Risk Mitigation Analysis of Wet Cocoa Beans Supply Chain in North Luwu Regency

Winda Kamal*, Novita Erma Kristanti, Anggoro Cahyo Sukartiko

Department of Agroindustrial Technology, Faculty of Agricultural Technology, Universitas Gadjah Mada, Jl. Flora No. 1 Bulaksumur, Yogyakarta 55281, Indonesia
*Corresponding author: Winda Kamal, Email: windakamal@mail.ugm.ac.id

Submitted: June 28, 2023; Revised: February 7, 2024; June 11, 2024, June 20, 2024; Accepted: June 6, 2024; Published: May 28, 2025

ABSTRACT

Cocoa in North Luwu Regency is contributing greatly to the improvement of the economy. However, different factors have caused a decrease in the amount of production since 2019 and farmers mostly sell cocoa as wet beans. Therefore, this research aimed to reduce the impact of risk on the supply chain of North Luwu wet cocoa beans through Supply Chain Risk Management, which included the stages of mapping, risk identification, analysis, and mitigation. The results showed that the supply chain flow map was obtained by tracing and identifying the tiers using snowball sampling method. Subsequently, the list of risk for each tier was identified and assessed for the likelihood, severity, and detection levels through in-depth interviews using 5 Likert scales. Data analysis was also carried out by determining the mapping matrix in avoid, transfer, manage, and appetite risk, as well as assessing the Risk Priority Number (RPN). Avoid risk and those with a high RPN value were priorities in preparing mitigation. The stages considered were the interview and group discussion with risk owners and experts. Meanwhile, the flows of the wet cocoa bean supply chain were identified. In the farmer tier, 8 risks, 10 collectors, 9 cooperatives, and 9 industries were reported. High rainfall, classified as avoid risk, had the highest RPN value. This risk was identified in almost all tiers and mitigated through irrigation improvements, reservoir construction, and planting new adaptive clones.

Keywords: Cocoa; risk mitigation; supply chain risk management

INTRODUCTION

Indonesia is the largest cocoa-producing country, and the level of production is spread across different regions. In 2020, 720.66 thousand tons (99%), 3.08 thousand tons (0.43%), and 980 tons (0.14%) of cocoa production were obtained from community, private, and state plantations, respectively. According to the distribution area, 18%, 16%, 15%, 11%, 8%, and 32% of production is from Southeast Sulawesi, Central Sulawesi, South Sulawesi, West Sulawesi, West Sumatra, and 28 other provinces (Badan Pusat Statistik, 2021). North Luwu Regency is a region in South Sulawesi with natural conditions and geographical locations supporting cocoa cultivation (Firdaus, 2020).

Cocoa has a significant contribution to the economy in North Luwu but the production is decreasing due to various factors. Total cocoa production in North

DOI: http://doi.org/10.22146/agritech.86297
ISSN 0216-0455 (Print), ISSN 2527-3825 (Online)

Regency in 2020 and 2021 was 30 (30,856.05) and 28 (28,573.37) thousand tons, respectively (Badan Pusat Statistik, 2023). This is due to various factors such as access to fertilizer, price fluctuations, low levels of rehabilitation, disease and pest attacks (Anggraeni et al., 2020), as well as high rainfall. Meanwhile, the most common problem in the supply chain is high rainfall.

According to Indonesian Statistics (2023), rainfall data in 2019, 2020, 2021, and 2022 was 3,268, 4,708.7, 4,283, and 4,764.6 mm/year, respectively. The growing requirements for cultivating cocoa plants are rainfall ranging from 1,200-4,500 mm/year. A rainfall of more than 4,500 mm/year increases the susceptibility to fruit rot disease (*Phytophthora palmivora*) (Leiwakabessy et al., 2020).

The wet cocoa bean supply chain in the North Luwu district is closely related to the flow and transformation of goods and services, starting from farmers. The supply chain usually consists of several activities in the process of distributing goods, money, and information (Husnarti dan Handayani, 2021) to form a network between producers and suppliers in producing products and services (Teniwut et al., 2020). Different risk can disrupt and negatively affect the activities of the supply chain by reducing efficiency (Nadhira et al., 2019). Generally, the supply chain for selling dry cocoa beans is longer than the wet counterparts. In this context, most farmers dominate the sales of wet cocoa beans due to the effectiveness and efficiency. The long supply chain for the sale of dry cocoa beans is subjected to 5 tiers, namely farmers, collectors, small traders, large cooperatives, and industry. An example of the supply chain can be seen in Farhana et al. (2019), which has 5 tiers, including farmers, groups, associations, Griya Cokelat Nglanggeran, and retailers. Meanwhile, the sale of wet cocoa beans only has 3 tiers due to the shortness of the supply chain. Haynes et al. (2012) stated that the challenge in the agro-industry was the large number of process required to transform cocoa into the final product.

The sale of wet cocoa beans reduces the risk at the farmer level due to high rainfall. The drying process is not carried out by farmers who sell wet cocoa beans to avoid the risk caused by high rainfall during the drying process. An example of a risk avoided is the risk of moldy cocoa beans due to the rainy season or high rainfall. In this context, the drying process is not optimal and the cocoa beans are susceptible to contamination by fungal microorganisms when the weather is not sunny for a long time (Syuhada et al., 2018). Therefore, farmers sell wet cocoa beans more often to prevent risk.

Risk management is needed to avoid risk or minimize the impact. In addition, risk identification, analysis, and assessment are part of the process carried out to achieve the goals. Various actions related to managing risk are known as risk management processes (Mahardika et al., 2019) to reduce losses and increase opportunities (Aini et al., 2014). Moreover, this minimizes the negative impacts of risk and increases the chances of success for an organization or individual. Several risk management components should be fulfilled to identify and set goals, assess and measure risk, as well as conduct risk control. The process of risk management in the wet cocoa bean supply chain is very important. Therefore, the development of cocoa in terms of quality and quantity can be improved when the condition of the plantations tends to be unstable.

The unstable condition of cocoa plantations is caused by high rainfall and unhealthy conditions for trees and fruit. This affects the fruit quality, with many experiencing rot disease and decreasing the number of cocoa pods. The risk can be mitigated through the management process to avoid or reduce the impact. This research was aimed to identify and mitigate risk, reduce the possibility of occurring, and decrease the impact on the North Luwu wet cocoa bean supply chain.

METHODS

Framework

Research on wet cocoa bean supply chain risk mitigation analysis in North Luwu Regency had several stages. The first stage was carried out by literature and observation to understand the supply chain and various risk disrupting the process. Subsequently, the results were compiled into an interview form using the

Table1. Respondent criteria

Respondent	Criteria
Farmer	Farming cocoa > 3 years, owning private cocoa land ≥ 0.5 hectares, selling wet cocoa beans in the last 3 months, cocoa plantation location is located in the North Luwu Regency area
Collectors and cooperatives	Purchased wet beans in the last 3 months in North Luwu Regency.
Industry	The industry buys wet cocoa beans from collectors and cooperatives from the North Luwu Regency area.

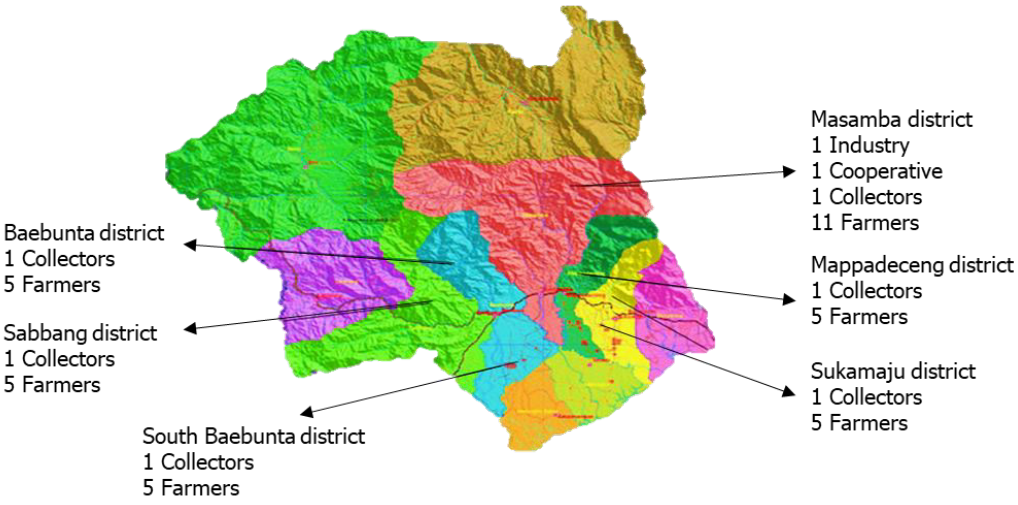

Figure 1. Map of Respondent Distribution in South Luwu Regency

in-depth method to obtain risk assessment data from each owner. Risk assessment begins with equalizing the perceptions of each respondent to avoid bias. The process is carried out by providing likelihood (L), severity (S), and detection (D) values for each risk. Meanwhile, LSD is determined using a 5-level Likert scale presented in Tables 2, 3, and 4. Mapping in the risk mapping matrix uses a combination of likelihood and severity to obtain 4 types of risk, namely avoid, transfer, manage, and appetitive. Risk with an avoid level and RPN value are prioritized for mitigation. The snowball sampling technique was used to select initial respondents based on an analogy in line with the respondent's criteria (Nurdiani, 2014), as presented in Table 1.

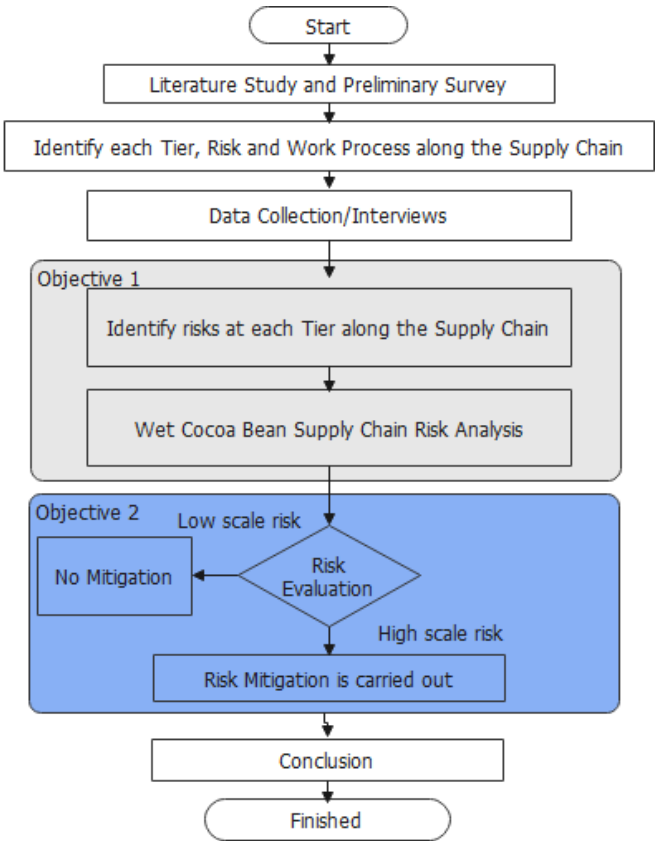

Figure 2. Research Flow Diagram

The respondents were 36 farmers, 6 collectors, 1 cooperative, and 2 cocoa processing industries. The cooperatives and cocoa processing industries used as samples amounted to 1 (50%) and 2 (100%), respectively. This proportion has exceeded half of the region's total cooperatives and cocoa processing industries. The cooperatives that did not meet the criteria for being a respondent were excluded, as shown in Figure 1.

Figure 2 presents the stages of this research, starting from the beginning and ending with the conclusions.

Supply Chain Mapping

Interviews were conducted with farmers, collectors and cooperatives, as well as industry to discover the supply chain mapping. These activities aim to simplify the process of identifying risk in the supply chain (Ridwan et al., 2020).

Identify Supply Chain Risk

After determining the supply chain mapping, the next stage is to identify the risk. The possibility of an unfavorable event occurring (Aven, 2016) is entered into the risk register presented in Table 2.

Table 2. Example of Risk Register

No	Code Risk	Risk Description	RPN			Person in Charge (risk owner)
			L	S	D	

Note :
L : Likelihood
S : Severity
D : Detection

Table 3. Likelihood value scale

Value	Possible event	Criteria
1	None	The possibility of a very small or remote event is at least 1/10,000
2	Low	The probability of occurrence is low since the ability to occur is at least 1/5000-1/500
3	Medium	The probability of occurrence is moderate since the process is in control, with occasional and insignificant failures. The probability of occurrence is at least 1/200
4	High	The probability of occurrence is very low at least 1/100
5	Very high	The possibility of this happening is very high at least 1/10 and failure is almost unavoidable.

Source: Stamatis, 2003 (has been modified)

Table 4. Severity value scale

Value	Impact Level	Criteria
1	Minor	It is unreasonable to anticipate that products and services will suffer an impact because of a small error.
2	Low	The nature of the failure was at a low severity level, causing only minor disruption and damage.
3	Medium	This is a medium rating because failure may cause dissatisfaction, discomfort, or annoyance. In addition, some performance degradation may be seen.
4	High	The level of dissatisfaction due to the nature of failure is high, comprising a problem with a product or service.
5	Very High	Very high level of severity and impact, undermining the entire process and non-compliance with the government.

Source: Stamatis, 2003 (has been modified)

Risk Assessment and Analysis

Risk analysis and assessment measure the level of previously identified risk and the process is carried out in 2 stages. The first stage is to determine the likelihood (L), severity (S), and detection (D) values. The second stage is to determine the RPN value. The reference used in determining the L, S, and D values is the scale from (Stamatis, 2003) modified to unify the perception of the respondents. Tables 3, 4, and 5 show the risk assessment scale reference table.

The risk level is determined with a combination of likelihood and severity. The values used in risk mapping are the result of calculating the mode of respondents for each tier, as shown in Figure 3.

Risk priorities are determined using two methods, namely, likelihood and severity. The determination is also carried out by calculating the RPN and multiplying the probability of a risk event (likelihood), the impact of the resulting damage (severity), as well as risk detection (detection) (Ulfah et al., 2016). A high RPN value is a priority risk calculated using Equation 1.

$$RPN = likelihood \times severity \times detection \quad (1)$$

Table 5. Detection value scale

Value	Detection	Criteria
1	Very high: The control will almost certainly detect a defect	The probability that a product will be distributed with a defect is very small (1/10,000). Functional defects are very easy to detect, and detection is around 99.99%.
2	High: The control has a good chance of detecting a failure	There is a small possibility that the product will be delivered defective, which is obvious (1/5,000-1/500) with a detection reliability of 99.80%.S
3	Medium: The control can detect a defect	Defects are easy to detect (1/200-1/50). Detection reliability is at least 98.00%.
4	Low: Controls are more likely not to detect any defects	There is a high possibility that the product will be distributed and sent with damage (1/20) and the detection is around 90%.
5	Very low: The control is very unlikely to detect any defects	Products and services are distributed and delivered in a damaged condition. The damage cannot be seen during the process (1/10+) and the detection is less than or equal to 90%.

Source: Stamatis, 2003 (has been modified)

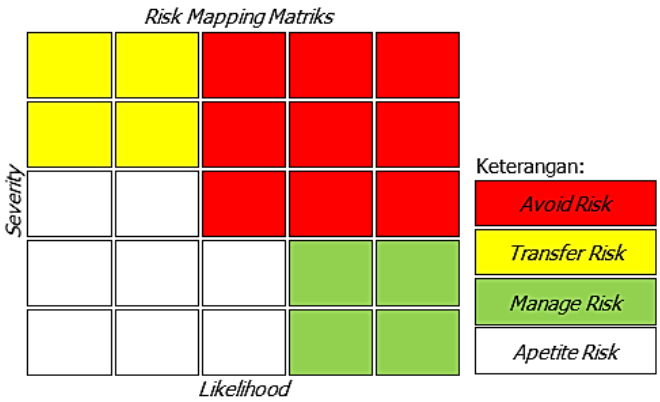

Figure 3. Example of risk mapping
Source: (Muchfirodin et al., 2015)

Risk Mitigation

The risk mitigation process is structured in two stages, the first includes interviews with risk owners, while the second comprises group discussions with representatives of risk owners and experts. An expert understands the risk of the cocoa supply chain in North Luwu Regency and the mitigation is an effort to reduce potential losses.

RESULT AND DISCUSSION

Supply Chain Flow Mapping

The wet cocoa bean supply chain consists of several tiers, namely farmers, collectors, cooperatives, as well as industries A and B. As shown in Figures 4 and 5, the chain has two flow patterns. Each wet cocoa bean supply chain pattern consists of three tiers. Farmers are the first tier, whose task is to carry out cultivation activities, starting with land preparation through harvest. Collectors are tasked with obtaining cocoa pods in certain areas, buying the fruit, and reselling to industry A. Meanwhile, cooperatives are organizations that include the farmers within a community. Besides providing services and assistance, these organizations have other tasks, namely buying wet cocoa beans, as well as fermenting and drying. Subsequently, Industry A buys wet cocoa beans from collectors and carries out the fermentation process under the SOP (Standard Operating Procedure), which the industry has determined. In this context, the fermented cocoa beans will be sent to Industry A's factory in another city. Industry B buys dry fermented cocoa beans from cooperatives, which

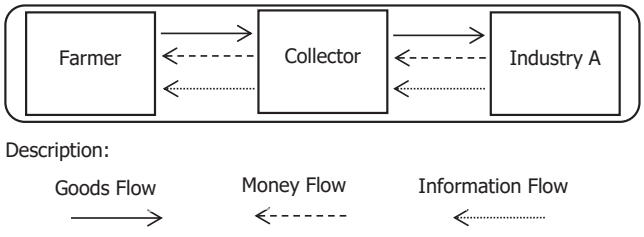

Figure 4. Supply Chain Flow Pattern 1

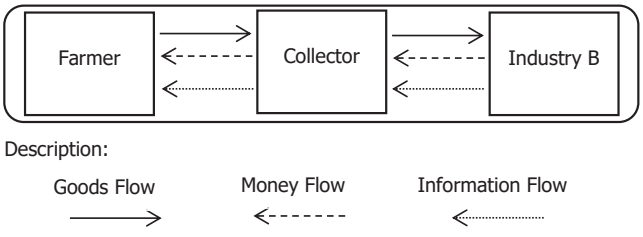

Figure 5. Supply Chain Flow Pattern 2

are processed into various processed products in the form of chocolate bars, candy, paste, and powder. Sales of wet beans are all processed into fermented products but the process is performed by industry A (supply chain pattern 1) and cooperatives (supply chain pattern 2). This research covers the entire wet cocoa bean supply chain from farmers to industry. However, the conditions of the on-farm production section are discussed based on the information and data obtained.

Identify Supply Chain Risk

The risk identification process is a step in managing cocoa bean supply chain risk. The process is carried out at each tier along the cocoa bean supply chain in North Luwu Regency. This includes identifying several factors related to risk, such as type, cause, effect, and owner or person responsible. Some of the identification process results are entered into the risk register, as shown in Table 6.

From Table 6, there are several similar risk in each tier, hence there are 24 tiers when identified based on type. The types in several tiers are the risk of high rainfall, flood, inappropriate specifications, and price fluctuations. Farhana et al. (2019) showed that the wet cocoa bean supply chain was longer than in the North Luwu Regency and had more risk (53). The types of risk include high rainfall, pests, disease, inappropriate fermentation processes, and machine jamming in the industry (Griya Cokelat Nglanggeran).

Risk Assessment and Analysis

Risk assessment is carried out by comparing likelihood and severity. Meanwhile, priority determination

Table 6. Risk register

Tier risk code	Risk description	Risk owner
A.A.1	Effect of high rainfall	Farmer
A.A.2	Flood	
A.B.1	Mistakes in planning fertilizer application	
A.B.2	Fertilizer stock difficulties	
A.B.3	Wrong use of pesticide dosage	
A.B.4	Harvest planning errors	
A.C.1	Pest and disease problems	
A.D.1	Price fluctuations	
B.B.5	Purchase information error	Collectors
B.B.6	Purchases are less/do not meet targets	
B.B.7	Overload/excess demand capacity	
B.D.1	Price fluctuations	
B.D.2	Late payment	
B.E.1	Delays in delivery	
B.E.2	Shipping loss	
B.F.1	Specifications do not match	
C.D.1	Price fluctuations	Cooperative
C.D.2	Late payment	
C.E.1	Delays in delivery	
C.E.2	Shipping loss	
C.F.1	Specifications do not match	
C.G.1	Fermentation process errors	Cooperative
C.G.2	Moldy cocoa beans	
D.B.5	Purchase information error	Industry A
D.B.6	Purchases are less/do not meet targets	
D.D.1	Price fluctuations	
D.D.3	Inflation	
D.E.1	Delays in delivery	
D.F.1	Specifications do not match	
D.G.1	Fermentation process errors	
D.G.2	Moldy cocoa beans	
E.D.1	Price fluctuations	Industry B
E.E.1	Delay in delivery of raw materials	
E.E.3	Product delivery planning errors	
E.F.1	Raw material specifications do not match	
E.G.2	Moldy cocoa beans	
E.H.1	Machine jammed	
E.H.2	Packaging damaged	
E.H.3	Defective product	
E.H.4	Product not sold	

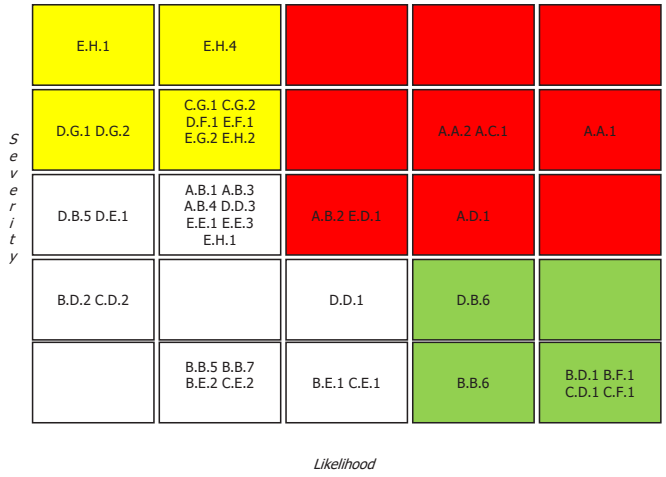

Figure 6. Risk mapping matrix for the wet cocoa bean supply chain in North Luwu Regency

is performed based on risk levels, which are divided into avoid, transfer, manage, and appetite risk. The risk mapping matrix for the wet cocoa bean supply chain can be seen in Figure 6.

Moreover, another risk (risk E.H.4) with a high RPN value is mitigated. Table 7 shows an evaluation of the RPN calculation for each risk related to the wet cocoa bean supply chain.

Risk Mitigation

The subsequent stage is to determine actions for risk mitigation classified as avoid and have the same RPN value. This is considered to be addressed first because the possibility of occurrence and impact are greater than the others. Risk mitigation carried out at each supply chain tier is shown in Table 8.

Tabel 7. Evaluation of RPN calculation results

Tier	Risk Code	Risk	Risk Level			RPN	Risk Category
			L	S	D		
Farmer	A.A.1	Effect of high rainfall	5	4	5	100	Avoid risk
Farmer	A.A.2	Flood	4	4	4	64	Avoid risk
Farmer	A.C.1	Pest and disease problems	4	4	3	48	Avoid risk
Farmer	A.D.1	Price fluctuations	4	3	3	36	Avoid risk
Farmer	A.B.2	Fertilizer stock difficulties	3	3	3	27	Avoid risk
Industry B	E.D.1	Price fluctuations	3	3	3	27	Avoid risk
Industry B	E.H.4	Product not sold	2	5	3	30	Transfer risk
Farmer	A.B.1	Fertilizer planning	2	3	3	18	Transfer Risk
Cooperative	C.G.1	Fermentation process error	2	4	2	16	Transfer risk
Cooperative	C.G.2	Moldy cocoa beans	2	4	2	16	Transfer risk
Industry B	E.F.1	Raw material specifications do not match	2	4	2	16	Transfer risk
Industry B	E.G.2	Moldy cocoa beans	2	4	2	16	Transfer risk
Industry B	E.H.2	Packaging damaged	2	4	2	16	Transfer risk
Industry A	D.G.1	Fermentation process error	1	4	3	12	Transfer risk
Industry B	E.H.3	Defective product	1	5	2	10	Transfer risk
Industry A	D.F.1	Specifications do not match	2	4	1	8	Transfer risk
Industry A	D.G.2	Moldy cocoa beans	1	4	2	8	Transfer risk
Collector	B.D.1	Price fluctuations	5	1	4	20	Manage risk
Cooperative	C.D.1	Price fluctuations	5	1	4	20	Manage risk
Industry A	D.B.6	Purchases are less/do not meet targets	4	2	2	16	Manage Risk
Collector	B.B.6	Purchases are less/do not meet targets	4	1	2	8	Manage Risk
Collector	B.F.1	Specifications do not match	5	1	1	5	Manage risk

Tier	Risk Code	Risk	Risk Level			RPN	Risk Category
			L	S	D		
Cooperative	C.F.1	Specifications do not match	5	1	1	5	Manage risk
Farmer	A.B.4	Harvest planning errors	2	3	3	18	Apetite Risk
Industry A	D.D.3	Inflation	2	3	3	18	Apetite risk
Industry B	E.H.1	Machine jammed	2	3	3	18	Apetite risk
Farmer	A.B.3	Wrong use of pesticide dosage	2	3	2	12	Apetite risk
Industry A	D.D.1	Price fluctuations	3	2	2	12	Apetite risk
Industry B	E.E.3	Product delivery planning errors	2	3	2	12	Apetite risk
Industry A	D.E.1	Delays in delivery	1	3	2	6	Apetite risk
Industry B	E.E.1	Delay in delivery of raw materials	2	3	1	6	Apetite risk
Collector	B.B.7	Overload/excess demand capacity	2	2	1	4	Apetite risk
Collector	B.E.1	Delays in delivery	3	1	1	3	Apetite risk
Cooperative	C.E.1	Delays in delivery	3	1	1	3	Apetite risk
Industry A	D.B.5	Purchase information error	1	3	1	3	Apetite risk
Collector	B.B.5	Purchase information error	2	1	1	2	Apetite risk
Collector	B.D.2	Late payment	1	2	1	2	Apetite risk
Collector	B.E.2	Shipping loss	2	1	1	2	Apetite risk
Cooperative	C.D.2	Late payment	1	2	1	2	Apetite risk
Cooperative	C.E.2	Shipping loss	2	1	1	2	Apetite risk

A total of 6 types of risk receive mitigation treatment in the wet cocoa bean supply chain. These risk include the influence of high rainfall and flooding, difficulties in fertilizer stocks, pest and disease problems, price fluctuations, and failure to sell products.

Risk mitigation of the high rainfall effect

The influence of high rainfall is the risk that occurs most frequently, and significantly impacts farmer productivity. The detection of this risk is not easy for the owner since rainfall increased significantly from 2019 to 2022 (Badan Pusat Statistik, 2021; Badan Pusat Statistik, 2023). Meanwhile, fruit rot attacks and flooding are related to rainfall above 4,500 mm/year (Indah et al., 2021). The high rainfall can be mitigated by training farmers to rehabilitate cocoa plants. According to the strategy offered by the Ministry of Agriculture to anticipate climate change in cocoa plants, several factors considered are sanitation and rehabilitation of cocoa plants by pruning, harvesting ripe fruit or frequent harvests, and side grafting new clones. The North Luwu Regency Government (2021), in its Official Portal, reported that to increase sustainable cocoa production, replanting is needed by planting clone types to withstand as well as prevent pest and disease attacks.

Risk mitigation of flood

Flood risk mitigation is conducted by constructing irrigation and holding tanks on cocoa plantations, where irrigation channels do not have final discharge or rivers. In this context, the North Luwu Regency government has developed a strategy following the contents of the Regional Long-Term Development Plan (RLTDP) to improve irrigation as well as empower the community through irrigation repair and maintenance programs on the network managed by the community (North Luwu Regency Government, 2020). This risk mitigation is also supported by Murtiningrum et al. (2023), where efforts to mitigate risk in overcoming flooding problems on agricultural land are achieved by implementing good water management. Different risk originate from natural disaster events that are difficult to predict (Kusumaningtyas dan Purwantoro, 2023). Therefore, external risk from natural disturbances is the biggest in the cocoa supply chain because the potential to occur is in the high category. The impact is very large and detecting the occurrence is difficult,

Table 8. Risk mitigation for each tier

Risk Code	Risk	Risk Category	Risk Mitigation
A.A.1	Effect of high rainfall	Avoid risk	- Provide training to farmers regarding several steps taken to deal with high rainfall. - Carry out garden rehabilitation by planting cocoa clones more resistant to pests and diseases in cocoa plantations due to high rainfall. - Construction of irrigation and storage tanks
A.A.2	Flood	Avoid risk	- Improvement of irrigation and construction of holding tanks
A.B.2	Fertilizer stock difficulties	Avoid risk	- Always monitor fertilizer availability - Providing alternative fertilizer in the form of organic fertilizer
A.C.1	Pest and disease problems	Avoid risk	- Carry out garden rehabilitation by planting cocoa clones that are more resistant to pests and diseases - Harvest as often as possible, every 4-7 days. This process can prevent fruit rot and CPB (Cocoa Pod Borer) pests.
A.D.1, E.D.1	Price fluctuations	Avoid risk	- Implementing a simple agroforestry system, thereby farmers do not only rely on one crop commodity hence when cocoa experiences price fluctuations, other crops can be an alternative. - Carry out regular monitoring of the market and economic situation to help predict future price fluctuations.
E.H.4	Product not sold	Transfer Risk	- Carrying out market analysis to determine consumer needs - Performed evaluations on various product aspects, such as quality, price, and consumer needs - Carrying out product development following developments and market conditions - Designing marketing strategies to increase product sales - Increase consumer trust by strengthening brand image

hence mitigation is the effort made to deal with the matter.

Risk mitigation of fertilizer stock difficulties

Fertilization adds certain nutrient elements to the soil in order to increase the photosynthesis process in plants (Marpaung, 2013). Cocoa farmers generally use several chemical fertilizers, such as Urea and NPK Phonska, which are subsidized by the government. In addition, subsidized fertilizer scarcity is a risk currently faced by cocoa farmers. The large difference in prices cannot make farmers select non-subsidized fertilizers as an alternative to the scarcity of subsidized. An example of the difference in prices found during interviews with risk owners and experts is the IDR 112,500/50kg cost of government-subsidized urea fertilizer. In contrast, the price of non-subsidized fertilizer ranges from IDR 510,000/50kg to IDR 600,000/50kg. The regional government has made no special effort to overcome the scarcity since the national and international levels are affected. In maintaining and increasing farmer productivity, local governments continue to make various efforts to mitigate the risk of fertilizer stock difficulties, including providing alternatives. This is consistent with the RLTDP's (Regional Long-Term Development Plan) goals of developing policies that support the use of organic fertilizer to rehabilitate land and plants (North Luwu Regency Government, 2020).

Rist mitigation of pests and disease

The types of pests and diseases attacking the plants are Cocoa Fruit Borer or CPB pest (*Conopomorpha cramerella*) and fruit rot disease *Phytophthora palmivora* (Syakur et al., 2018). The North Luwu Regency Government (2021) in the official portal to increase farmers' desire of returning to planting cocoa was realized by the existence of MCC 02 clone recognized as a national superior by Minister of Agriculture Decree No. 1082/Kpts/SR.120/10/2014. In this context, it is difficult for CPB (Cocoa Pod Borer) pests to reproduce because the fruit skin surface is slippery and smoother. Therefore, the pest eggs are damaged before hatching (Lilis et al., 2022). Based on the interviews, farmers harvest cocoa fruit with a harvest period of 1 to 2 times a month. Harvesting at intervals of every 4-7 days (Amalia et al., 2020) followed by sanitation is recommended. Garden

sanitation is performed to prevent pests and diseases from breeding on cocoa plants, hence regular cleaning is required (Managanta, 2020).

Risk mitigation of price fluctuations

Price fluctuations are the most frequent risk in the cocoa supply chain. This can be caused by several factors, including the country's economic conditions, export-import policies, and fluctuating demand conditions. The risk mitigation measures taken to deal with the problem is implementing a simple agroforestry system. Meanwhile, Sumilia et al., (2019) compared farmer productivity in different agroforestry systems. The simple agroforestry, non-agroforestry and complex agroforestry systems produce 596.39 kg/ha/year, 400.46 kg/ha/year, and 397.03 kg/ha/year. Aside from implementing an agroforestry system, the risk of price fluctuations can be addressed by regularly monitoring the market and economic situation. Farmers with a wet beans sales system cannot easily monitor market prices since the process of selling should be sold immediately after harvest. The North Luwu Regency Government (2021) recommended the selling of dry cocoa beans in fermented form to increase productivity and sustainably add value.

Risk mitigation of products not being sold

Market analysis is performed to determine consumer needs, as well as market trends and conditions. After conducting the analysis, the subsequent step is to design a marketing strategy to increase product sales and create consumer interest. Some strategies implemented are product diversification or differentiation to increase the attraction level. The product is made in different sizes and prices, allowing people to buy according to the purchasing ability (Astutik dan Dwi B, 2019).

CONCLUSION

In conclusion, North Luwu Regency was reported to have 2 supply chain flow patterns, consisting of 3 tiers. The supply chain flow pattern 1 comprised farmer, collector, and industry A tiers, while pattern 2 included farmer, cooperative, and industry B tiers. A total of 45 risk were identified from all wet cocoa bean supply chain tiers, where 8, 10, and 9 were obtained from the farmer tier, collector tier, as well as cooperative, industry A, and industry B tiers, respectively. The risk assessment and analysis results showed that 6 types of risk were priorities for mitigation, namely high rainfall and flood risk mitigated by training farmers, improving irrigation systems and storage tanks, as well as planting new and more adaptive clonal varieties. In addition, the risk of stock scarcity was mitigated by providing alternatives in the form of organic fertilizer. The risk of pest and disease problems was mitigated by selecting and planting new clones (MCC 02) resistant to pests and fruit rot diseases. Meanwhile, price fluctuations were mitigated by implementing a simple agroforestry system on cocoa plantations. The failure to sell products was mitigated by conducting market analysis and developing strategies according to segmentation.

ACKNOWLEDGEMENT

The authors are grateful to various parties who assisted in the data collection process, namely, the Masagena Farmers' Cooperative chairman, who has given access by providing data on farmers in North Luwu Regency and mapping the supply chain. In addition, the authors thank the collectors, who have assisted in mapping the supply chain and directed the fulfilment of respondents' needs, as well as experts who have assisted in preparing risk mitigation.

CONFLICT OF INTEREST

There is no potential conflict of interest with any parties.

REFERENCES

Aini, H., Syamsun, M., & Slamet, A. S. (2014). Risiko Rantai Pasok Kakao di Indonesia dengan metode Analytic Network Process dan Failure Mode Effect Analysis Terintegrasi. *Jurnal Manajemen & Agribisnis*, *11*(3), 209–219.

Amalia, D., Muslimah, M., & Indra, S. B. (2020). Analisis PendapatandDan Kelayakan Usahatani Kakao (Theobroma cacao L) di Kecamatan Pante Bidari Kabupaten Aceh Timur. *MEDIAGRO*, *16*(1), 81–92.

Anggraeni, E. Y., Hartati, S., & Mufadila, I. (2020). Sistem Pendukung Keputusan Menentukan Kualitas Pada Biji Kakao Dengan Menggunakan Metode Weighted Product (Wp) (Studi kasus : CV. Bulok Kakao Sentosa Kecamatan Bulok). *Respati*, *15*(2), 1. https://doi.org/10.35842/jtir.v15i2.342

Astutik, W. S., & Dwi B, K. P. (2019). Strategi Pemasaran terhadap Peningkatan Volume Penjualan (Studi pada perusahaan Unilever Tbk th 2015 -2019). *Jurnal Binawakya*, *14*(3), 2085–2094.

Aven, T. (2016). Risk assessment and risk management: Review of recent advances on their foundation. *European Journal of Operational Research*, *253*(1), 1–13. https://doi.org/10.1016/j.ejor.2015.12.023

Badan Pusat Statistik (2020). *Kabupaten Luwu Utara dalam Angka 2020* (B. Badan Pusat Statistik (ed.)). BPS Kabupaten Luwu Utara.

Badan Pusat Statistik (2021). *Kabupaten Luwu Utara dalam Angka 2022*. BPS Kabupaten Luwu Utara.

Badan Pusat Statistik (2023). *Kabupaen Luwu Utara dalam Angka 2023*. BPS Kabupaten Luwu Utara.

Farhana, E. L., Senjawati, N. D., & Utami, H. H. (2019). Analisis dan Mitigasi Risiko Rantai Pasok Kakao di Griya Cokelat Nglanggeran Gunungkidul Yogyakarta. *Jurnal Dinamika Sosial Ekonomi*, *20*(1), 55–64.

Firdaus, R. (2020). Peran Pemerintah Daerah sebagai Regulator, Dinamisator, Fasilitator dan Katalisator dalam Pemberdayaan Petani Kakao di Kabupaten Luwu Utara. *Jurnal I La Galigo | Public Administration Journal*, *3*(1), 32–40.

Haynes, J., Cubbage, F., Mercer, E., & Sills, E. (2012). The Search for Value and Meaning in the Cocoa Supply Chain in Costa Rica. *Sustainability*, *4*(7), 1466–1487. https://doi.org/10.3390/su4071466

Husnarti, H., & Handayani, R. (2021). Analisis Rantai Pasok dan Peran Lembaga yang Terlibat dalam Pemasaran Pepaya di Kecamatan Payakumbuh Utara Kota Payakumbuh. *Jurnal Ekonomi Pertanian Dan Agribisnis*, *5*(2), 433–441. https://doi.org/10.21776/ub.jepa.2021.005.02.13

Indah, P. N., Sugiyarto, S., Putra, C. A. P., Endahwati, L., & Maulana, H. (2021). *Pasca Panen Kakao & Pembuatan Sabun Kecantikan* (P. N. Indah (ed.); Kedua, Okt). Unggul Pangestu Nirmana.

Kusumaningtyas, D. D., & Purwantoro, K. (2023). Peran Pilihan Pendekatan Pemecahan Masalah dan Karakteristik Risiko Dalam Mengatasi Gangguan pada Risiko Rantai Pasokan. *Jurnal Imliah Manajemen, Ekonomi Dan Bisnis*, *2*(2017), 37–63.

Leiwakabessy, C., Masauna, E. D., & Uruilal, C. (2020). Kejadian Penyakit Busuk Buah Kakao (Phytophthora palmivora var . palmivora) di Desa Karlutu , Kecamatan Seram Utara Barat , Kabupaten Maluku Tengah (Disease Incidence of Cocoa Fruit Rot (Phytophthora palmivora var . palmivora) in Karlutu Village. *JPK*, *4*(January).

Lilis, L., Rahmiana, R., Isnaeni, I., Virna, V., Hikma, N., & Thamrin, S. (2022). Sarungisasi Buah Kakao Klon Mcc01 Dan Mcc 02 Di Kabupaten Soppeng Sulawesi Selatan. *Agroplantae: Jurnal Ilmiah Terapan Budidaya Dan Pengelolaan Tanaman Pertanian Dan Perkebunan*, *11*(2), 79–86. https://doi.org/10.51978/agro.v11i2.460

Mahardika, K. B., Wijaya, A. F., & Cahyono, A. D. (2019). Manajemen Risiko Teknologi Informasi Menggunakan Iso 31000 : 2018 (Studi Kasus: Cv. Xy). *Sebatik*, *23*(1), 277–284. https://doi.org/10.46984/sebatik.v23i1.572

Managanta, A. A. (2020). Perbaikan Produksi dan Kualitas Buah Kakao Melalui Peningkatan Kompetensi Petani di Desa Sepe Kecamatan Lage Kabupaten Poso. *PRIMA: Journal of Community Empowering and Services*, *4*(2), 70. https://doi.org/10.20961/prima.v4i2.41442

Marpaung, R. (2013). Pertumbuhan Bibit Kakao (Theobroma Cacao. L) dengan Pemberian Beberapa Dosis Pupuk NPK (16:16:16) pada Tanah Ultisol di Polybag. *Jurnal Ilmiah Universitas Batanghari Jambi*, *13*(4), 95–98.

Muchfirodin, M., Guritno, A. D., & Yuliando, H. (2015). Supply Chain Risk Management on Tobacco Commodity in Temanggung , Central Java (Case Study at Farmers and Middlemen Level) ScienceDirect Supply Chain Risk Management on Tobacco Commodity in Temanggung, Central Java (Case study at Farmers and Middlemen. *Agriculture and Agricultural Science Procedia*, *3*(December). https://doi.org/10.1016/j.aaspro.2015.01.046

Murtiningrum, Mawanda, H. G., Zaki, M. K., Lestari, P., Setyawan, C., Nugroho, B. D. A., & Ngadisih. (2023). Mitigasi Bencana Banjir Dan Rob Terhadap Lahan Pertanian Di Kota Pekalongan. *Jurnal Litbang Kota Pekalongan*, *21*(1), 1–8. https://jurnal.pekalongankota.go.id/index.php/litbang/article/view/235/169

Nadhira, A. H. K., Oktiarso, T., & Harsoyo, T. D. (2019). Manajemen Risiko Rantai Pasok Produk Sayuran Menggunakan Metode Supply Chain Operation Reference dan Model House of Risk. *KURAWAL Jurnal Teknologi Dan Industri*, *2*, 101–117.

Nurdiani, N. (2014). Teknik Sampling Snowball dalam Penelitian Lapangan. *ComTech*, *5*(2), 1110–1118.

Ridwan, A., Ferdinant, F. P., & Ekasari, W. (2020). Perancangan mitigasi risiko rantai pasok produk pallet dan dunnage menggunakan metode house of risk. *Teknika: Jurnal Sains Dan Teknologi*, *16*(01), 35–44.

Stamatis, D. . (2003). Failure Mode and Effect Analysis: FMEA From Theory to Execution. In *Technometrics* (2nd ed., r, Vol. 38, Issue 1). American Society for Quality. https://doi.org/10.1080/00401706.1996.10484424

Sumilia, S., Akhir, N., & Syarif, Z. (2019). Produktivitas kakao dan keanekaragaman tanaman dalam berbagai sistem agroforestri berbasis kakao di kabupaten pasaman sumatera barat. *Jurnal Agroforestri Indonesia*, *2*(2), 51–62.

Syakur, A., Saparuddin, & Sohriati, E. (2018). Penggunaan biopestisida dan pupuk kompos untuk meningkatkan produktivitas kakao di Desa Buangin Kecamatan

Sabbang Kabupaten Luwu Utara. *Jurnal Pengabdian Masyarakat*, *2*(2), 54–61.

Syuhada, A., Sary, R., & Isnan, F. (2018). Kaji Sistem pengering Kakao dengan Menggunakan Energi Hybrid (Energi Matahari dan Bahan Bakar Gas). *Jurnal Teknik Mesin Unsyiah*, *6*(1), 17–24.

Teniwut, W. A., Betaubun, K. D., Marimin, M., & Djatna, T. (2020). Mitigasi Rantai Pasok Rumput Laut dengan Pendekatan House of Risk dan Fuzzy AHP di Kabupaten Maluku Tenggara. *AgriTECH*, *40*(3), 242. https://doi.org/10.22146/agritech.27770

Ulfah, M., Maarif, M. S., Sukardi, S., & Raharja, S. (2016). Analisis dan Perbaikan Manajemen Risiko Rantai Pasok Gula Rafinasi Dengan Pendekatan House Of Risk. *Jurnal Teknik Industri Pertanian*, *Vol.26*(No.1), 87–103.