RISK MITIGATION OF NILE TILAPIA (OREOCHROMIS NILOTICUS) BIOFLOC SYSTEM: A CASE STUDY OF THE BIOFLOC NETWORK AT ULAM TIRTA FISH FARM IN DEPOK AND BOGOR AREA

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ABSTRACT

Research aims to identify the causes and occurrence of risks, measure the level of risk, map the risks, determine the risk mitigation of biofloc tilapia Aquaculture process. Data analysis used severity index and probability and impact matrix methods. The data used were primary and secondary, collected through observation, interviews, questionnaires, and literature studies. Respondents totaled 12 farmers. The results showed there were 120 risk events and 52 risk causes. Validity and Reliability test results show 50 valid risk causes. Based on the results of the severity index measurement, the frequency level of risk causes is 1 category very rarely, 11 rarely, 25 quite often, and 13 often. The level of impact of risk agents is 1 small category, 13 medium, 33 large, and 3 very large. the results of risk mapping found that there were 13 dominant/extreme risk agents, 1 in seedling rearing, 3 in biofloc pond preparation, 2 in biofloc application, 1 in seed stocking, 4 in water quality management, and 2 in harvest and post-harvest. risk mitigation actions were determined through Focus Group Discussion (FGD), there are 9 priority mitigations that represent the entire process of biofoc system tilapia farming.

Keywords: *risk mitigation; severity index; probability and impact matrix; focus group discussion.*

INTRODUCTION

Aquaculture sector continues to be developed from conventional to modern, Aquaculture can be carried out on empty land or residential areas to prevent land conversion. One of them is the city of Depok and Bogor Regency which have started to switch from conventional fish farming to biofloc fish farming. Depok City has even become a pilot project for catfish and tilapia Aquaculture using the biofloc system so that many conventional tilapia farmers have participated in fish farming training using this system (Depok Food Security, Agriculture and Fisheries Service, 2018).

According to Andriani (2018: 1), *Oreochromis niloticus* tends to be easy to breed and easy to maintain in various containers, one of which is a tarpaulin pond such as biofloc. Sucipto (2020: 148) stated that biofloc comes from "*Bios*" which means life and "*Floc*" which means clump. So it can be said that biofloc is a collection of organisms such as *bacteria, protozoa*, and so on which together reduce non-organic and organic materials in the pond so that they can maintain water quality so that it remains ideal for fish development. According to the Kulon Progo Regency Marine and Fisheries Service (2020), Biofloc will be formed if it consists of 4 components such as the presence of a carbon source, organic material from leftover feed and fish waste, decomposing bacteria, and the availability of oxygen supply. Gusrina (2020: 2 & 3) stated that Aquaculture uses a biofloc system as an artificial environmental engineering in the form of a pond that relies on oxygen, the use of microorganisms with culture media water which is put into the pond once, and will be used until harvest.

One of the main training places and tilapia Aquaculture businesses using the biofloc system is in the city of Depok, namely Ulam Tirta Fish Farm. This business also opens intensive training to learn about the biofloc system. This business was established in 2017 and formed a great biofloc community called the Great Biofloc Network of Ulam Tirta Fish Farm.

The Great Biofloc Network of Ulam Tirta Fish Farm is a group of biofloc tilapia fish farmers spread across Jakarta, Bogor, Depok, Tangerang, Bekasi, (JABODETABEK) This network was formed in 2018 with approximately 100 members. The product form of quality fresh tilapia fish which has been trusted by middlemen and restaurants, especially in Depok and Bogor. The fish farming is *larasati type* and *red tilapia (Citralada) or Bangkok*. According to Gusrina (2020: 2 & 3), Aquaculture using the biofloc system is able to decompose fish waste and make additional snacks for fish. The biofloc system also increases productivity and efficiency of feed use, reduces operational costs, better meat quality, and grows quickly. Research results according to Nova, et al. (2023: 259) also state that the biofloc system has many advantages, one of which is better meat quality compared to conventionally farmed fish. However, in Aquaculture there are many risks such as poor quality seeds, poor water quality in terms of pH, salinity, and temperature, fish attacked by disease, and suboptimal aeration channels. This can cause impacts in the form of fish death.

In 2018, almost all fish were infected with *Aeromonas hydrophila* or commonly known as pineapple scale disease so that many fish were infected and eventually died (Ulam Tirta Fish Farm, 2022) There was a fire during the rain which caused an electrical short circuit at the end of 2022. This incident got worse when the fire spread to various points including the aerator machine through the paranet as the roof of the pond and caused the aerator machine to stop. This caused mass fish deaths. In early 2023, there were always fish that died and floated on the surface of the pond around 1-2 fish/day, which was caused by various factors such as seeds not being able to adapt to the new environment, temperatures being too hot and high rainfall, lack of oxygen, poor water quality, and being attacked by disease. The following is the average data on fish mortality in tilapia biofloc. Aquaculture businesses and those included in the Great Ulam Tirta Fish Farm Biofloc Network in the JABODETABEK region, which is listed in Table 1.

Table 1. Average Fish Mortality in Businesses Included in the Great Ulam Tirta Fish Farm Biofloc Network in the JABODETABEK Region

No	Region	Frequency of Death per week (Head)	Frequency of Death per month (Head)	Frequency of Death in one harvest cycle (Head)
1	Jakarta	6	24	144
2	Bogor	7	28	168
3	Depok	7	28	168
4	Tangerang	7	28	168
5	Bekasi	6	24	144

Source: Great Biofloc Network Chairman Archives (2024)

In Table 1, each biofloc tilapia farming business with 100 members and spread across the JABODETABEK area has an average fish mortality rate that is almost the same, namely 6-7 fish per week, and in one harvest cycle for 6 months, 144-168 fish die per pond. From the description of the risk events that occurred from 2018 to 2023 at Ulam Tirta Fish Farm, it is necessary to pay attention and identify further, especially in the Depok and Bogor areas which have the highest risks such as those experienced by Ulam Tirta Fish Farm. The businesses that are members of the Ulam Tirta Fish Farm Great Biofloc Network in the Depok area have 8 members. In the Bogor area, there are 4 members. The following is data on fish mortality in each biofloc tilapia farming business in the Depok and Bogor areas presented in Table 2.

Table 2. Fish Mortality Data in Biofloc Aquaculture Efforts in the Ulam Tirta Fish Farm Great Biofloc Network in the Depok and Bogor Areas (November 2023- April 2024).

No	Business Name	Mortalit Frequen (1 week)	Mortality frequency (per month)	Total (1 harvest cycle/pond)
1	Ulam Tirta Fish Farm	7	28	168
2	Tabanan Fish Farm	6	24	144
3	Banyu Coklat Fish Farm	6	24	144
4	Ikanomic Fish Farm	7	28	168
5	The Nature Farm	8	32	192
6	Captain Trafena	8	32	192
7	The Best Fish Farm	9	36	216
8	Jali-Jali Fish Farm	8	32	192
9	Agra Fish farm	8	32	192
10	Nilavia Fish Farm	5	20	120
11	Saraya Fish Farm	8	32	192
12	Pavin Fishery	5	20	120

Source: Great Biofloc Network Tilapia Farmers (2024)

In Table 2, the average fish mortality in each biofloc pond in the Depok and Bogor areas was 7. The traded biofloc tilapia contained 4 fish/kg. In 1 harvest cycle, approximately 168 fish died, indicating that the farmers experienced a loss of up to 42 kg.

The impact of fish mortality on the entire biofloc Aquaculture process indicates a fairly crucial risk potential. On the other hand, risk management of all Aquaculture efforts included in the Great Biofloc Network has not been carried out comprehensively and systematically. According to Sucipto (2020: 34), Aquaculture process using the biofloc system consists of several stages, namely seed nursery, biofloc pond preparation, seed distribution, biofloc application, feeding, water quality management, harvesting and post-harvest. Judging from the entire process of tilapia biofloc Aquaculture that has not been fully accompanied by proper risk management, it is necessary to minimize the impact of these risk agents to reduce the possibility of risks that cause fish death, so that identification, measurement, mapping, and preparation of mitigation actions are needed in the tilapia biofloc Aquaculture process. If no treatment is given, the possibility of fish death will continue throughout the Aquaculture process and can reduce productivity levels and cause losses. Risk mitigation is very necessary to reduce the impact of fish death on tilapia biofloc Aquaculture in the Great Ulam Tirta Fish Farm Biofloc Network in the Depok and Bogor areas.

METHOD

This study discusses the risks in tilapia biofloc Aquaculture in the Great Ulam Tirta Fish Farm Biofloc Network in the Depok and Bogor areas.

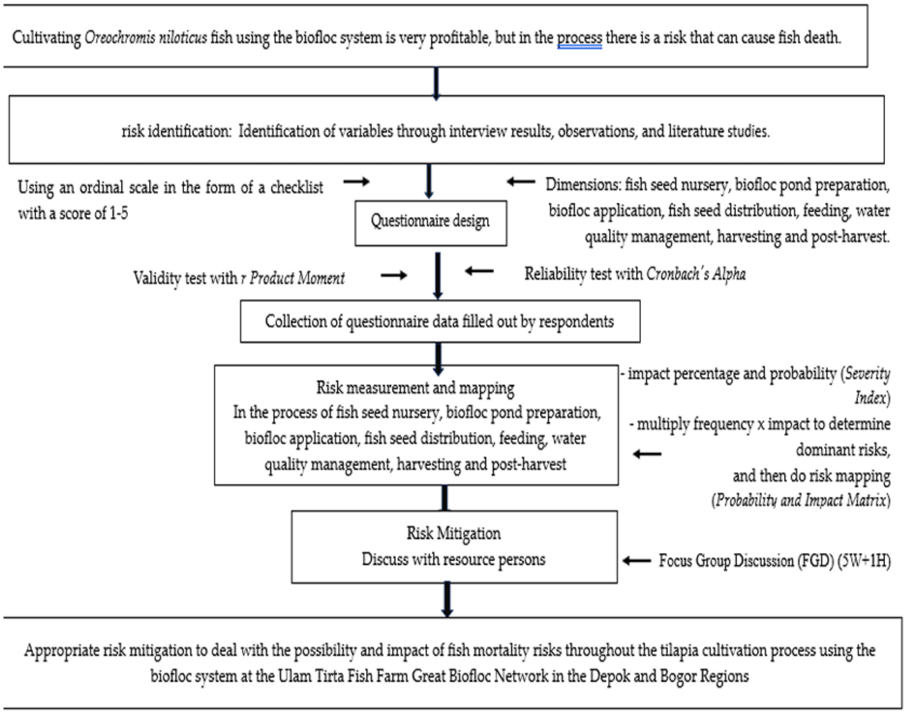

Figure 1. Framework Diagram

To determine risk mitigation actions, it begins with identifying the causes and events of risk, analyzing the risk by measuring the risk using the severity index to determine the percentage of risk, then multiplying the frequency and impact to determine the dominant or extreme risk. After that, grouping it into a risk mapping using the Probability and Impact Matrix. To obtain risk mitigation, a Focus Group Discussion activity with 3 expert, speakers in the field of Aquaculture (was done/ conducted), Thus, the results of risk mitigation actions were obtained to minimize the level of fish mortality throughout the process of tilapia biofloc Aquaculture.

Location and Time of Research

This research was conducted on 12 tilapia fish farmers using the biofloc system who are members of the Ulam Tirta Fish Farm Great Biofloc Network specifically in the Depok and Bogor areas, West Java in May 2024 - July 2024. The selection of this research location was carried out intentionally (purposive) to determine what dominant risks occur in the tilapia fish farming process using the biofloc system along with its mitigation steps.

Types and Sources of Data

The types of data used are qualitative data and quantitative data sourced from primary and secondary data. Qualitative data types are obtained from interview results and literature studies. While quantitative data types are obtained from calculation results such as validity and reliability tests, percentage data on risk levels using severity index analysis, dominant risk data from mapping using Probability and impact matrix through the multiplication process between impact and probability calculated using a calculator and Microsoft Excel. According to Sugiyono (2021: 194), data collection methods can be carried out through interviews, questionnaires, observations, and literature studies. The primary data source in this study is the processing of the results of the questionnaires that have been filled out by respondents, namely inputting values to test validity and reliability, calculating the percentage value of the severity of risk agents, and calculating the dominant risk value. Secondary data in this study were obtained from farmers and literature studies.

Sampling

Sampling in this study used the Census sampling technique or total sampling. According to Sugiyono (2021: 134), the total sampling technique is a sampling technique where all members of the population are used as samples or respondents, "The total population used as samples in this study was 12 people."

Data Processing and Analysis Methods

The data analysis method in this study is descriptive statistics by describing the Aquaculture process using the biofloc system so that identification is easier because the Aquaculture process is explained in detail. Then the identification results are used as a questionnaire that will be measured using the severity index analysis tool and the Probability and Impact Matrix which are processed with Microsoft Excel. In addition, the validity and reliability of the questionnaire were also tested using the SPSS program. The results of the study are presented in the form of tables, percentages, and mapping. Referring to Sugiyono (2021: 207), descriptive statistics as a presentation of data through tables, graphs, percentages, diagrams, calculations of mode, mean, median and others.

The Severity Index is used to find the severity of a risk by finding the impact value and its frequency first, then categorizing it based on the magnitude of the impact and its frequency in the probability and impact matrix so that these two analysis tools are closely related and cannot be separated from each other. The Severity Index method is very good for calculating risks because the results issued are more accurate and consistent with the results of respondents' answers in the form of percentages (Habir & Mukti, 2019: 30).

The reason for using the Severity Index analysis tool is because it is in accordance with the research objectives, namely to measure the level of impact and frequency of risk agents and map them to determine the risk category from low to extreme. According to Yoe (2019: 420), to find the value of each frequency (how often the risk occurs), and the consequences/impacts of the risk occurring (how big the impact of the risk is) a severity index calculation is required which uses a categorization of the probability level and impact to determine the percentage of risk. Then risk mapping is carried out using a probability and impact matrix to determine the lowest to extreme risk through the multiplication of the magnitude of the impact and the frequency of the calculation results from the severity index.

1. Risk Identification

Identification is done by interview to gather information related to impact, risk events and risk causes. The interview results are used as an illustration for compiling the questionnaire

a. Risk Measurement Scale in Questionnaires

Each questionnaire statement is given an ordinal rating scale of 1-5 to make it easier for respondents to determine the most frequent risks and their greatest impact on fish mortality. This type of research is qualitative research that is quantified with the help of an ordinal scale in the form of a checklist. Referring to Sugiyono (2021: 11), an ordinal scale is used to measure non-numerical data and express the results with numbers from the ranking. The measurement scale for the consequences/impacts and probability/frequency of risk agents is listed in Table 3.

Table 3. Measurement Scale Scores for the Consequences of Risk Occurrence and Probability of Risk Occurrence on Tilapia Mortality

Consequences/Impact			Probability/Frequency		
Category	Description	Scale	Category	Description	Scala
Very Small (VS)	The impact of the risk agent is very small	1	Very Rare (VR)	Risk agents occur very rarely	1
Small (S)	The impact of the risk agent is small	2	Rare RJ)	isk agents occur rarely	2
Medium (M)	The impact of the risk agent is medium	3	Quite Often (QO)	Risk agents occur quite often	3
Large (L)	The impact of the risk agent is large	4	Often (O)	Risk agents occur frequently	4
Very Large (VL)	The impact of the risk agent is very large	5	Very Often (VO)	Risk agents occur very frequently	5

Source: Habir & Mukti (2019: 30).

b. Validity test

Referring to Sujarweni (2019: 106-108), research data originating from questionnaires and filled out by respondents must be tested for validity and reliability. To measure validity, an analysis of the relationship between the score of each item and the total score is carried out using the Product moment correlation formula. The requirement to be considered valid is that the calculated r must be greater than the r Table. Validity testing is carried out using SPSS with the following Validity Correlation Coefficient or calculated r formula.

$$r_{xy} = \frac{n\sum XiYi-(\sum Xi)(\sum Yi)}{\sqrt{\{n\sum Xi^2-(\sum Xi)^2\}\{n\sum Yi^2-(\sum Yi)^2\}}} \qquad (1)$$

Description:
r Calculate = Validity correlation coefficient;
$\sum Xi$ = Total score of items;
$\sum Yi$ = Total score (all items)
n = Number of Respondents

c. Reliability test

Referring to Sujarweni (2019: 108-109), reliability as a questionnaire measuring tool to measure the stability and consistency of respondents' answers. To calculate reliability using the following Cronbach's Alpha formula.

$$\alpha = \left(\frac{k}{k-1}\right)\left(1 - \frac{\sum \sigma i^2}{\sigma i^2}\right) \text{..............................} (2)$$

Description:
α = instrumen reliability coefficient;
k = number of statement items;
$\sum \boldsymbol{\sigma i}^2$ = sum of item variances for each item;
$\boldsymbol{\sigma t}^2$ = total variance od the overall score.

Reliability test can be done using SPSS program. The following level of reliability based on Cronbach's Alpha value can be seen in Table 4. Table 4. Reliability Level based on Cronbach's Alpha value.

Cronbach's Alpha Value	Reliability Level
0,0 – 0,20	Less Reliable
> 0,2 – 0,40	Slightly Reliable
> 0,40 – 0,60	Quite Reliable
> 0,60 – 0,80	Reliable
> 0,80 – 1,00	Very Reliable

Source: Sujarweni (2019: 111)

2. Risk Measurement

After conducting risk identification, a risk analysis process is carried out, namely risk measurement with the aim of determining the percentage of frequency levels and the magnitude of the impact on fish mortality. The risk analysis process is carried out using the severity index method (Saputro, 2022: 143).

$$SI = \frac{\sum_{i=0}^{4} \alpha i X i}{4 \sum_{i=0}^{4} X i} \text{ x } 100\% \text{........................} (3)$$

The use of the severity index formula in analyzing the risks of biofloc tilapia agriculture is described as follows:

$$SI = \frac{\{(a0.x0)+(a1.x1)+(a2.x2)+(a3.x3)+(a4.x4)\}}{4 \sum (xi)} (100) \text{..........} (4)$$

Description:
ai = Severity Index assessment constant; a0 = 0, a1 = 1, a2 = 2, a3 = 3, a4 = 4.
a0 = score for who choose risk agents including 'very rare/very small' = 0
a1 = score for respondents who choose risk agents including 'rare/small'=1
a2 = score for who choose risk agents including 'Quite Often/Moderate'=2
a3= score for respondents who choose risk agents including 'Often/large"=3
a4 = core for who choose risk agents including 'Very Often/Very large" = 4
xi = Number of respondents who provide answers to the probability

and consequence categories of tilapia biofloc fish farming risk agents. Consists of x0, x1, x2, x3, x4.
x0 = Number of respondents who gave answers to the probability and consequence
categories 'very rare/very small' of the risk agents of biofloc tilapia farming
x1 = Number of respondents who gave answers to the probability and consequence
categories 'rare/small' of the risk agents of biofloc tilapia farming
x2 = Number of respondents who gave answers to the probability and consequence
categories 'Quite/Moderate' of the risk agents of biofloc tilapia farming
x3 = Number of respondents who gave answers to the probability and consequence
categories 'Often/large' of the risk agents of biofloc tilapia farming
x4 = Number of respondents who gave answers to the probability and consequence
categories 'Very Often/Very large' of the risk agents of biofloc tilapia farming.

After the severity index value is calculated and produced in the form of a percentage, the next step is to categorize all risk agents throughout the biofloc tilapia Aquaculture process into several groups according to the Severity Index percentage categories listed in Table 5.

Table 5. Percentage Categories in the Severity Index

Category	**Percentage (%)**
Very Rare (VR)/Very Small (VS)	$0{,}00 \leq SI < 12{,}5$
Rare (R)/Small (S)	$12{,}5 \leq SI < 37{,}5$
Quite Often (QO)/Moderate (M)	$37{,}5 < SI < 62{,}5$
Often (O)/Large (L)	$62{,}5 < SI < 87{,}5$
Very Often (VO)/Very Large (VL)	$87{,}5 < SI < 100$

Source: Saputro (2022: 144)

3. Risk Mapping Using Probability and Impact Matrix

According to Sopiyah & Salimah (2020: 49), Probability and Impact Matrix means the level of risk that has been measured in percentage. In this study, the probability and Impact Matrix is a mapping of the results of multiplying the frequency value by the impact value of the risk agent throughout the biofloc tilapia Aquaculture process. In agreement with Hakim (2022: 2), through the Probability and Impact Matrix, the process of mapping risks and determining priority risks can be determined. The results of the multiplication will be plotted into a matrix table as shown in Figure 2. To find out the level of risk from the lowest to the extreme risk, you can use the formula.

$$\mathbf{R = P \times I} \text{ .... } (5)$$

Description: R = risk level; P = frequency value (Probability) that occurs; I = consequence value (Impact).

Probability	Very Often	5	*Medium (5x1)*	*High (5x2)*	*Extreme (5x3)*	*Extreme (5x4)*	*Extreme (5x5)*
	Often	4	*Low (4x1)*	*Medium (4x2)*	*High (4x3)*	*Extreme (4x4)*	*Extreme (4x5)*
	Quite Often	3	*Low (3x1)*	*Medium (3x2)*	*High (3x3)*	*High (3x4)*	*Extreme (3x5)*
	Rarely	2	*Low (2x1)*	*Low (2x2)*	*Medium (2x3)*	*Medium (2x4)*	*High (2x5)*
	Very Rarely	1	*Low (1x1)*	*Low (1x2)*	*Low (1x3)*	*Medium (1x4)*	*High (1x5)*
			1	2	3	4	5
			Very Small	Small	Medium	Large	Very Large
			Impact				

Figure 2. *Probability and Impact Matrix Source:* ISO 31000: 2018

There are 4 levels of risk in the Probability Impact Matrix according to Hakim (2022: 232), which also refers to ISO 31000: 2018 in the Center for Risk Management Studies or CRMS (85: 2018), namely Low Risk, Medium Risk, High Risk, and Extreme High Risk. The levels of low to extreme risk marked with several colors are listed in Table 6.

Table 6. Risk Level Scale

Risk Level	**Description**
	Low Risk
	Medium Risk
	High Risk
	Extreme High Risk

4. Risk Mitigation through Focus Group Discussion (FGD)

According to Sopiyah & Salimah (2020: 48), risk mitigation is carried out to reduce the impact and frequency of risks that occur within a threshold that is acceptable to a business. Risk mitigation in this study was carried out using a qualitative descriptive method, namely through the Focus Group Discussion (FGD) process with the help of 5W + 1H to obtain risk responses which will later be embedded as priority risk mitigation actions.

RESULTS AND DISCUSSION

1. Risk Identification

The risk identification process in each tilapia fish farming business using the biofloc system that is part of the Ulam Tirta Fish Farm great biofloc network in Depok and Bogor areas is carried out through observation, literature studies and interviews with the Head of the Ulam Tirta Fish Farm Great Biofloc Network related to the tilapia biofloc fish farming process with the aim of determining the risk factors and impacts caused by these risks. The tilapia biofloc fish farming process consists of 7 processes as listed in the Figure 3.

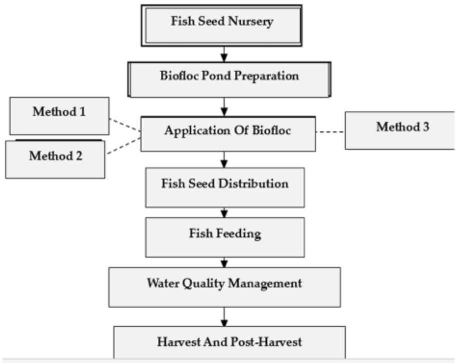

Figure 3: Biofloc Aquaculture process in the Great Biofloc Network.
Source: Ulam Tirta Fish Farm Archives

a. **Seed Nursery:** Since the end of 2022, seed nurseries have been carried out independently by Ulam Tirta Fish Farm since the seeds are 1.5-9 cm in size for approximately 2 months until they reach 9-12 cm in length as the size of fish seeds that are ready to be cultivated by providing feed sizes -1 and 0 twice a day. Monosex treatment is given before the broodstock mates and additionally when the fish larvae are being cultivated so that it is certain to produce monosex seeds.
b. **Biofloc Pond Preparation**: Using a circular pond with an average pond diameter of 2 to 6, a pond height of around 1.2 meters with a pond water height ranging from 80-100 cm. The construction of the tarpaulin pond consists of a woven iron frame, a woven iron coating in the form of fiber, a tarpaulin as a base and pond wall, pipes or hoses installed around the pond and as an aeration channel into the pond, a water

drainage pipe coated with a filter. and building materials such as cement and bricks to make the base of the pond.

c. **Biofloc Application:** The method of applying biofloc consists of 3 methods, namely by managing the biofloc water first. After 5 days, the seeds are allowed to enter the pond on condition that the seeds are of good quality, so they do not need to be quarantined. The second method is carried out by first putting the
d. fish seeds into ordinary water media (quarantine) after which biofloc is applied. While the third method can be carried out when the Aquaculture is already underway. The ponds owned are quite a lot, so pond preparation is only done by injecting water from one pond to another biofloc pond that is short of water.
e. **Seed Distribution:** Fish seeds distributed by the Great Ulam Tirta Fish Farm Biofloc Network are 9-12 cm in size. In the seed distribution process, floc and dolomite lime are given four times in one month because the fish are in the process of physiological growth. While in the second and third months, the addition of floc and dolomite lime is only done once.
f. **Feeding:** Providing intensive feed at the beginning of seed maintenance in the biofloc pond every morning and evening. During seed maintenance, feeding is done using a large tub or bucket mixed with various vitamins and then spread into the pond. The types and sizes of feed used are Hi Pro Vite 781 Feed, -1 for fish that have not been transferred to the rearing pond ranging from 1-10 cm, feed -2 is given to 2-month-old fish seeds, and feed -3 is given to tilapia in the rearing pond aged 3 months to 4 months.
g. **Water Quality Management:** In water quality management, biofloc tilapia farmers who are members of the Ulam Tirta Fish Farm Great Biofloc Network usually do several things starting from checking temperature, salinity, and pH, measuring the thickness of the floc in the pond, controlling the pond, and controlling diseases.
h. **Harvest and Post-Harvest:** The ideal harvest carried out by biofloc farmers is when the size of the fish has started to reach a weight of 250 grams/tail. However, there are some who have harvested when the weight of the fish is still 125 grams/tail. The harvest process is usually carried out in the sixth month. Tilapia that are getting bigger approaching the harvest period or during the harvest will be treated intensively again by providing floc materials, dolomite lime, Amino Liquid, and Nitrobacter 2-3 times.

Identification Causes and Risk Events in the Biofloc Tilapia Process

Based on the interview results, it is known that in each process there are critical points and many risk causes that cause incidents and have an impact on fish deaths, so observations are made to see the number of fish deaths in each business. The impact in the form of fish deaths is the basis for focusing on risk agents and finding out which risk agents are dominant in causing fish deaths throughout the Aquaculture process. So the focus of the discussion of this study is carried out on risk agents and the impacts in the form of deaths caused.

Total of 52 risk agent statements were found that could cause fish death and consisted of 5 risk agents in the seed nursery process, 8 risk agents in the biofloc pond preparation process, 7 risk agents in the biofloc application process, 7 risk agents in the seed spreading process, 6 risk agents in the feeding process, 11 risk agents in the water quality management process, 8 risk agents in the harvest and post-harvest process. The results of the identification of causes and risk events in each process of biofloc tilapia Aquaculture are presented in Table 7.

Table 7. Identification of Risk Causes in Each Process of Biofloc Tilapia Aquaculture

No	Dimensions (Frequency Level and Impact Magnitude Level)	Couse Of Risk	
1.	Fish Seed Nursery (A/H)	A1/H1	Seeds come from unhealthy parents
		A2/H2	Pond water quality is not controlled
		A3/H3	Temperature is too hot above 34℃
		A4/H4	In appropriate fish larvae rearing process
		A5/H5	In appropriate use of seed nursery hormones
2.	Biofloc Pond Preparation (B/I)	B1/I1	The pond frame is not made using sturdy and quality materials
		B2/I2	The aerator channel does not use pipes
		B3/I3	The bottom of the pond is not reinforced using cement bricks and sand
		B4/I4	The pond is not round
		B5/I5	The rainy season is prolonge
		B6/I6	The temperature is too hot above 34℃
		B7/I7	The pH of the water source is too acidic/alkaline
		B8/I8	The number of oxygen aeration channels is lacking

No	Dimensions (Frequency Level and Impact Magnitude Level)	Couse Of Risk	
3.	Application of Biofloc (C/J)	C1/J1	Excessive application of coarse salt and dolomite lime
		C2/J2	Poor quality biofloc making materials
		C3/J3	Excessive application of molasses and probiotics
		C4/J4	Oxygen aeration does not function optimally for floc stirring
		C5/J5	Power outage
		C6/J6	Aeration control is not carried out routinely for 1 week since the start of floc material application
		C7/J7	In appropriate application of biofloc and anti-bacterial/fungal/parasite probiotics
4.	Seed spreading (D/K)	D1/K1	Seed distribution is carried out during the day
		D2/K2	Poor quality seeds
		D3/K3	Fish seed size is not safe enough to be cultivated
		D4/K4	Seeds are not quarantined first
		D5/K5	In accurate stocking density calculation
		D6/K6	Differences in temperature and pH parameters of pond water before and after fish are moved
		D7/K7	Seeds are unable to adapt to the new pond
5.	Fish Feeding (E/L)	E1/L1	Excessive frequency and amount of initial feeding
		E2/L2	Excessive/insufficient follow-up feeding
		E3/L3	Poor quality of fish feed
		E4/L4	Fish feed not in accordance with the fish's life stage

Table 7. Identification of Risk Causes in Each Process of Biofloc Tilapia Aquaculture (continuation of table 7)

No	Dimensions (Frequency Level and Impact Magnitude Level)	Couse Of Risk	
5.	Fish Feeding (E/L)	E5/L5	Scarcity of stock of tilapia feed that is usually ordered
		E6/L6	Lack of vitamins in feed
		F1/M1	Floc levels exceed the limit

No	Dimensions (Frequency Level and Impact Magnitude Level)	Couse Of Risk	
6	Water Quality Management (F/M)	F2/M2	Never drained and added water during 1 harvest cycle
		F3/M3	Aeration machine is less than optimal
		F4/M4	Ammonia increases
		F5/M5	Imbalance of pH, temperature, and salinity of pond water
		F6/M6	Temperature is too hot above 34℃
		F7/M7	Pond is not shaded
		F8/M8	Inappropriate addition of probiotics and molasses
		F9/M9	No addition of probiotics, molasses, and multivitamins during 1 harvest cycle
		F10/M10	No addition of dolomite lime to neutralize pH
		F11/M11	Oxygen aeration channel is released
7	Harvest and Post-Harvest (G/N)	G1/N1	Lack of careful monitoring of fish activity and stability of harvest ponds
		G2/N2	High density of fish in harvest ponds
		G3/N3	Improper harvesting methods
		G4/N4	Slow harvesting activities
		G5/N5	Careless fish transfer
		G6/N6	No water flow in harvested fish holding ponds
		G7/N7	Oxygen aeration not running

Description: Slash (/) = or; Letters A to G = Questionnaire of Risk Agent Frequency in the Seed Nursery to Harvest and Post-Harvest process; Letters H to N = Questionnaire of the Impact Magnitude of Risk Agents in the Seed Nursery to Harvest and Post-Harvest process.

Validity Test Results

The criteria used in testing the validity of the questionnaire statement items are r count with a significance level of 5% or α = 0.05 with n = 12 which has an r Table value of 0.576. If r Count > r Table, then the statement item can be considered valid. And vice versa. The results of the Validity Test of Questionnaire 1 and 2 are listed in Table 8 and 9.

Tabel 8. Results of Validity Test of Questionnaire 1 (Frequency of Occurrence of Risk Agents)

Agent Risk Code	Total Risk Correlation (r Calculate)	r Table	Description
Questionnaire 1. Frequency of Occurrence of Risk Agents			
Seed Nursery (A)			
A1	0,624	0,576	Valid
A2	0,602	0,576	Valid
A3	0,704	0,576	Valid
A4	0,656	0,576	Valid
A5	0,601	0,576	Valid
Biofloc Pond Preparation (B)			
B1	0,638	0,576	Valid
B2	0,646	0,576	Valid
B3	0,594	0,576	Valid
B4	0,667	0,576	Valid
B5	0,613	0,576	Valid
B6	0,589	0,576	Valid
B7	0,675	0,576	Valid
B8	0,592	0,576	Valid
Biofloc Application (C)			
C1	-0,552	0,576	Tidak Valid
C2	0,781	0,576	Valid
C3	0,679	0,576	Valid
C4	0,603	0,576	Valid
C5	0,763	0,576	Valid
C6	0,667	0,576	Valid
C7	0,803	0,576	Valid
Seed Distribution (D)			
D1	0,607	0,576	Valid
D2	0,724	0,576	Valid
D3	-0,227	0,576	Tidak Valid
D4	0,668	0,576	Valid
D5	0,641	0,576	Valid
D6	0,693	0,576	Valid
D7	0,688	0,576	Valid
Fish Feeding (E)			
E1	0,788	0,576	Valid
E2	0,653	0,576	Valid
E3	0,657	0,576	Valid
E4	0,676	0,576	Valid
E5	0,602	0,576	Valid
E6	0,624	0,576	Valid
Water Quality Management (F)			
F1	0,647	0,576	Valid

Agent Risk Code	Total Risk Correlation (r Calculate)	r Table	Description
Questionnaire 1. Frequency of Occurrence of Risk Agents			
F2	0,653	0,576	Valid
F3	0,730	0,576	Valid
F4	0,679	0,576	Valid
F5	0,647	0,576	Valid
F6	0,747	0,576	Valid
F7	0,693	0,576	Valid
F8	0,599	0,576	Valid

Tabel 8. Results of Validity Test of Questionnaire 1 (Continuation of Table 8)

Agent Risk Code	Total Risk Correlation (r Calculate)	r Table	Description
Questionnaire 1. Frequency of Occurrence of Risk Agents			
Harvest and Post-Harvest (G)			
G1	0,640	0,576	Valid
G2	0,675	0,576	Valid
G3	0,636	0,576	Valid
G4	0,628	0,576	Valid
G5	0,721	0,576	Valid
G6	0,670	0,576	Valid
G7	0,647	0,576	Valid
G8	0,668	0,576	Valid

Source: Data processed in spss, (2024)

Based on Table 8, from 52 questionnaire statement items 1 spread in 7 risk variables, there are 50 questionnaire statements that can be said to be valid because r Calculation > r Table (0.576). There are 2 questionnaire statements that obtain r Calculation < Table (0.576) namely instrument item C1 on the biofloc application risk variable, the statement "Excessive application of coarse salt and dolomite lime" with r Calculation only of -0.552 and instrument item D3 on the seed distribution risk variable statement item "The size of fish seeds is not safe enough to be cultivated" with r Calculation only of -0.227. for the results of validity test 2 are listed in table 9 below.

Tabel 9. Results of Validity Test of Questionnaire 2 (How Much Impact is Generated by Risk Agents)

Agent Risk Code	Total Risk Correlation (r Calculate)	r Table	Description
Questionnaire 2. The Magnitude of The Impact Generated By Risk Agents			
Seed Nursery (H)			
H1	0,621	0,576	Valid
H2	0,661	0,576	Valid
H3	0,630	0,576	Valid
H4	0,710	0,576	Valid
H5	0,688	0,576	Valid
Biofloc Pond Preparation (I)			
I1	0,685	0,576	Valid
I2	0,605	0,576	Valid
I3	0,664	0,576	Valid
I4	0,681	0,576	Valid
I5	0,663	0,576	Valid
I6	0,601	0,576	Valid
I7	0,622	0,576	Valid
I8	0,674	0,576	Valid
Biofloc Application (J)			
J1	0,146	0,576	Tidak Valid
J2	0,659	0,576	Valid
J3	0,732	0,576	Valid
J4	0,656	0,576	Valid

Tabel 9. Results of Validity Test of Questionnaire 2 (How Much Impact is Generated by Risk Agents) (Continuation of Table 9)

Agent Risk Code	Total Risk Correlation (r Calculate)	r Table	Description
Questionnaire 2. The Magnitude of The Impact Generated By Risk Agents			
Biofloc Application (J)			
J5	0,584	0,576	Valid
J6	0,614	0,576	Valid
J7	0,580	0,576	Valid
Seed Distribution: (K)			
K1	0,749	0,576	Valid
K2	0,703	0,576	Valid
K3	0,127	0,576	Tidak Valid
K4	0,622	0,576	Valid
K5	0,660	0,576	Valid
K6	0,632	0,576	Valid
K7	0,731	0,576	Valid
Fish **Feeding:** (L)			
L1	0,749	0,576	Valid

Agent Risk Code	Total Risk Correlation (r Calculate)	r Table	Description
Questionnaire 2. The Magnitude of The Impact Generated By Risk Agents			
L2	0,703	0,576	Valid
L3	0,622	0,576	Valid
L4	0,660	0,576	Valid
L5	0,632	0,576	Valid
L6	0,731	0,576	Valid
Water Quality Management: (M)			
M1	0,608	0,576	Valid
M2	0,630	0,576	Valid
M3	0,703	0,576	Valid
M4	0,687	0,576	Valid
M5	0,663	0,576	Valid
M6	0,658	0,576	Valid
M7	0,658	0,576	Valid
M8	0,630	0,576	Valid
M9	0,687	0,576	Valid
M10	0,688	0,576	Valid
M11	0,633	0,576	Valid
Harvest and Post-Harvest (N)			
N1	0,643	0,576	Valid
N2	0,691	0,576	Valid
N3	0,643	0,576	Valid
N4	0,644	0,576	Valid
N5	0,708	0,576	Valid
N6	0,713	0,576	Valid
N7	0,647	0,576	Valid
N8	0,604	0,576	Valid

Source: Data processed in spss, (2024)

Based on Table 9, from 52 questionnaire statement items spread in 7 Risk Variables, there are 50 valid questionnaire statements because r Calculation > r Table (0.576). There are 2 questionnaire statements that obtain r Calculation < r Table (0.576) namely item J1 on the biofloc application risk variable statement item "Excessive application of coarse salt and dolomite lime" with r Calculation only 0.146 and item

K3 on the seed distribution risk variable statement item "The size of fish seeds is not safe enough to be cultivated" with r Calculation only 0.127, so that both questionnaire statement items are considered invalid.

Reliability Test Results

The questionnaire is declared reliable if the questionnaire can be relied on when used repeatedly and provides results that are not much different or relatively the same. If the reliability coefficient value is greater than 0.6, it can be said that the questionnaire is reliable. The results of the Reliability Test of questionnaire 1 related to the frequency of occurrence of risk agents are listed in table 10, while the results of the Reliability Test of questionnaire 2 related to how much impact is generated by the risk agent are listed in table 11.

Tabel 10. Results of the Reliability Test of Questionnaire 1 (Frequency of Occurrence of Risk Agents)

No	Risk Variabel	*Cronbach's Alpha*	*N of Items*
1	Risks in Seed Nursery Process	0,635	5
2	Risks in Biofloc Pond Preparation Process	0,764	8
3	Risks in Biofloc Application Process	0,806	6
4	Risks in Seed Spreading Process	0,754	6
5	Risks in Feeding Process	0,813	6
6	Risks in Water Quality Management Process	0,848	11
7	Risks in Harvesting and Post-Harvest Process	0,802	8

Source: Data processed in spss, (2024)

Based on the calculation of the Reliability Test of Questionnaire 1, the results of the Cronbach's Alpha value for each risk variable of Questionnaire 1 related to frequency are > 0.60. This means that each risk agent item in each risk variable can be said to be reliable. The results of the reliability test of questionnaire 2 are listed in table 11.

Tabel 11. Results of the Reliability Test of Questionnaire 2 (Frequency of Occurrence of Risk Agents)

No	Risk Variabel	*Cronbach's Alpha*	*N of Items*
1	Risks in Seed Nursery Process	0,658	5
2	Risks in Biofloc Pond Preparation Process	0,796	8
3	Risks in Biofloc Application Process	0,634	6
4	Risks in Seed Spreading Process	0,750	6
5	Risks in Feeding Process	0,750	6
6	Risks in Water Quality Management Process	0,866	11
7	Risks in Harvesting and Post-Harvest Process	0,803	8

Source: Data processed in spss, (2024)

Based on the calculation of the Reliability Test of questionnaire 2, the results of the Cronbach's Alpha value on each risk variable of questionnaire 2 related to the magnitude of the impact are > 0.60. This means that each risk agent item on each risk variable can be said to be reliable.

Percentage Measurement of Risk Agent Frequency Against Fish Mortality

The following is an example of calculating the frequency of risk agents using the severity index (SI) method. Based on the data obtained from the results of filling risk agents in the seed nursery process is "Seeds come from unhealthy parents" the results obtained were 1 person answered Very Rarely (VR), 8 people answered Rarely (R), 2 people answered Quite Often (QO), 0 people answered Often (O) and 1 person answered (VO). So it can be calculated as follows:

a0= 0, a1=1, a2=2, a3=3, a4=4,

x0= 1, x1=8, x2=2, x3=0,x4=1

$$SI = \frac{\sum_{i=0}^{4} \alpha i X i}{4\sum_{i=0}^{4} Xi} \text{ x } 100\%$$

$$SI= \frac{\{(0.x1)+(1.x8)+(2.x2)+(3.x0)+(4.x1)\}}{4.12} (100\%)$$

SI= 33,33%

If the percentage result of SI value is in the range of 12.5 ≤ SI < 37.5. then, the frequency of the risk agent "Seeds come from unhealthy broodstock" is included in the risk category with a frequency level of Rare (R) with a percentage of 33.33%. The following are the results of measuring the percentage frequency of risk agents against fish deaths in each biofloc tilapia Aquaculture process that has been listed.

Table 12. Level and Percentage of Frequency of Risk Agents for Fish Mortality in the Very Rare (SJ), Rare (J), Quite Often (QO), Often (O), and Very Often (VO) Categories

Risk Variabel	Questionnaire Items (Frequency of Risk Agents on the Impact of Fish Mortality)	1	2	3	4	5	T	SI (%)	Result
		VR	R	QO	O	VO			
Fish Seed Nursery (A)	A1	1	8	2	0	1	12	33,33	Rare
	A2	1	1	7	1	2	12	54,17	Quite Often
	A3	1	0	2	5	4	12	72,92	Often
	A4	2	3	3	4	0	12	43,75	Quite Often
	A5	1	8	1	1	1	12	35,42	Rare
Biofloc Pond Preparation (B)	B1	4	7	1	0	0	12	29,16	Rare
	B2	0	5	5	2	0	12	43,75	Quite Often

Risk Variabel	Questionnaire Items (Frequency of Risk Agents on the Impact of Fish Mortality)	1 VR	2 R	3 QO	4 O	5 VO	T	SI (%)	Result
	B8	0	2	4	5	1	12	60,42	Quite Often
	B3	1	9	2	0	0	12	27,08	Rare
	B4	2	6	2	2	0	12	33,33	Rare
	B5	0	0	7	2	3	12	66,67	Often
	B6	0	2	4	4	2	12	62,50	Often

Table 12. Level and Percentage of Frequency of Risk Agents for Fish Mortality in the Very Rare (SJ), Rare (J), Quite Often (QO), Often (O), and Very Often (VO) Categories (Continuation of Table 12)

Risk Variabel	Questionnaire Items (Frequency of Risk Agents on the Impact of Fish Mortality)	1 VR	2 R	3 QO	4 O	5 VO	T	SI (%)	Result
Biofloc Pond Preparation (B	B7	0	0	3	6	3	12	75,00	Often
Application of Biofloc (C)	C1	NOT VALID							
	C2	1	7	0	4	0	12	39,58	Quite Often
	C3	0	4	6	2	0	12	45,83	Quite Often
	C4	0	2	4	4	2	12	62,50	Often
	C5	0	0	6	3	3	12	68,75	Often
	C6	0	5	4	3	0	12	45,83	Quite Often
	C7	4	5	2	1	0	12	29,17	Rare
Seed Spreading (D)	D1	3	7	2	0	0	12	22,92	Rare
	D2	0	4	5	3	0	12	47,92	Quite Often
	D3	NOT VALID							
	D4	0	5	4	3	0	12	45,83	Quite Often
	D5	0	2	6	3	1	12	56,25	Quite Often
	D6	0	0	4	4	4	12	75,00	Often

Risk Variabel	Questionnaire Items (Frequency of Risk Agents on the Impact of Fish Mortality)	1	2	3	4	5	T	SI (%)	Result
		VR	R	QO	O	VO			
	D7	0	1	5	5	1	12	62,50	Often
Fish Feeding (E)	E1	1	4	4	1	2	12	47,92	Quite Often
	E2	0	1	7	3	1	12	58,33	Quite Often
	E3	3	5	4	0	0	12	27,10	Rare
	E4	3	6	3	0	0	12	25,00	Rare
	E5	2	5	4	1	0	12	33,33	Rare
	E6	0	7	4	1	0	12	37,50	Quite Often
Water Quality Management (F)	F1	0	3	4	5	0	12	54,17	Quite Often
	F2	2	3	3	3	1	12	52,08	Quite Often
	F3	0	0	3	4	5	12	79,17	Often
	F4	2	1	2	3	4	12	62,50	Often
	F5	2	4	2	2	2	12	54,17	Quite Often
	F6	0	0	2	5	5	12	81,25	Often

Table 12. Level and Percentage of Frequency of Risk Agents for Fish Mortality in the Very Rare (SJ), Rare (J), Quite Often (QO), Often (O), and Very Often (VO) Categories (Continuation of Table 12)

Risk Variabel	Questionnaire Items (Frequency of Risk Agents on the Impact of Fish Mortality)	1	2	3	4	5	T	SI (%)	Result
		VR	R	QO	O	VO			
Water Quality Management (F)	F7	1	6	1	1	3	12	47,92	Quite Often
	F8	1	5	2	4	0	12	43,75	Quite Often
	F9	2	8	2	0	0	12	25,00	Rare
	F10	8	3	1	0	0	12	10,42	Very Rare
	F11	2	3	2	1	4	12	54,17	Quite Often

Risk Variabel	Questionnaire Items (Frequency of Risk Agents on the Impact of Fish Mortality)	1	2	3	4	5	T	SI (%)	Result
		VR	R	QO	O	VO			
Harvest and Post-Harvest (G)	G1	2	2	3	3	2	12	52,10	Quite Often
	G2	0	2	2	5	3	12	68,75	Often
	G3	1	3	7	1	0	12	41,67	Quite Often
	G4	0	6	2	4	0	12	45,83	Quite Often
	G5	0	9	1	0	2	12	39,58	Quite Often
	G6	0	8	3	0	1	12	37,50	Quite Often
	G7	0	0	3	6	3	12	75,00	Often
	G8	2	2	7	1	0	12	39,58	Quite Often

Source: Data processed in Microsoft Excel, (2024)
Description: VR = Very Rare; R = Rare; QO = Quite Often; O = Often; and VO = Very Often; T = Total; SI (%): Percentage of severity index

In Table 12, it is known that in each Aquaculture process has a severity index percentage level. There is 1 risk agent included in the Very Rare (VR) category in the water quality management risk variable (F10) with a risk percentage result of 10.42%. In addition, for the risk category, there are 11 risk agents included in the rare (R) category, with a risk percentage result between 12.5% ≤ SI < 37.5%. 25 risk agents included in the Quite Often (QO) category, with a risk percentage result between 37.5% < SI < 62.5%, and 13 risk agents included in the often (O) category, with a risk percentage result between 62.5% < SI < 87.5%.

Percentage Measurement of the Magnitude of the Impact of Risk Agents

The following are the results of the calculation of the level and percentage of the impact of risk agents on fish mortality in each biofloc tilapia Aquaculture process which have been listed in Table 13.

Table 13. Percentage of the Impact of Risk Agents on Fish Mortality in the Categories Very Small (VS), Small (S), Medium (M), Large (L), and Very Large (VL)

Risk Variabel	Questionn -aire Items (Magnitud e of Risk Agent Impact)	1	2	3	4	5	T	SI ()	Resulit
		VS	S	M	L	VL			
Fish Seed Nursery (H)	H1	0	0	3	5	4	12	77,08	Large
	H2	0	1	3	3	5	12	75,00	Large
	H3	0	0	2	8	2	12	75,00	Large
	H4	0	0	3	7	2	12	72,92	Large
	H5	0	1	3	6	2	12	68,75	Large
Biofloc Pond Preparation (I)	I1	0	0	3	5	4	12	77,08	Large
	I2	0	2	7	2	1	12	54,17	Medium
	I3	0	6	5	0	1	12	41,67	Medium
	I4	0	4	6	2	0	12	45,83	Medium
	I5	0	0	0	7	5	12	85,42	Large
	I6	0	0	3	7	2	12	72,92	Large
	I7	0	0	1	8	3	12	79,17	Large
	I8	0	0	2	4	6	12	83,33	Large
Application of Biofloc (J)	J1	NOT VALID							
	J2	0	3	2	5	2	12	62,50	Large
	J3	0	0	6	4	2	12	66,67	Large
	J4	0	0	2	2	8	12	87,50	Very Large
	J5	0	0	1	5	6	12	85,42	Large
	J6	0	0	4	4	4	12	75,00	Large
	J7	0	1	2	4	5	12	77,08	Large
seed spreading (K)	K1	0	0	3	6	3	12	75,00	Large
	K2	0	0	2	8	2	12	75,00	Large
	K3	NOT VALID							
	K4	0	0	3	4	5	12	79,17	Large
	K5	0	0	4	5	3	12	72,92	Large
	K6	0	2	7	3	0	12	52,08	Medium
	K7	0	0	4	4	4	12	75,00	Large
Fish Feeding (L)	L1	2	6	4	0	0	12	29,17	Small
	L2	0	0	3	6	3	12	75,00	Large
	L3	0	4	6	2	0	12	45,83	Medium
	L4	0	0	4	6	2	12	70,83	Large
	L5	0	3	3	3	3	12	62,50	Large
	L6	0	0	5	4	3	12	70,83	Large
Water Quality Management (M)	M1	0	1	3	6	2	12	68,75	Large
	M2	0	1	8	2	1	12	56,25	Medium
	M3	0	0	3	4	5	12	77,55	Large
	M4	0	0	2	4	6	12	83,33	Large

	M5	0	0	1	6	5	12	83,88	Large
	M6	0	0	1	5	6	12	85,42	Large
	M7	0	3	7	2	0	12	47,92	Medium
	M8	0	2	5	5	0	12	55,10	Medium
	M9	0	0	2	4	6	12	83,33	Large

Table 13. Percentage of the Impact of Risk Agents on Fish Mortality in the Categories Very Small (VS), Small (S), Medium (M), Large (L), and Very Large (VL) Category (Continuation of Table 13).

Risk Variabel	**Questionn-aire Items (Magnitude of Risk Agent Impact)**	**1**	**2**	**3**	**4**	**5**	**T**	**Nilai SI (%)**	**Resulit**
		VS	**S**	**M**	**L**	**VL**			
Water Quality Management (M)	M10	0	1	8	3	0	12	54,17	Medium
	M11	0	0	1	3	8	12	89,58	Very Large
Harvest and Post-Harvest (N)	N1	0	0	5	5	2	12	68,75	Large
	N2	0	0	3	6	3	12	75,00	Large
	N3	0	2	8	2	0	12	50,00	Medium
	N4	0	6	4	2	0	12	41,67	Medium
	N5	0	1	8	2	1	12	56,25	Medium
	N6	0	0	3	5	4	12	77,08	Large
	N7	0	0	1	4	7	12	87,50	Very Large
	N8	0	0	8	3	1	12	60,42	Medium

Source: Data processed in Microsoft Excel, (2024)
Description: Vs = Very Small; S = Small; M = Medium; L= Large; VL= Very Large; T = Total; SI (%): Percentage of severity index

In Table 13, it is known that each Aquaculture process has a severity index percentage level ranging from small to very large impacts. There is 1 small (S) impact risk agent with a percentage of 29.17%. 13 risk agents are included in the medium (M) category with a risk percentage result between 37.5% < SI < 62.5%. 33 risk agents are included in the large (L) category with a risk percentage result between 62.5% < SI < 87.5%, and 3 risk agents are included in the Very Large (VL) impact category with a risk percentage result between 87.5% < SI < 100%

Risk Mapping

Based on the measurement results that have been carried out using the Severity Index, the next step is risk mapping by categorizing the risks that have been obtained into an Ordinal scale (scale 1-5). Scale 1 is used for very rare/very small answers (SJ/SK) with a severity index score of 0.00% - 12.5%, scale 2 is used for rare/small answers (J/K) with a severity index score of 12.5% - 37.5%, scale 3 is used for quite frequent/quite large answers (CS/CB) with a severity index score of 37.5% - 62.5%, scale 4 is used for frequent/large answers (S/B) with a severity index score of 62.5% - 87.5%, and scale 5 is used for very frequent/very large answers (SS/SB) with a severity index score of 87.5% - 100%. The results of the calculation of dominant risks through the Probability and Impact Matrix mapping are presented in Table 14.

Table 14. Results of Calculation and Risk Mapping in Biofloc Tilapia Aquaculture

Risk Variabel	**Questionnaire Statement Items**		**Frequency of Risk Agents**	**Impact of Risk Agents**	**Level of Risk**	**Categories in the Matrix**
			P	**I**	**R = (P.I)**	
Fish Seed Nursery	1	Seeds come from unhealthy parents	2	4	8	**Medium**
	2	Pond water quality is not controlled	3	4	12	**High**
	3	Temperature is too hot above 34℃	4	4	16	**Extreme**
	4	In appropriate fish larvae rearing process	3	4	12	**High**
	5	In appropriate use of seed nursery hormones	2	4	8	**Medium**
Biofloc Pond Preparation	1	The pond frame is not made using sturdy and quality materials	2	4	8	**Medium**
	2	The aerator channel does not use pipes	3	3	9	**High**
	3	The bottom of the pond is not reinforced using cement bricks and sand	2	3	6	**Medium**
	4	The pond is not round	2	3	6	**Medium**
	5	The rainy season is prolonge	4	4	16	**Extreme**
	6	The temperature is too hot above 34℃	4	4	16	**Extreme**
	7	The pH of the water source is too acidic/alkaline	4	4	16	**Extreme**
	8	The number of oxygen aeration channels is lacking	3	4	12	**High**

Risk Variabel	Questionnaire Statement Items		Frequency of Risk Agents	Impact of Risk Agents	Level of Risk	Categories in the Matrix
			P	I	R = (P.I)	
Application of Biofloc	1	Poor quality biofloc making materials	3	4	12	High
	2	Excessive application of molasses and probiotics	3	4	12	High
	3	Oxygen aeration does not function optimally for floc stirring	4	5	20	Extreme
	4	Power outage	4	4	16	Extreme
	5	Aeration control is not carried out routinely for 1 week since the start of floc material application	3	4	12	High
	6	In appropriate application of biofloc and anti-bacterial/fungal/parasite probiotics	2	4	8	Medium
seed spreading	1	Seed distribution is carried out during the day	2	4	8	Medium
	2	Poor quality seeds	3	4	12	High

Table 14. Results of Calculation and Risk Mapping in Biofloc Tilapia Aquaculture (Continuation of Table 14).

Risk Variabel	Questionnaire Statement Items		Frequency of Risk Agents	Impact of Risk Agents	Level of Risk	Categories in the Matrix
			P	I	R = (P.I)	
seed spreading	3	Seeds are not quarantined first	3	4	12	High
	4	In accurate stocking density calculation	3	4	12	High
	5.	Differences in temperature and pH parameters of pond water before and after fish are moved	4	3	12	Medium
	6.	Seeds are unable to adapt to the new pond	4	4	16	Extreme
Fish Feeding	1	Excessive frequency and amount of initial feeding	3	2	6	Medium
	2	Excessive/insufficient follow-up feeding	3	4	12	High

Risk Variabel	Questionnaire Statement Items		Frequency of Risk Agents	Impact of Risk Agents	Level of Risk	Categories in the Matrix
			P	I	R = (P.I)	
	3	Poor quality of fish feed	2	3	6	Medium
	4	Fish feed not in accordance with the fish's life stage	2	4	8	Medium
	5	Scarcity of stock of tilapia feed that is usually ordered	2	4	8	Medium
	6	Lack of vitamins in feed	3	4	12	High
Water Quality Management	1	Floc levels exceed the limit	3	4	12	High
	2	Never drained and added water during 1 harvest cycle	3	3	9	High
	3	Aeration machine is less than optimal	4	4	16	Extreme
	4	Ammonia increases	4	4	16	Extreme
	5	Imbalance of pH, temperature, and salinity of pond water	3	4	12	High
	6	Temperature is too hot above 34℃	4	4	16	Extreme
	7	Pond is not shaded	3	3	9	High
	8	Inappropriate addition of probiotics and molasses	3	3	9	High
	9	No addition of probiotics, molasses, and multivitamins during 1 harvest cycle	2	4	8	Medium
	10	No addition of dolomite lime to neutralize pH	1	3	3	Low
	11	Oxygen aeration channel is released	3	5	15	Extreme

Table 14. Results of Calculation and Risk Mapping in Biofloc Tilapia Aquaculture (Continuation of Table 14).

Risk Variabel	Questionnaire Statement Items		Frequency of Risk Agents	Impact of Risk Agents	Level of Risk	Categories in the Matrix
			P	I	R = (P.I)	
Harvest and Post-Harvest	1	Lack of careful monitoring of fish activity and stability of harvest ponds	3	4	12	High
	2	High density of fish in harvest ponds	4	4	16	Extreme
	3	Improper harvesting methods	3	3	9	High
	4	Slow harvesting activities	3	3	9	High
	5	Careless fish transfer	3	3	9	High
	6	No water flow in harvested fish holding ponds	3	4	12	High
	7	Oxygen aeration not running	4	5	20	Extreme
	8	Unstable water temperature in containers/packaging	3	3	9	High

Source: Data processed in Microsoft Excel, (2024)
Description: P= Probability; I= Impact; R= Risk Level.

From the results of the risk mapping of the entire biofloc tilapia Aquaculture process, it is known that there is 1 risk included in the low risk level, 13 risk agents included in the medium risk level, 23 risk agents included in the high risk level, and 13 risk agents included in the extreme risk level. These 13 extreme risk agents must be given risk priority to reduce the impact of fish mortality.

Extreme Risk Mapping To Prioritize Risk Mitigation Actions

Figure 4 presents the results of mapping conducted on 13 extreme risk agents. From the mapping results, it is known that there is 1 risk agent that falls into the extreme category with a f Quite Often frequency level and has a very large impact with a score of 15. There are 10 other risk agents that fall into the extreme category with a Often frequency level and have a large impact with a score of 16. In addition, there are 2 other risk agents that fall into the extreme category with a Often frequency level and have a very large impact with a score of 20.

Probability	Very Often	5	*Medium*	*High*	*Extreme*	*Extreme*	*Extreme*
	Often	4	*Low*	*Medium*	*High*	*Extreme* (10 Agen Risiko)	*Extreme* (2 Agen Risiko)
	Quite Often	3	*Low*	*Medium*	*High*	*High*	*Extreme* (1 Agen Risiko)
	Rare	2	*Low*	*Low*	*Medium*	*Medium*	*High*
	Very Rare	1	*Low*	*Low*	*Low*	*Medium*	*High*
			1	2	3	4	5
			Very Small	Small	Moderate	Large	Very Large
			Impact				

Figure 4. Results of Mapping of Extreme/Very High Category Risk Agents.

Table 15 Shows the Priority Risk Agents to be Assigned Risk Mitigation Actions.

Questionnaire Statement Items (Frequency and Magnitude of Risk Agents for Fish Mortality)			**P**	**I**	**Risk Level**	**categories in matrix**
Dimension	**No. Risk Agent**	**Risk Agent**			**(P.I)**	
Fish Seed Nursery	3	Temperature is too hot above 34 ℃	4	4	16	Extreme
Biofloc Pond Preparation	5	The rainy season is prolonge	4	4	16	Extreme
	6	The temperature is too hot above 34℃	4	4	16	Extreme
	7	The pH of the water source is too acidic/alkaline	4	4	16	Extreme
Application of Biofloc	3	Oxygen aeration does not function optimally for floc stirring	4	5	20	Extreme
	4	Power outage	4	4	16	Extreme
Seed spreading	6	Seeds are unable to adapt to the new pond	4	4	16	Extreme
Water Quality Management	3	Aeration machine is less than optimal	4	4	16	Extreme
	4	Ammonia increases	4	4	16	Extreme

Questionnaire Statement Items (Frequency and Magnitude of Risk Agents for Fish Mortality)			P	I	Risk Level	categories in matrix
Dimension	**No. Risk Agent**	**Risk Agent**			**(P.I)**	
	6	Temperature is too hot above 34℃	4	4	16	Extreme
	11	Oxygen aeration channel is released	3	5	15	Extreme
Harvest and Post-Harvest	2	High density of fish in harvest ponds	4	4	16	Extreme
	7	Oxygen aeration not running	4	5	20	Extreme

Source: Data processed in Microsoft Excel, (2024)
Description: P= Probability; I= Impact.

There are a total of 13 dominant risk agents that must be prioritized for risk. Risk mitigation measures have been discussed by 3 expert resource persons, namely the Head of the Great Biofloc Network: Mr. Ariestika, Head of Aquaculture Production at the Seed Center, Depok: Mr. Nahrowi, and the owner of Aquabiofresh and a Masters Degree Graduate of Aquaculture IPB University: This is listed in Table 16

Table 16. Risk Mitigation Priorities for Extreme Risk Agents

No	Risk Agent	Mitigation Action Priorities
1	Oxygen aeration does not function optimally for floc stirring (In the application of biofloc)	Consistently check the engine and aeration channels routinely
2	Oxygen aeration not running (in the harvest and post-harvest)	
3	Aeration machine is less than optimal (In water quality management)	
4	Oxygen aeration channel is released (In water quality management)	
5	Power outage (In the application of biofloc)	Increase the supply of Genset engines to anticipate long power outages
6	Seeds are unable to adapt to the new pond (On seed spreading)	Consistently carry out quarantine activities on fish
		Consistently acclimatize fish seeds
7	Temperature is too hot above 34 ℃ (In seed nursery)	Make permanent shelters or pond roofs on all ponds
8	Temperature is too hot above 34℃ (In the preparation of biofloc ponds)	
9	The rainy season is prolonge (In the preparation of biofloc ponds)	
10	Temperature is too hot above 34 ℃ (In water quality management)	
11	The pH of the water source is too acidic/alkaline (In the preparation of biofloc ponds)	Control and ensure the pH of pond water sources is stable

No	Risk Agent	Mitigation Action Priorities
12	Ammonia increases (In water quality management)	Improve water quality management
		Use the Water Test Kit to control pond water quality
13	High density of fish in harvest ponds (in harvest and post-harvest)	Consistently grade fish into different ponds according to their size

Source: Aquaculture resource persons and literature studies, (2024)

CONCLUSION AND SUGGESTIONS

Conclusion

The results of this study can be concluded as follows:

1. Based on the results of risk identification, 52 risk agents and 1 major impact in the form of fish death were found which were the focus of this study. There were 5 risk agents in the seed nursery process, 8 in the biofloc pond preparation process, 7 in the biofloc application process, 7 in the seed distribution process, 6 in the feeding process, 11 in the water quality management process, and 8 in the harvest and post-harvest process. Based on the results of the validity test, there were 50 valid risk agent items that had r count > r Table 0.576 and 2 invalid risk agents, namely in the biofloc application process, risk agent statement item 1 with r Count -0.552 (in the frequency level questionnaire) and r Count 0.146 (in the impact magnitude questionnaire), in the seed distribution process, statement item 3 with r Count -0.227 (in the frequency level questionnaire) and r Count 0.127 (in the impact magnitude questionnaire).
2. The results of measuring the percentage of frequency and magnitude of risk impact using *the Severity Index* are as follows;
   a. The results of measuring the percentage of frequency and the magnitude of the risk impact using the Severity Index are as follows; a. Percentage of the Very Low Frequency (VL) category in F10 with a percentage of 10.42%. There are 11 risk agents in the Rare (R) frequency category, namely (A1), (A5), (B1), (B3), (B4), (C7), (D1), (E3), (E4), (E5), and (F9) with risk percentages of 33.33%, 35.42%, 29.16%, 27.08%, 33.33%, 29.17%, 22.92%, 27.10%, 25.00%, 33.33%, 25.00%
   b. Here are 25 risk agents in the Quite Often (QO) frequency category, namely (A2), (A4), (B2), (B8), (C2), (C3), (C6), (D2), (D4), (D5), (E1), (E2), (E6), (F1), (F2), (F5), (F7), (F8), (F11), (G1), (G3), (G4), (G5), (G6), and (G8), with a risk percentage of 54.17%, 43.75%, 43.75%, 60.42%, 39.58%, 45.83%, 45.83%, 47.92%, 45.83%, 56.25%,

47.92%, 58.33%, 37.50%, 54.17%, 52.08%, 54.17%, 47.92%, 43.75%, 54.17%, 52.10%, 41.67%, 45.83%, 39.58%, 37.50, and 39.58%,

c. There are 13 risk agents in the Often (O) frequency category, namely (A3), (B5), (B6), (B7), (C4), (C5), (D6), (D7), (F3), (F4), (F6), (G2), (G7) with a risk percentage of 72.92%, 66.67%, 62.50%, 75.00%, 62.50%, 68.75%, 75.00%, 62.50%, 79.17%, 62.50%, 81.25%, 68.75%, and 75.00%.

d. Percentage of the Small (S) impact magnitude category is in (L1) with a risk percentage of 29.17%. For risk agents in the Medium (M) impact magnitude category consisting of 13 risk agents, namely (I2), (I3), (I4), (K6), (L3), (M2), (M7), (M8), (M10), (N3), (N4), (N5), and (N8) with risk percentages of 54.17%, 41.67%, and 45.83%, 52.08%, 45.83%, 56.25%, 47.92%, 55.10%, 54.17%, 50.00%, 41.67%, 56.25%, and 60.42%.

e. There are 3 risk agent statement items included in the Very Large (VL) Impact category level, namely (J4), (M11), and (N7) with risk percentages of 87.50%, 89.58%, and 87.50%. For the Large (L) Impact category, there are 33 risk agent statement items included in the Large Impact (B) category level, namely (H1), (H2), (H3), (H4), (H5), (I1) (I5) (I6), (I7), (I8), (J2), (J3), (J5), (J6). (K1), (K2), (K4) (K5), (K7), (L2), (L4), (L5), (L6), (L7), (M1), (M3), (M4), (M5), (M6), (M9), (N1), (N2), and (N6), with risk percentages of 77.08%, 75.00%, 75.00%, 72.92%, 68.75%, 77.08%, 85.42%, 72.92%, 79.17%, 83.33%, 62.50%, 66.67%, 85.42%, 75.00%, 77.08%, 75.00%, 75.00%, 79.17%, 72.92%, 75.00%, 75.00%, 70.83%, 62.50%, 70.83%, 68.75%, 77.55%, 83.33%, 83.88%, 85.42%, 83.33%, 68.75%, 75.00%, and 77.08%.

3. Based on the results of risk mapping to determine the risk level through the Probability and Impact Matrix, namely:
   a. In the seed nursery process, it is known that there are 2 medium risk agents, namely risk agents 1 and 5, high category risk agents consist of risk agents 2, and 4, extreme risk agents in risk agent 3.
   b. In the biofloc pond preparation process, it is known that there are 3 medium risk agents, namely risk agents 1, 3, and 4, high category risk agents consist of agents 2 and 8, and extreme risk agents, namely 5, 6, and 7.
   c. In the biofloc application process, it is known that there is 1 medium risk agent, namely risk agent 6, high category risk agents consist of risk agents 1,2, and 5, dominant risk agents in the extreme category, namely risk agents 3 and 4

d. In the seed spreading process, it is known that there are 2 medium risk agents, namely risk agents 1 and 5, high category risk agents consist of risk agents 2, 3, and 4, and extreme risk agents in risk agent 6.
e. In the feeding process, it is known that there are 4 medium risk agents, namely risk agents 1, 3, 4, and 5, while high category risk agents consist of risk agents 2 and 6.
f. In the water quality management process, it is known that there is 1 low risk agent, namely risk agent 10. For medium category risk agents, namely risk agent 9, while high category risk agents consist of risk agents 1, ,2, 5, 7, and 8, and extreme risk agents are found in risk agents 3, 4, 6, and 11.
g. In the harvest and post-harvest process, it is known that there are 6 medium risk agents, namely risk agents 1, 3, 4, 5, and 8. For extreme category risk agents, they consist of risk agents 2 and 7.

4. Based on the results of the discussion of risk mitigation actions through Focus Group Discussion (FGD) with 3 resource persons. It is known that there are 13 risk agents in the extreme or very high category and 9 priority risk mitigation actions have been determined which represent all stages of the tilapia Aquaculture process using the biofloc system.

Suggestion

Based on the research results, the researcher provides several suggestions as follows:

1. Biofloc tilapia farmers should take priority risk mitigation measures to be implemented immediately. The main overall things that need to be considered are the construction of a permanent roof so that all activities do not depend on temperature and weather, control of channels and aeration machines, anticipation of electrical power outages, quarantine and acclimatization of seeds, management of water quality, and fish density in the pond.
2. Farmers are advised to install an electrical detector alarm or alarm system to detect reduced oxygen content in the pond due to a detached aeration channel. Both of these tools can be found in online and offline electrical equipment stores.
3. Farmers are advised to switch from using different floc materials (molasses, probiotics, additional bacteria) to using 1 Prebiomix which contains bacteria, molasses and other organic decomposing materials.

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