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Mitigation of red chilli supply chain risks in Bali, Indonesia

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Abstract
Red chilies (*Capsicum annum*) are perishable, seasonal, and come in all shapes and sizes. Throughout the supply chain, various treatments have been experienced, resulting in accelerated damage, both physiologically and mechanically, causing economic losses. The purpose of this study was to formulate identification, ranking, and risk mitigation plans for the red chillies supply chain at the red chili supply chain level in Bali Province. Supply Chain Operations Reference (SCOR) mapping is used to identify risk events and risk agents; risk ranking using the Failure Mode and Effect Analysis (FMEA) method; formulation of a risk mitigation plan in accordance with AS/NZS. Risk events and risk agents at every level of the supply chain are spread out in the plan, source, make, deliver, and return activities, except for retailers who are only identified in the plan, source, and make activities. The highest risk in the red chilli supply chain in the Intolerable category is at the farmer level, while the highest risk is for collecting traders, wholesalers, and retailers in the As Low As is Reasonably Practicable (ALARP) category. Supply chain actors are recommended to carry out periodic risk assessments and integrated risk mitigation planning according to the risk agent they are facing to minimize the impact of risk.

Keywords: Red chilies, supply chain, risk mitigation, Bali province

Introduction
One of the vegetables that have the potency to be developed in the province of Bali is red chilli. The demand for red chilli in Bali is relatively high because in addition to local people's consumption it also meets the needs of hotels and restaurants (Dewi & Parinning, 2017) [13]. On the other hand, red chilli (*Capsicum annum*) is perishable, seasonal, and has various shapes and sizes (Dahlan *et al*., 2017) [12].

Red chilli farming in Bali Province in 2020 was carried out in eight districts. Bangli Regency and Karangasem Regency are centers of red chilli production in Bali Province. In 2020, chilli production in Bangli Regency was 4,883 tons (60.67% of the production of Bali Province), and in Karangasem Regency as much as 1,075 tons (13.36%) of production in Bali Province. Red chilli production in Bali Province fluctuates and tends to decline. Red chilli production in 2020 decreased by 21% compared to 2019 production (BPS Provinsi Bali, 2020) [7]. Most of the production factors are not efficient (Wijayanti *et al*., 2018) [29]. The effectiveness of the use of red chilli production factors is below 80%, so it is not effective in terms of farming (Sangurjana *et al*., 2015) [24].

According to Adnyasari *et al*., (2017) [1], there are six red chilli trading systems in Karangasem Regency, Bali Province, and involve several institutions in each channel. According to Andersen (2008) [2], there are several differences in the activities carried out by trade administration institutions, so each channel has various operational efficiencies, ranging from 135.27-1, 242.26%. This value indicates the complexity of the supply chain network, which indicates that there is a risk in the red chilli supply chain (Dewi & Parinning, 2017) [13].

Risk is everywhere, can come at any time, and is difficult to avoid. If these risks happen to an organization, the organization can suffer significant losses. (Hanafi, 2021) [33]. In the red chilli supply chain, post-harvest actors in the red chilli supply chain need to carry out risk mitigation, namely the strategy taken to reduce farming losses (Hariharan *et al*., 2018) [16].

Based on this risk mitigation development, the supply chain will run smoothly, supply chain actors will benefit, and consumers will be satisfied (Bjorkan & Billing, 2022) [8]. The purpose of this study is to formulate risk identification, risk ranking, and risk mitigation plans at each level of the red chili supply chain.

Research Methods

Materials

This research was conducted in Bali Province in 2021. The types of data used are quantitative data and qualitative data, which are obtained from primary data and secondary data. Data was collected through in-depth interviews and documentation studies. The tools used include structured questionnaires, writing instruments, and recording devices. The research population is all actors in the red chili supply chain in the province of Bali. The sample of supply chain actors is determined by the Snowball Sampling method.

Research Implementation

This research is a qualitative descriptive study to identify risks, rank risks, and create risk mitigation plans. The stages of research and analytical methods used at each stage follow Septiana *et al*. (2016) [26] as follows: (i) Identifying the risks that may occur is carried out in two steps. The first step is to map the company's supply chain activities with the SCOR model which is assessed from the plan, make, source, deliver, and return framework that has been adjusted to the research limits. The second step is to conduct in-depth interviews to identify risk events and risk agents (Pujawan and Mahendrawathi, 2017) [21]. (ii) Risk ranking is carried out in three steps, namely (1) assessing risk using the FMEA method, taking into account where there are three factors that are taken into account, namely severity (S), occurrence (O), and detection (D) with a scale of 1-10; (2) ranking the weighting of the Risk Priority Number (RPN) on a scale of 1-1000 obtained from the multiplication of three factors, which is formulated as follows (RPN = Severity x Occurrences x Detection); (3) mapping the risk level using the FMEA risk level map (Pujawan & Mahendrawathi, 2017) [21]. Create a risk mitigation plan through the formulation of risk mitigation as described by AS/NZS 4360 (2004) [4] and Lestari *et al*. (2018) [19] as follows: (i) Mitigate risk, namely reducing the opportunities and impacts of risks that occur; (ii) Transfer risk, namely transferring and transferring risk to other parties; (iii) Avoid risk, namely avoiding the opportunities and impacts of risks that occur; (4) Retail risk, which is accepting the existing risks because the opportunities and impacts are not too disruptive to the company's supply chain processes.

Observation Variable

Observational variables in this study are the activities of supply chain actors including plan, make, source, deliver, and return; risk event and risk agent for each activity of supply chain actors; severity (S) of risk events and occurrences (O) and detection (D) of risk agents for each supply chain actor; mitigate risk, transfer risk, and avoid risk for each supply chain actor.

Data Analysis

The data analysis method used in this study was in line with to the research objectives, namely: (i) To identify possible risks, it is analyzed by (1) mapping the company's supply chain activities using the SCOR model and (2) identifying risk events and risk agents (Pujawan & Mahendrawathi, 2017) [21]. (ii) To rank the risks, it is analyzed through (1) risk assessment using the FMEA method; (2) risk priority number (RPN) weighting ranking and (3) risk level mapping using FMEA risk level map (Pujawan and Mahendrawathi, 2017) [21]. (iii) To make a risk mitigation plan, it is analyzed through the formulation of risk mitigation as described by AS/NZS 4360 (2004) [4] and Lestari *et al*. (2018) [19].

Results and Discussions

Identification of Risk Events and Risk Agents of Red Chilli Supply Chain in Bali Province

Risk events have been identified and categorized in the SCOR model. The results of risk event identification for each supply chain actor can be seen in Table 1 below.

Farmers, collectors, and red chilli wholesalers face risk events on plan, source, make, deliver, and return. Specifically, retailers do not face risk events or deliver and return. This is because the sales system at retailers does not accept returns of goods that have been purchased by consumers and consumers who come to retailers to buy red chilli, so there is no delivery of goods. (Christopher & Holweg, 2011) [11].

The risk agents for each red chilli supply chain actor are identified and categorized in the SCOR model. Table 2 presents the risk agents for each actor in the red chilli supply chain in Bali Province.

The types of risk agents due to *risk events* for red chilli supply chain actors are relatively diverse. The number of *risk agents* at retailers is the lowest, which is 11 types compared to the other three actors. This is partly due to the fact that retailers do not have *deliver* and *return* activities (Avinadav *et al*., 2015) [5]. The risks inherent in each of its activities are related to the success or failure of a supply chain. The main cause of these various risk factors is due to imperfect coordination and lack of information sharing between nodes/levels in the agricultural product supply chain (Wang *et al*., 2020) [28].

Risk Ranking at Each Level of the Red Chilli Supply Chain

The ranking or risk assessment is shown based on the results of the recapitulation of the accumulated RPN values at each level of the red chilli supply chain in Figure 1a-4a. After obtaining the ranking as shown in Figure 1a-4a, then mapping is carried out based on the RPN value and severity value at each level of the supply chain. The risk agent map for each level of the red chili supply chain is shown in Figure 1b-4b

Table 1: Risk events for red chili supply chain actors in Bali Province

No	SCOR	Risk Event	Ei
1	2	3	4
Risk Event on Red Chili Farmers			
1	Plan Source	Not finding the right planting location	E1
		Not getting accurate planting area information	E2
		Not punctuate in planting time	E3
		Incorrect selling price prediction	E4
		The number of production facilities does not match the needs	E5
	Make	Productivity is not in accordance with the expectations	E6
	Deliver	Quality not as expected	E7
		Selling price is not in accordance with expectation	E8
		Rejection of chilli which has not match the standard quality	E9
	Return	Experiencing financial loss	E10
		Work termination	E11
Risk Event to Red Chili Collecting Traders			
2	Plan	The results of the mapping of harvest locations are not correct	E1
		Purchase price not as expected	E2
		Short supply of red chilli	E3
		Return on capital is not smooth	E4
	Source	Labor scarcity	E5
		The quantity of chilli does not match the results of the negotiations	E6
		Chilli quality is not as expected	E7
	Make	Decrease in chilli quality	E8
		Chilli Quantity Depreciation	E9
		Increase in operational cost	E10
		Capital turnover is not smooth	E11
		Selling price of chilli is not in accordance with expectation	E12
	Deliver	Decrease of chilli quantity	E9
		Decrease of chilli quality	E8
	Return	Costumers' loss	E13
		Experiencing financial loss	E14
Risk Event to Red Chili Wholesalers			
3	Plan	The results of the mapping of harvest locations are not accurate	E1
		Price not as expected	E2
		The prediction of the determination of the collecting trader is not appropriate	E3
	Source	The quality is not in accordance with the order	E4
		The quantity is not in accordance with the order	E5
	Make	Decrease of chilli quantity	E6
		Decrease of chilli quality	E7
		Financial loss due to reduced demand	E8
		Capital turnover is not smooth	E9
	Deliver	Decrease in quality	E7
		Financial loss due to an accident in delivery	E10
	Return	Financial loss due to product being returned	E11
Risk Event to Red Chili Retailers			
4	Plan	Inappropriate sales location	E1
		Price not as expected	E2
		Inappropriate demand prediction	E3
	Source	Quantity not as expected	E4
		Quality not as expected	E5
	Make	Decrease in the chilli quantity	E6
		Decrease of chilli quality	E7
		Decrease of the selling price	E8
		Financial loss	E9

Source: primary data (processed), 2021

Risk ranking for red chilli farmers

The results of the risk assessment on red chilli farmers are shown in Figure 1a and the results of the evaluation of the risk agent are shown in Figure 1b. The highest risk agent for red chilli farmers is disease, followed by pest attacks, price distortions, price fluctuations, abundant production capacity, and weather uncertainty. This shows that the causes of the risk of conventional red chilli farming are disease, pests, and weather uncertainty. The influence of climate change affects the incidence of pests and diseases, host-pathogen interactions, so it becomes a major setback for vegetable cultivation (Ayyogari *et al*., 2014) [6]. Pest and disease attacks and price variations are risks that require urgent intervention (Ebile *et al*., 2021) [14].

In general, red chilli farmers are small farmers, with low status, production and business capital. This situation resulted in farmers being bound to sell their products of to the owner of the capital and receive the price determined by the owner of the capital. In addition, distortions and price fluctuations often occur. The sensitive farmers are weak in making decisions on the commodities they cultivate. The risk agent category for red chilli farmers can be seen in Figure 1b below.

Table 2: Risk agent on red chili supply chain actors in Bali Province

No	SCOR	Risk Agent	Ai
1	**2**	**3**	**4**
Risk Agent to the red chili farmers			
1	Plan	Subak member agreement in determining cropping pattern	A1
		Limited information on chili planting area	A2
		Mistake in setting planting time	A3
		Excess production capacity	A4
	Source	Limited capital	A5
		Availability of inputs that are not on time	A6
	Make	Pest attack	A7
		Disease attack	A8
		Weather uncertainty	A9
		The technology used is not suitable	A10
		Distortion of price information	A11
		Price Fluctuation	A12
	Deliver & Return	Chili quality is not in accordance with demand	A13
Risk Agent to Red Chili Collecting Traders			
2	Plan Source	Limited information on harvest locations	A1
		Mistakes in predicting the purchase price of chilli	A2
		Yield prediction mistake	A3
		Collecting trader's competition	A4
		Farmers cannot pay their debts due to crop failure	A5
		Low labor ethos	A6
		Holiday leave	A7
		Farmer loyalty is low	A8
		Mistake in harvest prediction	A3
		Young chilli being harvested	A9
	Make	Excess of chilli stocks	A10
		Sorting and grading mistake	A11
		Wet chilies are exposed to rain when delivery to collecting traders	A12
		Low consumer loyalty	A13
		Error predicting supply and demand	A14
		Collector's competition	A4
	Deliver	The packaging of chilli is not right	A15
		Delivery time uncertainty	A16
		Damage during delivery	A17
	Return	The quality of the chili is not according to the demand	A18
Risk Agent on Red Chili Wholesalers			
3	Plan	Limited harvest location information	A1
		Weather uncertainty	A2
		Price Fluctuation	A3
		Low loyalty of the collecting traders	A4
	Source	Mistakes on quality control by the whole seller	A5
		Limited supply at the collecting traders	A6
		Low loyalty of the collecting traders	A4
	Make	Sorting and grading mistakes by wholesalers	A7
		Excess of chilli stocks	A8
		Decrease of demand	A9
		Low loyalty of the consumers	A10
		Price Fluctuation	A3
		Excess of chilli stocks	A8
	Deliver Return	Wet chilli exposed to rain when delivery to traders	A11
		Incompetent of delivery personnel	A12
		Accident in delivery	A13
		The quality of the chilli does not match the order	A14
Risk Agent to Red Chili Retailers			
4	Plan	Weaknesses in seeing potential market	A1
		Place of sale is regulated by Regional Company Market (PD Pasar)	A2
		Distortion of price information	A3
		Price Fluctuation	A4
		Uncertainty on the number of demands	A5
	Source	Uncertainty of the supply number	A6
		Variations in supply quality in packaging	A7
	Make	Sorting and grading mistake	A8
		Product handling mistake	A9
		Excess of stocks	A10
		Decrease of chilli quality	A11
		Decrease of Demand	A12

Source: primary data (processed), 2021

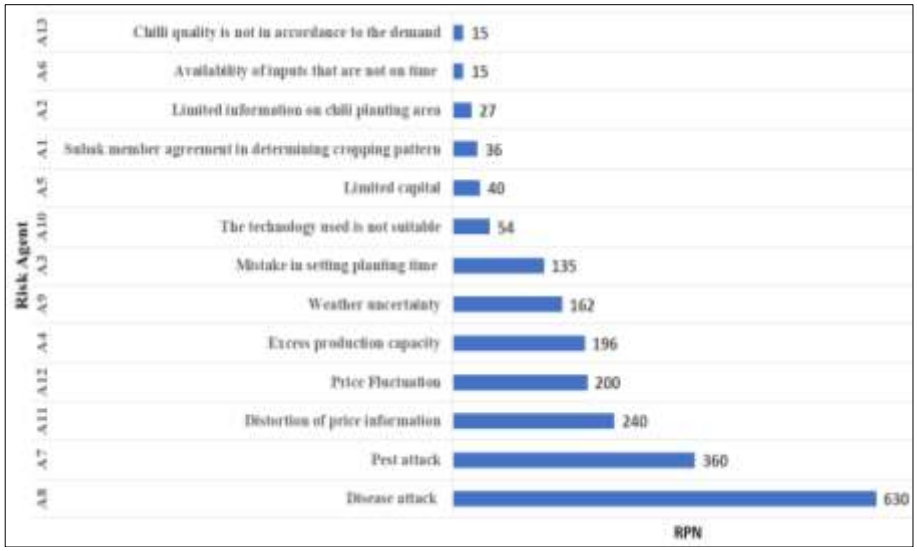

Fig 1a: Recapitulation of the accumulated value of farmers' RPN (Source: result of primary data processed, 2021)

Risk Level		RPN		
		1-71	72-391	392-1000
Severity	1-6	A1, A2, A5, A6, A13	A4	
	7-8			
	9-10	A10	A3, A7, A9, A11, A12	A8

Fig 1b: Map of red chili farmers' risk agent (Source: result of primary data processed, 2021)

Based on the results of the evaluation of risk agents contained in the Farmer Risk Agent Map (Figure 1b), that the risks faced by farmers are in three risk categories, namely the acceptable category, the category that requires action to handle or control risks which must be determined immediately, and the category that requires risk management or control measures, and category which requires immediate action (Chen *et al*., 2015) [9]. Risk agents in the acceptable category consist of six risk agents (46.15%), meanwhile 7.70% in the category that requires action to handle or control risks that must be determined immediately, and 46.15% risk agents are in the category that requires fast action.

Risk ranking of red chilli collecting traders

The results of the risk assessment on the red chilli collectors are shown in Figure 2a and the results of the evaluation of the risk agent are shown in Figure 2b. The three highest risk agents for collecting traders are mistakes in predicting crop yields, followed by mistake in predicting the purchase price of chilies, and farmers are being unable to pay their debts due to crop failure.

Fig 2a: Recapitulation of the accumulated RPN value of collecting traders (Source: result of primary data processed, 2021)

Next, we can observe the risk agent map on the red chilli collecting traders in Figure 2b. Based on the results of the risk agent evaluation contained in Figure 2b, that the risk agents faced by collecting traders are 88.89% are in the acceptable risk category and only 11.11% are in the category that requires risk management actions that must be determined immediately, namely the excess stock of chili and the error in predicting demand (Ray, 2021) [23].

Risk Level		RPN		
		1-71	72-391	392-1000
Severity	1-6	A1, A6, A7, A8, A12, A13, A16, A15	A4, A9, A18, A3, A11, A2, A5	
	7-8	A17	A10, A14	
	9-10			

Fig 2b: Risk agent map collecting traders (Source: result of primary data processed, 2021)

Risk ranking of red chilli wholesalers: The results of the risk assessment on red chilli wholesalers are shown in Figure 3a and the results of the evaluation of the risk agent are shown in Figure 3b. The three highest risk agents for wholesalers are limited supplies at collecting traders, followed by price fluctuations, and a decline in demand due to the COVID-19 pandemic. Next, the Risk Agent Map for Red Chili Wholesalers can be seen in Figure 3b.

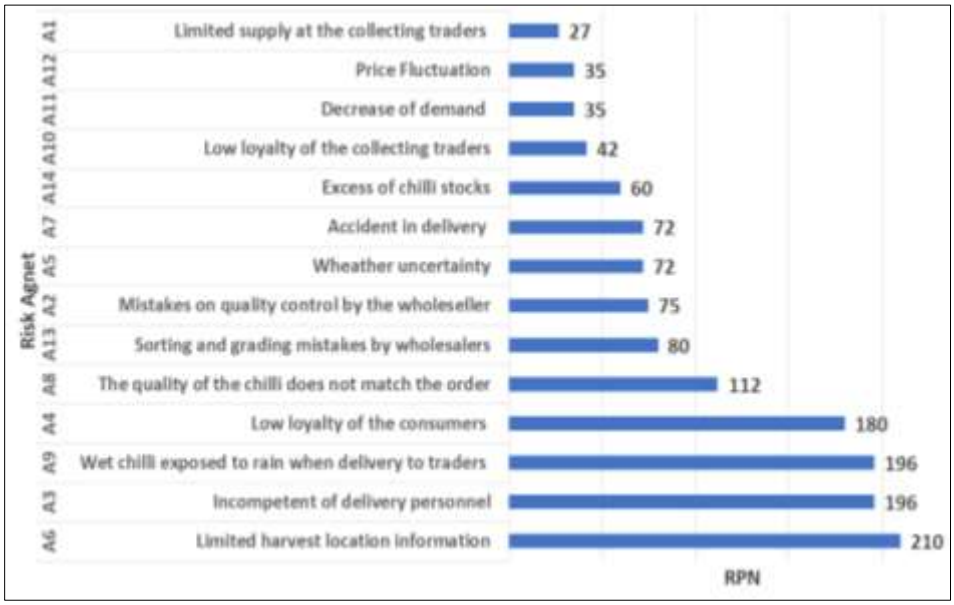

Fig 3a: The results of the risk assessment on red chilli wholesalers

Based on the results of the risk agent evaluation contained in Figure 3b, the risks faced by wholesalers fall into two risk categories, namely the acceptable category and the category requiring risk management actions that must be determined immediately. Risk agents in the acceptable category consist of 10 risk agents (71.43%) and four risk agents (28.57%) in the category that requires risk management actions that must be determined immediately (Ray, 2021) [23]. Figure 3a. Recapitulation of the Accumulated RPN Value of Wholesalers (Source: result of primary data processed, 2021)

Risk Level		RPN		
		1-71	72-391	392-1000
Severity	1-6	A1, A14	A6, A4, A2, A5, A7	
	7-8	A10, A11, A12	A13, A3, A9, A8	
	9-10			

Fig 3b: Risk agent map for wholesalers (Source: result of primary data processed, 2021)

Risk ranking of red chilli retailers: The results of the risk assessment on red chili retailers are shown in Figure 4a and the results of the evaluation of the risk agent are shown in Figure 4b.

Fig 4a: Recapitulation of accumulated RPN value of retailers (Source: result of primary data processed, 2021).

The three highest risk agents at retailers are the uncertainty of the amount of demand, followed by price fluctuations, and excess of stock. Next, the Risk Agent Map for Red Chilli Retailers can be seen in Figure 4b. Based on the results of the evaluation of risk agents contained in Figure 4b, that the risk agents faced by retailers are in two risk categories, namely seven risk agents in the acceptable category and four risk agents in the category that requires risk management actions that must be determined immediately.

Based on the four risk agent maps, supply chain actors can find out the risk categories they face. Therefore, supply chain actors at every level need to carry out risk assessments on a regular basis in order to be able to mitigate risks early to reduce losses (Chowdhury & Quaddus, 2015) [10].

Risk Level		RPN		
		1-71	72-391	392-1000
Severity	1-6	A11, A1, A2	A10, A8, A9, A6	
	7-8		A3, A4, A5, A7	
	9-10			

Fig 4b: Risk agent map retailer

In Figure 1a-4a it can be observed that the highest RPN value at each level, the highest is found in farmers, which is 630 and the lowest is found in collecting traders, which is 179. This shows that farmers who face the greatest risk and collecting traders who face the lowest risk in red chilli supply chain in Bali Province. The highest risk in the red chilli supply chain in Bali Province based on the RPN value is included in the *Intolerable* category at the farmer level. This is supported by Dewi & Parining (2017) [13], that the level of risk of red chilli production at the farmer level is relatively high as indicated by the coefficient of variation of 4.3. Therefore, farmers need to carry out mitigation planning and implement it. Situmeang (2011) [27] also argues that farmers need to carry out preventive strategies, namely carrying out routine and planned maintenance from seeding to harvesting. The results of this study are also supported by the results of the research from Kurniawan *et al*. (2014) [6], i.e., there are still red chilli distribution channels that are not efficient when viewed from the value of the share of producers or the level of profit of red chilli farmers, which is less than 70%. Partially there are red chili production factors that are not efficient, namely seeds and manure, as well as inefficient production factors, namely foliar fertilizers, calcium fertilizers, pesticides, and labor. (Wijayanti *et al*., 2018) [29]. In addition, in their study of the Cocoa supply chain in Kare Village showed that supply chain performance conditions were not optimal.

The highest risk at the level of collecting traders, wholesalers, and retailers is in the As Low As is Reasonably Practicable (ALARP) category. Risks in the Intolerable and ALARP categories still need risk mitigation planning. This is intended to minimize the impact of the risk that will be faced and the probability of the emergence of the cause of the risk, so as to minimize losses (Ray & Jenamani, 2016; Le *et al*. 2022) [22, 18].

In the risk agent map (Figure 1b-4b), only risk agents for farmers consist of three risk categories, namely categories that are acceptable, categories that require action to handle or control risks that must be determined immediately, and categories that require quick action. The risk agent for farmers in the category that requires risk control measures that must be determined immediately is 46.15%. This value is relatively high, but farmers in the province of Bali continue to do red chilli farming in every planting season, both rainy and dry seasons. This attitude of farmers is supported by the results of research by Arifin & Wartapa (2021) [3], that most farmers in Sumberharjo Village, Prambanan District have the attitude of wanting to continue red chili farming.

Risk mitigation planning for red chili supply chain actors

Mitigation planning is carried out after knowing the results of the FMEA risk level map. Risk mitigation planning in this study was carried out in accordance with AS/NZS 4360 (2004) [4], namely mitigate risk, transfer risk, avoid risk, and retain risk. However, treatment with retain risk is not used because it is risk-accepting. The risk agent given by the mitigation plan is a risk agent that is in the ALARP and Intolerable categories (Xu *et al*., 2016) [30], because it is considered to disrupt the red chili supply chain flow. Risk mitigation planning for red chili supply chain actors in Bali Province is presented in Table 3.

Table 3: Risk mitigation planning for red chili supply chain actors in Bali Province

Ai	Risk Agent	Mitigation Planning
1	**2**	**3**
Farmer		
A10 A8 A7 A9 A3 A11 A12	**ALARP:** Inappropriate application of technology **Intolerable:** Disease attack Pest attack Uncertainty of weather Mistakes in setting planting time Distortion of price information Price fluctuation	Farmers who have capital will plant chilies in green houses to minimize pests and diseases, as a result of weather uncertainty and overcome inaccuracies in planting time. Farmers who lack capital will improve the size of drainage channels, mound size, spacing, use high-yielding varieties, apply fertilizer as recommended, control pests and plant diseases intensively, diversify plants that are not favored by pests. Selling crops to more than one trader; establish communication with other production centers; dividing the members of subak/farmer groups into the planting season in the dry season and the planting season in the rainy season.
Collecting Traders		
A14 A10	**ALARP:** Mistake in prediction of demands Excess of chilli stocks	Improve communication with customers (Hayuningtyas,2019) [17] Adding sales locations Purchase chilli on demand Increase sales time Lowering the selling price
Wholesalers		
A3 A9 A8 A13	**ALARP:** Price Fluctuation Decrease of demands due to pandemic covid19 Excess of chilli stocks Accident during delivery	Increase the frequency of searching for price information Building partnerships with collecting traders (Hayuningtyas, 2019) [17] Improving demand analysis according to the economic conditions being faced. Adding sales locations Lowering the selling price Improve chili handling to maintain quality Improve vehicle condition control and select a reliable workforce.
Retailers		
A5 A4 A3 A7	**ALARP:** Uncertainty of the number of demands Price Fluctuation Distortion of price information Variation in quality supply in packaging	Improve demand analysis according to the conditions encountered. Build partnerships with wholesalers and or collecting traders or integration between supply chain actors (Hayuningtyas, 2019) [17]. Increase the frequency of searching for price information by using the interne (Yan *et al*., 2017) [31] Sorting and grading, then determining different prices according to quality. When the price is high, the low-quality chilli is still sold, but when the price is low, the low-quality chilli is consumed for the family. Chilli with very poor quality will be returned to collecting traders and/or wholesalers. Retailers in modern markets make contracts with suppliers, including price, quantity, quality, delivery time, payment system.

Source: Primary data (processed), 2021

The results show that the risk mitigation planning for each red chilli supply chain actor varies, so it is necessary to carry out an integrated risk mitigation plan according to the risk agent. Integrated risk mitigation planning as a mitigation strategy to improve the ability of the red chilli supply chain (Nooraie & Parast, 2016; Asrol *et al*., 2020) [20, 32]. This also in line with Ray (2021) [23], proposes a single approach is not sufficient to provide solutions in all types of risk scenarios; whereas, a combination of approaches is most effective, particularly in the supply chain of perishable agricultural products, price and demand uncertainty. Through the implementation of integrated supply chain management, it is hoped that consumers will get better product quality, better service, and lower price; retailers will get increased sales volume, faster and better process of procurement goods and selling them, stable prices, better profits; traders will get more controlled inventory, better product quality, and increased profits; and farmers as producers will get higher productivity and selling prices, so their incomes increase (Saptana *et al*., 2018) [25].

Conclusion

Based on the results of the analysis and discussion, in the red chilli supply chain, 11 risk events and 13 risk agents have been identified at the farmer level, 14 risk events and 18 risk agents at the level of collecting traders, 11 risk events and 14 risk agents at the whole seller level, and nine risk agents, and 12 risk agents at retailer level. The highest risk in the Intolerable category is at the farmer level, while the highest risk in the other three supply chain actors is in the ALARP category. The risk mitigation planning for each red chilli supply chain actor varies, so it is necessary to carry out an integrated risk mitigation planning according to the risk agent.

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Author contributions
RKD as well as the corresponding author plans, designs, carries out the research and creates the manuscript, NP carries out research, analyzes the data and reports, BAH analyzes the data, creates and translates the manuscript.

Conflict of interest
The author declares that there is no potential conflict of interest in connection with the research, writing, and/or publication of this article.

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