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Risk Management Analysis in Snake Fruit Supply Chain through House of Risk Approaches (Case study in CV "MT")

Dinar Fitriandini[1♥], Wiludjeng Roessali[1], Suci Wulandari[2]

[1]Agribusiness Graduate Program, Faculty of Animal Science and Agriculture, Universitas Diponegoro, Semarang, Indonesia
[2]Research Center for Cooperatives, Corporations, and the People's Economy, National Research and Innovation Agency, Jakarta, Indonesia
♥Corresponding author email: dinarfitriandini@gmail.com

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Abstract. Snake fruit is a native Indonesian fruit that has become one of the leading export horticultural commodities. However, the distribution process of snake fruit exports to foreign countries faces several risks, such as perishability, bulky, diverse quality, and seasonality. Therefore, qualified management of risk barriers in the snake fruit supply chain system is needed, which is not only found in the distribution process but also in the production process and financial risks to maintain the quality of snake fruit. This study aims to identify potential risks, analyze the level of risk, and formulate risk mitigation measures in the snake fruit supply chain. The research method uses the intrinsic case study method and is analyzed using the House of Risk approach. The results showed that there were 32 risk events and 33 risk agents. Two of them are priority risks for mitigation, namely the risk of natural factors and demand fluctuations, which have led to 3 recommendations for mitigation actions, consisting of collaborating with related agencies and institutions, conducting intense communication among supply chain actors, and providing counselling and supervision of farmer-level snake fruit cultivation activities.

Keywords: agribusiness; house of risk; risk management; snake fruit; supply chain management

INTRODUCTION

Java Island is the pillar of the agricultural production process in Indonesia (Idris, 2017). According to the Badan Pangan Nasional (2021), Java Island has the highest average food security index, with six provinces in the good and best food security categories. Central Java Province has the second highest food security index nationally with 82.73, followed by Yogyakarta Province (81.43), East Java (79.70), DKI Jakarta (78.01), West Java (77.79), and Banten (74.38). The food security index calculation is based on food availability, affordability, and utilization (Zamrodah, 2020).

This is since infrastructure support for food crops and horticulture production is still centralized in Java. Infrastructure development such as transportation networks, warehouse facilities, and irrigation systems, can improve the efficiency and effectiveness of the existing agricultural supply chain (Gunawan *et al.*, 2022). This condition causes the need to distribute agricultural products from Java Island to other islands in the country or even abroad.

Horticulture is an agricultural sub-sector that includes the cultivation of vegetables and fruits (Tafolla-Arellano *et al.*, 2018). In 2021, the horticulture sub-sector was able to contribute 1.55% to the National GDP (Gross Domestic Product) (Kusnandar, 2022). The highest proportion of commodities in the horticulture sub-sector in Indonesia is derived from fruit commodities which reached 31.34% (Santika, 2023). This is due to the fact that fruits have their own special potential to be developed as the main export commodity of the horticulture subsector (Surbakti *et al*., 2024).

Snake fruit (*Salacca zalacca*) is one of Indonesia's leading horticultural products. In 2022, it was recorded that the snake fruit commodity produced a harvest of 1.40 million tons (Rizaty, 2023). Kementerian Pertanian (2020) noted that up to September 2020 snake fruit exports reached a volume weight of 763 tons with an export value of 928 thousand US dollars, with an average export volume growth of 22.81% and an

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average export value growth of 10.34% from 2016 to 2019.

However, (Behzadi *et al*., 2018a) summarizes some of the characteristics of agricultural products, especially in horticultural commodities, which generally have high water content, are easily damaged, bulky, have diverse qualities, and are seasonal. These characteristics of agricultural products make it impossible to tolerate significant delays in the supply chain of agricultural products, especially in horticulture (Behzadi *et al*., 2018b). Therefore, a qualified supply chain system is needed to ensure that the quality of snake fruit can be maintained and guaranteed.

The supply chain is the cycle of a product that starts as raw materials from suppliers, which are then processed through operational activities by the company, up to the distribution to end consumers through distributors (Tooy *et al.*, 2021). In contrast, supply chain management in the horticulture industry faces a wide range of risks that are increasingly diverse, complex, and interconnected in terms of production, distribution, and finance (Duong *et al.*, 2019; Wulandari *et al.*, 2021). It is then interesting to analyze more deeply the risk management faced by the horticultural industry's ongoing supply chain system, especially in the snake fruit supply chain.

Supply chain flow consists of goods flow, cash flow, and information flow, involving several actors, such as manufacturers, suppliers, transporters, warehouses, retailers, logistics service providers (distributors), and end consumers (Leppe & Karuntu, 2019). In the agribusiness sector itself, the supply chain that runs starts from farmers who act as producers of agricultural products, which then in product marketing, farmers generally have several destination markets, such as traditional markets, modern markets, or export markets, which causes differences in the actors involved subsequently where farmers partner with more than one dealer (middlemen) or other logistics service providers according to the market destination (Perdana & Hermiatin, 2019).

In general, the supply chain system can be grouped into 5 processes, namely the planning process (plan), the process of supplying raw materials from suppliers (source), the process of transforming raw materials into ready-to-consume products (make), the distribution and warehousing process (deliver), to the product return process which consists of information and payment aspects (return) (Hahn, 2020).

This research offers a new location to analyze risk management in agro-industry, where previous research was conducted on a micro business scale that has not implemented certain quality standards, by providing research suggestions in the form of implementing quality standards (Kurniasih *et al.*, 2023; Nadhira *et al.*, 2019). In contrast to that, this research was conducted on an agro-industrial company that has an export market orientation and has implemented GHP (Good Handling Practices) and GAP (Good Agricultural Practices) quality standards, with the aim of enriching the literature related to risk management in agro-industry.

This research aims to identify and analyze potential risks in the supply chain and realize mitigation actions that are in accord with company resources. Therefore, this research uses the House of Risk method to define the research objectives. The SCOR (Supply Chain Operations Reference) model is also used to facilitate the process of mapping the business processes that run in the snake fruit supply chain. Ikatrinasari *et al.* (2020) explained that the SCOR model can identify supply chain activities carried out in each supply chain process, thereby making it easier to specify performance analysis in the supply chain.

The research contribution to the snake fruit horticulture industry is a mitigation strategy expected to reduce risks in the snake fruit supply chain. This research is also expected to increase the awareness of farmers and other similar agro-industries in implementing quality standards in their

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business processes. Therefore, the horticulture supply chain, especially the snake fruit supply chain, can run adequately in order to keep product quality at its best condition.

Table 1. Snake fruit supply chain activities

Business Process	Supplier Farmers	CV "MT"	Distributor
Plan	• Forecasting local and/or export market demand • Cultivation and/or harvesting planning • Farmer-level price determination	• Forecasting local and/or export market demand • Management planning • Inventory control of snake fruit stock • Supply chain adjustment in accord with company finances • Warehouse capacity planning for snake fruit stock • Farmer-level price determination	• Forecasting local and/or export market demand
Source	• Selection of quality seedlings according to standards • Purchase of fertilizer	• Ordering snake fruit to farmers • Selection of supplier farmers • Scheduling the shipment of snake fruit from farmers • Receipt of snake fruit • Authorization of payment for snake fruit delivered by farmers • Evaluation of farmer performance	• Ordering snake fruit to CV "MT"
Make	• Implementing SOP of GAP in snake fruit cultivation • Implementing SOP of GHP in harvesting snake fruit	• Snake fruit reception • Snake fruit drying • Snake fruit cleaning • Snake fruit sortation • Snake fruit weighing • Snake fruit inspection • Snake fruit labeling • Snake fruit binding • Snake fruit storation	-
Deliver	• Ready-to-harvest registration to CV "MT" • Distribution of snake fruit to CV "MT"	• Scheduling shipment to distributor • Shipping snake fruit to distributor • Sending payment invoices to distributor	• Scheduling shipment from CV "MT" • Authorization for payment of snake fruit as ordered to CV "MT"
Return	• Discussed with CV "MT" regarding returns procedure	• Identification of snake fruit rejects • Handling the return of rejected snake fruit • Return shipment of new snake fruit to distributor	• Identification of snake fruit rejects • Discussed with CV "MT" regarding returns procedure

METHODS

This research uses an intrinsic case study that is based on the researcher's personal interest (Rahardjo, 2017) as a basic research method to describe risk management in the snake fruit supply chain run by a company that has implemented certain quality standards. The research was conducted in February 2024 at CV Mitra Turindo (CV "MT") located in Kapanewon Turi, Sleman Regency, Yogyakarta Special Region Province. The research location was determined purposively, based on CV "MT" which is an agro-industrial company that

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offers packing house services for snake fruit that has implemented certain quality standards, namely GHP and GAP. Moreover, Sleman Regency is known as the center of snake fruit production, where Kapanewon Turi contributed the largest harvest in 2020, reaching 38.12 thousand tons. Data collection was conducted together with supply chain actors, through interviews with 4 CV "MT" officers, 20 partner farmers representing 10 partner farmer groups, and 1 distributor. Observations were also conducted to justify the existing data and the situation at the location.

Table 2. Results of risk event measurement

Code	Risk Event	Impact Level
E1	Sudden request	6
E2	Order cancellation	5
E3	Change in order quantity	5
E4	Low price	5
E5	High expenditure on seeds and fertilizers	2
E6	Unmet demand	5
E7	Farmers are unable to supply	5
E8	There are snake fruits that did not meet the requested quality criteria	3
E9	Snake fruit contamination	6
E10	Snake fruit damaged during storation	6
E11	Decrease in quantity of snake fruit from demand	5
E12	Damage to snake fruit	5
E13	Unavailability of harvested snake fruit from farmers	7
E14	Errors in the drying process	6
E15	Errors in the cleaning process	7
E16	Officers have a different understanding of the quality of each grade	5
E17	Officers make weighing errors	5
E18	Officers lack of understanding the SOP of GHP	5
E19	Officers did not do labeling	5
E20	Officers do labeling that is not in accord with existing information	5
E21	Basket binding is not strong	5
E22	Wrong number of snake fruit delivered	6
E23	Error in filling out the return administration	5
E24	Quantity of returned snake fruit did not match the administration	5
E25	Delay in arrival of snake fruit	4
E26	Delay in shipment of snake fruit	4
E27	Delayed arrival of hauling transportation	7
E28	Disruption of transportation	8
E29	Delayed receipt of money	6
E30	Delayed transportation of snake fruit	10
E31	Snake fruit fell out of the basket during haulage	1
E32	Delayed payment of bills	8

Supply Chain Activity Mapping

The SCOR model is used to identify the journey of snake fruit from farmers to end consumers, which is specified in the activities of plan, source, make, deliver, and return. Supply chain activity mapping is needed to facilitate the identification of risks that occur in the snake fruit supply chain.

House of Risk

This research uses the House of Risk (HOR) method to process and analyze research data. The HOR method is divided

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into two phases; where Phase 1 aims to define the impact level of risk events and the probability level of existing risk agents. The phase 1 HOR model helps in mapping the correlation between risk events and risk agents so as to calculate the impact level, probability level, and risk correlation value, which results in an aggregate risk potential (ARP) value (Yustika & Tan, 2021). The ARP values are then sorted from highest to lowest to find the risk agents prioritized to be mitigated with a cumulative percentage of up to 20% based on Pareto's law.

Furthermore, risk agents that become mitigation priorities are analyzed in the HOR Phase 2 model. In this phase, mitigation actions are identified by calculating the total effectiveness (TEk) value, degree of difficulty (Dk) value, and the total effectiveness of degree of difficulty (ETD) value to formulate appropriate mitigation actions.

Table 3. Results of risk agent measurement

Code	Risk Agent	Probability Level
A1	Demand fluctuations	7
A2	Natural factors	10
A3	Difficulty in accessing seeds and fertilizers	2
A4	Seed quality is not in accord with the SOP of GAP	1
A5	Inappropriate planting schedule	5
A6	Inappropriate harvesting schedule	5
A7	Not implementing SOP of GAP-GHP	2
A8	Cultivation process errors	1
A9	Unavailability of harvested snake fruit to farmers	7
A10	Absence of harvesting farmers	7
A11	Supplying farmers run out of ready-to-harvest snake fruit stock	7
A12	Lack of coordination with supplying farmers	2
A13	Inadequate warehouse capacity	1
A14	Unavailability of refrigerator	1
A15	Inappropriate temperature in snake fruit storage room	1
A16	Storage method is not in accord with SOP of GHP	1
A17	Lack of maintaining equipment	1
A18	Damage in processing tools	1
A19	Electricity outage	1
A20	Failure to do demand forecasting	5
A21	Human error	2
A22	Failure in determining schedule for transporting snake fruit from farmers	3
A23	Long lead time	5
A24	Limited number of transportation	3
A25	Lack of maintaining shipping transportation	3
A26	Officers did not wear PPE	6
A27	Exceeding storage time	3
A28	Lack of coordination with distributors	2
A29	Improper handling of snake fruit during shipment	1
A30	Lack of coordination with CV “MT”	6
A31	Delayed payment from buyer	6
A32	Cancellation of order from buyer	5
A33	Incomplete export documents	6

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RESULTS AND DISCUSSION

House of Risk Phase 1

The identification of risk events and risk agents in **Table 2** and **Table 3** is based on the supply chain activities mapped through the business processes implemented by each supply chain actor in **Table 1**. The identification results show that the snake fruit supply chain at CV "MT" has 32 risk events and 33 risk agents. Natural factors (A2) are the risks that have the highest probability of occurrence with a value of 10.

Table 5. Pareto calculation of risk agent

No.	Code	Risk Agent	ARP Value	Percentage	Cumulative	Category
1.	A2	Natural factors	2.232	11.55%	11.55%	Priority
2.	A1	Demand fluctuations	1.710	8.85%	20.40%	
3.	A9	Unavailability of harvested snake fruit to farmers	1.313	6.80%	27.20%	Non-Priority
4.	A20	Failure to do demand forecasting	1.303	6.74%	33.94%	
5.	A23	Long lead time	1.095	5.67%	39.61%	
6.	A33	Incomplete export documents	1.094	5.66%	45.27%	
7.	A21	Human error	1.089	5.63%	50.90%	
8.	A10	Absence of harvesting farmers	1.024	5.30%	56.20%	
9.	A11	Supplying farmers run out of ready-to-harvest snake fruit stock	1.024	5.30%	61.50%	
10.	A28	Lack of coordination with distributors	848	4.39%	65.88%	
11.	A30	Lack of coordination with CV "MT"	782	4.04%	69.93%	
12.	A27	Exceeding storage time	626	3.24%	73.17%	
13.	A24	Limited number of transportation	585	3.03%	76.20%	
14.	A25	Lack of maintaining shipping transportation	455	2.35%	78.55%	
15.	A5	Inappropriate planting schedule	449	2.33%	80.88%	
16.	A6	Inappropriate harvesting schedule	449	2.33%	83.20%	
17.	A31	Delayed payment from buyer	432	2.24%	85.44%	
18.	A12	Lack of coordination with supplying farmers	385	1.99%	87.43%	
19.	A32	Cancellation of order from buyer	360	1.86%	89.29%	
20.	A18	Damage in processing tools	335	1.73%	91.02%	
21.	A17	Lack of maintaining equipment	316	1.63%	92.65%	
22.	A16	Storage method is not in accord with SOP of GHP	267	1.38%	94.04%	
23.	A7	Not implementing SOP of GAP-GHP	199	1.03%	95.07%	
24.	A19	Electricity outage	153	0.79%	95.86%	
25.	A26	Officers did not wear PPE	134	0.69%	96.55%	
26.	A8	Cultivation process errors	130	0.67%	97.22%	
27.	A14	Unavailability of refrigerator	119	0.62%	97.84%	
28.	A15	Inappropriate temperature in snake fruit storage room	119	0.62%	98.45%	
29.	A22	Failure in determining schedule for transporting snake fruit from farmers	113	0.58%	99.04%	
30.	A29	Improper handling of snake fruit during shipment	61	0.31%	99.35%	
31.	A4	Seed quality is not in accord with the SOP of GAP	57	0.29%	99.64%	
32.	A13	Inadequate warehouse capacity	53	0.28%	99.92%	
33.	A3	Access to seeds and fertilizers is difficult	16	0.08%	100.00%	
		Total	**19.323**	**100%**		

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Natural factors cover weather and seasonal changes, as well as pest attacks. Risks in natural factors are experienced by every supply chain actor, where pest attacks can reduce the performance of farmers in supplying snake fruit to CV "MT". In addition, changes in weather and seasons not only affect the cultivation process, but also affect the harvest, post-harvest, and distribution processes. The risk event with the highest impact level is the delay in the transportation of snake fruit (E30) with a value of 10. This risk event is the most dangerous risk because it can cause significant time and financial losses due to damage of the snake fruit caused by the long distribution process.

The results of the HOR Phase 1 calculation in **Table 4** shows that the ARP value of 16 as the lowest value, comes from the A3 risk agent (difficulty in accessing seeds and fertilizers), while the ARP value of 2,232 is the highest value, comes from the A2 risk agent (natural factors). The ARP values that have been obtained are then sorted from the highest to the lowest value and calculated the percentage proportion to be able to determine the priority risk of mitigation.

Based on Pareto's law, risks that have a cumulative percentage of 20% are risks that are prioritized for mitigation. The cumulative percentage of 20% is included in code A2 with a proportion of 11.55% and code A1 with a proportion of 8.85%, making the risk agents of natural factors and demand fluctuations as mitigation priorities. The calculation of the Pareto percentage of risk agents is shown in **Table 5** and the Pareto diagram can be seen in **Figure 1**.

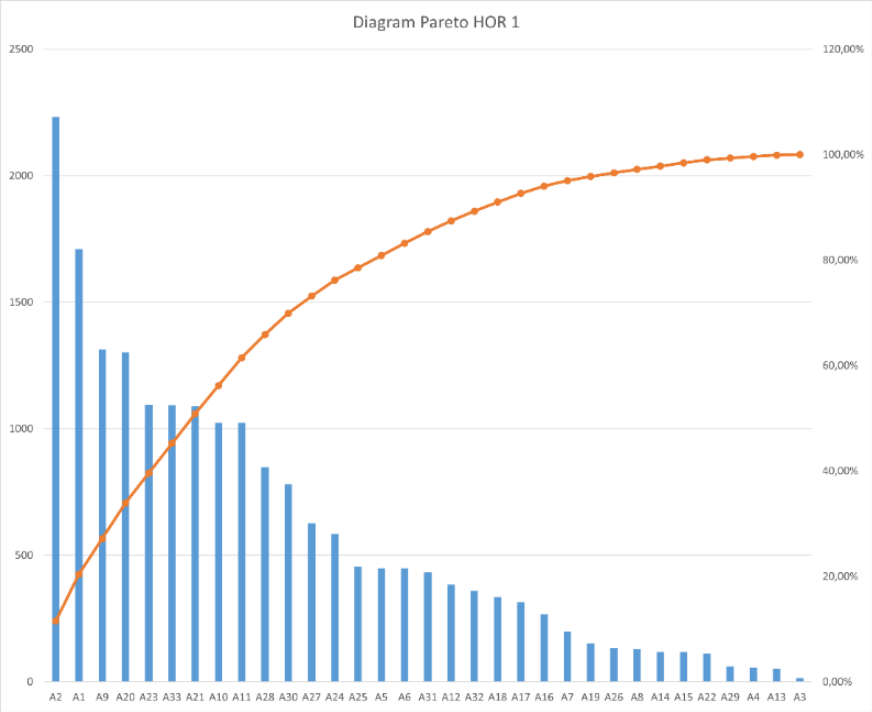

Figure 1. Pareto diagram of risk agents

Table 6. Formulation of mitigation actions

Priority Risk Agents	Mitigation Actions
Natural factors (A2)	Collaboration with the Department of Agriculture, Indonesian Agency for Agricultural Research and Development (IAARD) of Yogyakarta, universities, and other related institutions (PA-1)
Demand fluctuations (A1)	• Counseling and supervision of the implementation of GAP SOPs at the farm level (PA-2) • Intense communication with farmers and distributors (PA-3)

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Table 7. Degree of difficulty scale

No.	Scale	Description
1.	3	Implementation of mitigation is easy
2.	4	Implementation of mitigation is somewhat difficult
3.	5	Implementation of mitigation is difficult

Figure 1 shows the Pareto diagram of the 33 sources of risk contained in the CV "MT" snake fruit supply chain. The horizontal lines from left to right consecutively show the risk source codes from highest to lowest ARP values. The left vertical line shows the ARP value, while the right vertical line shows the percentage. Meanwhile, the blue bars in the graph show the value of ARP from each risk source, while the red line in the graph shows the accumulated percentage of all existing risk sources. In detail, the Pareto diagram is able to show the source of risk with the highest to lowest ARP value, which is also able to show the percentage contribution of risk caused by each source of risk to the current supply chain and thus determine which source of risk is a mitigation priority.

Table 8. House of risk phase 2

Priority Risk Agents		**Mitigation Actions**			**ARP**
		PA-1	PA-2	PA-3	**Value**
Natural factors	(A2)	9			2.232
Demand fluctuations	(A1)		9	9	1.710
TE_k Value		20.088	15.390	15.390	
Dk Scale		3	4	3	
ETD Value		6.696	3.847,5	5.130	
Priority Ranking		1	3	2	

House of Risk Phase 2

House of Risk Phase 2 is aimed at formulating mitigation actions that are in accord with the mitigation priority risk agents that have been identified to minimize the impact of these risk agents. The formulation of mitigation actions is adjusted to the resources available at CV "MT", both human resources and cost resources, to ensure that mitigation actions can run effectively and efficiently.

The mitigation actions that have been identified in **Table 6** are then measured for their correlation with the risk agents that are prioritized for mitigation using a scale of 0, 1, 3, and 9 which consecutively describes no correlation, low correlation, medium, and high. Furthermore, the measurement in the consideration of mitigation actions using available resources is carried out through the degree of difficulty (Dk) scale.

The Dk scale as shown in **Table 7** is intended to determine the level of difficulty of the identified mitigation actions, thus mitigation can be in accord with available resources and can be effectively and efficiently realized. The Dk scale is also used to measure the ETD (effectiveness to difficulty ratio) value, which is the result of the division between the total effectiveness (TEk) value and the difficulty degree scale (Dk). The TEk value is obtained from multiplying the ARP value of each priority risk with the correlation value between the priority risk and its mitigation action.

Based on the HOR phase 2 calculation as shown in **Table 8**, it can be concluded that the collaboration between CV "MT" and the Department of Agriculture, IAARD of Yogyakarta, Universities, and other related institutions (PA-1) is the most ideal mitigation action because it has the highest ETD value. The other ideal mitigation action is to conduct intense communication between CV "MT" with farmers and distributors (PA-3), while counseling and supervision on the

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implementation of GAP SOPs at the farm level (PA-2) is a less ideal mitigation action.

Mitigation Action Recommendations

Based on the risk analysis that has been carried out using HOR phase 1 and 2, there are 3 recommendations for mitigation actions that can be taken by CV "MT" in preventing or minimizing the impact of the 2 identified mitigation priority risk agents.

Mitigation actions to collaborate with the Department of Agriculture, IAARD of Yogyakarta, universities, and other related institutions (PA-1) can answer the pest problems experienced by farmers on their land. One of the pests that attack farmers' snake fruit plants is the fruit fly. Collaboration with these institutions can help procure agricultural technology, especially pest control technology.

The mitigation action of intensifying communication with farmers and distributors (PA-3) can help determine the exact amount of forecasted market demand and the amount of ready-to-harvest snake fruit stock owned by farmers. Intensification of communication means holding regular meetings and providing more accurate data on market demand and snake fruit stocks.

Mitigation actions to conduct counseling and supervision of the implementation of SOP of GAP at the farm level (PA-2) can help farmers in conducting daily recording of plant growth, which is one of the SOP of GAP. Recording the growth of snake fruit plants daily results in more accurate harvest forecast data that can help CV "MT" in adjusting market demand to the existing stock of ready-to-harvest snake fruit to reduce fluctuations in demand.

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Table 4. House of risk phase 1

Risk Event	Risk Agent																															Impact Scale
	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12	A13	A14	A15	A16	A17	A18	A19	A20	A21	A22	A23	A24	A25	A26	A27	A28	A29	A30	A31	A32	A33	
E1	9																			3								3						6
E2	1											9								1								3						5
E3	9											3								9								3						5
E4	3	9																		3								1						5
E5			1																															2
E6	9	9		3			3	3	9			1								9								3						5
E7	9	9		3	9	9	9	9																										5
E8		3		9	9	9	9	9																										3
E9													3	9	9	9	9	9	3		1					1	9							6
E10													3	9	9	9			9								9							6
E11		9	1		3	3	1	1	9	9	9	9	1	1	1	1	1	1	1		3		3	1	1		9	1	3	1			3	5
E12							3	3				1	3	3	3	3	3	3	1		3		9	3	3	1	9	3	9	3			3	5
E13	3								9	9	9	1								9								3						7
E14																9	9	9	9		9					1								6
E15																9	9	9	3		9					1								7
E16												1				3					9													5
E17																1	9	9			9													5
E18												1				1			1		9													5
E19																	1	3			9													5
E20																	9	9			9													5
E21																	1	3			9													5
E22																	1	1			3							3						6
E23																					3							1						5
E24																					3							1						5
E25																						3												4
E26																	3	3				3						9						4
E27		1										3										3	9	9	9			1		1			9	7
E28																					9							9						8
E29																				1							1	9						6
E30		3																			3		9	9	9			3		3			9	10
E31							9									9					9													1
E32																												9		9	9	9		8
Probability Scale	8	10	2	1	5	5	2	1	7	7	7	2	1	1	1	1	1	1	1	5	2	3	5	4	3	6	3	2	1	6	6	5	6	
ARP Value	1697	2232	14	57	432	432	234	108	1036	725	725	298	53	119	119	267	300	319	153	971	1064	135	1069	606	433	140	578	812	61	776	432	360	1094	
Ranking	2	1	33	31	15	15	23	29	6	10	10	21	32	27	27	22	20	19	24	7	5	26	4	12	14	25	13	8	30	9	15	18	3	

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CONCLUSION

The supply chain run by CV "MT" has 3 main actors, namely partner farmers, CV "MT" itself, and distributors. Based on risk identification, there are 32 risk events and 33 risk agents in the supply chain that has been running. The risk analysis formulated 3 mitigation actions for 2 priority mitigation risks, namely the risk of natural factors and the risk of fluctuating demand, including: (1) Collaborate with the Department of Agriculture, IAARD of Yogyakarta, universities, and other related institutions; (2) Communicate intensely with farmers and distributors; and (3) Conduct counseling and supervision of the implementation of the SOP of GAP at the farm level. The risk analysis conducted in this study is still limited to the results of the formulation of mitigation measures, therefore it is necessary to conduct further research on related risk analysis using a simulation approach in order to assess the effectiveness and efficiency of the mitigation measures that have been formulated.

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