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File name:	45_Ars_Boletin_de_Literatura_Oral.pdf
File size:	384.32K
Page count:	12
Word count:	6,354
Character count:	34,139
Submission date:	03-May-2024 10:53AM (UTC+0700)
Submission ID:	2369510781

Boletín de Literatura Oral

BOLETÍN DE LITERATURA ORAL, 11 (2024), PP. 455-465

The Production and Income Risk Analysis of Traditional Milkfish Pond in Sidoarjo, Indonesia: A Seasonal Perspective

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ABSTRACT:
The research aims to analyze production and income along with its risks in milkfish pond cultivation during the rainy season and dry season. The research was conducted in Jabon District, Sidoarjo, Indonesia. Primary data was taken from interviews with 62 farmers of milkfish pond. Income analysis was carried out using quantitative descriptive methods, while risk analysis was carried out using the Coefficient of Variation (CV) from the production and income of milkfish cultivation businesses in both rainy and dry seasons. The results show that the average expected value of milkfish production in the rainy season is 747 Kg/Ha, while in the dry season is 474 Kg/Ha. The average expected income value in the milkfish pond business is IDR 9,980,956/Ha in the rainy season, and IDR 7,569,411 in the dry season. This study found that the risk level for milkfish production is low in the rainy season and vice versa in the dry season. However, the risk level for milkfish farming business income is high in both seasons. These findings indicate that milkfish pond farmers need to consider more intensive risk management strategies, especially during the dry season. Practical implementations can be drawn that entails the development of business diversification strategies, increasing resilience to extreme weather conditions, and the implementation of technology that reduce production and income risks.

KEYWORDS: income risk, milkfish pond, production risk.

Introduction

As a staple food in many coastal communities that plays a pivotal role in the global seafood market, milkfish *(Chanos chanos)* production has significant economic and nutritional importance (Norman et al., 2019). In Sidoarjo, Indonesia, milkfish ponds are an important business in the field of aquaculture with large production. Besides being marketed fresh, milkfish has also been marketed as processed products, involving small and medium businesses (Sukoso et al., 2022).

In the aquaculture business, sustainable and profitable cultivation of fish species depends on various factors (Agusanty et al., 2021; Aung et al., 2023; Ottinger et al., 2022). Seasonal production variations, indeed, determine the income of pond farmers. This present study explores the complex dynamics of milkfish production through a meticulous examination of the associated risks and financial implications during the rainy and dry seasons in Indonesia.

The contrast between the rainy and dry seasons raises several challenges and opportunities for milkfish farmers in Sidoarjo, Indonesia. This condition calls for a comprehensive analysis prior to adaptive strategies. This present study seeks to reveal the level of risk affecting milkfish farming, including variations in production and income earned from cultivating this fish species.

Concurrently, milkfish production fluctuates quite a bit over time or between different seasons (Lee et al., 2022; Olivia et al., 2022). Fish products in Diyala Governorate, Iraq, reach around 6.5

ISSN: 2173-0695

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Submission date: 03-May-2024 10:53AM (UTC+0700)
Submission ID: 2369510781
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Word count: 6354
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tons/ha/season (Alobaidy & Jbara, 2021), or around 2 tons/day. Meanwhile, the production of other types of fish such as *lemuru,* is influenced by the weather (Rizkina et al., 2023). Milkfish production also varies (Olivia et al., 2022), indicating a production risk in its cultivation business. However, limited research on production-level risk analysis has been documented, including those focus on the differences between the rainy and dry seasons.

Production risk is the margin between the expectation of maximum production and actual production (Shanta et al., 2019). Sources of production risk include low productivity, crop failure, disease attacks, climate and weather differences, and human error. Production risks can be caused, among other things, by fish mortality (Wanja et al., 2020).

Along with the complex dynamics in the milkfish farming business, risk management has become a crucial aspect in ensuring the sustainability and stability of farmers' income. It is an important step in assessing uncertainty that may be faced in the production and income of a farm business (Biagini et al., 2022; Ivanov & Atanasov, 2023). One method commonly used in risk analysis is the Coefficient of Variation (CV) approach. The CV approach provides an idea of the relative level of variability of data, such as production or income. In the context of milkfish farming, CV approach provides deeper insight into the extent of the influence of fluctuation on business results. In particular, the results of risk analysis using the CV approach offer a more detailed view of the risks faced by milkfish pond farmers, so that effective risk management strategies can be designed to reduce the potential impact of these uncertainties (Supriyadi, Abdillah, et al., 2022).

Consequently, financial risks arise in the presence of production risks (Klapper et al., 2019) including the risk of farm business income. Financial risks in milkfish farming businesses pose more complex factors than production risks. Several complex factors involve external and internal aspects that can influence the welfare and continuity of the business (Mardi & Siregar, 2021; Rascón & Posada Velázquez, 2019). Besides being influenced by climate and weather, income risk also depends on market price fluctuations. In this case, milkfish price can experience significant fluctuations in the market. Other factors such as market demand, season, and competition can also influence fish prices (Yildiz et al., 2023).

Several studies have been conducted on milkfish farming, including the large profit of cultivation business (Agusanty et al., 2021; Lee et al., 2022; Zulma et al., 2023). In Muna, Indonesia, cultivation income earned per farmer during the COVID-19 pandemic reached more than IDR 6,000,000 (Zulma et al., 2023). This price was also affected by socio-economic factors and the price of fish feed (Omeje et al., 2021).

Accordingly, income risk is not only caused by ups and downs in production, but also by fluctuating production costs and fish selling prices (Lee et al., 2022; Purwaningsih & Hermawan, 2021). In terms of attitudes towards risk, 25% of pond fish farmers are willing to take risks, while the remaining 53% chose neutral or moderate risk, and only 22% prefer to avoid risks (Alobaidy & Jbara, 2021). Of course, the level of production and income risk varies between seasons. Differences between seasons have been studied, with the results of variations in fish production and income. However, comparisons of production and income between seasons have not been studied in milkfish farming. Differences in production due to the influence of the winter season occured in Egypt (Maher, Azab, Radwan, & Husein, 2023); another study revealed comparison between seasonal ponds and annual ponds, in which annual pond production was better despite its less significance compared to seasonal ponds (Mustafa et al., 2019); and many valuable fish production in winter experiences death (Maher, Azab, Radwan, & Abu Husein, 2023). These studies similarly show that different seasons pose different risks. In Indonesia, there is a need to study the differences between the rainy season and the dry season.

This present study offers novelty through the analysis of production risks and income of milkfish pond cultivation businesses in the rainy and dry seasons. The research objectives are: 1) to analyze the production and income of traditional milkfish pond cultivation in the rainy season and dry season; and

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2) to analyze production and income risks in traditional milkfish pond cultivation during the rainy season and dry season.

By exploring the nuances of seasonal variation, results of this study are expected to contribute valuable insights to the aquaculture community, policymakers, and researchers. Our results are anticipated to assist stakeholders in developing targeted risk management strategies, optimizing production practices, and driving sustainable growth in the milkfish industry. As we begin this exploration of risk analysis in the context of milkfish production, we endeavour to provide a foundation for informed decision-making, promoting resilience and prosperity in the face of seasonal uncertainty.

Research Method

The research was conducted from May to July 2023 in Jabon District, Sidoarjo, Indonesia. Sidoarjo is an area in East Java famous for pond cultivation, especially milkfish. Primary data was taken from 62 respondents from traditional milkfish pond farmers. The samples were determined purposively, with the criteria of pond cultivation in the rainy season without feeding, and seaweed-feeding in the dry season. Data collection was carried out using interview techniques with pond farmers and field observations (Balińska, 2020), taking into account pond cultivation activities and the socio-economic situation of pond farmers.

Data for the first research question was analyzed using a quantitative descriptive method, through the calculation of the volume of milkfish production by converting data per area in Ha. Meanwhile, the second research question was answered by analyzing the CV of milkfish products in both rainy and dry season. Milkfish farming business income is analyzed from the difference between the value of production revenue minus farming costs. The level of income risk was also analyzed from the CV of milkfish farming income in both rainy and dry seasons. The CV production formula is calculated by dividing the standard deviation of production by average production (Sd/E.Prod) (Amdouni et al., 2017; Syabandina & Suliadi, 2023), where SD is the standard deviation, and E.Prod is the average production value; Income CV is formulated with Sd/E. Income, where SD is the standard deviation, and E.Income is the average value of income (Alobaidy & Jbara, 2021; Supriyadi, Sari, et al., 2022).

Results and Discussion

Production and income of milkfish pond cultivation

Milkfish ponds are one of the fisheries activities with an important role in supporting the community's economy (Annaja et al., 2022). Milkfish cultivation at the research site is carried out throughout the year, with a production cycle of six months. The production cycle will go through a rainy season and a dry season, as the seasonal cycle in tropical areas, including Indonesia.

Milkfish pond production is not only influenced by technical factors, but is also closely related to weather conditions, including the rainy and dry seasons (Lopes et al., 2020; Nzilu et al., 2023). In the rainy season, milkfish pond production tends to increase due to more abundant water and temperatures suitable for fish growth. On the other hand, the dry season makes milkfish pond production tends to decrease drastically due to limited water availability and suboptimal temperatures. This impact is reflected in the income of the milkfish pond business as income is much lower due to decreased production in the dry season. Table 1 shows the average results of production and income from milkfish farming businesses, compared respectively between the rainy season and the dry season.

Table 1. Production and income of milkfish farming business

Notes	Rainy season	Dry season
Production (Kg/Ha)	693	348
Standard deviation	367	219
Income (IDR/Ha)	9,989,867	4,970,204

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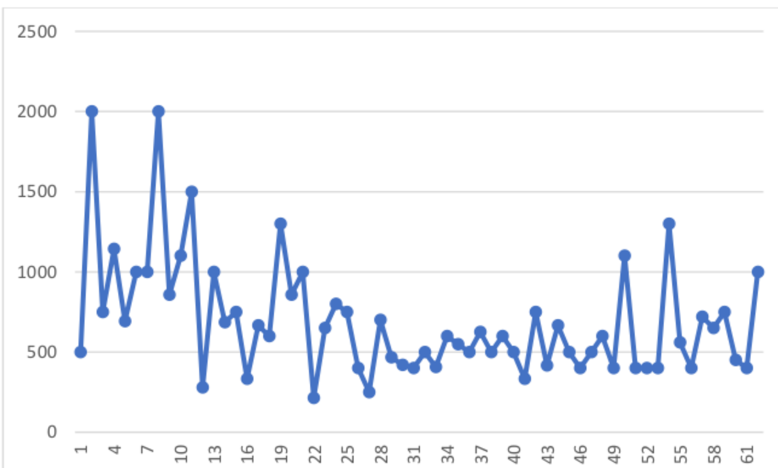
Standard deviation	6,474,255	3,762,963

Source: Primary data analysis.

Milkfish pond production shows significant variations between the rainy and dry season. In the rainy season, milkfish pond farmers achieved an average production of 693 Kg/ha, illustrating environmental conditions that support optimal fish growth. As the opposite, average production decreased sharply to 348 Kg/ha in the dry season. Both average values are accompanied by quite large SD, reflecting a high degree of variability in production output. A large SD is the main cause of production risk in milkfish farming businesses due to several factors, namely, fluctuations in water temperature, feed availability, and varying water quality, which could contribute significantly to unstable production results (Lopes et al., 2020). This seasonal production risk was also discovered by previous research on *lemuru* fish, thereby affecting the smooth supply chain (Rizkina et al., 2023). An in-depth understanding of the factors that cause variability and risk management is the key to increasing the sustainability of milkfish farming businesses.

Fluctuations in milkfish pond production per hectare in the rainy season are presented in Graph 1, and fluctuations in the dry season are presented in Graph 2. The difference between both graphs lies in the lower and upper limits, as well as the contrast or difference in productivity between farmers. The lower and upper limits of production per hectare in the rainy season are 509 Kg and 876 Kg, respectively, with an average production per hectare of 693 Kg. In the dry season, the lower limit and production limit per hectare are 238 Kg and 457 Kg, respectively, with an average production per hectare of 348 Kg.



Graph 1. Fluctuations in milkfish pond production in the rainy season (Kg/Ha)

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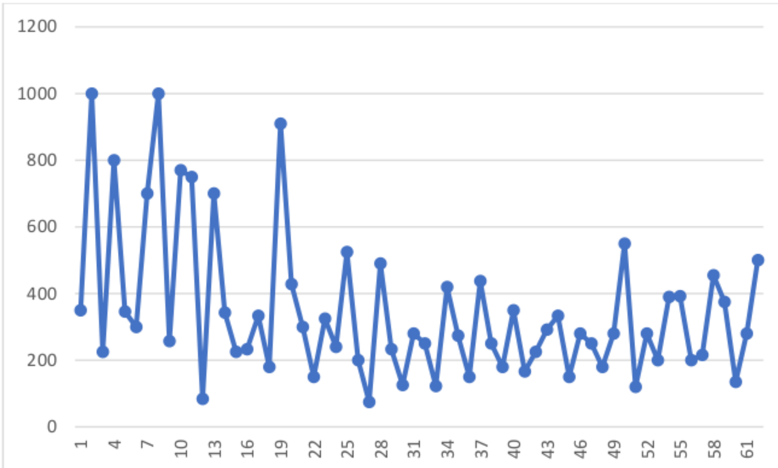


Graph 2. Fluctuations in milkfish pond production in the dry season (Kg/Ha)

From the data presented in Graph 1 and Graph 2 on the fluctuations in milkfish pond production per hectare, it is readily apparent that the rainy and dry seasons have different characteristics. In the rainy season, the lower limit of production per hectare (509 Kg) showed that even in the worst conditions, farmers were still able to achieve relatively high production figures. The upper limit of production per hectare (876 Kg) also indicated a great potential to increase the productivity of milkfish ponds in the rainy season.

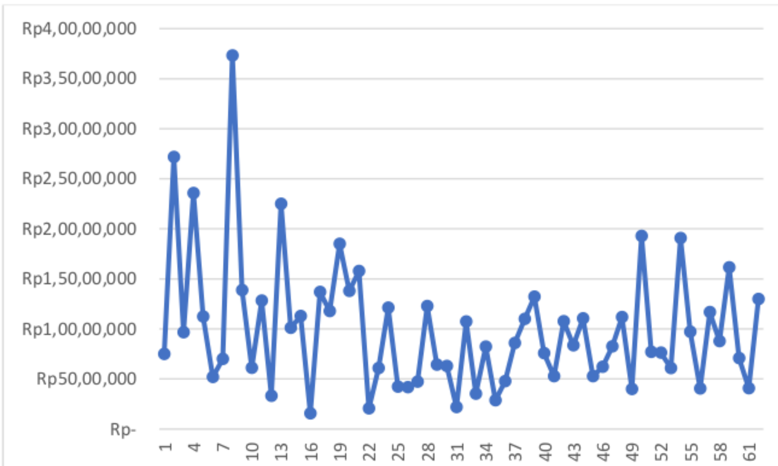
Meanwhile, in the dry season, the lower limit of production per hectare (238 Kg) posed greater challenges in achieving adequate yields. This lower floor predicted factors, such as dry weather and water availability, were significant constraints. However, the upper limit of production per hectare (457 Kg) in the dry season still provided opportunities for increasing productivity, although not as potential as observed in the rainy season.

The difference in the average value of production per hectare between the rainy season (693 Kg) and the dry season (348 Kg) reflected a much higher level of productivity in the rainy season. This contrast might be caused by several factors, for instance, more stable water temperatures, better food availability, and other environmental conditions that support the growth of milkfish (Primo et al., 2021; Zhang et al., 2022).

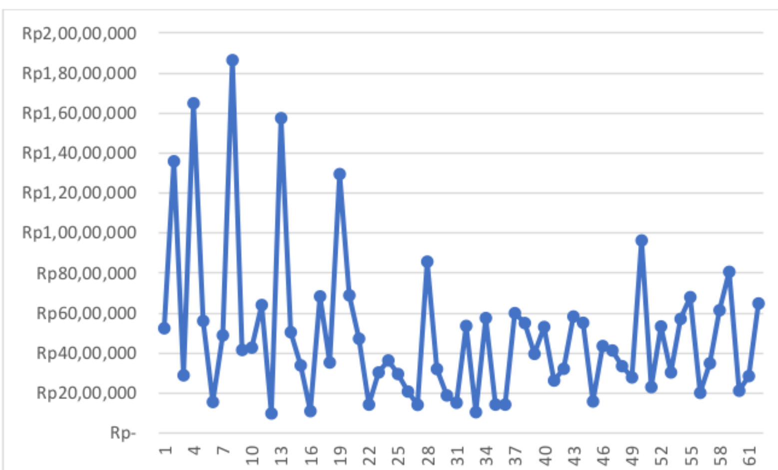
Concurrently, production fluctuations in the milkfish farming business caused direct consequences for income fluctuations. Uncertainty in production creates instability in milkfish farming business income (Harkness et al., 2023), considering that income is directly related to the number of fish successfully produced. Fluctuations in fish prices also affect the income of fish farms. Thus, analysis of income fluctuations in the rainy and dry seasons is essential to gain a holistic understanding of the economic dynamics of milkfish ponds and to design effective risk management strategies in facing varied production challenges.

Milkfish farming business income showed a striking disparity between the rainy and the dry season (Table 1). During the rainy season, milkfish pond farmers managed to achieve an average income of IDR 9,989,867/ha, reflecting conditions that support high productivity. On the other hand, during the dry season, average income dropped drastically to IDR 4,970,204/ha. Both mean values were accompanied by a large SD, indicating a significant level of variability in milkfish farming business income. A high SD is the main factor causing income risk due to factors such as fish price fluctuations, changing production costs, and other environmental factors, which can have a big impact on pond farmers' income (Novickytė, 2018; Rosa et al., 2019). The visualization of income fluctuations is presented in Graph 3 and Graph 4.

The average income value per hectare reached IDR 9,989,867, with a lower limit of IDR 6,752,740 and an upper limit of IDR 13,226,995. The average income value was lower than milkfish ponds combined with mangroves in silvofishery cultivation (Harefa et al., 2022). Meanwhile, during the dry season, the average income was IDR 4,970,204, with a lower limit of IDR 3,088,723 and an upper limit of IDR 6,851,686. These results showed a significant difference in the value of milkfish farming business income between the rainy and the dry season. In the rainy season, the average income per hectare reached IDR 9,989,867, with a lower limit of IDR 6,752,740 and an upper limit of IDR 13,226,995. This figure reflected the high productivity and income potential achievable in the rainy season, where more stable environmental conditions and adequate feed availability contributed to better yields. On the other hand, in the dry season, the average income per hectare decreased to IDR 4,970,204, with a lower limit of IDR 3,088,723 and an upper limit of IDR 6,851,686. These fluctuations reflected the economic challenges faced by milkfish pond farmers in the dry season, where lower production directly affected their income, as also found in previous studies (i.e., Aung et al., 2023; Duarah & Mall, 2020; Omeje et al., 2021; Ottinger et al., 2022).



Graph 3. Fluctuations in income of milkfish pond farmers in the rainy season (IDR/Ha)



Graph 4. Fluctuations in income of milkfish pond farmers in the dry season (IDR/Ha)

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A comparison of fluctuations in milkfish pond income between the rainy season (Graph 3) and the dry season (Graph 4) reveals striking differences. The graph shows that income fluctuations in the dry season were much sharper than in the rainy season. In the rainy season, variations were seen to be more controlled, with a more stable income curve throughout the period. In contrast, in the dry season, the income curve shows larger and deeper fluctuations, indicating higher instability in milkfish farming business income. Factors such as low production due to dry weather, limited feed availability, and unfavorable environmental conditions appear to have contributed significantly to these sharp fluctuations (Fancourt et al., 2018).

Prodcution risks and income in milkfish pond production

To further understand and manage risks in milkfish farming businesses, Table 2 is presented to display the results of production and income risk analysis using CV analysis. This analysis provides a more detailed picture of the relative level of variability of production and income data in milkfish ponds (Syabandina & Suliadi, 2023). Through this table, we can identify the extent to which fluctuations can affect the consistency of business results, providing information essential for the planning and implementation of effective risk management strategies. Referring to the results of CV analysis, business actors can make more precise and responsive decisions to changes in market and environmental conditions, thereby increasing the resilience and sustainability of milkfish farming businesses amidst complex dynamics.

Table 2. Production and income risk level with Coefficient of Variation (CV)

Description	Rainy season	Dry season
Expected Production (Kg/Ha)	747	474
Standard of deviation (Kg/Ha)	329	249
Coefficient of Variation (CV)	0.4405	0.5249
Percentage of risk	44.05	52.49
Expected Income (IDR/Ha)	9,980,956	7,569,411
Standard of deviation (IDR/Ha)	5,558,797	4,859,110
Coefficient of Variation (CV)	0.5569	0.6419
Percentage of risk	55.69	64.19

Source: Primary data analysis.

Table 2 shows the results from CV value calculation for the expected production of milkfish ponds during the rainy season of 747 Kg/Ha. This number was higher than the actual average production value of 693 Kg/Ha. The figure reflects a significant degree of variability in production over the period. This is in line with the notion that a relatively high CV indicates production fluctuations greater than average, showing a higher potential risk in achieving production targets (Cox & Sadiraj, 2011).

With the expected value of milkfish production of 474 Kg/Ha during the dry season, there was a significant decrease compared to the production achieved during the rainy season, which reached 747 Kg/Ha. These differences might reflect the impact of dry weather and different environmental conditions during the dry season, which can affect fish growth and health. Indeed, factors such as higher water temperatures, limited feed availability, and other environmental stresses can cause decreased production (Fancourt et al., 2018).

Table 2 presents the CV figures for milkfish pond production during the rainy and dry season. The results show that during the rainy season, the CV of production is 0.4405 or the equivalent of a risk percentage of 44.05%, classified as low risk. This indicates a relatively high level of production stability during the rainy season. On the other hand, in the dry season, the CV increased to 0.5249, reflecting a risk level of 52.49%, included in the high-risk category. The decrease in production stability during the dry season can be attributed to weather and environmental factors which were more unpredictable and harming milkfish production. Even so, this level of risk was relatively low compared to the production risk of ornamental fish (CV=1.05) (Supriyadi, Sari, et al., 2022), and also

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lower than the risk of fish production in ponds in Iraq which reached 0.64 or 64% (Alobaidy & Jbara, 2021).

Based on the results, significant fluctuations are prevalent in the expected value of income between the rainy and dry seasons. In the rainy season, the expected income value reached IDR 9,980,956; while in the dry season, it decreased to IDR 7,569,411. Interestingly, both show quite high SD, indicating a significant degree of variation from the mean values. The presence of a high SD indeed reflects the high risk of income in the milkfish farming business (Syabandina & Suliadi, 2023). This may be caused by factors such as climate fluctuations, feed availability, or other factors that influence pond production.

The analysis results in Table 2 present the CV value of the milkfish farming business income of 0.5569, equivalent to a risk level of 55.69%. These results illustrate that there was a fairly large level of variation in the overall income of milkfish farming businesses. The high level of risk reflects the potential for significant risk in managing this business. Interestingly, during the dry season, the income risk level increased to 64.19%, indicating a more susceptible period to fluctuations and uncertainty, which can affect the income of milkfish ponds. Therefore, further efforts are needed to manage risk during the dry season, including careful planning, business diversification, or implementing risk management strategies to reduce the impact of fluctuations and maintain financial stability in the long term.

Our data analysis also found that the overall risk of income in the milkfish farming business was high. There is an interesting comparison between income and production risk, in which income risk showed a higher level compared to each production risk. This indicates that income fluctuations had a more significant impact on the financial stability of milkfish farming businesses than risks associated with production. In addition, it appeared that the risk of income in the dry season was higher than in the rainy season. Larger deviations in income during the dry season might mean that external factors affecting income, such as weather conditions or market demand, could be unpredictable and detrimental during that period. These findings support the results of previous research that water management affects efficiency and income in pond cultivation (Iliyasu & Mohamed, 2016; Omeje et al., 2021). Therefore, careful risk management and adaptation strategies during the dry season can be the key to reducing the negative impact of income fluctuations and maintaining the continuity of milkfish farming businesses (Thokchom et al., 2023).

In Sidoarjo, the pond farmers have mitigated risks by diversifying their business. In the dry season, farmers also cultivate seaweed besides milkfish, as a form of business diversification. Besides being sold, some of the seaweed production is also used as milkfish feed, showcasing their ability to perform a circular economy.

The decision of pond farmers in Sidoarjo to diversify their business, especially by adding seaweed cultivation during the dry season, reflected a smart strategy for risk management. Business diversification is a significant step, especially considering the high risk of the dry season affecting milkfish production (Sène-Harper et al., 2019). In this case, seaweed cultivation as an alternative business not only aims to diversify sources of income, but is also an innovative solution in overcoming the risk of milkfish feed shortages that may occur due to seasonal conditions. The sale of seaweed production also has a positive impact on farmers' income, which can help offset the potential decline in income from milkfish cultivation during the dry season.

Conclusion

The results of this present study reveal that traditional milkfish farming businesses in the region have significant risk characteristics, especially during the dry season. The risk of milkfish production in the rainy season is low, but increases significantly in the dry season. Likewise, income risk tends to be high in both seasons. Farmers and related stakeholders thus must be aware of and acknowledge the importance of effective risk management in supporting the sustainability of milkfish farming businesses. In addition, collaboration between farmers or consultation with agricultural experts and

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related stakeholders can be a practical step in designing more effective risk mitigation measures. Our findings can serve as a basis for the development of policies that support the local agricultural sector and the formation of practical strategies to increase farmers' resilience to seasonal fluctuations and external risks.

In the context of differences in productivity between farmers, it is noteworthy that greater fluctuations in production during the rainy season may indicate variations in the abilities and strategies used by farmers. Therefore, further research can be carried out to identify factors that contribute to differences in productivity between farmers in the two seasons.

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