainable
3	Economy	61.03	Quite Sustainable
4	Social	76.54	Sustainable
Average		**72.78**	**Quite Sustainable**

Based on the calculation results, there are two dimensions with quite sustainable status, namely the technological and economic dimensions, namely 72.73% and 61.03% respectively. Meanwhile, the other two dimensions, namely the ecological and social dimensions, received sustainable status with index values of 80.8% and 76.54%. So, the sustainability index value for Catfish cultivation in Tulungagung Regency is obtained at 72.78%, with quite a sustainable status.

The technological dimension of catfish cultivation in Tulungagung Regency has achieved "quite sustainable" status because not all farmers use modern cultivation systems with high stocking densities and intensive care, resulting in greater production. Most still use traditional methods, so cultivation results are not optimal. [20] stated that the shift from traditional to modern systems is a market demand and an increase in demand for fish which requires farmers to adapt.

The economic dimension also received the status of "moderately sustainable," with the lowest sustainability index compared to other dimensions. The main influencing factors are the instability of fish prices and high feed prices. Fluctuating fish prices and continuously rising feed prices make farmers' profit margins increasingly thin. These two factors contribute most to the low value of economic sustainability. According to [21], profits in aquaculture businesses are greatly influenced by production costs and revenues, where increases in production costs must be minimized to maximize profits.

Strategy for Catfish Cultivation Development in Tulungagung Regency

In developing strategy for catfish cultivation, a SWOT analysis was used. First, internal and external factors are determined based on field observations, identifying strengths, weaknesses, opportunities and threats that influence catfish cultivation. Next, IFAS and EFAS analysis is carried out to assess the weight and influence of each factor on business sustainability [12]. Based on the results of this analysis, the strategic position of catfish cultivation is determined in the SWOT matrix, which is then used to formulate development strategies. This strategy is designed to exploit strengths and opportunities and overcome weaknesses and threats to ensure the development of technology that supports the sustainability of catfish cultivation in Tulungagung Regency.

Based on field observations and discussions with farmers, the following are the internal and external factors that influence the catfish cultivation business in Tulungagung Regency.

Internal Factors

Strengths:

- Good water quality: The research area in five sub-districts in Tulungagung has water quality that is suitable for cultivating catfish, with pH, temperature, dissolved oxygen and salinity that support fish growth.
- Availability of quality seeds: Farmers can easily obtain healthy and uniform catfish seeds, which is important for successful cultivation.
- Superior human resources: The experience and skills of cultivators in catfish cultivation support business success.

Weaknesses:

- Inability to determine prices: Fish prices are determined by collectors, causing unstable and unprofitable prices for farmers.
- High feed prices: Rising feed prices and dependence on manufactured feed increase production costs, while the ability to produce independent feed remains low.

External Factors

Opportunities:

- Wide market share: The existence of three fillet factories and many catfish suppliers around Tulungagung makes it easier to market fish ready for harvest.
- Government support: The active role of the government and related agencies, including training and technical assistance from the Fisheries Service, really supports the development of catfish cultivation businesses.

Threats:

- Pests and diseases: The emergence of pests and diseases that are difficult to detect can cause crop failure, posing a major threat to cultivators.
- Unpredictable climate and weather: Sudden weather changes disrupt water quality and fish health, threatening the stability of aquaculture businesses.
- Abundant stock due to the large number of new cultivators: The increase in cultivators causes excess catfish stocks, reducing demand and prices on the market.

Table 9. IFE Analysis

NO	Internal Factors	Weight	Ratings	Score
	Strengths/ Strength			
1	Good water quality (pH, temperature, and other contents suitable for catfish cultivation)	0.27	3.61	0.98
2	Good seed quality (random & healthy)	0.25	3.37	0.86
3	Superior and experienced human resources in fish cultivation	0.21	2.75	0.57
Total		0.7		2.41
NO	**Weaknesses/ Weaknesses**	**Weight**	**Ratings**	**Score**
1	Stable selling price of fish	0.14	1.92	0.28
2	Affordable feed prices	0.12	1.61	0.19
Total		0.3		0.47
TOTAL IFE		**1**		**2.88**

In the internal factor table above, it consists of strengths and weaknesses. The weight value in the table above is obtained from the total value for each statement divided by the total value for all statements on internal factors, where the total weight is 1. The branch is obtained from the total value for each statement divided by the total number of respondents, where the total number of respondents is 71 people. Column The last is the score, obtained from the weight multiplied by the branch.

The highest score for the strength factor is for good water quality, with a score of 0.98. The second place is occupied by easy access to good quality seeds, getting a score of 0.86, and the last place is the factors of superior human resources and experience in cultivating catfish cultivation businesses, getting a score of 0.57.

The highest score on the weakness factor of cultivators in carrying out the first catfish cultivation business, namely the selling price of fish, which is difficult to predict, gets a score of 0.28, then in second place, namely the price of feed, which is increasingly uncontrollable, gets a score of 0.19. EFE matrix analysis in opportunities and threats is calculated based on weights and ratings. The EFE matrix calculation can be seen in the table below.

Table 10. EFE Analysis

No	External Factors	Weight	Ratings	Score
	Opportunities			
1	Market share is easy to achieve (domestic and foreign)	0.2	2.45	0.49
2	There is village support / related agencies	0.2	3.34	0.67
Total		0.4		1.16
No	**Threats**	**Weight**	**Ratings**	**Score**
1	Pests and diseases are difficult to predict and manage	0.2	3.31	0.66
2	Unpredictable climate and weather cause unstable fish health	0.2	2.75	0.55
3	Many new catfish cultivators have caused an abundance of goods, and the price of fish has fallen	0.2	3.04	0.61
Total		0.6		1.82
TOTAL EFE		**1**		**2.98**

The table of external factors above includes opportunities and threats. The weight value is obtained by dividing the total value of each statement by the total value of all external factor statements, with a total weight of 1. The rating is calculated from the average value of each statement, obtained by dividing the total value by the number of respondents (71 people). The final score is obtained from the product of weight and rating. From the opportunity factor, the highest score is support from the village and related agencies, with a score of 0.67, followed by ease of market access, with a score of 0.49. In terms of threat factors, the highest score was obtained from fish pests and diseases with a score of 0.66, followed by the large number of new cultivators, which caused a decrease in fish prices (score of 0.61), and erratic weather, which had an impact on fish health (score 0.55).

A SWOT analysis diagram can be prepared by looking for the coordinates of the X-axis and Y-axis. The total value of the strength indicator score is a positive value of 2.41, while the total value of the weakness indicator score is a negative value of -0.47. Meanwhile, the total value of the opportunity's indicator score is positive 1.16, and the total value of the Threats Indicator score is negative -1.82. The X-axis coordinates are obtained using (Strengths + Weaknesses) so that the number 1.94 is obtained, and the Y-axis coordinates (Opportunities + Threats) are -0.66. Where more details can be seen in the following SWOT analysis diagram.

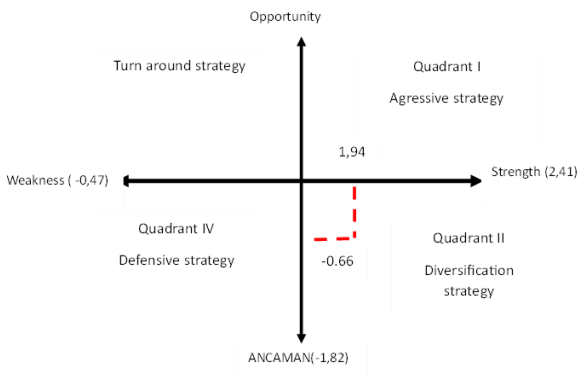

Figure 4. SWOT Analysis Diagram

Based on Figure 4 the position of catfish farmers in Tulungagung Regency is in Quadrant II (Supporting Diversification Strategies). This means that catfish cultivation in Tulungagung Regency is supported by internal solid cultivation strengths (water quality, seed quality and human resource skills) even though it also has significant threat factors (pests, uncertain climate, and competitors of catfish farmers), so that the strategy what is determined is related to the products produced or existing market share.

After analyzing the position of catfish farmers in Tulungagung Regency, which is in quadrant II in the SWOT (Supporting Diversification Strategy) matrix, the next step is to determine the appropriate strategy based on the results of this analysis. This strategy will be formulated using a SWOT matrix, which combines the strengths, weaknesses, opportunities and threats that have been previously identified. The priority scale above is known to be the highest ranking in KII ST, where the first priority in the business strategy is to use every strength to overcome threats that are likely to occur, in second place is KI SO where the second priority in the business strategy is to take advantage of opportunities with existing strengths to develop the catfish farming business. Next, the one in third place is KIV WT, which means the third priority in the business strategy is to minimize weaknesses in order to be able to face threats that may occur during the catfish cultivation process. In the last sequence, namely K III WO, this is the last priority in the catfish cultivation business strategy, which means taking advantage of opportunities to minimize their weaknesses.

Table 11. SWOT Analysis Matrix

INTERNAL / **EXTERNAL**		**INTERNAL FACTORS**	
		Strength (S) 1. water quality 2. Seed quality 3. Superior human resources and experience in cultivation	Weakness (W) 1. selling price of fish 2. price of feed
EXTERNAL FACTORS	Opportunity (O) 1. support from related agencies 2. Market share is easy to achieve	I. ST Strategy 1. Maintain water quality by regularly checking water quality indicators to ensure it is safe during uncertain climate and weather conditions 2. Be careful in choosing superior seeds so that the fish are not easily attacked by pests and diseases 3. superior resources and experience in cultivation also determine success in fish cultivation so that it can overcome the abundance of catfish production and declining prices	II. SO Strategy 1. Support from the department for the development of catfish cultivation by providing training to farmers on handling pond water quality 2. Support from the department is also related to training for catfish hatcheries so that they can carry out their own hatcheries that have superior quality 3. Superior human resources and experience in cultivation influence the ease of marketing catfish

	Threat (T) 1. pests and diseases 2. goods are abundant and prices fall 3. Uncertain climate and weather	III. WT Strategy 1. When catfish production is abundant, the selling price of fish decreases, so farmers must be clever in utilizing the harvest from catfish. 2. Utilize natural food around us so that food costs can be minimized 3. Cultivators must be clever in managing water quality during uncertain seasons so that cultivators do not experience losses and can continue to produce catfish.	WO Strategy 1. Support from the fisheries department for the development of catfish cultivation businesses can bring together fish collectors to discuss fish price agreements 2. The fisheries department holds independent feed training so that farmers can produce their own fish feed

In quadrant II of the SWOT matrix, the strategy for developing catfish cultivation in Tulungagung Regency emphasizes the importance of utilizing internal strengths to face external threats. One main strategy is maintaining water quality, which is the key to successful cultivation. [22] emphasized that good water quality, such as pH, temperature, and dissolved oxygen levels, is very important for fish health and aquaculture productivity. The application of water quality monitoring technology is also supported by [23] which recommends careful water quality management in aquaculture to anticipate climate change and prevent disease emergence.

Apart from that, selecting superior seeds is another important strategy. [16] stated that high-quality and healthy seeds resist disease and environmental stress, ultimately increasing survival and production yields. In the context of product diversification, [22] stated that business diversification can expand markets and reduce risks by offering value-added products. This is relevant in catfish cultivation, where farmers can process catfish into meatballs, shredded meatballs, or crisps to increase selling value and deal with price fluctuations.

Collaboration with hotels and restaurants is also a strategic step to ensure a stable market. [24] showed that collaboration with downstream supply chains can increase distribution efficiency and provide price stability for producers. Finally, developing creative and knowledgeable human resources is also the key to long-term success. [25] emphasized that innovative human resources are an essential asset in maintaining competitive advantage, enabling cultivators to overcome existing challenges better and exploit opportunities in the market.

CONCLUSION

Based on research regarding strategies for developing sustainable catfish (Pangasius sp) cultivation in Tulungagung Regency, it can be concluded that the sustainability status of catfish cultivation in this region is quite sustainable, with an average index of 72.78%. In detail, the technological dimension has a sustainability index of 72.73% (quite sustainable), the ecological dimension of 80.8% (sustainable), the economic dimension of 61.03% (quite sustainable), and the social dimension of 76.54% (sustainable). The recommended business development strategy is the ST strategy, which focuses on overcoming external threats by utilizing internal strengths. Recommended steps include maintaining water quality through regular checks, selecting superior seeds to prevent disease, and optimizing experienced human resources. Apart from that, cultivators are encouraged to collaborate with hotels and restaurants for marketing stability, as well as to process products made from catfish to increase added value and selling prices, which overall can increase the sustainability and success of catfish cultivation businesses in Tulungagung Regency.

For the government and related agencies, such as the Fisheries Service, it is

recommended to increase technical support and training for cultivators, especially in terms of modern cultivation technology and risk management. The government is also expected to facilitate wider market access, both domestic and international, as well as assist in providing facilities and infrastructure that support business sustainability. In addition, initiatives to develop regional catfish processing industries, such as fillet factories or other processed products, must continue to be encouraged to create added value and price stability for farmers.

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