

Integrating fuzzy logic-house of risk for risk mitigation analysis of bondowoso arabica coffee supply chain (a case study in Indonesia)

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Editor: Samuel Pereira de Carvalho

Received in Mayr 05, 2025 and approved in December 10, 2025

ABSTRACT

Indonesia is one of the world's largest coffee producers. One of Indonesia's leading Arabica coffee-producing areas is Bondowoso Regency, East Java. UD Barokah is one of the leading coffee processors in Bondowoso Regency, with a production capacity of 30 – 40 tons of green Arabica beans per year. Currently, UD Barokah faces several obstacles in supply chain management that impact the quality of the final processed green Arabica coffee bean product. These obstacles have the potential to cause a risk of loss. Risks that arise in the supply chain can be minimized by implementing a risk management process to enhance competitiveness. This research was conducted during the coffee harvest season from May to August 2024, involving 67 respondents consisting of farmers, suppliers, academics, representatives from the agroindustry, and local government officials. This study used an integration between the House of Risk (HOR) method and fuzzy logic (FHOR). HOR is used as the main framework for risk mapping and designing mitigation strategies. Meanwhile, the fuzzy approach is applied to accommodate uncertainty and subjectivity in assessing the level of risk importance. The results of the study using FHOR integration for all actors in the supply chain can identify risks in all supply chain actors in detail, from 65 identified risk agents, 31 of which are prioritized, and a risk mitigation strategy design is obtained that can be implemented. Risk agents can be mitigated with the most effective and least difficult mitigation strategy approach.

Key words: Supply chain; fuzzy-house of risk; arabica coffee; risk management.

1 INTRODUCTION

Indonesia is the second-largest coffee-producing country in Asia and Oceania after Vietnam (International Coffee Organization - ICO, 2023). The United States Department of Agriculture (2024) reported that Indonesia's total coffee production is estimated to reach around 10.90 million bags per year. The diversity of climate and topography makes Indonesia have various types of high-quality coffee, one of which is Arabica coffee, which thrives in the highlands (Hanan et al., 2024). One of Indonesia's leading Arabica coffee-producing areas is Bondowoso Regency, East Java (Wibowo, Purnomo, & Kristio, 2021). According to data from the Central Bureau of Statistics (BPS) in 2023, coffee production in the Bondowoso area totaled 8,271.96 tons, accounting for 18.68% of the total production in East Java Province. Sumber Wringin district is the center of the Java Ijen Raung arabica coffee industry cluster development and has obtained a Geographical Indication (GI) certificate from the Ministry of Law and Human Rights (Herminingsih et al., 2023). This area is the largest smallholder arabica coffee production center in Bondowoso Regency, contributing approximately 58%, or 4,813.43 tons, of the total 8,271.95 tons of Arabica coffee production in 2023 (Indonesian Central Bureau of Statistics, 2023).

Abundant coffee production has significant potential for business development in the agro-industry sector, particularly in coffee-based operations. The coffee agroindustry is defined as an industry that processes coffee cherries into various derivative products (Hoseini et al., 2021). Green beans are

the primary product of the coffee agroindustry and serve as the basic raw material for various further coffee processing steps (Hall, Trevisan, & De Vos, 2022). Green beans are dried coffee beans that have undergone a process of removing the fruit skin, pulp, and horn skin (Fadri et al., 2020; Ghosh & Venkatachalapathy, 2014).

Green bean processing is widely carried out by micro, small, and medium enterprises in Sumber Wringin district, Bondowoso, where they compete to gain consumer trust. According to Farida and Setiawan (2022), product quality is a key factor in global market competition. Quality reflects superior characteristics that distinguish a product from similar products in the market (Sohl, Vroom, & McCann, 2020; Onufrey & Bergek, 2021). Among the many coffee processors in the region, UD Barokah is a leading business player due to its production capacity and market reach, requiring it to maintain consistent quality. UD Barokah has a green bean production capacity of 30 – 40 tons per year, where raw materials are supplied from its own 125 ha plantation and from local farmers around the cluster area. UD Barokah's green bean products have penetrated international markets, especially the United States and the United Kingdom, through collaboration with shipping companies (forwarders), and are marketed domestically to major cities such as Jakarta, Medan, Bandung, and Surabaya.

As part of the arabica coffee industry ecosystem in the Sumber Wringin district, UD Barokah, as an actor, needs to develop strategies to strengthen competitiveness. One approach that can be applied is effective supply chain management. The

supply chain includes the management of the flow of raw materials, information, and finance from upstream (suppliers) to downstream (consumers) (Purnomo, Ni'maturrahmat, & Wibowo, 2024). Good supply chain implementation can improve product quality, ensure production timeliness, and reduce inventory and distribution costs (Lin, Lin, & Wang, 2022; Khedr & Rani, 2024). Currently, UD Barokah faces several obstacles in supply chain management that have an impact on the quality of the final processed green bean Arabica coffee product. First, errors in the coffee bean picking procedure by farmers cause the mixing of raw and ripe coffee beans, thereby reducing the uniformity of the quality of the coffee beans. Second, the coffee bean sorting process by farmers and middlemen results in less than optimal results, in the mixing of high and low quality beans, which then reduces the quality of the product. Third, limitations in the quantity and quality of the workforce affect the achievement of production targets. These problems have the potential to cause a risk of loss for UD Barokah. In the context of supply chain management, risk is defined as uncertainty over future events that can harm planned results (Ghadge, Dani, & Kalawsky, 2012).

Every risk that arises needs to be prevented so as not to cause losses, so UD Barokah needs to carry out good supply chain planning, namely by identifying risks in the supply chain and taking preventive measures. Planning for risks that arise in the supply chain can be minimized by carrying out a risk management process (Emrouznejad, Abbasi, & Sıcakyüz, 2023). In this study, an integration between the House of Risk (HOR) method and fuzzy logic, known as Fuzzy House of Risk (FHOR), is used. This integration aims to improve accuracy and objectivity in the risk assessment process in the supply chain. The HOR method itself is an analytical approach used to systematically identify, analyze, and mitigate risks in the supply chain system. This method is used by Pujawan and Geraldin (2009) and consists of two main phases. The first phase aims to identify risk events and their causes (risk agents) and calculate the Aggregate Risk Potential (ARP) value of each risk agent to determine the priority of handling. The second phase is used to design and evaluate risk mitigation strategies based on the level of effectiveness and efficiency of the proposed actions. In this study, HOR is used as the main framework for risk mapping and designing mitigation strategies. Meanwhile, the fuzzy approach is applied to accommodate uncertainty and subjectivity in assessing the level of risk importance, especially in calculating the Aggregate Risk Potential (ARP) value. Fuzzy-based assessments enable more realistic risk evaluations by considering expert opinions linguistically, which are then converted into numerical values (Hsueh, Hsu, & Liu, 2012). Fuzzy logic is the best tool for dealing with uncertain, imprecise, and unclear meanings of natural human language and is one of the important tools developed from the field of artificial intelligence (Isizoh et al., 2012; Kozarević & Puška, 2018). Furthermore, the Pareto diagram is used to

determine the most dominant risk agents, thus facilitating the determination of mitigation strategy priorities.

The application of the FHOR method in an integrated manner in the context of supply chain risk analysis has not been widely applied comprehensively in the coffee agro-industry sector. The advantage of this FHOR approach is its ability to handle uncertain and ambiguous data through fuzzy logic, while maintaining the systematic framework of HOR in risk mapping and mitigation. The main objectives of this study are to identify the structure of activities in the supply chain, classify risk events and causes based on their priority levels, and formulate effective and applicable risk mitigation strategies.

2 MATERIAL AND METHODS

This research was conducted at the UD Barokah agroindustry, an Arabica coffee processing unit located in Bondowoso Regency. The types of data used in this study consist of primary data obtained through observation, interviews, and questionnaires. Secondary data were obtained from scientific journals, related government documents, books, and other related scientific sources.

2.1 Observation of Current Condition Supply Chain Risk

The preliminary survey stage was conducted to understand the operational conditions and supply chain activities in the UD Barokah agroindustry, Bondowoso. Data collection was conducted through direct observation and semi-structured interviews with several respondents involved in the production process. Respondents included various actors who play important roles in the supply chain, namely farmers, suppliers, academics, representatives from the agroindustry, and local government officials. This activity aims to identify the flow of activities, potential risks, and challenges faced in the production process. Data collection in this study was carried out during the harvest season of May to August in 2024. The number of respondents is presented in aggregate based on their profiles in Table 1.

2.2 Risk Identification and Analysis (FHOR-Phase 1)

Mapping of Arabica coffee supply chain activities at UD Barokah, Bondowoso uses the SCOR (Supply Chain Operations Reference) method, which includes five main processes, namely Plan, Source, Make, Deliver, and Return. The SCOR model in this study only uses level-1, which is a diagnostic tool for supply chain management that allows users to understand the processes involved in a business organization and identify important features that lead to customer satisfaction (Ntabe et al., 2015). The activities identified include various activities that occur in the company's supply chain. Furthermore, the creation of HOR-Phase 1 to identifying risks and developing handling strategies.

(1) This stage begins with mapping the risk events and risk agents that have the potential to occur in every activity of the Arabica coffee supply chain at UD Barokah; (2) Measuring the risk impact or severity (S_i) using a scale of 1 to 10, where a higher value indicates the magnitude of the impact caused; (3) Assessing the chance of the risk agent or occurrence (O_i) using a scale of 1 to 10, with a higher value indicating a more frequent probability of occurrence; (4) Assessing the level of correlation between the risk event and the risk agent with a scale of 0, 1, 3, and 9, which reflects the strength of the relationship between the two where a value of 0 means no correlation and a value of 9 means a robust correlation. This correlation assessment is based on the results of questionnaires and interviews with experts and practitioners who have in-depth knowledge of the supply chain process.

2.3 Fuzzy Data Generation

Fuzzy-HOR data generation is done from the assessment of risk events and risk agents. Data generation begins by determining the value variables and names of fuzzy sets and the universe of discourse used. The results of fuzzy-HOR data generation can be seen in Table 2.

The Fuzzy Aggregate Risk Potential (FARP) calculation is carried out to determine the rating value and potential risk that will be given mitigation strategy handling (Ulfah et al., 2022; Puspitasari & Yuwono, 2022). This stage is carried out using a fuzzy logic process assisted by Matlab® software. In the process of calculating Fuzzy Aggregate Potential Risk after making fuzzy rules, it is continued with defuzzification. The purpose of using defuzzification is to emphasize the ranking of fuzzy ARP results for each risk agent that occurs in the supply chain at UD Barokah, Bondowoso using the centroid method with equation 1.

$$z^* = \pi r^2 = \frac{\int z \cdot \mu_C(z) dz}{\int \mu_C(z)} \quad (1)$$

Where z^* = Defuzzified value

The results of the defuzzification process will produce the FARP value of each risk agent, which will be used to determine the value of the most dominant risk agent using a

Pareto diagram. The process of determining the most dominant risk agent uses a Pareto diagram with the principle of 80:20, which means that 80% of risk agents with the highest FARP value can represent the existing population. The results of determining the most dominant risk are the priorities of the risk sources in the company's supply chain process.

2.4 Risk Evaluation and Mitigation (FHOR-Phase 2)

After obtaining the risk agent priority, it is continued in the HOR phase 2 to design mitigation actions. This action is an effort or action to reduce the impact of the risk agent before the risk occurs. At this stage, a brainstorming process is carried out with experts regarding the priority of the selected risk agents in the Bondowoso Arabica coffee supply chain. The results of determining alternative mitigation strategies for risk agents are included in the list of risk agent mitigation strategies. The next process is to calculate the total effectiveness value of each action to know how effective it is if the mitigation strategy is applied using the Total Effectiveness Score formula presented in equation 2.

$$TE_k = \sum (FARP_j E_{jk}) \quad (2)$$

Where:

TE_k : Total Effectiveness

$FARP_j$: Fuzzy Aggregate Risk Potential

E_{jk} : Correlation Value

However, the strategy with the highest score is not necessarily immediately selected. One of the advantages of the HOR method is its ability to combine best practices in risk mitigation. Therefore, each strategy will be reviewed based on the Effectiveness to Difficulties (ETD Score) level. The strategy with the highest ETD score will be the main recommendation for implementation. The Effectiveness to Difficulties (ETD) formula is presented in equation 3.

$$TED_K = TE_k / D_k \quad (3)$$

Where:

ETD_k : Ratio score ETD of treatment strategy

TE_k : Total Effectiveness score of treatment strategy

D_k : The difficulty level score of the treatment strategy

Table 1: Interviewee profiles.

Profiles	Number of interviewees	Education Level	Years of Experience
Farmers	20	No formal education – Secondary	9 – 13
Suppliers	9	High school – Bachelor's	10 – 13
Processing workers	30	No formal education – High school	5 – 13
Business owner	1	Bachelor's Degree	13
Academics	4	Doctorate Degree	20 – 30
Government officials	3	Bachelor's – Master's Degree	15 – 20

Table 2: Generation of the Fuzzy Sets.

Function	Variable	Fuzzy state	Curve Type [Value Range]	Fuzzy sets
Input	Severity	Hazardous Without Warning (HWOW)	Triangular [1-10]	[9; 10; 10]
		Hazardous With Warning (HWW)		[8; 9; 10]
		Very High (VH)		[7; 8; 9]
		High (H)		[6; 7; 8]
		Moderate (M)		[5; 6; 7]
		Low (L)		[4; 5; 6]
		Very Low (VL)		[3; 4; 5]
		Minor (R)		[2; 3; 4]
		Very Minor (VR)		[1; 2; 3]
		None (N)		[1; 1; 2]
	Occurrence	Very High (VH)	Trapezoid [1-10]	[8; 9; 10; 10]
		High (H)		[6; 7; 8; 9]
		Moderate (M)		[4; 5; 6; 7]
		Low (L)		[2; 3; 4; 5]
		Minor (R)		[1; 1; 2]
	Correlation	High (H)	Sigmoid [0; 1; 3; 9]	[3; 9]
		Moderate (M)		[1; 3; 3; 9]
		Low (L)		[1; 3]
Output	Aggregate Risk Potential	Very High (VH)	Triangular [0-1]	[0.75; 1; 1]
		High (H)		[0.5; 0.75; 1]
		Moderate (M)		[0.25; 0.5; 0.75]
		Low (L)		[0; 0.25; 0.5]
		Very Low (VL)		[0; 0; 0.25]

2.5 Policy Analysis

This stage is the final stage obtained from the results of the overall analysis, which combines the analysis of effectiveness and challenges of its implementation to produce optimal mitigation recommendations. This approach is very relevant for supply chains that require a balance between risk management and resource limitations. The proposed policy recommendations are expected to be input for supply chain actors in making improvements to existing problems to mitigate the risks that occur.

3 RESULTS

3.1 Supply Chain of Arabica Coffee Processor

The supply chain is an activity that occurs in an industry that starts from upstream to downstream and has a relationship with each other to form a chain (MacCarthy, Ahmed, & Demirel, 2022). The supply chain consists of several elements and parties involved in the industrial chain, both directly and indirectly (Lestari et al., 2020). The parties involved in the

supply chain at UD Barokah include the Indonesian coffee and cocoa research institute (Puslitkoka) as a seed supplier, farmers, and collectors as suppliers of coffee beans. UD Barokah itself is an intermediary between farmers and Puslitkoka, a processor of raw materials into green beans and as a seller. The supply chain flow at UD Barokah is presented in Figure 1.

The supply chain activity mapping process is carried out based on the supply chain flow from suppliers to consumers using the SCOR model. The SCOR model can measure supply chain performance objectively based on existing data and can identify where improvements need to be made (Nguyen, 2024). In this study, supply chain activity mapping focuses on farmers and collectors as suppliers of raw materials and UD Barokah as the manufacturer. Supply chain activities at UD Barokah can be seen in Figure 2.

To simplify risk mapping and provide a clearer picture based on the SCOR (Plan, Source, Make, Deliver, Return) process, this study also groups risk into five categories, namely productive risk, price risk, contractual risk, legal risk, and operational risk, which are presented in Table 3. This classification is carried out to facilitate understanding of the risk groups analyzed. From the

results of risk mapping, it was found that most of the risks faced by UD Barokah fall into the productive and operational risk categories, while price and legal risks have the smallest proportion.

3.2 Risk Identification and Analysis (FHOR-Phase 1)

3.2.1 Risk analysis results at the farmer level

Risk in a company refers to a situation that can potentially harm and hinder the company's goals (Mohammed & Knapkova, 2016). Risks in production can also be observed in the context of this study, specifically in coffee fruit production carried out by farmers. Throughout the production process, from planting to marketing, various risks impact the quality and quantity of coffee fruit produced (Santoso et al., 2025). The risk identification process is carried out by conducting direct observations and interviews with farmers. After the risks that occur in coffee cultivation activities are

known, the FARP calculation is then carried out to determine the severity of the risk event caused by the risk agent. The results of risk analysis and FARP calculations for farmers can be seen in Table 4. Furthermore, the results of the assessment and calculations are visualized in a Pareto diagram (Figure 3).

3.2.2 Risk analysis results at the collector level

Collectors have an important role in the agro-industrial system, where they function as intermediaries between farmers and industry players (Abebe, Bijman, & Royer, 2016). Collectors also act as capital providers for farmers, which helps farmers meet their needs during the planting to harvest period (Sudrajat, Isytar, & Arifin, 2021), simplify the logistics process by transporting the harvest from remote areas to collection centers or sales points, and conducting initial sorting of the coffee beans to help ensure quality standards before entering the coffee processor (Baihaqi et al., 2021).

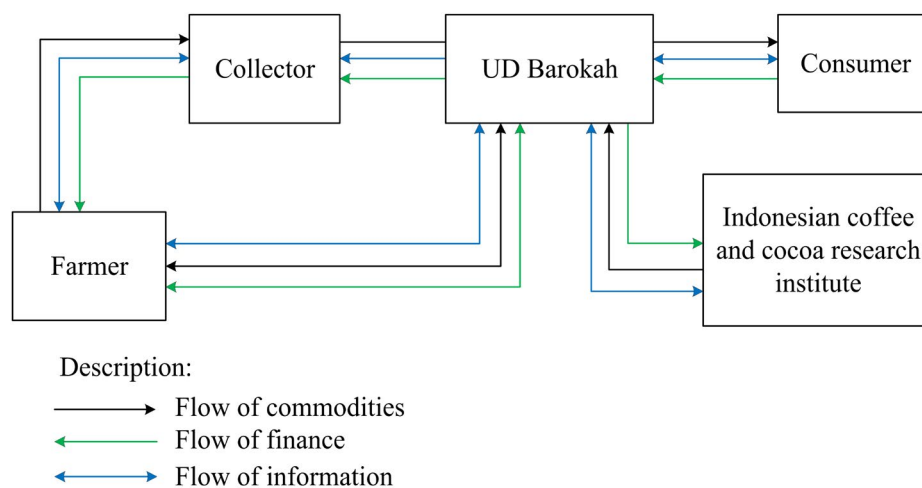


Figure 1: Arabica coffee processor supply chain flow.

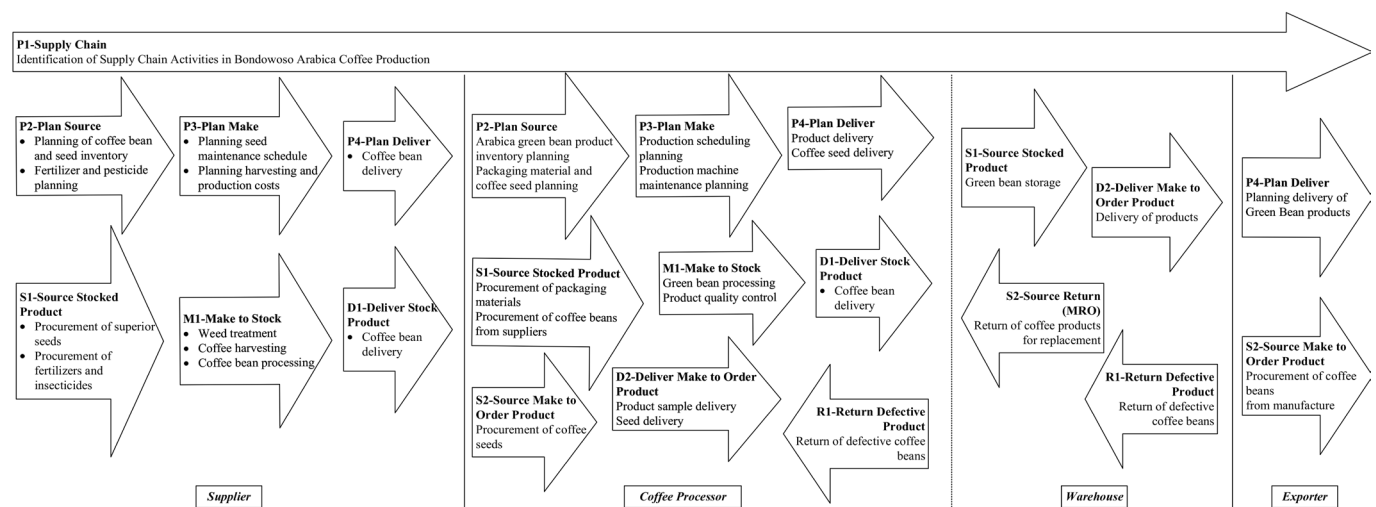


Figure 2: Arabica coffee processor supply chain activities.

Table 3: Identification of supply chain risk events for Bondowoso Arabica coffee.

Level	Process	Risk Event	Code	Category
Farmer	Plan	Inaccurate seed purchase planning	E1	Productive
		Inaccurate fertilizer purchasing planning	E2	Productive
		Inaccurate fungicide and insecticide purchasing planning	E3	Productive
		Inaccurate labor requirement planning	E4	Operational
		Inaccurate harvest scheduling planning	E5	Productive
		Inaccurate maintenance cost planning	E6	Operational
		Inaccurate harvesting cost planning	E7	Operational
		Inaccurate planning of the procurement of tools & machines	E8	Operational
		Inaccurate packaging material planning	E9	Operational
		Inaccurate determination of production targets	E10	Productive
		Inaccurate selection of superior seeds	E11	Productive
	Source	Use of fake fungicides and insecticides	E12	Legal
		Fertilizer stock unavailable	E13	Productive
		Seed stock unavailable	E14	Productive
	Make	Weeds grow	E15	Productive
		Plants are underdeveloped	E16	Productive
		Harvesting unripe fruit	E17	Productive
		Fruit scattered on the ground	E18	Productive
		Coffee beans in a wet condition	E19	Productive
		Unpeeled coffee beans	E20	Productive
		Damaged packaging	E21	Operational
		Improper seed maintenance	E22	Productive
	Deliver	Delayed product delivery	E23	Contractual
Collector	Plan	Inaccurate raw material procurement cost planning	E1	Operational
		Inaccurate labor requirement planning	E2	Operational
		Inaccurate production capacity planning	E3	Productive
		Inaccurate product delivery cost planning	E4	Operational
		Inaccurate raw material procurement cost planning	E5	Operational
		Inaccurate production cost planning	E6	Operational
		Inaccurate processing machine procurement planning	E7	Operational
		Inaccurate maintenance costs planning	E8	Operational
	Source	Delay in receiving raw materials	E9	Operational
		Raw materials unavailable	E10	Productive
		Delay in receiving packaging materials	E11	Operational
		Packaging materials unavailable	E12	Operational
		Raw materials prices are expensive	E13	Price
	Make	Defective products	E14	Productive
		Coffee beans in a wet condition	E15	Productive
		Unpeeled coffee beans	E16	Productive
		The fermentation process is not appropriate	E17	Productive
		The washing process is not appropriate	E18	Productive
		Stones and foreign debris	E19	Productive
		Damaged packaging	E20	Operational
	Deliver	Delayed raw materials delivery	E21	Operational
		Delayed product delivery	E22	Contractual

Continua...

Table 3: Continuation.

Level	Process	Risk Event	Code	Category
Coffee Processor	Plan	Inaccurate packaging material procurement planning	E1	Operational
		Inaccurate warehouse capacity planning	E2	Operational
		Inaccurate production capacity planning	E3	Productive
		Inaccurate raw material procurement planning	E4	Productive
		Inaccurate raw material procurement costs planning	E5	Operational
		Inaccurate labor cost planning	E6	Operational
		Inaccurate raw material procurement cost planning	E7	Operational
		Inaccurate product delivery cost planning	E8	Operational
		Inaccurate production cost planning	E9	Operational
		Inaccurate labor requirements planning	E10	Operational
		Inaccurate maintenance cost planning	E11	Operational
		Inaccurate product delivery scheduling and planning	E12	Contractual
		Inaccurate production scheduling planning	E13	Productive
		Inaccurate processing machine procurement planning	E14	Operational
		Late payment	E15	Contractual
		Inaccurate seed requirement planning	E16	Productive
		Inaccurate seed procurement cost planning	E17	Operational
	Source	Delay in receiving raw materials	E18	Operational
		Packaging materials unavailable	E19	Operational
		Defective products	E20	Productive
		Delay in receiving seeds	E21	Operational
	Make	Coffee beans in a wet condition	E22	Productive
		Unpeeled coffee beans	E23	Productive
		Stones and foreign debris	E24	Productive
		Inaccuracy weighing process	E25	Operational
		Damaged packaging	E26	Operational
		Raw materials don't meet quality standards	E27	Productive
		Inaccuracy in the recruitment of additional workers	E28	Operational
		Machine damage/jamming	E29	Operational
	Deliver	Incorrect information data	E30	Operational
		Delayed product delivery	E31	Contractual
		Delay in sample delivery	E32	Contractual
		Delay in loading and unloading goods	E33	Operational
		Cancel order	E34	Contractual
	Return	Delayed raw materials delivery	E35	Operational
		Production capacity is not met	E36	Productive

Collectors who cooperate with UD Barokah have the potential to face a risk of failure that can disrupt the smooth production of green beans. Risk identification is carried out through direct observation and interviews. After identifying the risks that occur, the next step is to calculate the FARP to determine the level of severity caused by the risk agent. The results of risk analysis and FARP calculations at the collector level can be seen in Table 5. The results of the assessment and calculations are visualized in a Pareto diagram (Figure 4).

3.2.3 Risk analysis results at the coffee processor level

In coffee processing activities at UD Barokah, various potential risks can arise from the stage of receiving raw materials to shipping the final product. In the early stages, risks can come from the quality of raw materials that are not up to standard, such as damaged, moldy, or mixed with foreign objects, which can affect the quality of the final product (Poltronieri & Rossi, 2016). During processing, risks include

equipment damage, incorrect temperature or roasting time settings, and contamination from unhygienic environments, all of which can reduce product quality and safety (Febrianto & Zhu, 2023). In addition, the risk of human error, such as errors in recording or handling materials, can also impact production efficiency (Musavi et al., 2024). At the packaging and storage stage, there is a risk of using inappropriate packaging, storing in suboptimal conditions, and damage due to insects or humidity

(Girma, 2024). During shipping, risks can include distribution delays, physical damage during transportation, or incorrect delivery destination (Abushaega et al., 2021). If not managed properly, all these risks can result in financial losses, decreased consumer trust, and damage to the company's reputation. The results of risk analysis and FARP calculations on coffee processors can be seen in Table 6. The results of the assessment and calculations are visualized in a Pareto diagram (Figure 5).

Table 4: Results of risk analysis and FARP calculations at the farmer level.

Risk Event (Code)	S_i	Risk Agent (Code)	O_j	C	FARP
Inaccurate seed purchase planning (E1)	2	Miscalculation of needs (A1)	3	9	1.22
Inaccurate fertilizer purchasing planning (E2)	2	Miscalculation of needs (A1)	3	9	1.22
Inaccurate fungicide and insecticide purchasing planning (E3)	3	Miscalculation of needs (A1)	3	9	1.22
Inaccurate labor requirement planning (E4)	2	Miscalculation of needs (A1)	3	9	1.22
Inaccurate harvest scheduling planning (E5)	1	Miscalculation of needs (A1)	3	3	1.22
		Different harvest time (A2)	2	3	0.08
Inaccurate maintenance cost planning (E6)	3	Miscalculation of needs (A1)	3	9	1.22
Inaccurate harvesting cost planning (E7)	2	Miscalculation of needs (A1)	3	9	1.22
Inaccurate planning of the procurement of tools & machines (E8)	2	Miscalculation of needs (A1)	3	9	1.22
Inaccurate packaging material planning (E9)	3	Miscalculation of needs (A1)	3	9	1.22
Inaccurate determination of production targets (E10)	4	Miscalculation of needs (A1)	3	9	1.22
Inaccurate selection of superior seeds (E11)	4	Lack of understanding in determining superior seeds (A3)	4	9	0.25
Use of fake fungicides and insecticides (E12)	2	Incompetent manufacturer (A6)	2	3	0.08
		Resistant pests (A7)	2	9	0.08
Fertilizer stock unavailable (E13)	7	Restrictions from the government (A4)	6	9	0.50
		Competing with other farmers (A5)	6	3	0.58
Seed stock unavailable (E14)	2	Competing with other farmers (A5)	6	3	0.58
Weeds grow (E15)	6	Weeds grow thickly (A8)	6	9	0.50
		Wrong planting method (A9)	6	3	0.50
Plants are underdeveloped (E16)	5	Miscalculation of needs (A1)	3	3	1.22
		Lack of expertise(A10)	4	9	0.25
Harvesting unripe fruit (E17)	4	Lack of qualified human resources (A11)	6	3	0.50
Fruit scattered on the ground (E18)	4	Lack of qualified human resources (A11)	6	3	0.50
		Improper work procedures (A12)	6	9	0.50
Coffee beans in wet condition (E19)	4	Weather factors (A13)	6	9	0.25
Unpeeled coffee beans (E20)	3	Lack of maintenance (A14)	5	9	0.25
		Improper work procedures (A12)	6	9	0.5
Damaged packaging (E21)	2	Overcapacity/Overload (A15)	3	3	0.08
		Low-quality packaging (A16)	3	9	0.08
Improper seed maintenance (E22)	3	Inaccurate in maintenance schedules (A17)	7	9	0.25
Delayed product delivery (E23)	2	Disruption of transportation equipment (A18)	2	9	0.08
		Disaster/accidents occur (A19)	2	3	0.08
		The delivery location is difficult to reach (A20)	6	9	0.08

Where: S_i is Severity. O_j is Occurrence. C is Correlation. FARP is fuzzy aggregate risk potential.

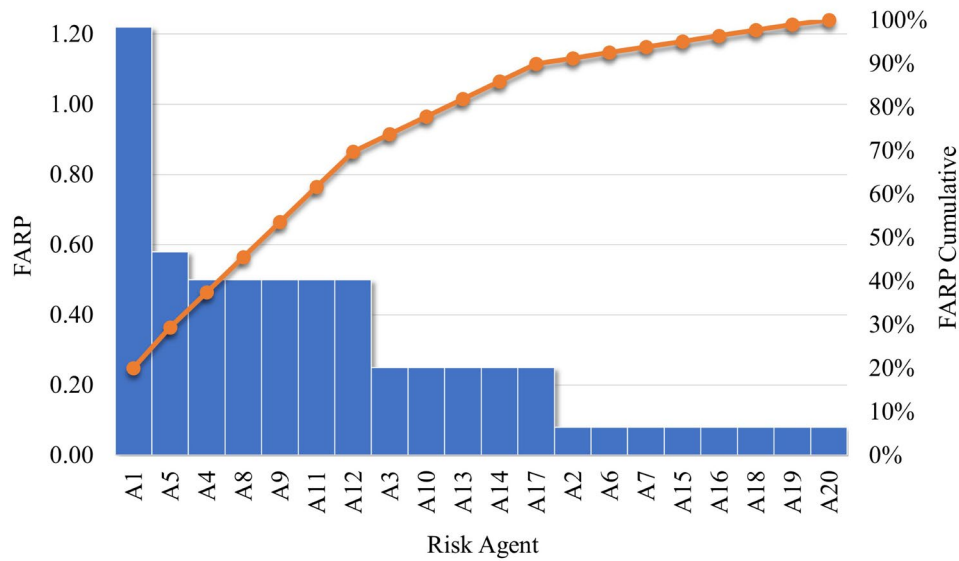


Figure 3: FARP Pareto chart at the farmer level.

Table 5: Results of risk analysis and FARP calculations at the collector level.

Risk Event (Code)	S_i	Risk Agent (Code)	O_i	C	FARP
Inaccurate raw material procurement cost planning (E1)	2	Fluctuations in employee capacity & production (A16)	3	9	0.08
		Coronavirus outbreak (A7)	2	9	0.58
		Uncertain world coffee bean prices (A15)	4	3	0.08
Inaccurate labor requirement planning (E2)	3	Miscalculation of needs (A1)	3	3	0.90
Inaccurate production capacity planning (E3)	4	Miscalculation of needs (A1)	3	3	0.90
		Farmer productivity decreases (A4)	6	3	0.33
Inaccurate product delivery costs planning (E4)	2	Miscalculation of needs (A1)	3	3	0.90
Inaccurate raw material procurement cost planning (E5)	2	Miscalculation of needs (A1)	3	3	0.90
Inaccurate production costs planning (E6)	3	Miscalculation of needs (A1)	3	3	0.90
Inaccurate processing machine procurement planning (E7)	2	Miscalculation of needs (A1)	3	3	0.90
Inaccurate maintenance costs planning (E8)	4	Miscalculation of needs (A1)	3	3	0.90
		Replacement of damaged tools/machines (A19)	4	9	0.25
Delay in receiving raw materials (E9)	3	Transportation equipment disruption (A2)	3	9	0.49
		Disaster/accident occurs (A3)	3	3	0.49
		Product doesn't meet quality standards (A17)	4	3	0.08
Raw materials unavailable (E10)	2	Farmer productivity decreases (A4)	6	9	0.33
Delay in receiving packaging materials (E11)	3	Transportation equipment disruption (A2)	3	1	0.49
		Disaster/Accident occurs (A3)	3	3	0.49
Packaging materials unavailable (E12)	2	Competing with other farmers (A5)	4	9	0.08
Raw materials price is high (E13)	6	Uncertain dollar price (A6)	3	9	0.58
		Coronavirus outbreak (A7)	2	9	0.58
Defective products (E14)	6	Poor storage (A8)	3	9	0.50
		Mold (A9)	4	9	0.50
Coffee beans in wet condition (E15)	3	Weather factors (A10)	4	9	0.75

Continua...

Table 5: Continuation.

Risk Event (Code)	S_i	Risk Agent (Code)	O_i	C	FARP
Unpeeled coffee beans (E16)	4	Lack of maintenance (A11)	4	3	0.25
		Poor quality human resources (A12)	3	9	0.65
The fermentation process is not appropriate (E17)	2	Poor quality human resources (A12)	3	9	0.65
The washing process is not appropriate (E18)	2	Poor quality human resources (A12)	3	9	0.65
Stones and foreign debris (E19)	3	Poor quality human resources (A12)	3	9	0.65
Damaged packaging (E20)	4	Overcapacity/overload (A13)	2	3	0.25
		Poor quality packaging (A14)	2	9	0.25
Delayed raw materials delivery (E21)	5	Transportation equipment disruption (A2)	3	9	0.49
		The delivery location is difficult to reach (A18)	4	9	0.75
		Disaster/accident occurs (A3)	3	3	0.49
Delayed product delivery (E22)	3	Disaster/accident occurs (A3)	3	3	0.49
		Transportation equipment disruption (A2)	3	9	0.49
		The delivery location is difficult to reach (A18)	4	9	0.75

Where: S_i is Severity. O_i is Occurrence. C is Correlation. FARP is fuzzy aggregate risk potential.

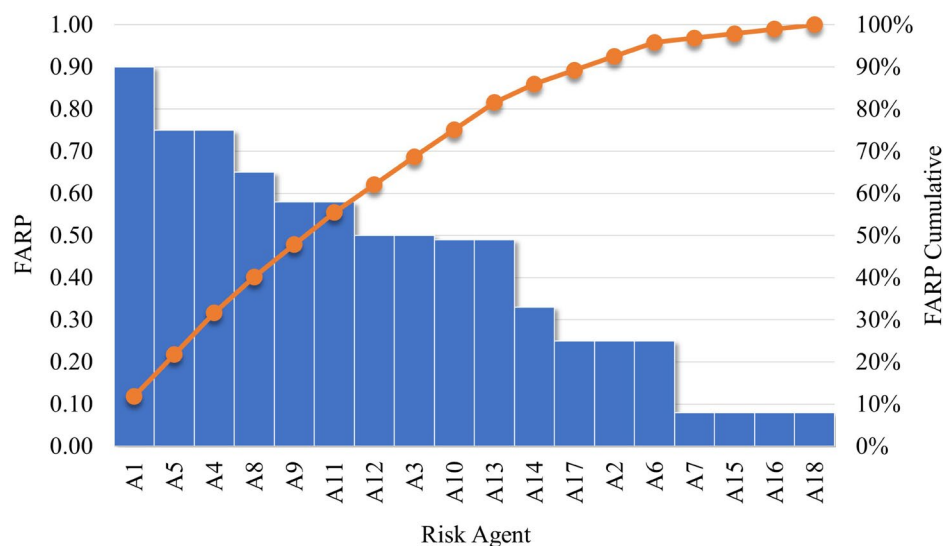


Figure 4: FARP Pareto chart at the collector level.

3.3 Risk Evaluation and Mitigation (FHOR-Phase 2)

HOR-Phase 2 is the stage of preparing a handling strategy (Preventive action) for priority risk agents to design mitigation strategies. This stage begins with the process of identifying and assessing alternative mitigation strategy designs. Handling strategies are used to control and minimize a risk agent that can cause losses (Purnomo, Suryadharma, & Al-hakim, 2021). Each handling strategy is assessed based on the level of difficulty of implementation, expressed by the Degree of Difficulty (D_k) value, and the level of effectiveness of the strategy, expressed by the Effectiveness (TE_k) and Effectiveness to Difficulty (ETD_k) values (Tama, Eunike,

& Hamdala, 2019). This assessment presents the costs and resources needed to implement the strategy. The process of developing the handling strategy is carried out through a brainstorming process with experts. The results of the risk mitigation strategy assessment at the farmer level are presented in Table 7.

Based on the results of expert assessment, 16 risk mitigation strategies were obtained at the collector level. The ETD_k value reflects the priority of actions based on the overall risk reduction potential. The strategy with the highest ETD_k value can be prioritized in implementation as the most impactful risk mitigation step. The results of the risk mitigation strategy assessment at the collector level are presented in Table 8.

Table 6: Results of risk analysis and FARP calculations at the coffee processor level.

Risk Event (Code)	S_i	Risk Agent (Code)	O_j	C	FARP
Inaccurate packaging material procurement planning (E1)	8	Miscalculation of needs (A1)	4	3	4.83
Inaccurate warehouse capacity planning (E2)	7	Miscalculation of needs (A1)	4	9	4.83
Inaccurate production capacity planning (E3)	6	Miscalculation of needs (A1)	4	3	4.83
		Farmer productivity decreases (A2)	7	9	3.00
		Raw materials don't meet quality standards (A12)	8	3	2.00
Inaccurate raw material procurement planning (E4)	3	Miscalculation of needs (A1)	4	3	4.83
		Farmer productivity decreases (A2)	7	9	3.00
		Raw materials don't meet quality standards (A12)	8	9	2.00
		No other supplier options (A11)	2	1	0.83
Inaccurate raw material procurement costs planning (E5)	8	Uncertain world coffee bean prices (A3)	4	9	0.83
Inaccurate labor cost planning (E6)	3	Miscalculation of needs (A1)	4	9	4.83
		Weather factors (A16)	8	9	3.00
Inaccurate raw material procurement cost planning (E7)	3	Miscalculation of needs (A1)	4	3	4.83
Inaccurate product delivery cost planning (E8)	8	Miscalculation of needs (A1)	4	3	4.83
Inaccurate production cost planning (E9)	8	Miscalculation of needs (A1)	4	9	4.83
		Weather factors (A16)	8	9	3.00
Inaccurate labor requirements planning (E10)	8	Fluctuations in employee capacity & production (A4)	2	9	1.75
		Poor quality human resources (A18)	2	9	4.75
Inaccurate maintenance cost planning (E11)	6	Miscalculation of needs (A1)	4	3	4.83
		Replacement of damaged tools/machines (A25)	2	1	0.25
Inaccurate product delivery scheduling planning (E12)	6	Farmer productivity decreases (A2)	7	3	3.00
		Raw materials don't meet quality standards (A12)	8	9	2.00
		Weather factors (A16)	8	9	3.00
Inaccurate production scheduling planning (E13)	6	Different harvest time (A8)	1	1	0.25
		Delay in receiving raw materials (A9)	6	3	0.50
Inaccurate processing machine procurement planning (E14)	6	Fluctuations in employee capacity & production (A4)	2	3	1.75
		The machine doesn't meet specifications (A24)	6	1	0.50
Late payment (E15)	2	Uncertain world coffee bean prices (A3)	4	3	0.83
		Coronavirus outbreak (A27)	1	9	1.33
Inaccurate seed requirement planning (E16)	2	Miscalculation of needs (A1)	4	9	4.83
Inaccurate seed procurement cost planning (E17)	3	Miscalculation of needs (A1)	4	9	4.83
Delay in receiving raw materials (E18)	8	Disaster/accident occurs (A7)	2	3	2.75
		The delivery location is difficult to reach (A10)	8	3	2.00
		No other supplier options (A11)	2	1	0.83
		Transportation equipment disruptions (A6)	3	3	2.25
Packaging materials unavailable (E19)	7	Delayed product delivery (A5)	2	1	0.75
		Low supplier capacity (A13)	6	1	0.75
Defective products (E20)	8	Poor storage (A14)	8	9	0.75
		Mold (A15)	8	9	0.75
Delay in receiving seeds (E21)	2	Seed stock unavailable (A26)	6	9	0.88

Continua...

Table 6: Continuation.

Risk Event (Code)	S_i	Risk Agent (Code)	O_j	C	FARP
Coffee beans in wet condition (E22)	8	Weather factors (A16)	8	9	3.00
		Poor quality human resources (A18)	2	3	4.75
Unpeeled coffee beans (E23)	8	Lack of maintenance (A17)	2	9	3.00
		Poor quality human resources (A18)	2	3	4.75
Stones and foreign debris (E24)	8	Lack of maintenance (A17)	2	9	3.00
		Poor quality human resources (A18)	2	3	4.75
Inaccuracy weighing process (E25)	8	Inaccuracy weighing process (A19)	6	1	0.75
		Lack of maintenance (A17)	2	9	3.00
Damaged packaging (E26)	8	Overcapacity/Overload (A20)	3	3	1.25
		Low-quality packaging (A21)	2	1	0.75
Raw materials don't meet quality standards (E27)	8	Farmer productivity decreases (A2)	7	3	3.00
		Weather Factors (A16)	8	9	3.00
		Improper work procedures (A22)	7	3	0.75
Inaccuracy in the recruitment of additional workers (E28)	6	Fluctuations in employee capacity & production (A4)	2	9	1.75
		Poor quality human resources (A18)	2	3	4.75
Machine damage/jamming (E29)	8	Lack of maintenance (A17)	2	9	3.00
		Poor quality human resources (A18)	2	3	4.75
Incorrect information data (E30)	3	Incorrect information data (A23)	2	9	0.33
Delayed product delivery (E31)	8	Transportation equipment disruption (A6)	3	3	2.25
		Disaster/accident occurs (A7)	2	3	2.75
		Coronavirus outbreak (A27)	1	9	1.33
Delay in sample delivery (E32)	6	Disaster/accident occurs (A7)	2	3	2.75
		The delivery location is difficult to reach (A10)	8	3	2.00
		Coronavirus outbreak (A27)	1	9	1.33
Delay in loading and unloading goods (E33)	6	Poor quality human resources (A18)	2	3	4.75
		Overcapacity/Overload (A20)	3	3	1.25
		Incorrect information data (A23)	2	1	0.33
Cancel order (E34)	8	Coronavirus outbreak (A27)	1	9	1.33
Delayed raw materials delivery (E35)	8	Transportation equipment disruption (A6)	3	3	2.25
		Disaster/accident occurs (A7)	2	3	2.75
		The delivery location is difficult to reach (A10)	8	3	2.00
Production capacity is not met (E36)	8	Farmer productivity decreases (A2)	7	3	3.00
		Raw materials don't meet quality standards (A12)	8	9	2.00

Where: S_i is Severity. O_j is Occurrence. C is Correlation. FARP is fuzzy aggregate risk potential.

At the coffee processor level, 18 relevant risk mitigation strategies were obtained to be implemented according to the results of expert assessments. Risk mitigation strategies aim to maintain the stability of business operations, increase competitiveness with competitors, and serve as a reference for continuous improvement. The results of the risk mitigation strategy assessment at the coffee processor level are presented in Table 9.

4 DISCUSSIONS

4.1 Supply Chain of Arabica Coffee Processor

UD Barokah is a coffee processor that processes green Arabica beans located in Bondowoso Regency, precisely in Sumber Wringin district, which is the main center with a land area of around 18,885 ha and production reaching 4,813.43 tons of a total of 8,271.95 tons of Bondowoso Arabica coffee in 2023 (Indonesian Central Bureau of Statistics, 2023).

This coffee processor focuses on the processing and trading of Arabica green bean coffee, with a marketing coverage covering regional, national, and export markets. In meeting the need for coffee seeds, UD Barokah collaborates with the Indonesian coffee and cocoa research institute (Puslitkoka) as a seed provider, where UD Barokah acts as an intermediary between Puslitkoka and farmers. Arabica coffee bean raw materials are obtained from farmers and collectors. Currently, UD Barokah has established partnerships with 38 partner farmers, both individuals and farmer groups, spread across the Bondowoso, Jember, and Situbondo areas, as well as a combination of coffee farmer groups in East Java. These partners receive various facilities such as the provision of seeds in the early stages of cultivation, education on coffee cultivation techniques, capital assistance for plant care, and

the provision of coffee bean processing machines. These facilities are provided so that the quality of the coffee beans produced follows the standard specifications set by the company. After going through the final processing, the coffee product is packed in plastic bags and marketed to consumers, namely companies or countries that process green bean Arabica into ground coffee. Before shipping is carried out, product samples are first sent to be tested for suitability with consumer demand. Once approved, the payment and shipping process is continued. UD Barokah's green bean products have been exported to international markets, especially to the United States and the United Kingdom, through collaboration with shipping service companies (forwarders), and are also marketed domestically to major cities such as Jakarta, Medan, Bandung, and Surabaya.

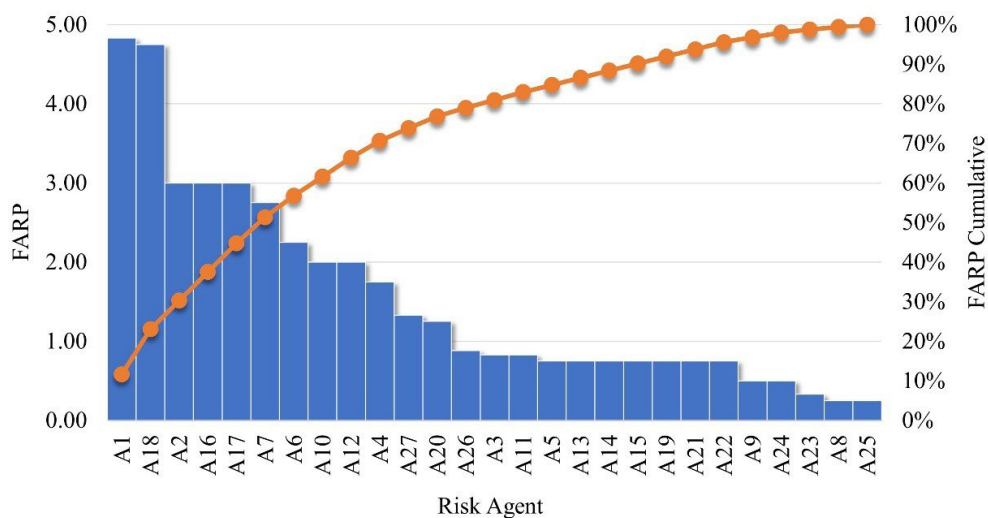


Figure 5: FARP Pareto chart at the coffee processor level.

Table 7: Risk mitigation strategy at the farmer level.

Code	Preventive Action (PA)	D_k	TE_k	ETD_k
P1	Providing training for workers	4	13.5	3.38
P2	Hiring casual workers	3	1.5	0.5
P3	Giving rewards and punishments to workers	3	9	3
P4	Buying fertilizer from other stores	5	1.5	0.3
P5	Mixing fertilizer with manure	3	4.5	1.5
P6	Hiring people to buy fertilizer	4	0.5	0.13
P7	Buying from other farmers	5	1.74	0.35
P8	Ordering more stock from sellers	4	1.74	0.44
P9	Spraying	3	4.5	1.5
P10	Conducting regular checks	3	9	3
P11	Creating a scheduling system	4	10.98	2.75
P12	Adding experienced permanent workers	5	1.5	0.3
P13	Making your seeds	4	0.75	0.19

Table 8: Risk mitigation strategy at the collector level.

Code	Preventive Action (PA)	D_k	TE_k	ETD_k
P1	Creating a scheduling system	5	8.1	1.62
P2	Conducting inventory control	4	8.1	2.03
P3	Improving a clear coordination mechanism	3	2.25	0.75
P4	Providing training to workers	3	5.85	1.95
P5	Updating the world coffee bean price information	4	1.74	0.44
P6	Conducting supervision of workers	3	5.85	1.95
P7	Implementing marketing strategies	5	5.22	1.04
P8	Predicting the weather well	4	6.75	1.69
P9	Developing new methods and technologies in coffee processing	4	6.75	1.69
P10	Making a schedule for regular maintenance	3	4.41	1.47
P11	Bringing in technicians and replacing spare parts	4	2.94	0.74
P12	Providing rewards and punishments	3	5.85	1.95
P13	Rearranging storage in the warehouse	3	4.5	1.5
P14	Cleaning the storage warehouse regularly	3	4.5	1.5
P15	Repairing or renovating the storage warehouse	4	1.5	0.38
P16	Conducting warehouse management	4	4.5	1.13

Table 9: Risk mitigation strategy at the coffee processor level.

Code	Preventive Action (PA)	D_k	TE_k	ETD_k
P1	Create a scheduling system	4	45.72	11.43
P2	Conduct inventory control	4	61.47	15.37
P3	Provide training for workers	3	42.75	14.25
P4	Provide rewards and punishments to workers	3	42.75	14.25
P5	Add permanent and non-permanent workers	4	14.25	3.56
P6	Supervise farmers	4	3	0.75
P7	Provide counselling and training to farmers	3	27	9
P8	Provide supporting facilities to farmers	5	9	1.8
P9	Predict the weather well	3	9	3
P10	Develop new methods and technologies for processing	4	27	6.75
P11	Make a schedule for periodic maintenance	4	47.25	11.81
P12	Bring in technicians and replace spare parts	4	15	3.75
P13	Evaluate suppliers who have collaborated	3	20.25	6.75
P14	Improve contracts with suppliers	3	6.75	2.25
P15	Select new suppliers	3	2.25	0.75
P16	Improve clear coordination mechanisms	4	18	4.5
P17	Implement marketing strategies	4	11.97	2.99
P18	Add machines or production equipment	5	3.75	0.75

4.2 Risk Identification and Analysis (FHOR Phase 1)

The results of risk identification and FARP value calculations presented in Table 4 show various risk events faced by farmers in the coffee cultivation process. Based on

the analysis results, it is known that the risk with the highest FARP value is the miscalculation of needs, which occurs in several risk events such as errors in setting production targets, errors in planning fungicide and insecticide purchases, and errors in planning maintenance costs. The four events have a FARP value of 1.22 with high levels of severity (S_i),

probability of occurrence (O_j), and correlation (C). This shows that these risks are very important to be addressed immediately because they have the potential to have a significant impact on the productivity and efficiency of agricultural activities. Conversely, the risk event with the lowest FARP value is damaged packaging due to overcapacity transportation, with a value of only 0.08. This shows the importance of designing a supply chain network to reduce the impact of damage during delivery (Abushaega et al., 2021). In addition, another risk agent that has a low FARP value is the occurrence of disasters/accidents, with a value of 0.08, which is related to errors in planning the harvest schedule. Although disasters/accidents cannot be predicted, they can be reduced by implementing supply chain disruption and natural disaster management (Ivanov & Wendler, 2017).

Table 5 presents the results of risk identification and calculation of FARP values that occur at the collector level in the coffee supply chain. Based on the assessment results, the risk with the highest FARP value is the error in planning needs that occurs repeatedly in various events, such as errors in planning production capacity, maintenance costs, and procurement of raw materials. These risks have a relatively high FARP value of 0.90, indicating the need for increased accuracy in the planning and estimation process of needs. On the other hand, the risks with the lowest FARP values include unstable dollar prices and difficult shipping distances, each of which has a FARP value of 0.08. Although external factors such as currency exchange rates and geographic location can affect coffee collection and distribution activities, the severity and likelihood of occurrence are considered relatively low compared to other risks. Risks related to human resources, such as a lack of competence in the fermentation process and washing of coffee beans, are also important to note in the results of this analysis. Although it has a low FARP with a value of 0.65, the quality of human resources is one of the critical factors that affect the quality of the harvest received by collectors (Yunanto & Kristanti, 2024).

The results of risk identification and FARP value calculation at the coffee processor level in the coffee supply chain are presented in Table 6. The analysis results show that the risk with the highest FARP value is the error in demand planning that occurs repeatedly about warehouse capacity planning, production cost planning, demand planning and seed procurement costs. This risk has an FARP value of 4.83, indicating that errors in demand planning can have a very large impact on the stability of the overall production process. In addition, several other risks with a high FARP value of 4.75 appear repeatedly about low-quality human resources, which affect various activities such as tool maintenance, coffee bean cleaning processes, and weighing processes. The quality of human resources is a crucial factor that affects the operational performance of a company (Ullah et al., 2022). Meanwhile,

risks with lower FARP values such as replacing damaged tools/machines (0.25) or late supply of raw materials (0.50), are considered to have a lower impact or probability than other major risks. However, these risks still need to be monitored to prevent the accumulation of minor disruptions that can lead to a decrease in overall efficiency. Pandemic-related risks, such as the COVID-19 virus outbreak, also emerged several times, both in the context of delayed deliveries and order cancellations. The FARP values for these risks ranged from 1.33 to 1.35, indicating that the pandemic still has an impact on manufacturing activities, especially in terms of distribution and market demand (Rinaldi & Bottani, 2023).

4.3 Risk Evaluation and Mitigation (FHOR-Phase 2)

This stage is designed to develop a handling strategy (Preventive action) for priority risk agents to design mitigation strategies, and to carry out the identification and assessment process for alternative mitigation strategy designs. This handling strategy is used to control and minimize a risk agent that can cause losses (Purnomo, Suryadharma, & Al-hakim, 2021). Table 7 presents risk mitigation strategies that can be applied at the farmer level, along with their evaluation parameters. There are 13 preventive actions proposed, but only one action shows the highest effectiveness, namely providing training to workers (P1) with an ETDk value of 3.38. This indicates that this action is very efficient in reducing the most severe risks. Meanwhile, actions such as providing rewards and punishments (P3) and routine inspections (P10) have an ETDk of 3, indicating that the human resource management approach and periodic monitoring are quite effective in addressing risks. Human resource competence is a crucial factor that affects a company's operational performance (Ullah et al., 2022). Actions with high Dk values, namely buying fertilizer from other shops (P4) and buying from other farmers (P7), have relatively low ETDk. This suggests that although the risks faced are significant, the existing solutions are not yet optimal. This emphasizes the need for a more comprehensive approach or a combination of several strategies for high-severity risks.

Table 8 presents various risk mitigation strategies at the collector level. There are 16 preventive actions covering operational aspects, human resource management, technology, and logistics. Several actions show high effectiveness, such as inventory control (P2) with an ETDk value of 2.03, worker training (P4) with an ETDk value of 1.95, and worker supervision (P6) with an ETDk value of 1.95. These actions are not only effective in reducing risk but also efficient in the use of resources, so they deserve to be a priority. Meanwhile, actions with moderate effectiveness, such as routine maintenance scheduling (ETDk 1.47) and warehouse management (ETDk 1.13), still need to be supported by accompanying steps to maximize their impact. Possible actions include developing

inventory management strategies that encourage sustainable development (Tao et al., 2024).

Table 9 shows the risk mitigation strategies implemented at the coffee processor level. This table contains 18 preventive actions (Preventive Action) designed to reduce risks in the coffee processing process. Several actions that have significant risk mitigation effectiveness values include conducting inventory control (P2) with an ETDk value of 15.37, providing training to workers (P3) and providing rewards and punishments to workers (P4) each with an ETDk value of 14.25, and preparing a periodic maintenance schedule (P11) with an ETDk of 11.81. This shows that these actions have great potential in reducing disruptions or losses in the coffee production process, both from technical and managerial aspects. According to Wibowo, Purnomo and Kristio (2021), one of the elements of constraints in the coffee agroindustry is the limited control of the quality of the products produced due to poor human resource skills. Therefore, human resource development is needed in agroindustry actors. If these actions are taken immediately, the operational efficiency of the UD Barokah coffee processor can be achieved to drive company performance in responding to increasing business competition. Currently, companies must prioritize increasing their operational efficiency to remain competitive in a dynamic market (Handoyo et al., 2023).

This research is limited in scope to risks that can be monitored and controlled by supply chain actors. Uncontrollable external risks such as extreme weather conditions, natural disasters, or global geopolitical factors are not included in the analysis. The focus of this research is on productive, price, contractual, legal, and operational risks that can be mitigated through managerial intervention.

5 CONCLUSIONS

The integration of the House of Risk method and fuzzy logic in this study can be used to address issues in the Arabica coffee supply chain management. Integrating these methods across all actors in the supply chain enables the identification of detailed risks throughout the entire supply chain, leading to the design of appropriate and implementable risk mitigation strategies. With the implementation of appropriate mitigation strategies, it is hoped that the negative impacts of these risk factors can be minimized.

6 AUTHORS' CONTRIBUTIONS

Conceptual Idea: Wibowo, Y.; Methodology design: Wibowo, Y.; Ni'maturrakhmat, V.N.; Data collection: Wibowo, Y.; Ni'maturrakhmat, V.N.; Data analysis and interpretation: Ni'maturrakhmat, V.N., and Writing and editing: Wibowo, Y.; Ni'maturrakhmat, V.N.

7 DATA AVAILABILITY STATEMENT

Data available upon request to authors.

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