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Risk Analysis on the Cassava Value Chain in Central Lampung Regency

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ABSTRACT

The Central Lampung Regency is the center of cassava production in Lampung Province, the Indonesia's largest cassava-producing province. Cassava has much promise; however, various risks arise throughout the value chain. Risks in the agricultural sector, including cassava farming, are unavoidable and severely impact stakeholders and consumers. This study aimed to identify the risks and the most effective mitigation measures for the cassava value chain. This research was conducted using the House of Risk (HOR) method, divided into two phases: HOR 1 and HOR 2. It involved 286 samples encompassing 263 farmers, six traders, three tapioca industries, eight non-tapioca industries, and six financial institutions. The risks were determined through the Supply Chain Operational Reference (SCOR) model. The results unveiled several priority risks in the cassava value chain, consisting of unpredictable weather changes, scarcity of fertilizers, the absence of farming standards, limited capital, delivery technical problems, price fluctuations, negligence of the workforce, default credit, and lack of customer or farmer knowledge leading to confusion. Furthermore, the risk mitigation actions covered preventing the risks of cassava farming; applying appropriate technology; utilizing production, marketing, and financing system assistance; preventing the risks of cassava trading business; implementing a structured market system; developing access to financing, institutions, and markets; developing marketing infrastructure; developing adaptive farming; monitoring during the credit period; socializing risk management to employees; and providing institutional, financing, and production assistance.

Keywords: Cassava; House of risk method; Risk analysis; Risk mitigation; Value chain

INTRODUCTION

Cassava is a tuber plant with essential starch and grows well in tropical and subtropical countries. It also contributes to food security due to it can survive in poor soil conditions and has long-term underground storage (Amelework, Bairu, Maema, Venter, & Laing, 2021). As a promising commodity for food security, it can replace staple foods, such as rice and corn, animal feed ingredients, and industrial raw materials (H. S. Rahayu, Dewi, & Febrianti, 2021). However, as one of Indonesia's exportable food commodities, it necessitates the government's attention. In 2020, Indonesia was included in the category of the world's five largest cassava-producing countries, along with Nigeria, Congo DR, Thailand, and Ghana (Food and Agriculture Organization [FAO], 2020). Following the data from the Ministry of Agriculture of the Republic of Indonesia, Lampung Province is the largest national producer of cassava, with a harvested area of 208,000 hectares, yielding 5,400,000 tons. This province contributed 25% of the total national production in 2020, reaching 19,000,000 tons (Ministry of Agriculture of The Republic of Indonesia, 2021). Cassava is the raw material for making tapioca flour, and Lampung Province is its most prominent supplier in Indonesia.

When managed effectively, cassava holds significant promise for Indonesia, much like its success in Thailand, where locally sourced fresh cassava has successfully replaced imported potatoes in chip production (Chancharoenchai & Saraithong, 2022). Similarly, in Nigeria, cassava has evolved from being a crop with limited yields to a lucrative resource with diverse applications, including animal feed, food production, and the creation of agro-industrial raw materials (Apata, 2019). Government intervention and support are essential to fully tap into cassava's potential. Addressing the stagnant state of cassava processing and product development requires concerted efforts to align with public policy, fostering plant diversification and crop expansion to stimulate economic growth (Alamu, Ntawuruhunga, Chibwe, Mukuka, & Chiona, 2019). The government also plays a crucial role in combining sustainable agricultural practices and effective communication strategies, facilitating the development of the resilient value chain in developing countries (Hidayati, Garnevska, & Childerhouse, 2023).

A supply chain is pivotal in agribusiness, serving as the essential foundation of global trade (Dolgui, Ivanov, & Sokolov, 2022). With the massive potential of cassava in Lampung Province, especially in Central Lampung Regency, various risks inevitably occur in the agricultural value chain. The literature on supply chain risks has been expanding in recent years in response to the growing global risks (Choudhary, Singh, Schoenherr, & Ramkumar, 2023). The problems due to the risks in agriculture have gained some concern (Ajah, Ofem, Effa, & Ubabuko, 2022). Agricultural business activities and farmers are more likely to face risks than other business sectors because agricultural products and services are closely related to natural processes, biological assets, and plant and animal diseases (Girdžiūtė, 2012). The potential risks in the agricultural sector encourage actors to recognize the types of potential risks and how appropriate control measures are taken before these risks develop and are detrimental. Each risk should be given anticipatory action against more significant losses, also known as mitigation (Sijabat & Noor, 2020).

Risks in the agricultural sector are inherent and pervasive, with the potential for severe impacts on stakeholders and consumers. Risks can obstruct the supply chain, causing widespread financial and economic losses. Agricultural risks also cause temporary food insecurity, creating a poverty trap for millions of households across developing countries (World Bank Group, 2016). Risk management is an integral part of planning business activities and is designed to reduce or eliminate certain events impacting these business activities. It aims to identify potential problems; thus, its activities can be planned and implemented to reduce the impact on business activities (Dinu, 2012). Several risks exist in the agricultural value chain, such as production, price, market, payment default, currency, and other risks (KIT & IIRR, 2012). In addition, the agricultural risks include production, supply, finance, marketing, price, and climate (Bank Indonesia, 2015). Agricultural production risks are higher than non-agricultural due to the nature significantly influences agricultural activities, such as weather, pests, diseases, drought, and floods (Sulili et al., 2021).

The high risk in the agriculture value chain is one of the main reasons for this sector's low realization of financing. A value chain is a group of actors (businesses or agents) engaged in related or various processes and activities moving a good or service from the production, distribution, and marketing phases to the consumers (Kaplinsky, 2012). Credit restrictions are caused by value chain challenges, such as agroecological uncertainties, inadequate technical skill training, weak farmer groups, and market insecurity (Agyekumhene et al., 2018). The primary source of financing risks in the agriculture value chain is the production risks of agricultural products. Crop failures due to drought, theft, warehouse leaks, and spoilage are the primary triggers for production risks (KIT & IIRR, 2010). Price is another risk; the agricultural market could be more stable as the price rises and falls. It could vary to 100% or more during the same season. Price risks rise if market information is scanty, or the market is not connected to the other. Besides, price falls if the supply exceeds demand; thus, some farmers cannot sell their products. As a result, farmers' revenues are reduced, and they even suffer losses.

Several risk agent sources for cassava farmers can arise, for example, uncertain weather changes, limited farmer capital, the absence of farming standards, price fluctuations, and delays in payments from traders or factories. A risk event usually causes more than one risk impact (Pujawan & Geraldin, 2009). These risk sources can cause various other risk impacts to the farmers, requiring risk mitigation strategies. One of the considerations for a loan provider in the agricultural sector in distributing their finance, especially cassava farming in Lampung Province, is the risk factors of the business. Agricultural businesses are indeed highly vulnerable to various risks (Kahan, 2013). Therefore, a good business activity requires risk-related analysis to prevent and reduce risk losses.

Risk analysis minimizes risks or disruption to agribusiness activities (Pedekawati, Karyani, & Sulistyowati, 2017). Risks must be managed by proper risk management to help farmers obtain quality results (Noor & Kusnandar, 2018). The value chain analysis is expected to obtain handling strategies to prevent or eliminate risks in the cassava value chain (Wahyuningtyas, Haryati, Pratiwi, & Situmeang, 2021). This research's novelty depends on the analyzed actors and commodity. In contrast, most previous studies conducted mitigation analysis on only one factor, such as farming or production activities, not analyzing the cassava commodity. However, this study conducted mitigation analysis on all value chain actors, from farmers to those in financial support institutions. This research aims to identify risks and proper risk mitigation to help farmers and value chain actors understand the characteristics of agricultural business. Implementing risk management mitigation strategies aims to reduce the frequency and impact of risks on the value chain (Yahman, Widada, & Profita, 2020).

RESEARCH METHOD

Research Location

The research location was determined using the multistage purposive method (Gumanti, Moeljadi, & Utami, 2018). This study was conducted in Lampung Province in Indonesia due to it is the country's largest producer of cassava. In particular, it was undertaken in Central Lampung Regency, a center for cassava production. The BPS-Statistics of Lampung Province asserted that Central Lampung Regency produced 2,200,000 tons of cassava in 2020, with a total production share of 36% (BPS-Satistics of Lampung Regency, 2021). In addition, cassava in Central Lampung has become an essential superior crop with a comparative advantage (Zulkarnain, Zakaria, Haryono, & Murniati, 2021).

Furthermore, as the two largest cassava producers in the value chain, with the tapioca flour processing industry and cassava processing other than tapioca flour, the Districts of Terbanggi Besar and Seputih Banyak were determined as study areas. Terbanggi Besar District represents the value chain of cassava to tapioca flour with four large tapioca flour factories. In contrast, Seputih Banyak District illustrates how the cassava value chain expanded beyond tapioca flour. Figure 1 displays the map of research locations.

FIGURE 1. MAP OF RESEARCH LOCATIONS OF RISK ANALYSIS ON THE CASSAVA VALUE CHAIN IN CENTRAL LAMPUNG REGENCY

Data Collection Method

The research employed a mixed methods approach, integrating both qualitative and quantitative methods (Creswell & Creswell, 2018). The research location was determined by a multistage purposive method (Gumanti et al., 2018). It began with deliberately selecting Lampung Province as Indonesia's largest cassava producer, followed by designating Central Lampung Regency as the highest cassava production center in the province. This study employed a survey through interviews and a Focus Group Discussion (FGD). The minimum number of FGD group participants is 7-10 people but can be increased to 12 people (Paramita & Kristiana, 2013). Interviews were conducted with 286 samples, consisting of 263 farmers, six traders, three tapioca industries, eight non-tapioca industries, and six financial institutions. Meanwhile, an FGD was carried out with 30 farmers, six traders, three tapioca industries, eight non-tapioca industries, and six financial institutions. Farmer respondents were selected using simple random sampling based on the focus of the study by applying the Isaac and Michael formula, with a population of 10,535 and an error rate of 10%, yielding a sample size of 263 people (Sugiyono, 2021).

The respondents were value chain actors of cassava farming in Central Lampung District, grouped into on-farm value chain actors (farmers) and off-farm actors (traders), processing industries (tapioca and non-tapioca processing), and financial support institutions. The on-farm agribusiness group, including farmers, is the primary agricultural sector (Krisnamurthi, 2020). Conversely, off-farm agribusiness involves actors processing primary agricultural products from farmers, such as wholesalers, processing industries, and supporting services, such as financial institutions and others.

Analysis Method

Data were analyzed using the House of Risk (HOR) method. Since risk agents or sources of risk are the causative factors driving the emergence of risk events, the fundamental goal of this method is to identify risks and design handling strategies to mitigate the emergence of risk agents. Hence, reducing risk agents also lowers the potential for rising the risk. Several advantages led to the selection of the HOR method. The HOR method reports and considers the possibility of risk events (Magdalena & Vannie, 2019). Other risk mapping methods do not account for all the events that risk agents create. One further benefit highlighted is that the HOR method prioritizes risks and provides strategic priority for quality enhancement (Hartono, Christiani, & Lasiman, 2018).

The HOR 1 and HOR 2 steps made up this method. On the one hand, HOR 1 determined which risk agents should be prioritized to take precautions. On the other hand, HOR 2 focused on proactive actions to maximize the effectiveness of actions dealing with risk agents but remain financially viable and meet resource commitments (Pujawan & Geraldin, 2009).

Using the Supply Chain Operational Reference (SCOR) model, the HOR 1 stage, risk identification, began with identifying activities in each actor or business process, encompassing planning, source, production, delivery, and return (Puffal & Kuhn, 2018). The subsequent stage was identifying risk events. Each risk event's severity was determined by an assessment on a scale of 1 to 10, where the higher the severity score, the more severe the impact. It was followed by identifying the risk agents or sources of the risk events and the risk occurrence level using a scaled assessment of 1 to 10. As the score increases, the probability of the agent or source of risk being present also increases details can be seein (Table 1).

TABLE 1. SEVERITY SCALE AND OCCURRENCE OF RISK ANALYSIS ON THE CASSAVA VALUE CHAIN IN CENTRAL LAMPUNG REGENCY

Rank	Severity	Occurrence
1	None	Almost certain
2	Very minor	Very high
3	Minor	High
4	Low	Moderately high
5	Moderate	Moderate
6	Significant	Low
7	Major	Very low
8	Extreme	Remote
9	Serious	Very remote
10	Hazardous	Absolute uncertainly

Source: Sankar & Prabhu (2001)

Furthermore, it proceeded with identifying the correlation between risk events and risk agents expressed by a score of 0, 1, 3, or 9, with 0 implying no correlation, 1 representing a low correlation, 3 demonstrating a medium correlation, and 9 indicating a high correlation. Then, the Aggregate Risk Potential (ARP) was determined using the following formula.

$$ARP_j = O_j \sum_i S_i R_{ij} \quad (1)$$

Oj depicted the occurrence score of the risk agent, *Si* was the severity of the risk event, and *Rij* signified the correlation between risk agent *j* and risk event *i*. After obtaining the ARP, the values were ranked from the highest to the lowest.

The HOR 2 stage, risk management, determined the adequate strategies to decline the potential risk agents. This stage began with selecting several risk agents with the highest priority to be immediately handled based on the ARP at HOR 1. Then, the most effective preventive action (P) or mitigation strategies were identified to eliminate potential risk agents. This mitigation measure could be utilized for one or more risk agents. After that, the correlation between each mitigation action (P) and the cause of risk (A) was examined using the assessment score of 0, 1, 3, or 9. Subsequently, the total effectiveness value (*TEk*) for each strategy was calculated using the following formula.

$$TE_k\text{: } \sum_i ARP_j E_{jk} \quad (2)$$

Ejk signified a relationship between each strategy and risk agent. Then, the degree of difficulty (*Dk*) for action from each planned mitigation was determined. It was assessed using three levels (3, 4, and 5): 3 represented an easily implemented action, 4 depicted a moderately tricky action, and 5 means a severely hard to implement. Thus, the total ratio between the total effectiveness value (*TEk*) and the degree of difficulty (*Dk*) was calculated using the following formula.

$$ETDk = \frac{TEk}{Dk} \quad (3)$$

A range of priority rankings was selected based on each risk strategy action (*Rk*), orderly sorted based on the highest Effectiveness to Difficulty (ETD). The mitigation action with the highest ETD was considered a priority strategy requiring further attention to prevent the risk agent from arising.

RESULTS AND DISCUSSION

Characteristics of On-farm Value Chain Actors (Farmers)

The characteristics of cassava farmers in Central Lampung Regency were classified based on several criteria: age, education, farming experience, family size, and land area. Most cassava farmers (44%) were 35 to 49 years old, averaging 47. This fact aligns with the previous research by Ndem and Osondu (2018), summarizing similar results that most cassava farmers in Abia state were 31 to 50 years old, with an average age of 48. It fell into the productive age category, ranging from 15 to 64 years. Moreover, those aged 65 or older belonged to the old age category. Older farmers had a risk preference as risk-averse (Ainurrahman, Fariyanti, & Tinaprilla, 2022). Furthermore, 38% of farmers completed their studies at the high school level. A total of 102 farmers (39%) had a cassava farming experience of one to ten years. The average farmer (31%) had three family sizes. The majority of farmers (56%) grew cassava on a land area of half to one hectare, classified as medium land scale.

Characteristics of Off-farm Value Chain Actors

The characteristics of each off-farm value chain actor of cassava farming in Lampung Tengah Regency comprised age, education, and working experience. Six retailers participated in this study; most were 35 to 49 years old, with an elementary education level and working experience of one to ten years. Furthermore, the cassava processing industry actors involved those working in both tapioca and non-tapioca industries.

TABLE 2. CHARACTERISTICS OF OFF-FARM VALUE CHAIN ACTORS OF CASSAVA

Variable	Category	Retailer	Tapioca Industry	Non-Tapioca	Financial Institution
		Total	Total	Total	Total
Age	20-34	1	1	-	5
	35-49	5	2	4	1
	≥ 50	-	-	4	-
Education	Elementary	3	-	-	-
	Junior High	1	1	4	-
	Senior High	2	1	4	-
	Diploma	-	-	-	3
	Bachelor	-	1	-	3
Working experience	1-10	4	1	5	6
	11-20	2	2	1	-
	>20	-	-	2	-

The actors in the tapioca industry, totaling three people, were also in the age range of 35 to 49 years. However, they had a balanced level of education, encompassing elementary, junior high, and senior high schools. Most had worked for 11 to 20 years. Moreover, those working in the non-tapioca industry were also aged 35 to 49 years and 50, totaling eight people. Four of them completed their junior high school, and the remaining four completed their senior high school.

Most possessed working experience of one to ten years. Additionally, concerning financial institution actors, most were 20 to 34 years old. Out of six actors, half hold a Diploma degree, and the other half had a bachelor's degree. All had worked for one to ten years. Table 2 lists the characteristics of off-farm value chain actors.

Risk Analysis on the On-farm Value Chain of Cassava in Central Lampung Regency

Risk Identification

As global dependence on the agricultural sector continues to rise, the risks associated with agriculture and the behavior of farmers in handling these risks have become increasingly crucial (Shah & Alharthi, 2023). Risk management has gained greater significance for the agricultural supply chain due to seasonal challenges, supply surges, extended supply lead times, and perishability (Behzadi, O'Sullivan, Olsen, & Zhang, 2018). Therefore, effective supply chain risk management is vital for ensuring business continuity and resilience, emphasizing the need for organizations to proactively approach risk management (Emrouznejad, Abbasi, & Sıcakyüz, 2023). The threats posed by various risk factors have become one of the reasons behind the growing food vulnerability (Mbah, Molua, Bomdzele, & Egwu, 2023).

The concept of SCOR, comprising planning, source, production, return, and delivery, was utilized for risk identification. The variables comprised the opportunity for occurrence and the severity of risk impacts (Table 3). Previous studies conducted risk analysis using the HOR method and risk identification with the SCOR model (Mustaniroh, & Ndadari, 2018; Pedekawati et al., 2017; Ulfah, Maarif, & Raharja, 2016; Ummi, Ferdinant, Irman M.S, & Gunawan, 2018; Wahyudin & Santoso, 2016; Wulandari, Ernah, Hapsari, & Hendra, 2021).

TABLE 3. RESULTS OF IDENTIFICATION AND SEVERITY OF RISK EVENTS

Process	Risk Event	Code	Severity
Planning	Capital estimation error	E1	6
	Harvesting time prediction error	E2	6
Source	Poor input procurement	E3	6
	Limited input usage	E4	6
	Labor shortage	E5	6
	Reduced profit	E6	8
Production	Crop failure	E7	8
	Low production	E8	8
	Low quality	E9	8
	Pests and diseases	E10	6
	Lack of technology	E11	6
	Selling price fluctuations	E12	8
Delivery	Late delivery	E13	6

Once the types of various risk events were identified, the sources of risk (risk agents) and the probability of occurrence were determined to design appropriate and effective risk mitigation handling. The FGD with cassava farmers in Central Lampung Regency yielded information on six potential risk agents. Improper farming planning, erratic climate change, limited capital, fertilizer scarcity, the absence of farming standards, and price fluctuations were all potential risk agents. One risk agent could trigger several risk events. In addition to the results of the FGD with farmers, the determination of risk agents related to erratic climate change was based on research by Amelework et al. (2021), demonstrating the unavoidable impact of climate change on agriculture. Thus, it could be included as a risk in cassava farming. Moreover, price and production fluctuations were among the most significant factors of uncertainty (Septiani, Utami, & Putri, 2019). Table 4 portrays the results of each risk source's identification and opportunity score.

TABLE 4. IDENTIFICATION RESULTS AND RISK AGENT OPPORTUNITIES

Risk Agent	Code	Occurrence
Improper farming planning	A1	6
Erratic climate change	A2	7
Lack of capital	A3	6
Fertilizer scarcity	A4	7
No farming standards	A5	6
Price fluctuations	A6	6

House of Risk 1

Thirteen risk events and six risk agents were then processed by testing the correlation level of the two variables in the HOR 1 table using the assessment scores of 0, 1, 3, and 9. Table 5 depicts the HOR 1 data processing.

TABLE 5. HOUSE OF RISK 1 CALCULATION

Activity	Risk Agent Risk Event	A1	A2	A3	A4	A5	A6	SEVERITY
Planning	E1	3	0	1	0	1	1	6
	E2	1	9	0	3	1	0	6
Source	E3	9	0	3	1	3	0	6
	E4	0	0	9	1	0	0	6
	E5	1	0	9	0	0	0	6
Production	E6	1	3	3	9	3	1	8
	E7	9	3	0	3	3	0	8
	E8	3	9	9	9	9	0	8
	E9	9	9	3	9	9	0	8
	E10	1	9	1	0	1	0	6
	E11	1	0	3	0	1	0	6
	E12	0	9	0	9	9	9	8
Delivery	E13	0	0	0	0	0	9	6
OCCURRENCE		**6**	**7**	**6**	**7**	**6**	**6**	
Aggregate Risk Potential (ARP)		**1,578**	**2,696**	**1,550**	**2,398**	**1,736**	**801**	
Rank		**4**	**1**	**5**	**2**	**3**	**6**	

A classification of priority agents was formed into a Pareto diagram after calculating the ARP and determining the dominant risk agents. After determining the cumulative percentage of each ARP, the Pareto diagram was employed to observe the agents with the highest ARP. Figure 2 exhibits the Pareto diagram of the HOR 1 data analysis.

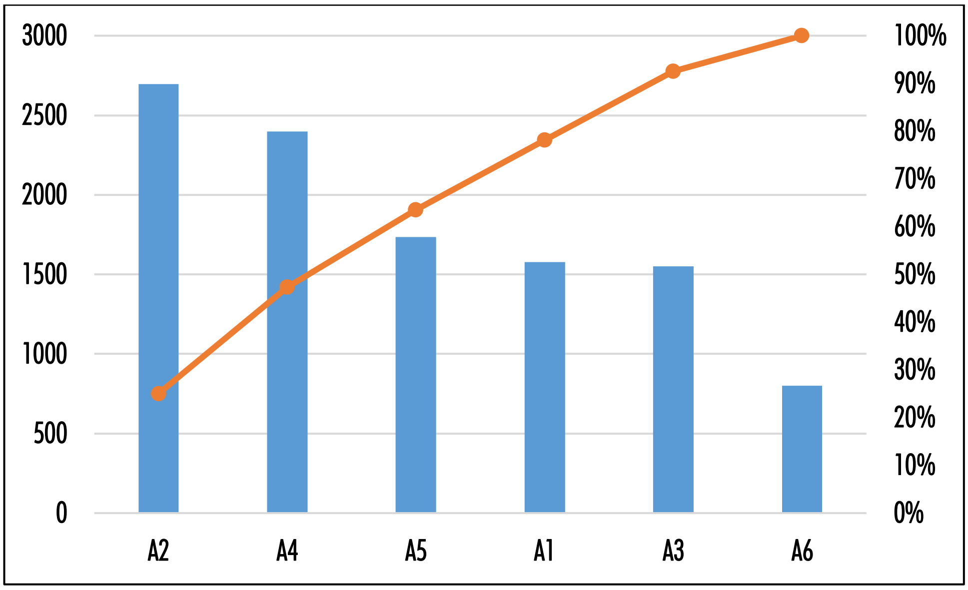

FIGURE 2. PARETO CHART OF RISK ANALYSIS ON THE CASSAVA VALUE CHAIN IN CENTRAL LAMPUNG REGENCY

The ARP calculations revealed three types of risk agents posing the greatest threat to the success of cassava farming in Central Lampung Regency. They were the risk of erratic climate change (A2) with 2,696, the risk of fertilizer scarcity (A4) with 2,398, and the risk of no farming standards (A5) with 1,736. This study's results align with (Pedekawati et al., 2017), discovering that climate change belonged to the priority risk agents of *gedong gincu* mango farming, requiring the preparation of mitigation actions. They are also consistent with the findings of E. S. Rahayu, Setyowati, and Rahwadwiati (2021) on the risks faced by farmers due to climate change, and with those of Pratiwi, Haryono, and Abidin (2020), identifying climate change and uncertain whether as the risks or threats to cassava production. It illustrates the significant impact of environmental conditions on agriculture. Findings from Kuizinaitė, Morkūnas, and Volkov (2023) also affirmed that natural disasters constituted a primary risk, whether on a global or local scale. It is further corroborated by research conducted by Hua, Liu, Tse, and Yu (2023), demonstrating that natural disasters substantially influenced specific agricultural commodities, such as soybeans and wheat. Agriculture was vulnerable to climate change as it affected planting patterns, planting period, production, and yield quality (Ferrianta, Makki, Suprijanto, & Rifiana, 2015). Penet, Barthe, Alleyne, and Blazy (2016) conducted a study highlighting the potential risks posed by uncertain climate change, raising disease prevalence, and subsequently hindering agricultural production. Similarly, Ambarawati, Wijaya, and Budiasa (2018) suggested that various risks, including natural disasters like floods, droughts, and pest and disease outbreaks, could significantly contribute to crop failure.

Nevertheless, the study conducted by Ekaria and Muhammad (2018) revealed contrasting findings. They emphasized costs as the most significant risk in cassava farming. This disparity in results could be attributed to variations in research locations and the analytical tools employed. In this study, some respondents expressed concerns regarding the scarcity of fertilizers, highlighting the unavailability of these resources when needed. Farmers indicated their willingness to purchase fertilizers if they were readily accessible. The research conducted by Wadu, Yuliawati, and Nuswantara (2019) and Nura, Fajri, and Indra (2021) regarding other food crops disclosed that land area, seeds, herbicides, pesticides, urea fertilizer, and *phonska* fertilizer influenced production risks. In contrast to the present study, herbicides were not deemed a risk factor, but the availability of fertilizers. This discrepancy could be associated with the nature of cassava farming, which typically does not require herbicides. Consequently, fertilizers play a more significant role in enhancing production.

After obtaining data on the types of priority risk agents, a risk mitigation strategy was designed to handle these risk agents through the HOR 2 processing. Table 6 demonstrates the three types of risk agents with the highest priority.

TABLE 6. THE RESULTS OF RISK AGENT PRIORITY

Code	Risk Agent	Aggregate Risk Potential (ARP)
A2	Erratic weather forecast	2,696
A4	Fertilizer scarcity	2,398
A5	No farming standards	1,736

Identified Risk Management Strategies (Risk Mitigation)

Farmers are often inclined to be risk-takers rather than risk-averse; consequently, risk handling and prevention measures become essential to minimize risks (Asmara, Mamilianti, Hanani, & Mustadjab, 2022). Risks in the on-farm value chain could have cascading effects on subsequent stages. It emphasizes the need for risk mitigation endeavors in on-farm activities to prevent the propagation of risks along the supply chain, both in terms of quality and quantity (Guritno, Kristanti, & Tanuputri, 2019). Farmers' attitudes toward and perceptions of risks played a pivotal role in determining risk management strategies to address uncertainties and risks, as highlighted by Pham, Dang, Pham, and Dang (2021). Risk management strategies were determined through an FGD involving cassava farmers in Central Lampung Regency as participants in the study. Mitigation strategies were formulated based on the FGD results to address risks. Mitigation strategies represent proactive measures, techniques, tactics, or approaches employed to reduce and prevent the adverse impacts of a given event (Sijabat & Noor, 2020). Table 7 exhibits the identified risk mitigation strategies.

TABLE 7. IDENTIFIED RISK MITIGATION STRATEGIES

Code	Risk Mitigation
P1	Preventing the risks of cassava farming
P2	Applying appropriate technology
P3	Implementing production, marketing, and financing system assistance
P4	Implementing a structured market system

House of Risk 2

HOR 2 was an advanced stage of the HOR 1 calculation, attempting to obtain the most effective handling strategy that must be performed on priority risk agents in the HOR 1 analysis. Similar to the stages in HOR 1, in HOR 2, a correlation assessment was carried out using the score of 0, 1, 3, and 9 against two variables: priority risk agents (A) and risk handling or mitigation strategies (P), which were then processed and presented in the HOR 2 table.

TABLE 8. HOUSE OF RISK 2 CALCULATION

Risk Mitigation / Risk Agent	Preventing the risks of cassava farming (P1)	Applying appropriate technology (P2)	Implementing production, marketing, and financing system assistance (P3)	Implementing a structured market system (P4)	Aggregate Risk Potential (ARP)
Erratic weather forecast (A2)	9	9	0	0	2,696
Fertilizer scarcity (A4)	9	3	3	0	2,398
No farming standards (A5)	1	9	9	1	1,736
Total Effectiveness Value (TeK)	**47,584**	**47,088**	**22,821**	**1,736**	
Degree of Difficulty (Dk)	**4**	**4**	**3**	**5**	
Effectiveness to Difficulty (ETD)	**11,896**	**11,772**	**7,607**	**347**	
Ranking	**1**	**2**	**3**	**4**	

Table 8 displays the order of priority mitigation strategies based on the highest ETD. Table 9 details the rank priority of the mitigation strategies based on the HOR 2 calculation.

TABLE 9. PRIORITY RISK MITIGATION RESULTS OF CASSAVA FARMERS

Code	Risk Mitigation	Priority
P1	Preventing the risks of cassava farming	1
P2	Applying appropriate technology	2
P3	Implementing production, marketing, and financing system assistance	3
P4	Implementing a structured market system	4

Table 9 outlines the recommended sequence of priority risk mitigation that farmers should undertake to reduce or prevent the identified risks associated with cassava farming, as indicated in Table 6. Risk mitigations were prioritized based on the previously identified priority risk factors. However, this study's findings differ from the research conducted by Wadu et al. (2019) regarding the strategy for addressing risks, which involved attending training and coaching sessions and fostering increased collaboration with government entities and other stakeholders. Despite the variations in approaches, both studies shared the common objective of risk mitigation in cassava farming. The identified mitigation strategies included applying appropriate technology; implementing production, marketing, and financing system assistance; and establishing a structured market system. Training and assistance provided by the government or other parties, as highlighted by Wadu et al. (2019), could facilitate the implementation of these strategies. In addition, the study by Liu, Langemeier, Small, Joseph, and Fry (2017) demonstrated that technology utilization in farming could raise profitability. Furthermore, concerning implementing a structured market system, the research by Mutiara and Mutiara and Kholil (2022) uncovered that farmers opted to withhold their crops and sell them when the traders' warehouses began to deplete.

Risk Analysis on the Off-farm Value Chain of Cassava in Central Lampung Regency

Supply chain risks could be reduced by predicting the possible supply chain risks and designing effective mitigation concepts (Pradita, Ongkunaruk, & Leingpibul, 2020). Cassava value chain actors included input suppliers, farmers or cooperatives or associations, mills, retailers, shops or shop owners, and end consumers (Umoren, Akpan, & Umoren, 2021). The actors involved comprised producers, marketers, and processing and supporting services (Coulibaly, Arinloye, Faye, & Abdoulaye, 2014). Meanwhile, the cassava value chain actors consisted of processing equipment factories, farmers, processors, wholesalers, retailers, research institutes, and extension institutions (Darko-Koomson, Aidoo, & Abdoulaye, 2020). The off-farm value chain actors of cassava farming in Central Lampung Regency consisted of farmers, retailers, processing industries divided into tapioca and non-tapioca industries, and financial institutions. Similar to risk analysis in farmers, risks in off-farm value chain actors were also analyzed using the HOR method, calculated in HOR stages 1 and 2 to identify the priority risk agents and mitigation actions.

TABLE 10. RISK ANALYSIS RESULTS ON OFF-FARM VALUE CHAIN ACTORS OF CASSAVA FARMING

No	Actor Type	Risk Agent Priority	Risk Mitigation Priority
1	Retailer	1. Lack of capital 2. Technical issues in delivery 3. Price fluctuations	1. Implementing production, marketing, and financing system assistance 2. Preventing the risks of cassava trading business 3. Implementing a structured market system
2	Tapioca industry	1. Lack of capital 2. Workforce failure 3. Price fluctuations	1. Development of financing access 2. Institution and market 3. Development of marketing infrastructure
3	Non-tapioca industry	1. Lack of capital 2. Erratic climate forecast 3. Workforce failure	1. Development of financing access 2. Institution and market 3. Development of adaptive farming technology
4	Financial institution	1. Default or bad debts 2. Workforce failure 3. Lack of customers' knowledge leading to potential errors	1. Credit monitoring 2. Continuous socialization of risk management to employees 3. Institutional assistance, financing, production

Table 10 details the findings of many risk agents and priority risk mitigation for supporting actors in the cassava value chain in Central Lampung Regency based on the calculation of both HOR 1 and 2. HOR 1 for the retailers yielded three priority risk agents: limited capital, disruption or technical problems with the delivery, and price fluctuations. In line with Susanawati, Jamhari, Masyhuri, and Darwanto (2017), price risks emerged as one of the most significant risks at collecting retailers due to the unpredictable selling price. The study by Hayuningtyas, Marimin, and Yuliasih (2020) revealed nine priority risks in collecting traders, including selling price fluctuations, payment delays, damaged infrastructure, and limited means of transportation.

Price fluctuations posed a significant risk for cassava retailers, as the uncertain selling price directly impacted the traders' acceptance of the product. When traders purchased cassava at a high price, but the selling price suddenly dropped, their revenue decreased, leading to potential financial losses. This risk factor was consistent with the findings of Hayuningtyas et al. (2020), who highlighted that delayed buyer payments resulted in limited capital for traders, and price fluctuations contributed to the traders' limited capital. Technical problems during transit emerged as another priority risk identified in this study. It aligns with the observations made by Hayuningtyas et al. (2020), where issues such as damaged infrastructure and limited transportation options caused delays in product delivery for traders. Agricultural products are particularly vulnerable to damage or spoilage due to their high-water content (Arifin, 2016). Consequently, it becomes crucial for agricultural products to be sold promptly to prevent traders from incurring losses associated with product damage and subsequent financial setbacks. Furthermore, the HOR 2 analysis also generated priority mitigation actions encompassing (1) applying production, marketing, and financing system assistance; (2) preventing the risks of the cassava trading business; and (3) implementing a structured market system.

The cassava value chain actors were divided into those of the tapioca processing industry and non-tapioca ones. Three priority risk agents comprising capital constraints, workforce failure, and price fluctuations were identified out of six risk agents in the tapioca processing industry. Consistent with the research conducted by Irawan, Santoso, and Mustaniroh (2017), price fluctuations of raw materials posed a significant risk to an industry. It was primarily because raw materials constituted a crucial factor in production, and the absence of adequate raw materials hindered production. Regarding the availability of raw materials, Prakash, Soni, Rathore, and Singh (2017) also asserted that supplier-related risks took precedence when determining mitigation strategies. In this study, price fluctuations in raw materials were closely linked to the first identified risk factor, the availability of capital. If sufficient capital is available, the impact of raw material price fluctuations could be mitigated to some extent. Specifically, within the tapioca processing industry, the increase in the cassava price, serving as a key raw material, was not necessarily accompanied by a rise in the selling price of the final product. It stems from concerns that raising the selling price led to a reduction in demand, potentially diminishing the profit margin for the processing industry.

The rise in the selling price of raw materials could be attributed to the declining availability of these materials. Factors such as imperfect marketing channels and inactive farmer participation directly contributed to the inadequate supply of raw materials and restricted the production capacity of companies (Ye, Hou, Li, & Fu, 2018). Moreover, as Suripto, Machfud, Romli, and Rosidi (2018) highlighted in their study on farming-related risk factors, the lack of raw materials was also influenced by climatic conditions. Furthermore, Sujai (2011) emphasized that extreme climatic conditions and international geopolitical factors impacted the price fluctuations in agricultural commodities. These findings were relevant to the priority risk factor identified in cassava farming. In line with Sucipto, Wulandari, and Ariani (2021), labor priority mitigation actions consisted of developing access to financing, institutions, and markets and developing marketing infrastructure. In contrast to the findings of Irawan et al. (2017), this study proposed a different strategy for addressing risks, centering on maintaining the product quality of the raw material, production processes, and meeting market demand. The variation in risk management approaches was due to the different industries under investigation and the utilization of diverse analytical tools.

Furthermore, three priority risk agents were determined from the six risk agents analyzed in the non-tapioca processing industry: capital limitations, erratic climate change, and workforce failure. It is supported by the research findings of Jikrillah, Ziyad, and Stiadi (2021), revealing that a lack of capital and difficulties in accessing it significantly impacted the continuity of business operations. However, the sources of risk identified in this study differ from those of Yahman et al. (2020). The study highlighted buyer competitors, damage to the main driving force, and supplier competitors as the primary sources of risk. Aryani, Wahyuda, and Gunawan (2022) further contributed to understanding risks in processing by revealing that poor raw material quality and inappropriate dosage during production presented risks within the processing.

Moreover, Phiri, Sakumona, Hang'ombe, Fetsch, amd Schaarschmidt (2021) discovered that milk production failure was attributed to inadequate cleanliness among the workforce, leading to microbial contamination. Priority mitigation actions in the non-tapioca industry comprised developing access to financing, institutions, and markets, and developing adaptive farming technologies. Although these findings do not align precisely with the current study, it is still relevant, as inappropriate production doses could also be linked to worker negligence and lack of carefulness during production. Developing partnerships could be pursued to enhance access to finance in the industry. By establishing partnerships, the non-tapioca processing industry could more easily secure financing, in line with the risk mitigation strategy proposed by Yahman et al. (2020), emphasizing the benefits of forming partnerships as a means of risk reduction.

Given the rising importance of sustainable supply chain financing for green agriculture, it is essential for banks as financing institutions to assess risks and make scientifically sound decisions (Xia, Long, Li, & Wang, 2022). High risks related to agricultural loans have become one of the reasons banks and other financial institutions were reluctant to engage in agricultural finance (Köhn, 2014). Apart from that, problems in risk evaluation for agricultural financing have caused increasingly high levels of agricultural credit arrears (Bilal & Baig, 2019). Concerning financial institution actors, the priority risks covered default or bad debts by farmers due to crop failure and the inability to customize this paid credit to financial institutions. It also included the risk of workforce failure and lack of knowledge of consumers or farmers, potentially causing errors.

Credit risks refer to the potential risks arising from the failure or inability of customers to repay the loan and interest within the agreed-upon timeframe due to a decline in the financial institutions' available cash, leading to bankruptcy (Muhaimin, 2022). It is in line with Umoren et al. (2021), acquiring the risks of default on financial institutions in the cassava value chain in Nigeria. Similar research findings also revealed the risks of human error in employees, lack of knowledge of customers, and the potential to cause errors in Sharia People's Financing Bank (in Indonesia called as *Bank Pembiayaan Rakyat Syariah* (BPRS)) financing in the agricultural sector (Tsabita, 2014). Furthermore, financial institutions could perform priority mitigation actions, such as regularly assisting or monitoring farmers while still in the credit period, socializing employees, and providing assistance related to institutions, financing, and production to farmers as customers. In addition to the FGD results, these risk-handling actions also align with the study by Wijayanti and Adityawarman (2022), performing risk-monitoring activities with customers and observing the progress of their business following the specified time. Moreover, Tsabita (2014) and Bank Indonesia (2015) discovered similar results, unveiling mitigation actions for institutional, financing, and production assistance.

Supply chain risk management has been considered an increasingly popular global topic, and its focus has evolved, as indicated by Rinaldi, Murino, Gebennini, Morea, and Bottani (2022). Consequently, there has been a growing demand for research findings on supply chain risk management. Farmers could enhance their farming practices and produce high-quality products by implementing the risk assessment and mitigation knowledge gleaned from scientific studies. Canevari-Luzardo (2019) asserted that gathering information about interactions within each value chain enabled market-oriented products, both domestically and internationally. This research revealed that capital limitations predominantly influenced the value chain. This situation demands further improvement since it aligns with the statement made by Calatayud and Ketterer (2016) that insufficient access to funding resulted from a series of market failures, forming the basis for public policy interventions.

Farmers should grasp this concept to clearly understand the required mitigation actions. Ricketts, Turvey, and Gómez (2014) examined whether farmers' risk perceptions could channel them into a specific value chain by comparing three supply chains (certified production, high-value products, and conventional). The findings suggested that certified production and the high-value product value chain exhibited relatively lighter and less frequent price variability than conventional farmers. In other words, farmers' risk comprehension could influence their choice of the most suitable value chain, potentially reducing their risks.

CONCLUSION

The risk assessment on the HOR resulted in three risks and priority risk mitigation in each actor. Erratic climate change, fertilizer scarcity, and the absence of farming standards were three of the priorities encountered. Furthermore, priority risk mitigation consisted of preventing the risks of cassava farming, applying appropriate technology, and implementing production, marketing, and financing system assistance. Concerning retailers, the priority risks covered limited capital, technical problems in delivery, and price fluctuations. Meanwhile, priority mitigation comprised implementing production, marketing, and financing system assistance; preventing the risks of the cassava trading business; and implementing a structured market system. In tapioca industry actors, priority risks included limited capital, labor negligence, and price fluctuations. Priority mitigation actions encompassed developing access to financing, institutions, and markets, as well as developing marketing infrastructure. Moreover, the priority risks for non-tapioca industry actors involved limited capital, erratic climate change, and workforce failure. Developing access to financing, institutions, and markets and developing adaptive farming technology were the priority mitigation actions. Regarding financial institution actors, the identified risk included bad debts, labor negligence, and lack of customers' knowledge causing errors. Meanwhile, mitigation actions comprised monitoring during the credit period; continuously socializing risk management to employees; and institutional, financing, and production assistance.

The research findings exposed the risks of the value chain and each actor's mitigation actions to lessen their impact. On average, the priority risks identified in each value chain actor were related to capital limitations. Farmers must grasp this information to guide them in selecting the most suitable value chain, potentially reducing their risks. Concerning farmers' capital limitations, the government should establish policies of easy access to capital in all value chain actors, such as providing credit with low interest. However, it is essential to acknowledge the limitations of this study, which focused on analyzing the value chain risks within a specific condition and commodity. To address these limitations and provide further insights, future research could explore value chain risks before and after the implementation of public policy. This investigation would help determine whether there are variations in the risks and the corresponding mitigation actions. Additionally, it is recommended that future researchers conduct value chain analyses on other prominent commodities using a similar analytical approach.

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