



## **Qualitative Analysis of Risk Management in Palm Sugar Production: A Case Study of Farmers in Gunung Tua Pandapotan Village**

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### **Abstract**

This study aims to analyze the risk management practices in palm sugar production among farmers in Gunung Tua Pandapotan Village. Palm sugar farming is an important rural economic activity, but farmers face various uncertainties that may affect production sustainability and income stability. This research employed a qualitative descriptive approach to explore the types of risks and mitigation strategies experienced by farmers. Data were collected through interviews, observation, and documentation involving 10 informants consisting of palm sugar farmers and related local actors. The analysis followed the interactive model of Miles and Huberman, including data reduction, data display, and conclusion drawing. The findings reveal two major categories of risk: production risk and marketing risk. Production risks mainly arise from climate change, pest attacks, and fluctuating sap productivity, while marketing risks are associated with unstable prices and farmers' dependence on middlemen. These risks are closely interconnected and may reinforce each other's negative impacts on farmers' income. To address these challenges, farmers apply several risk mitigation strategies, including risk avoidance, risk reduction, risk transfer, and risk acceptance. This study provides empirical insights into local risk management practices among palm sugar farmers.

**Keywords:** Risk Management, Economic Impact, Palm Sugar, Farmers, Marketing

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### INTRODUCTION

Agriculture plays a highly strategic role as one of the main pillars of economic development in many developing countries, including Indonesia. In addition to providing food and raw materials for industry, this sector also serves as the primary source of income for approximately 28% of Indonesia's population working in the agricultural sector (Statistik, 2023). Agriculture also performs important social and ecological functions in maintaining the balance of rural development, reducing economic disparities, and preserving the environment (Tobing et al., 2023).

Agricultural enterprises in various regions of Indonesia continue to face increasingly complex challenges. Market globalization has intensified competitive pressures and contributed to greater fluctuations in commodity prices (Rai & Faisal, 2022). Climate change has had a tangible impact on agricultural production, such as declining yields due to extreme weather conditions, more frequent pest and disease attacks, and shifts in planting seasons (Hartono, 2023). In addition, farmers' limited access to appropriate technology, production inputs, and agricultural financing often becomes a barrier to improving productivity and product quality (Wulandari & Fadila, 2024).

Therefore, the implementation of structured risk management has become increasingly important as a strategy to adapt to and mitigate such uncertainties (Setiyowati, 2025). Agricultural risk management practices, including crop diversification, access to insurance schemes, and adoption of resilient farming techniques, have been shown to enhance farmers' capacity to cope with production uncertainties and market fluctuations (Komarek et al., 2020) (Arndt et al., 2020).

The Indonesian government has promoted the strengthening of the competitiveness of local agricultural commodities through various development policies and programs, including the promotion of regionally distinctive commodities based on local wisdom (Harahap dan Harahap, 2024). Palm sugar not only has economic value as a source of income for farmers but also holds cultural significance as part of Indonesia's culinary heritage (Effendi et al., 2023). Demand for natural sweeteners has tended to increase in both domestic and international markets, in line with the growing trend of health-conscious consumption among consumers (Bagus, 2023).

One of the regions with considerable potential for palm sugar production is Gunung Tua Pandapotan Village in South Tapanuli Regency. This village is recognized as a producer of traditional palm sugar with a distinctive taste and relatively good quality. Palm sugar production has long been part of the local livelihood system and contributes significantly to household income in rural communities.

However, this potential has not been fully optimized due to various structural and non-structural constraints. Farmers face limited infrastructure, such as inadequate roads and transportation facilities, which result in higher distribution costs and restricted market access (Lestari et al., 2025). Limited business capital also hinders the modernization of production equipment and innovation, while dependence on traditional processing techniques



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contributes to low production volume and product quality. Furthermore, farmers face external risks, including market price fluctuations, pest and disease attacks, and the increasingly unpredictable impacts of climate change (Daga & Samad, 2022). Risk management is therefore essential for micro, small, and medium enterprises (MSMEs) as it helps anticipate and minimize potential losses that may threaten business sustainability (Yudha et al., 2023).

Previous studies have highlighted the importance of systematic risk management among MSMEs. For example, Bakri et al., (2022) examined risk management among palm sugar farmers in Mangkanawi Village and found that the main risks included production risks related to sap and palm trees, cost risks, price and marketing risks, and income risks. Their risk mitigation strategies included renting palm trees, product diversification (for example, processing sap into palm wine), and intensive cultivation practices. Similarly, (Sari et al., 2020), in a study conducted in Lebak Regency, Banten, analyzed production and income risks faced by palm sugar producers using the coefficient of variation and standard deviation methods.

The results indicated a relatively high production risk with a coefficient of variation of 26% and an income risk reaching 43.7%, leading to the recommendation of optimizing input use to reduce risk. Furthermore, (Widyantara, 2019) investigated the production risk of molded palm sugar in Belimbing Village using a quantitative approach and found that the experience of producers and the volume of sap significantly influenced the level of risk, indicating that training and knowledge transfer are important strategies.

Despite these findings, a significant research gap remains, particularly the limited number of studies focusing specifically on risk management in the palm sugar commodity, especially at the local level such as in Gunung Tua Pandapotan Village. Previous studies generally adopt a broader scope or focus on other agricultural commodities, thereby failing to fully capture the specific challenges encountered by palm sugar farmers in this area. Moreover, limited research has documented in detail the types of risks faced by farmers, the frequency and impact of these risks on production and household income, as well as the strategies implemented by farmers to mitigate such risks. A contextualized local approach is therefore necessary to generate insights that are both empirically grounded and practically relevant for strengthening the sustainability of palm sugar farming.

Previous research has highlighted that localized studies are essential for understanding the specific risk dynamics faced by smallholder farmers, as risk exposure and adaptive capacity often vary significantly across regions and socio-economic contexts (Caputo & Lusk, 2022). Therefore, this study aims to analyze the risks faced by palm sugar farmers and to examine the risk management strategies applied in palm sugar production in Gunung Tua Pandapotan Village, South Tapanuli Regency. In addition, this study seeks to explore how these risks affect production activities and farmers' livelihoods, as well as to identify potential strategies that may enhance the resilience and sustainability of palm sugar farming in the region.

To achieve these objectives, this study addresses the following research questions:



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1. What types of risks are commonly faced by palm sugar farmers in Gunung Tua Pandapotan Village, particularly in relation to production, marketing, and financial aspects?
  2. How frequently do these risks occur, and what impacts do they have on production and farmers' income?
  3. What strategies do farmers employ to manage or mitigate these risks?
  4. How do institutional factors, such as farmer groups or cooperatives, contribute to supporting risk management practices?
  5. What potential measures can be implemented to improve the resilience and long-term sustainability of palm sugar farming in the study area?

## THEORETICAL FRAMEWORK

### Risk Identification

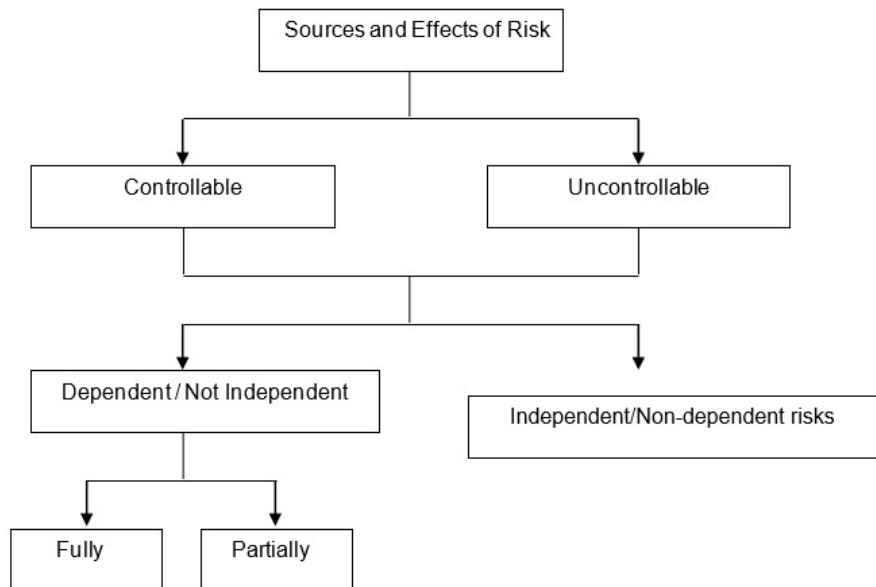
According to Roger Flanagan and George Norman in (Tambunan, 2024), risk can be identified through three main components: its source, the event, and the resulting effect. The relationship among these three components can be illustrated as shown in Figure 1.



**Figure 1**  
**Risk Identification Process**

Based on Figure 1, it can be explained that the first step is to clearly identify the source of the risk, followed by the event or occurrence, and finally the effect or impact resulting from the risk.

The risk identification stage is considered the most difficult and most crucial stage in risk management (Tobing et al., 2023). This difficulty arises from the inability to identify all potential risks that may occur due to the inherent uncertainty of future conditions. Therefore, in identifying risks, it is necessary to first attempt to determine the sources of risk and their potential effects in a comprehensive manner. One method for conducting risk identification, according to Roger Flanagan and George Norman, can follow the sequence of steps illustrated in Figure 2.



**Figure 2**  
**Steps in Risk Identification According to Flanagan and Norman**

In the context of agricultural production such as sugar palm farming, risk sources often encompass climatic variability, pest or disease outbreaks, price volatility, and labor availability. Farm-level studies indicate that farmers systematically identify such risk sources using checklists and expert consultations to anticipate production and market uncertainties (Rosdian et al., 2026)..

In the agribusiness context, including smallholder sugar palm farming and home-based sugar production, risks may emerge from multiple sources, such as instability in sap

supply, climate fluctuations, and marketing challenges throughout the value chain from tappers to final producers. Recent research on the sugar palm supply chain in Besan Village demonstrates that raw material supply and product quality risks are distributed across all actors (tappers, processors, collectors, and retailers), making multi-level risk identification critical for anticipating production and distribution risks (Arilaksmi et al., 2026).

Controllable sources of risk are categorized as risks that can be managed and remain under the influence of management, whereas uncontrollable risks represent the opposite condition. In sugar palm farming, controllable risks include labor practices, irrigation management, and production scheduling, while uncontrollable risks involve extreme weather events or sudden market price fluctuations. Some risks are interdependent; for example, inadequate irrigation (controllable) may exacerbate the effects of drought (uncontrollable), highlighting the need for integrated assessment across risk sources (Shi & Wang, 2022; Duong et al., 2019)

### **Risk Analysis**

According to Jacques (Derrida et al., 2015) , systematic risk analysis can help identify, assess, and rank risks clearly, focus attention on major risks, clarify decisions regarding acceptable loss limits, minimize potential damage in worst-case scenarios, control aspects of uncertainty, and define the roles and responsibilities of individuals or organizations involved in risk management.

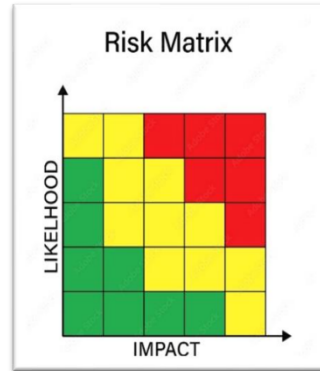
The objective of risk analysis and risk management is to help avoid failure and provide an overview of potential outcomes if an investment or activity does not proceed as planned. Risk analysis can be conducted using either qualitative or quantitative approaches. Qualitative analysis focuses on identifying and assessing risks, while quantitative analysis focuses on evaluating the probability of risk occurrence. In this process, sources of risk must be identified and their potential effects must be assessed or analyzed.

According to the Project Management Institute through the A Guide to the Project Management Body of Knowledge (PMBOK Guide), qualitative risk analysis is defined as a process of assessing the likelihood and impact of identified risks. This process prioritizes risks based on their potential consequences for the objectives of a project. The inputs required for conducting qualitative risk analysis include the risk management plan, identified risks, project status, project type, relevant data, probability and impact scales, and established assumptions. The techniques used in qualitative risk analysis include determining the probability and impact of each risk, evaluating these probabilities and impacts using an assessment matrix, testing the assumptions underlying risk identification, and ranking risks once the relevant data have been considered sufficient. Through this analytical process, several important outputs can be obtained, including the overall ranking of risks within a project, a prioritized list of risks requiring immediate attention, a list of risks requiring further analysis or management, and general trends identified from the qualitative risk analysis (Project Management Institute, 2017).

### **Risk Evaluation**

Evaluation is a process undertaken to determine how well the risk management approach aligns with the planned objectives. According to Marcal, Tommy, and Nasution (2022), risk management evaluation should include systematic identification, mitigation, and control strategies to maintain the operational continuity of organizations amid complex threats. Risk evaluation serves as a guideline for determining appropriate actions and identifying necessary solutions when a problem occurs.

Risk evaluation can be presented in the form of a matrix. A risk matrix is a tool used to assess the effectiveness of risk management practices and to enhance organizational awareness and clarity in dealing with potential risks. The matrix helps identify risks that require immediate responses based on the combination of likelihood scores and risk impact scores, as described below.



**Figure 3. Likelihood–Impact Matrix**

Figure 3 illustrates a matrix of probability (likelihood) and impact used to determine the magnitude of risk through the combination of probability and impact levels. This matrix reflects management’s attention to the handling of potential risks. The explanation of the color categories in risk levels can be described as follows. Low risk (dark green) represents an acceptable level of risk and does not require additional control measures, although monitoring is still necessary to ensure that existing control actions function effectively. Moderate risk (yellow) indicates that an activity should not be carried out until the risk has been reduced, thus requiring consideration of the resources that will be allocated for risk reduction efforts. If this category appears in an ongoing activity, immediate corrective actions must be taken. Meanwhile, high or extreme risk (red) indicates that an activity must not be carried out or continued until the risk has been reduced. If risk reduction is not feasible due to resource limitations, the activity should not be undertaken.

### **Risk Mitigation**

When risks arising from an activity have been identified, according to Roger Flanagan and George Norman (as cited in Harahap & Harahap, 2025)), the next step is to implement actions to reduce the identified risks. These actions are referred to as risk mitigation. While risks cannot always be completely eliminated, and some residual risk remains, appropriate mitigation strategies can reduce their likelihood and potential impact.

Mitigation strategies in the context of farming and agribusiness include production diversification, improved harvesting schedules, crop rotation, increased mechanization, and strengthening partnerships along the value chain. Recent research on the sugar palm supply chain in Bali highlights the importance of integrated strategies, such as mechanization of climbing tools, enhanced collaboration among actors, and quality-based pricing systems, to reduce critical risks across all actors (Arilaksmi et al., 2026). By applying these strategies, farmers and agribusiness managers can systematically address the most significant risks affecting production, supply continuity, and product quality, thereby enhancing the resilience and sustainability of sugar palm farming operations.

## RESEARCH METHODS

This study employs a qualitative method with a descriptive approach as the primary strategy for understanding the phenomena under investigation. The qualitative approach aims to comprehensively explore the experiences of research subjects, including their behaviors, perceptions, motivations, and actions within the context of their daily lives. The study is presented in a narrative form that represents social reality using relevant data collection techniques (Harahap, 2020). Descriptive qualitative design itself is rooted in the post-positivist paradigm and is commonly applied to research examining phenomena in natural settings, with the researcher serving as the primary instrument in the processes of data collection and interpretation (Badi, 2022). The selection of this approach is based on the consideration that it enables the researcher to obtain in-depth information directly from informants, thereby producing richer and more contextual understanding. The descriptive approach is considered appropriate for examining issues that require detailed explanations of particular situations or events.

This study specifically focuses on two main forms of risk faced by palm sugar farmers, namely production risk and marketing risk. Production risk includes uncertainties related to the quantity and quality of sap, the availability of raw materials, and disruptions in the tapping process. Meanwhile, marketing risk involves price fluctuations, dependence on intermediaries, and limited access to markets. The analysis of these two forms of risk constitutes the primary focus of this study in order to understand how farmers respond to and navigate uncertainties in their farming activities.

The research was conducted in Gunung Tua Pandapotan Village, Padang Bolak District, South Tapanuli Regency, North Sumatra Province. Research informants were selected using purposive sampling based on specific criteria: (1) being actively engaged in palm sugar farming, (2) having at least two years of experience in palm sugar production, and (3) being willing to participate in in-depth interviews. A total of 10 informants were included, comprising active palm sugar farmers, representatives of local farmer groups, village officials, agricultural extension officers, and market actors or palm sugar collectors. This number was deemed sufficient, and data collection continued until data saturation was achieved, meaning no new significant information emerged from additional interviews.

Data collection was carried out on 27 June 2025, using several techniques. In-depth interviews were conducted to explore farmers' perceptions regarding various types of risk, the resulting economic impacts, and the risk management strategies they employed. Each interview lasted approximately 45–60 minutes. In addition, the researcher conducted direct observations of the palm sugar production process, the condition of supporting facilities and infrastructure, and the distribution and marketing patterns. Additional supporting data were obtained through documentation, including production records, selling price data, and relevant documents from farmer groups.

Data were analyzed using the interactive analysis technique proposed by Matthew B. Miles and A. Michael Huberman (Milles et al., 2014), which consists of three main stages: data reduction, data display, and conclusion drawing and verification. In the data reduction stage, the researcher selected and simplified raw data according to the focus of the study. The data were then presented in the form of descriptive narratives, tables, or matrices to facilitate the identification of important patterns and themes. Finally, conclusions were drawn to address the research objectives and were continuously verified to ensure the validity of the findings.

To ensure data validity, this study employed several techniques, including source triangulation by comparing information obtained from farmers, collectors, and village authorities; member checking, which involves reconfirming findings and interpretations with informants; and peer discussion to obtain critical feedback and minimize potential researcher bias. Through this qualitative approach and case study method, the study is expected to generate an in-depth and contextual understanding of risk management and the economic impacts experienced by palm sugar farmers in Gunung Tua Pandapotan Village.

## **RESULTS AND DISCUSSION**

### **Results**

Based on information provided by the informants, the production capacity of palm sap per sugar palm tree shows considerable variation. Under minimum conditions, a single tree produces only around 5 liters of sap per day, while under typical daily production conditions the volume generally ranges between 20–30 liters. Under optimal conditions, when the tree is healthy and highly productive, the amount of sap collected can reach up to 60 liters per day. Although the marketing of palm sugar products still depends largely on middlemen, farmers are able to obtain a profit margin as long as they can produce at least 4 kilograms of palm sugar per day. This amount is considered the minimum threshold required to cover production costs and ensure a net profit for farmers. These findings indicate that the sustainability of farmers' income is strongly influenced by fluctuations in daily production and the limited marketing channels available.

Based on in-depth interviews, field observations, and document analysis, this study found that palm sugar farmers in Gunung Tua Pandapotan Village face two major categories of risk that significantly affect the sustainability of their business, namely production risk and marketing risk. Production risk occupies a crucial position because declining yields not only affect business continuity but also influence farmers' income and overall economic stability. The fluctuating and unpredictable nature of production risk makes it a factor that requires serious attention, particularly in maintaining consistent supply and product quality in the market. The study identified two dominant sources of production risk: extreme weather conditions and pest and disease attacks.

#### **1. Extreme Weather Threats**

Interviews with farmers indicate that the dry season now tends to last longer than usual, reaching up to five months per year. This prolonged dry period has become one of the main causes of reduced sap yield per palm tree. Under normal conditions, a palm tree can produce approximately 12 to 15 liters of sap per day. However, during extended dry seasons, the volume decreases significantly to only 7 to 9 liters per day. This decline directly affects total production and ultimately influences farmers' income. In addition, fluctuations in production results make the supply of raw materials for palm sugar processing unstable.

Extreme heat during the dry season also accelerates the natural fermentation process of palm sap, which reduces its quality and makes it less suitable for producing high-quality palm sugar. Conversely, during the rainy season with high rainfall intensity, palm sugar farmers face different challenges. Sap produced during the rainy season tends to have higher water content, resulting in lower sugar concentration and requiring longer boiling time during the processing stage. Heavy rainfall can also disrupt tapping activities. Rainfall in the morning often forces farmers to postpone or cancel tapping activities, resulting in lower

daily harvest volumes. Such disruptions affect not only daily yields but also the stability of the overall production process.

The main impacts of weather variability on palm sap production are summarized in Table 1.

**Table 1. Effects of Weather Variability on Palm Sap Product**

<b>Weather Condition</b>	<b>Impact on Production</b>
<b>Prolonged dry season</b>	Sap production decreases from 12–15 liters to 7–9 liters/day
<b>High temperature</b>	Faster sap fermentation and reduced sap quality
<b>Heavy rainfall</b>	Higher water content in sap and longer boiling process
<b>Rain during tapping time</b>	Disruption of tapping activities and lower daily harvest

## **2. Pest and Disease Attacks**

Field observations in Gunung Tua Pandapotan Village indicate that 34% of palm trees attacked by rhinoceros beetles experienced production declines of more than 50% within less than one harvest season. In addition to pests, diseases caused by pathogenic fungi affecting palm flowers also represent an important problem. This disease inhibits the formation of flower bunches, which are the main source of sap. Fungal infections are typically characterized by discoloration of the flowers to dark brown or black, followed by premature drying before reaching maturity. This condition not only reduces the number of productive flower bunches but may also result in total crop failure in affected trees. Field data indicate that fungal disease attacks can reach up to 18% of the total tree population during the rainy season when humidity levels are high.

In addition to production-related challenges, marketing risk also plays a crucial role in determining farmers' income and the sustainability of their businesses. Even when farmers manage to maintain productivity, the profits obtained depend heavily on market conditions that are often beyond their control. Based on research findings in Gunung Tua Pandapotan Village, nine respondents stated that marketing problems have an equal or even greater impact compared to production-related problems. These marketing risks primarily originate from three main factors: price fluctuations, dependence on middlemen, and limited direct market access.

## **3. Price Fluctuations**

The price of palm sugar at the farmer level fluctuates significantly throughout the year. Based on price data from January to December 2024, the price range at the farmer level varied between IDR 15,000 and IDR 25,000 per kilogram. Price declines generally occur during peak harvest periods or when supplies from other regions enter the local market at lower prices. For instance, in April 2024, the price dropped from IDR 22,000 to IDR 16,000 per kilogram due to the influx of palm sugar supplies from neighboring regions offering more competitive prices. This situation causes farmers' income to become unstable, and in some periods the selling price does not even cover production costs, which average around IDR 17,500 per kilogram. Such fluctuations create income uncertainty, complicate financial planning, and hinder long-term business investment.

## **4. Dependence on Middlemen**

Most farmers in the study area sell their palm sugar through local collectors or middlemen, who subsequently distribute the product to urban markets or large buyers. Survey data show that 85% of respondents rely on middlemen as their primary marketing channel. This dependence places farmers in a weak bargaining position, as prices are

largely determined by the collectors. Furthermore, the payment system often does not involve immediate cash transactions but instead uses a delayed payment system of one to two weeks, which slows the circulation of business capital. For small farmers who rely on daily income to meet their living expenses, this payment delay becomes an additional burden that affects their ability to purchase fuel, equipment, or meet household needs. In some cases, farmers are even forced to sell their products at lower prices in order to receive immediate cash payments, further reducing their potential income.

## **Discussion**

The results of this study indicate that palm sugar farmers in Gunung Tua Pandapotan Village face two major categories of risk that significantly affect the sustainability of their farming activities, namely production risk and marketing risk. These two risks are closely interconnected and mutually reinforce each other's negative impacts. Therefore, addressing these risks requires a holistic risk management approach that is sensitive to the local context.

### **Production Risk from a Risk Management Perspective**

Within the framework of risk management, risk identification represents the initial stage that determines the effectiveness of mitigation strategies. According to Flanagan and Norman (Tambunan, 2024), proper risk identification should clearly describe the source, event, and effect of the risk. In the field, the sources of production risk for palm sugar farmers originate from natural factors, such as extreme weather and climate change, as well as biological factors, including pest and disease attacks. These risks lead to several events, such as reduced sap yield, declining sap quality, and damage to palm trees. Consequently, farmers experience lower production volumes, higher processing costs, and reduced income.

The findings of this study are consistent with previous research emphasizing that production risk is one of the most dominant risks in palm sugar farming. Bakri et al., (2022), for example, identified raw material availability and biological disturbances as major sources of risk affecting palm sugar productivity in Mangkawani Village. Similarly, Sari et al., (2020) reported that fluctuations in palm sugar production in Lebak Regency were strongly influenced by environmental conditions and input management, which resulted in relatively high levels of production and income risk. These similarities suggest that production risk represents a structural characteristic of palm sugar farming systems in many rural areas of Indonesia, particularly those that rely heavily on natural conditions and traditional production techniques.

Climate change has altered the seasonal patterns in Gunung Tua Pandapotan Village. Prolonged dry seasons have reduced sap yields by nearly 40% compared to normal conditions. Meanwhile, heavy rainfall during the rainy season increases the water content in the sap, resulting in longer boiling times and higher production costs. In the context of qualitative risk analysis, weather-related threats can be categorized as high likelihood and high impact risks, as their frequency has increased annually and their effects directly influence production output. Moreover, extreme weather conditions often trigger secondary risks, such as delayed tapping activities and sap spoilage before processing, which ultimately reduce the quality of the final product. From a risk management perspective, this situation illustrates how environmental uncertainty can propagate through different stages of the production process and generate cascading effects on productivity and operational efficiency.

In addition to climatic factors, attacks from stem-boring beetles and fungal infections in palm flowers further exacerbate the decline in production. In severe cases, palm trees may permanently stop producing sap, causing farmers to lose valuable productive assets. This risk is cumulative because the recovery of damaged trees may take several years, thereby increasing economic pressure on farmers. Similar findings were reported by Widyanarti et al., (2024), who observed that biological disturbances in palm sugar production significantly reduce output levels and require long recovery periods. These conditions highlight that biological risks not only affect short-term productivity but also influence the long-term sustainability of production assets within palm sugar farming systems.

Current control efforts are primarily based on local knowledge-driven risk reduction strategies, such as the use of wood ash and herbal mixtures to control pests and diseases. However, limited financial resources and technical knowledge constrain the adoption of more advanced control methods. This condition reflects the adaptive capacity of smallholder farmers in managing risks by utilizing locally available resources. Within the risk management framework, pest and disease attacks can be categorized as medium-high risks with the potential to escalate if not properly managed. These findings also highlight the important role of local knowledge and adaptive practices in supporting effective risk management strategies within traditional palm sugar production systems.

### **Marketing Risk from a Risk Management Perspective**

In terms of marketing, the primary risks faced by farmers include price fluctuations, dependence on middlemen, and limited access to direct markets. According to risk management theory, these marketing risks are difficult for farmers to control directly because they are heavily influenced by external market dynamics. Consequently, mitigation strategies often require collective or institutional approaches. Price fluctuations at the farm level can reach up to 40% within a single year, particularly when market supply increases significantly. This condition reflects high market volatility. From a qualitative risk analysis perspective, this risk has high likelihood and high impact, as it directly affects farmers' profit margins.

Another critical issue is the dependence on middlemen as the main marketing channel. This dependence creates an asymmetric relationship in which farmers have limited control over pricing and payment terms. As a result, farmers face higher market risk exposure due to the absence of alternative distribution channels. Similar findings were also reported in studies of the sugar palm supply chain, which show that marketing actors such as collectors and distributors often play a dominant role in determining product prices and market access (Arilaksmi et al., 2026).

From a risk evaluation perspective, this dependence can be categorized as a medium-high risk because it may weaken farmers' bargaining position and increase financial uncertainty if efforts to diversify market access are not developed. These findings indicate that marketing risks in palm sugar farming are not only related to price fluctuations but also to structural constraints within the marketing system. Therefore, strengthening collective marketing institutions and expanding market access are important strategies to reduce farmers' vulnerability to market-related risks and to support more sustainable agribusiness development (Romadhon & M. Nawawi, 2022).

### **Interaction and Domino Effects between Risks**

One of the key findings of this study is the interdependence between production and marketing risks. A decline in production due to extreme weather or pest attacks reduces the

volume of products that can be sold, thereby weakening farmers' bargaining power with middlemen. Conversely, low market prices discourage farmers from investing in intensive tree maintenance, which ultimately leads to lower productivity in subsequent seasons. Similar interactions between production and market risks have also been identified in smallholder agricultural systems, where production instability and market uncertainty mutually influence farmers' decision-making and farm performance (Widyanarti et al., 2024).

This phenomenon indicates the presence of a negative feedback loop, where production and marketing risks reinforce each other's negative effects. In other words, problems occurring in one aspect of the farming system can trigger additional risks in other aspects, creating a chain or domino effect that threatens farm sustainability. From a risk management perspective, this finding supports the view that agricultural risks should not be managed in isolation but through an integrated approach that considers the interconnections among different risk sources. Therefore, effective mitigation strategies should combine technical control measures at the production level with institutional strengthening and market development strategies. Such an integrated risk management approach can help farmers reduce vulnerability and improve the resilience of palm sugar farming systems.

### Implications for Mitigation Strategies

**Table 2**  
**Risk Matrix of Production and Marketing among Palm Sugar Farmers in Gunung Tua Pandapotan Village**

No	Type of Risk	Source of Risk	Risk Category	Risk Management Strategy
1	Production	Extreme weather (prolonged drought, heavy rainfall)	High	Adjusting tapping schedules to avoid rainfall; drying firewood before use; accelerating sap processing during the rainy season; utilizing weather information for production planning; using sap protection during rain; centralized processing with shared facilities.
2	Production	Pest attacks (rhinoceros beetle – <i>Oryctes rhinoceros</i> ) and fungal diseases	High	Pest control using wood ash; manual removal of infected plant parts; application of traditional herbal mixtures; integrated organic pest management; technical training on disease control; provision of environmentally friendly pesticides through cooperatives.
3	Marketing	Price fluctuations	High	Selling products immediately after harvest even when prices are low to maintain cash flow; reducing production when prices decline; establishing price contracts with regular buyers or cooperatives; product diversification (palm sugar powder and palm syrup) to extend shelf life and allow sales when prices improve.

4	<b>Marketing</b>	Dependence on middlemen	Moderate	Selling most production to local collectors with delayed payment systems; maintaining good relationships to ensure product absorption; establishing marketing cooperatives for collective sales; expanding direct market access through online sales or partnerships with souvenir shops.
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Source: Author's data processing (2025)

Referring to the theoretical framework proposed by Flanagan and Norman, risk mitigation can be implemented through four main approaches: risk avoidance, risk reduction, risk transfer, and risk acceptance. Interestingly, the findings in Gunung Tua Pandapotan Village reveal that palm sugar farmers do not rely on a single approach. Instead, they combine these four strategies in their daily practices to address both production and marketing risks. This reflects a relatively strong practical awareness of risk management, although most strategies emerge from empirical experience and field necessities rather than from formally documented risk management planning.

In the production aspect, the threat of extreme weather is addressed primarily through risk reduction and risk avoidance strategies. Farmers adjust tapping schedules to avoid rainfall, dry firewood before use to prevent combustion problems, and accelerate sap processing during the rainy season to prevent fermentation that may reduce product quality. In addition, weather information from local sources and the Meteorology, Climatology, and Geophysical Agency has gradually been incorporated into production planning, helping farmers determine safer tapping periods. Other measures, such as installing protective covers for sap during rainfall and utilizing centralized processing facilities, have also been implemented to minimize quality deterioration.

To address pest and disease attacks, farmers combine risk reduction and risk transfer strategies. Traditional practices, such as the use of wood ash, manual removal of infected plant parts, and the application of herbal mixtures, continue to be maintained as forms of local wisdom. However, in recent years farmers have also begun adopting organic-based integrated pest management, participating in technical training on disease control, and utilizing environmentally friendly pesticides provided through cooperatives. The involvement of cooperatives in providing pest control resources reflects an effort to transfer part of the risk to institutions that possess greater capacity to manage it. This condition is consistent with the concept of risk transfer in risk management frameworks.

In the marketing aspect, the risk of price fluctuations is addressed through a combination of risk reduction and risk avoidance strategies. Farmers tend to sell their products immediately after harvest to maintain cash flow, reduce production volume when prices are at their lowest, and gradually adopt price agreements with regular buyers or cooperatives to stabilize income. Product diversification into palm sugar powder or palm syrup is also implemented to extend product shelf life, allowing farmers to sell their products when market prices become more favorable.

Meanwhile, the risk of dependence on middlemen is managed through risk acceptance and risk transfer approaches. Farmers maintain good relationships with local collectors to ensure that their harvests are absorbed by the market. At the same time, they establish marketing cooperatives to strengthen their bargaining position and expand market

access. Some cooperatives have even begun exploring online marketing channels and partnerships with souvenir shops, thereby reducing reliance on a single distribution pathway.

Overall, these strategies demonstrate that the risk mitigation practices implemented by palm sugar farmers in Gunung Tua Pandapotan Village are relatively comprehensive and operate at multiple levels of control. Although most strategies arise from adaptive responses to field conditions rather than from systematically documented risk management planning, their implementation has helped farmers sustain their livelihoods amid complex production and marketing challenges. Moving forward, the key challenge lies in maintaining the consistency of these strategies, strengthening institutional support, and encouraging continuous innovation so that the organically developed risk management practices can evolve into a more adaptive, resilient, and integrated system.

## CONCLUSION

This study concludes that palm sugar farmers in Gunung Tua Pandapotan Village face interconnected production and marketing risks that reinforce each other's negative impacts. Climate change and pest attacks reduce productivity, while price fluctuations and dependence on middlemen weaken farmers' bargaining position. These findings highlight the importance of integrated risk management strategies that combine risk avoidance, risk reduction, risk transfer, and risk acceptance. Academically, this study contributes to the agricultural risk management literature by emphasizing the interdependence between production and marketing risks in smallholder farming systems. However, this study is limited to qualitative analysis in a specific village context. Therefore, future research is recommended to apply quantitative risk assessment methods and explore policy interventions to strengthen cooperative institutions, promote product diversification, and support technological innovation in palm sugar farming.

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