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Risk Assessment on Supply Chain of the Geographical Indication Granulated Coconut Sugar in Kulon Progo Regency, Special Region of Yogyakarta, Indonesia

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Abstract*—Granulated Coconut Sugar Kulon Progo Jogja, one of the certified geographical indication organic food products in Yogyakarta Special Region Indonesia, is produced and distributed through a supply chain, starting from farmers to exporters. Throughout its supply chain, there are risks to each tier affecting overall supply chain performance. Even though they have risks, not all tiers have the same vulnerability, depending on the ability of the risk owner to overcome them. Therefore, this study aimed to conduct a vulnerability risk assessment of the certified coconut palm sugar in Kulon Progo Regency, Special Region of Yogyakarta, Indonesia. In-depth interviews with 54 risk owners throughout the product supply chain were then carried out using purposive and snowball samplings. The stages of risk assessment, starting from the identification, analysis, and evaluation of risks, were carried out using the ISO 31000:2009 framework. Risk categorization at the first assessment stage and mapping of expected loss and vulnerabilities at the second stage were carried out using the Rapid Agricultural Supply Chain Risk Assessment (RapAgRisk) instrument. The results showed that there were 35 risk events in the farmers, collectors, sub-Control Processing Units (sub-CPUs), Control Processing Units (CPUs), and Small and Medium Enterprises (SMEs) of sugar in Kulon Progo, which consisted of various risk categories, i.e., weather risk; natural disaster risk; biological and environmental risks; logistic and infrastructure risks; market risk; as well as management and operational risks. The risk events in the supply chain of the Granulated Coconut Sugar Kulon Progo have various degrees of vulnerability, starting from limited, low, moderate, highly, to extremely vulnerabilities. Risk events that are classified as limited vulnerability were considered acceptable, and the risk owner has been able to handle these risks well so that mitigation proposals were not given, while other risk events need to be mitigated to reduce their severities.

***Keywords*— Granulated coconut sugar; ISO 31000:2009; Rapid Agricultural Supply Chain Risk Assessment (RapAgRisk).**

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I. INTRODUCTION

Coconut sugar is palm sugar [1] made from sap derived from tapping coconut flower bud stems [2], [3], which is given a moderate heat treatment to vaporize its water content into a solid or granule form. This sugar has been used for a long time in Asia [1], [4] as a sweetener. It has been currently popular globally because of its naturalness, minimally processing, and low index glycemic content [1], up to 35+4 [5]. Besides, the sugar has a high mineral content and has a delicious taste, so it has been used in many food products [3].

Indonesia is the largest coconut producer in the world [6]. The tree is widely distributed in various areas in the country, and the processing of its sap is relatively high. Kulon Progo is one of the districts in the Special Region of Yogyakarta with the highest production of coconut sugar, both in the form of blocks and granules. The latter form has a higher selling price due to its better quality, longer shelf-life, and ease of serving [7], [8]. Granulated Coconut Sugar Kulon Progo is a geographical indication of organic products that have been certified. Most of the products are exported to countries in Asia, Europe, and America.

Coconut sugar in Kulon Progo can be made either from heating coconut sap moderately or by reprocessing the block sugar. Production, distribution, and sales of the sugar products involve various parties, from farmers, collectors, central processing units, to small and medium industries/ enterprises before then reaching the hands of exporters, forming a supply chain. The supply chain is a network of companies or organizations that work together to create and deliver a

product to the end consumer [9]. In its management, the network of organizations/companies is integrated so that it can produce and distribute products precisely both in quality and quantity at the right time and in the right place [10], [11]. Especially for food products, in addition to quality, food safety is also a matter that needs attention [12].

Because of its minimizing costs and maximizing services purposes, the supply chain has an essential role in an organization [10]. Throughout its supply chain, there are risks to each tier affecting overall supply chain performance that cannot be avoided [13], appears in various ways [14], and can function as a driver influencing company agility [15]. Risk can occur due to internal and external factors [16], including in the agricultural supply chain [17]. The risk is the possibility of an event that will occur with the potential negative impact on the performance farmer or company and/or on the success of the entire supply chain. Risk events can be characterized based on magnitude, scope or spread, frequency and duration, and history, which have an impact on vulnerability [11]. In agricultural supply chain, risks are mostly from weather; natural disaster; biological/environmental; market; logistic/infrastructure; politic; regulation; finance and operation/management [11], [17]. Even though they have risks, not all tiers have the same vulnerability, depending on the ability of the risk owner to overcome them.

Risks can arise in the supply chain of the coconut sugar. Previous observations in the research site indicated that weather is one of the causes of risk, such as the risk of falling product prices due to oversupply in the rainy season. In South Konawa [18], there was a decrease in production supply during the long dry season, which can hamper demand. Therefore, it is essential to manage the supply chain risk, reducing the consequences or losses [16], [17], [19], or improve the supply chain robustness [19]. In supply chain management, hence, the risk must be assessed to find out the level of vulnerabilities.

In this study, a risk assessment was carried out to determine the risk vulnerability of each tier in the granulated coconut sugar Kulon Progo supply chain. The stages of risk assessment, analysis, and evaluation were carried out using the ISO 31000: 2009 framework. ISO 31000: 2009 is an international standard in risk management that contains the principles and processes of risk management of an organization [20]. Meanwhile, risk categorization at the first assessment stage and mapping of expected loss and vulnerabilities at the second stage was carried out using the Rapid Agricultural Supply Chain Risk Assessment (RapAgRisk) instrument to find out a comprehensive picture of the risk of the sugar in perspective agricultural product supply chain management [11].

II. Materials and Method

Risk assessment was performed on the supply chain of granulated coconut sugar in Kulon Progo Regency, Yogyakarta Special Region, Indonesia, starting from the palm sugar farmers as the first tier to the exporter as the last tier, as depicted in Fig.1. Each tier has their roles. The farmers harvest the coconut sap from the flower bud stem and process the sap into coconut palm sugar, either in block or granules form. Collectors, the second tier in the chain, are those who collect the sugar products from the farmers, while the third and four tiers, called Sub Control Processing Units (sub-CPUs) and Control Processing Units (CPUs), are units that collect the sugar products from both previous tiers, farmers and collectors, with various activities, i.e., product reprocessing, water content reduction, granule sifting, and controlling quality of the products. The collected sugar in block form is reprocessed into granules form, while the collected granules sugar is heated moderately to decrease its water content. Unlike the CPUs that carry out moisture reduction activities using a drying oven, sub-CPUs do not conduct this process. Small and Medium Industries/ Enterprises (SMEs), the fifth tier in the chain, conduct a final inspection and packaging on the collected palm sugar from CPUs, by the specifications requested by the exporter. Besides, some SEMs have CPU in the same *tier*.

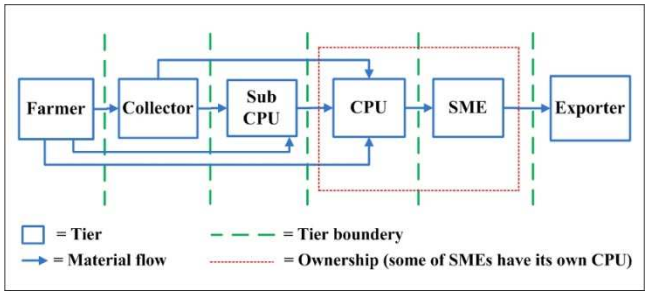

Fig. 1 Granulated coconut sugar supply chain in Kulon Progo

A. Steps of the Research Process

Risk assessment was carried out using the stages in the framework of ISO 31000:2009, starting from identification, analysis, and evaluation of risks [20]. To complement the results with the level of risk vulnerability in each tier, the RapAgRisk approach was then used to categorize risks and map the expected loss and vulnerability. Also, the overall risk picture in the supply chain of agricultural products can be obtained rapidly [11]. Using both approaches, this research was divided into three stages, including identification, analysis, and evaluation of risks.

The first stage was risk identification. This stage aimed to identify the risk that might occur and impact the quantity and quality of the sugar, lead to supply chain disruption. Identification was conducted through in-depth interviews of risk owners of each tier using RapAgRisk instrument to categorize the collected risks. Based on the instrument, the risks were categorized into weather-related risks, natural disasters, biological and environmental risks, market-related risks, logistical and infrastructural risks, management and operational risks, public policy and institutional risks, and political risks [11].

The second stage was risk analysis, aiming to determine the risk vulnerabilities. The analysis was conducted by mapping the risk event probability and its potential severity into the expected loss ranking matrix [11] as depicted in Table 1. The result of the mapping was then prepared with the capacity to management level and was shown in Table 2. The values of probability, severity, and capacity to manage were obtained from the risk owner of each tier along the sugar supply chain after previously given with an assessment guideline. The third stage was risk evaluation. This step was conducted by mapping several risks with different categories based on the results of the two previous steps.

TABLE I
EXPECTED LOSS RANKING MATRIX, ADAPTED FROM RAPAGRISK METHOD [11]

		Potential Severity of Impact				
		Negligible	Moderate	Considerable	Critical	Catastrophic
Probability of Event	Highly Probable					
	Probable					
	Occasional					
	Remote					
	Improbable					

Priority 1 = High expected loss Priority 2 = Medium expected loss Priority 3 = Low expected loss

TABLE II
VULNERABILITY TO RISK EVENT BASED ON EXPECTED LOSS AND CAPACITY TO MANAGE RISK, ADAPTED FROM RAPAGRISK METHOD [11]

	Capacity to Manage Risk				
Expected Loss	1	2	3	4	5
High					
Medium					
Low					

Note:
Extremely vulnerability
Highly vulnerability
Moderate vulnerability
Low vulnerability
Limited vulnerability

B. Data Collection

The data was collected through in-depth interviews with purposive sampling and snowball sampling techniques. Purposive sampling was carried out so that researchers can intentionally choose individuals and places to study or understand the phenomena [21]. In this case, the risk owner along the sugar supply chain in Kulon Progo. Snowball was also used to determine the flow of the sugar chains. In total, 54 respondents had been interviewed. Respondents are risk owners of tier farmers, collectors, sub-CPUs, CPUs, and SMEs.

III. RESULT AND DISCUSSION

A. Risk Identification

Risk identification is a systematic process of identifying and categorizing risks, as well as identifying the causes of the risks [22]. The results of risk identification in Table 3 show that the risks found in the supply chain of granulated coconut sugar in Kulon Progo are divided into several risk categories, namely weather, natural disaster, biological and environmental, managerial, and operational, market, and logistics and infrastructure risks.

Weather risks occur along the supply chain from farmers, collectors, Sub CPUs, CPUs, to SMEs. Weather causes a decrease in the quantity and quality of coconut sap in the farmers and has an impact on the reduced supply of products from the tiers of collectors, sub-CPUs, CPUs, and SMEs. Weather risk is often associated with a decrease in production, impacting on the quality of production, and disrupting the flow of goods and services [11]. In the case of a long dry season, the capacity to produce the granulated coconut sugar becomes vulnerable to a reduction, which consequently reduces the revenue and the ability to meet export demand. Drought often causes economic and financial difficulties for agricultural producers [23]. In fact, in 2011, there was also a severe drought in Texas, which caused a decline in production and a loss of 7.62 billion dollars in the agricultural sector [24].

The risk led by natural disasters, such as volcanic eruptions and landslides, could hamper operational activities along the supply chain. Volcanic eruption became one of the disasters faced by the supply chain of granulated coconut sugar. Yogyakarta is in an area with an active volcano. In October-November 2010, Mount Merapi erupted for about 2 weeks, which resulted in ash rain up to a radius of 30 km, even to West Java [25]. The volcanic ash of Mount Merapi also disturbed the people of Kulon Progo, including the actors who supply granulated coconut sugar. Kulon Progo has also experienced ash rain due to the eruption of Mount Kelud. The volcanic eruption caused the coconut trees to be covered with ash, which caused the branches to become brittle and the sap to become inevitably mixed with ash. Therefore, many farmers did not carry out the tapping process, so there was no supply of coconut sugar from farmers to downstream sugar producers. In addition to the absence of raw material supply, all the tiers, namely collectors, sub CPUs, CPUs, and SMEs did not carry out operational activities to prevent the presence of volcanic ash contaminating the sugar.

Kulon Progo is also a hilly area, so it is prone to landslides [26], especially during the rainy season. Landslides had caused the closure of road infrastructure, which hampered the flow of products in the supply chain of granulated coconut sugar. Biological and environmental risks are inherent in the agricultural product chain [11][17]. Biological and environmental risks are found at the farmer tier, which is usually caused by the attack of bees and rats on coconut sap or by the tapping process. The sap produced by coconut flowers can be a food source for honeybees. Therefore, during the tapping process, bees are often found mixed in the sap. Rats usually cut the ropes of the bamboo tubes and make them, which are used to tap the sap, fall. Absolutely this leads to a reduction in the amount of sap produced.

Managerial and operational risks are related to human decisions or responses and are part of the company's decisions [11]. These risks occur in almost all the granulated coconut sugar supply chain operators in Kulon Progo, except the collectors. These risks are related to quality control, production planning, work safety planning, supplier selection, and supplier performance. The consequences of these risks not only have an impact on product returns, product quantity, and quality but also on worker safety.

TABLE III
RISK IDENTIFICATION RESULT OF GRANULATED COCONUT SUGAR SUPPLY CHAIN IN KULON PROGO

Tier	No	Risk Code	Risk Event	Cause
Farmers	1.	P.A.1	Small amount of coconut sap production	Long drought
	2.	P.A.2	A mixture of coconut sap with rain water	Rainy season
	3.	P.A.3	Coconut sap precipitation	Significant weather changes from hot and cloudy or vice versa
	4.	P.B.1	Coconut trees are covered by volcanic ash	Volcanic eruption
	5.	P.B.2	Closed infrastructure (closed way)	Landslide
	6.	P.G.1	Coconut sap-sucking bee	Bee attack
	7.	P.G.2	Bamboo tube rope-cutting rats	Rat attack
	8.	P.M.1	Occupational accidents during the tapping process	Tapping workers who are not in fit condition or are wrong in climbing; slippery trees due to rain; or the absence of work safety equipment
	9.	P.R.1	A decline in the market price of block coconut sugar	No fixed prices or changes in demand in the market
Collectors	1.	L.A.1	Lack of raw material supply	Long drought
	2.	L.A.2	The quality of block coconut sugar from suppliers does not meet the standards	Significant weather changes from hot and cloudy or vice versa
	3.	L.B.1	Termination of production activities	Volcanic eruption
	4.	L.B.2	The access (infrastructure) to the plant is closed	Landslide
	5.	L.R.1	Increase in the market price of block coconut sugar	No fixed prices or changes in demand in the market
Sub-CPUs	1.	S.A.1	Lack of raw material supply	Long drought
	2.	S.B.1	Termination of production activities	Volcanic eruption
	3.	S.B.2	The access (infrastructure) to the plant is closed	Landslide
	4.	S.M.1	Product return	Incompliance of the supplied granulated coconut sugar with the criteria set by the CPUs
	5.	S.M.2	Too long storage period of granulated coconut sugar	Poor production planning
	6.	S.R.1	Increase in the market price of block coconut sugar	No fixed prices or changes in demand in the market
CPUs	1.	C.A.1	Lack of raw material supply	Long drought
	2.	C.B.1	Termination of production activities	Volcanic eruption
	3.	C.B.2	The access (infrastructure) to the plant is closed	Landslide
	4.	C.M.1	Product return	Unoptimal communication with consumers or production errors
	5.	C.F.1	Tool damages (the blower in the oven)	Continuous use
	6.	C.F.2	Power outages	Power outages by the State Electricity Company (PLN)
	7.	C.R.1	Increase in the market price of block coconut sugar	No fixed prices or changes in demand in the market
SEMs	1.	I.A.1	Lack of raw material supply	Long drought
	2.	I.B.1	Termination of production activities	Volcanic eruption
	3.	I.B.2	The access (infrastructure) to the plant is closed	Landslide
	4.	I.M.1	Granulated coconut sugar from suppliers is mixed with other ingredients	Lack of quality control by suppliers
	5.	I.M.2	The quality of raw materials from suppliers is not under the demand	Unoptimal communication or suppliers' production errors
	6.	I.M.3	Late delivery of raw materials from suppliers	Suppliers' production errors or due to terrain problem
	7.	I.M.4	Product return	Poor quality control or human error
	8.	I.F.1	Power outages	Power outages by the State Electricity Company (PLN)

Note: The risk codes used in this study consisted of 2 letters and 1 number. The first letter shows the tier of risk owner, namely P for farmer; L for collector; S for sub CPU; C for CPU; and I for SME. While the second letter shows the risk categories existing in RapAgRisk, namely A for weather; B for natural disaster; G for biological and environmental; F for logistics and infrastructure; R for market; M for management and operations; K for public and institutional policies; and T for politics. While the numbers show the order of risk in the same category.

The fluctuating price of block coconut sugar is a risk that must be faced by the actors of the granulated coconut sugar supply chain. The fluctuating price is due to the influence of the market, in contrast to granulated coconut sugar, the cost of which is more constant. A decline in the price of block coconut sugar can affect farmer income. But an increase in it can affect the income of collectors, sub-CPUs and CPUs.

One of the risks associated with logistics and infrastructure is the malfunction of infrastructure and service caused by power outages at the processor level, which can affect the quality [11]. The risk of a power outage is also experienced by CPU and SME tiers. In addition, the damage to the equipment experienced by the CPUs also affects their operational activities. So that logistics and infrastructure risks

not only affect product quality but can also disrupt production lines that have an impact on production capacity.

Overall, there were 35 risk events in the granulated coconut sugar supply chain in Kulon Progo. Farmers have the most risk events compared to others, namely nine risk events. In contrast, collectors have the least risk events, namely five events.

B. Risk Analysis

Risk analysis was carried out to determine the vulnerability of a risk measured by the probability of an event, the potential severity of impact, and the capacity to manage risk. The probability of an event and the potential severity of impact were used to determine losses due to the occurrence of risk events as described in Table 4.

TABLE IV
EXPECTED LOSS RANKING MATRIX

		Potential Severity of Impact				
		Negligible	**Moderate**	**Considerable**	**Critical**	**Catasthropic**
Probability of Event	**Highly Probable**	P.G.1				
	Probable		I.M.1			
	Occasional	L.A.2	P.R.1, P.G.2 L.R.1	P.A.2 S.R.1	P.A.1 L.A.1 S.A.1 C.A.1 I.A.1	
	Remote		C.F.2 I.M.3, I.F.1	C.R.1	P.A.3	
	Improbable		P.B.2 L.B.2 S.B.2, S.M.2 I.M.2	C.B.2, C.F.1 I.B.2	S.M.1 C.M.1	P.B.1, P.M.1 L.B.1 S.B.1 C.B.1 I.B.1, I.M.4

Note: Farmer tier — P.A.1 = small amount of coconut, P.A.2 = a mixture of coconut sap with rain water, P.A.3 = coconut sap precipitation, P.B.1 = coconut trees are covered by volcanic ash, P.B.2 = closed infrastructure (closed way), P.G.1 = coconut sap-sucking bee , P.G.2 = bamboo tube rope-cutting rats, P.M.1 = occupational accidents during tapping process, P.R.1 = decline in the market price of block coconut sugar

Collector tier — L.A.1 = lack of raw material supply, L.A.2 = the quality of block coconut sugar from suppliers does not meet the standards, L.B.1 = termination of production activities, L.B.2 = the access (infrastructure) to the plant is closed, L.R.1 = increase in the market price of block coconut sugar

Sub-CPU tier — S.A.1 = lack of raw material supply, S.B.1 = termination of production activities, S.B.2 = the access (infrastructure) to the plant is closed, S.M.1 = product return, S.M.2 = too long storage period of granulated coconut sugar, S.R.1 = increase in the market price of block coconut sugar

CPU tier — C.A.1 = lack of raw material supply, C.B.1 = termination of production activities, C.B.2 = the access (infrastructure) to the plant is closed, C.M.1 = product return, C.F.1 = tool damages (the blower in the oven), C.F.2 = power outages, C.R.1 = increase in the market price of block coconut sugar

SEM tier — I.A.1 = lack of raw material supply, I.B.1 = termination of production activities, I.B.2 = the access (infrastructure) to the plant is closed, I.M.1 = granulated coconut sugar from suppliers is mixed with other ingredients, I.M.2 = the quality of raw materials from suppliers is not under the demand, I.M.3 = late delivery of raw materials from suppliers, I.M.4 = product return, I.F.1 = power outages

Priority 1 = high expected loss Priority 2 = medium expected loss Priority 3 = low expected loss

One risk that has the greatest severity is the risk caused by volcanic eruptions. However, its probability of an event is very low (improbable), so it has a priority value of 2 or is considered as a medium expected loss. The same thing also happened in the risk of workplace accidents in the farmers and the risk of product return at the SMEs. Both risks have a large severity but a very low probability of an event (improbable) so that both risks are still classified as medium expected loss.

The risk of a sap-sucking bee attack has a high probability of occurrence because bees were often found in every tapping process. However, the impact of the bee attack is very low (negligible), so this risk is categorized as a low expected loss.

The results of the expected loss prioritization were then mapped together with the capacity to manage risk to produce a vulnerability value for each risk event. The scale of the capacity to manage risk for each tier was considered based on the ability of the risk owner to handle before the risk (ex-ante) and handling after the risk has occurred (ex-post). If a risk event has a high loss but the risk owner has a high ability to handle, the vulnerability will be low. Meanwhile, if the risk event has a low loss while the risk owner cannot handle it properly, then the risk is considered to have a high vulnerability.

TABLE V
VULNERABILITY TO RISK EVENT BASED ON EXPECTED LOSS AND CAPACITY TO MANAGE RISK

	Capacity to Manage Risk				
Expected Loss	**1**	**2**	**3**	**4**	**5**
High					
Medium	P.B.1 L.B.1 S.B.1	P.A.1, P.A.3, P.M.1 L.A.1 C.B.1 I.B.1	P.A.2 S.A.1, S.R.1 C.A.1 I.A.1, I.M.4	C.R.1 I.M.1	
Low			P.R.1 L.B.2 S.B.2, S.M.1 C.B.2, C.F.1	P.B.2, P.G.1, P.G.2 L.A.2, L.R.1 S.M.2 C.M.1, C.F.2 I.B.2, I.M.2, I.M.3, I.F.1	

Note: Farmer tier P.A.1 = small amount of coconut, P.A.2 = a mixture of coconut sap with rain water, P.A.3 = coconut sap precipitation, P.B.1 = coconut trees are covered by volcanic ash, P.B.2 = closed infrastructure (closed way), P.G.1 = coconut sap-sucking bee , P.G.2 = bamboo tube rope-cutting rats, P.M.1 = occupational accidents during tapping process, P.R.1 = decline in the market price of block coconut sugar

Collector tier L.A.1 = lack of raw material supply, L.A.2 = the quality of block coconut sugar from suppliers does not meet the standards, L.B.1 = termination of production activities, L.B.2 = the access (infrastructure) to the plant is closed, L.R.1 = increase in the market price of block coconut sugar

Sub-CPU tier S.A.1 = lack of raw material supply, S.B.1 = termination of production activities, S.B.2 = the access (infrastructure) to the plant is closed, S.M.1 = product return, S.M.2 = too long storage period of granulated coconut sugar, S.R.1 = increase in the market price of block coconut sugar

CPU tier C.A.1 = lack of raw material supply, C.B.1 = termination of production activities, C.B.2 = the access (infrastructure) to the plant is closed, C.M.1 = product return, C.F.1 = tool damages (the blower in the oven), C.F.2 = power outages, C.R.1 = increase in the market price of block coconut sugar

SEM tier I.A.1 = lack of raw material supply, I.B.1 = termination of production activities, I.B.2 = the access (infrastructure) to the plant is closed, I.M.1 = granulated coconut sugar from suppliers is mixed with other ingredients, I.M.2 = the quality of raw materials from suppliers is not in accordance with the demand, I.M.3 = late delivery of raw materials from suppliers, I.M.4 = product return, I.F.1 = power outages

Extremely vulnerability
Highly vulnerability
Moderate vulnerability
Low vulnerability
Limited vulnerability

The risks in the granulated coconut sugar supply chain have a degree of vulnerability that ranges from limited, low, moderate, highly, to extremely (Table 5). The risks due to volcanic eruptions have the highest vulnerability. Even so, the risk owner's ability to deal with risks due to volcanic eruptions can be classified as very low, especially of farmers, collectors, and sub-CPUs. CPUs and SMEs can cope with the risk of volcanic eruptions better than the other tiers. Meanwhile, the risk of long drought cannot be adequately handled by the tiers of farmers and collectors.

The risks of volcanic eruptions and long droughts can cause a reduction in production capacity, which has an impact that is categorized as a medium expected loss. Still, the risk owners do not have a high ability to overcome this problem. As a product of geographical indication, supply chain actors can only produce raw materials from their geographical indication area. Likewise, with international organic products, supply chain actors can only buy products or raw materials that are members of their organic certificate. Therefore, the production carried out by the granulated coconut sugar supply chain in Kulon Progo is limited to the geographical indication area and supply based on the membership of the organic certificate. This is a reason for the low ability of the risk owners to overcome the risk of lack of production capacity. The addition of members of farmers who are still in the Kulon Progo area can be an alternative way to deal with the risk of lack of supply, but financial factors even constrain this.

There are some risks that can be addressed moderately by supply chain actors, including weather, management, and operational, market, logistics and infrastructure, and even natural disaster risks. In addition, there are also some risks that have been overcome in a medium-high manner by the supply chain actors.

C. Risk Evaluation

Evaluation of risk is an effort to prioritize and identify risks that require treatment [22]. Based on the results of risk analysis, risk prioritization can be determined based on the levels of expected loss and vulnerability of each risk event at each tier (Table 6). From the expected loss and the vulnerability of risk events, each risk event has a different impact, and the ability of the risk owner to deal with these risks is also different. Risks that have limited value vulnerability are risks that are considered acceptable and can be handled properly by the risk owner. Therefore, the risks classified as having limited vulnerability do not require further handling or treatment. Of the 35 risk events in the granulated coconut sugar supply chain in Kulon Progo, 12 risk events are considered to have limited vulnerability levels.

A risk categorized above the limited vulnerability requires further mitigation to reduce the risk itself or even prevent its impact. Efforts to mitigate risks that have a high level of exposure are expected to improve supply chain performance [13]. A risk categorized extremely vulnerable requires a significant handling effort because its impact is high, while the risk owner's ability to deal with it is deficient. Farmers, collectors, and sub-CPUs still own risks at the extreme level.

TABLE VI
RISK CATEGORY

Tier	No	Risk Code	Risk Event	Expected Loss	Vulnerability
Farmers	1.	P.B.1	Coconut trees are covered by volcanic ash	Medium	Extremely
	2.	P.A.1	Small amount of coconut sap production	Medium	Highly
	3.	P.A.3	Coconut sap precipitation	Medium	Highly
	4.	P.M.1	Occupational accidents during tapping process	Medium	Highly
	5.	P.A.2	A mixture of coconut sap with rain water	Medium	Moderate
	6.	P.R.1	Decline in the market price of block coconut sugar	Low	Low
	7.	P.B.2	Closed infrastructure (closed way)	Low	Limited
	8.	P.G.1	Coconut sap-sucking bee	Low	Limited
	9.	P.G.2	Bamboo tube rope-cutting rats	Low	Limited
Collectors	1.	L.B.1	Termination of production activities	Medium	Extremely
	2.	L.A.1	Lack of raw material supply	Medium	Highly
	3.	L.B.2	The access (infrastructure) to the plant is closed	Low	Low
	4.	L.A.2	The quality of block coconut sugar from suppliers does not meet the standards	Low	Limited
	5.	L.R.1	Increase in the market price of block coconut sugar	Low	Limited
Sub-CPUs	1.	S.B.1	Termination of production activities	Medium	Extremely
	2.	S.A.1	Lack of raw material supply	Medium	Moderate
	3.	S.R.1	Increase in the market price of block coconut sugar	Medium	Moderate
	4.	S.B.2	The access (infrastructure) to the plant is closed	Low	Low
	5.	S.M.1	Product return	Low	Low
	6.	S.M.2	Too long storage period of granulated coconut sugar	Low	Limited
CPUs	1.	C.B.1	Termination of production activities	Medium	Highly
	2.	C.A.1	Lack of raw material supply	Medium	Moderate
	3.	C.R.1	Increase in the market price of block coconut sugar	Medium	Low
	4.	C.B.2	The access (infrastructure) to the plant is closed	Low	Low
	5.	C.F.1	Tool damages (the blower in the oven)	Low	Low
	6.	C.M.1	Product return	Low	Limited
	7.	C.F.2	Power outages	Low	Limited
SEMs	1.	I.B.1	Termination of production activities	Medium	Highly
	2.	I.A.1	Lack of raw material supply	Medium	Moderate
	3.	I.M.4	Product return	Medium	Moderate
	4.	I.M.1	Granulated coconut sugar from suppliers is mixed with other ingredients	Medium	Low
	5.	I.B.2	The access (infrastructure) to the plant is closed	Low	Limited
	6.	I.M.2	The quality of raw materials from suppliers is not in accordance with the demand	Low	Limited
	7.	I.M.3	Late delivery of raw materials from suppliers	Low	Limited
	8.	I.F.1	Power outages	Low	Limited

Note: The risk codes used in this study consisted of 2 letters and 1 number. The first letter shows the tier of risk owner, namely P for the farmer; L for the collector; S for sub CPU; C for CPU; and I for SME. In contrast, the second letter shows the risk categories existing in RapAgRisk, namely A for the weather; B for a natural disaster; G for biological and environmental; F for logistics and infrastructure; R for market; M for management and operations; K for public and institutional policies; and T for politics. In contrast, the numbers show the order of risk in the same category.

IV. CONCLUSION

The granulated coconut sugar supply chain in Kulon Progo has 35 risk events. Thirty-five risk events consist of several categories, namely weather risk, natural disaster risk, biological and environmental risk, logistical and infrastructure risk, market risk, management, and operational risk. The risk events in the supply chain of the Granulated Coconut Sugar Kulon Progo have various degrees of vulnerability, starting from limited, low, moderate, highly, to extremely vulnerabilities. Risk events that are classified as limited vulnerability were considered acceptable, and the risk owner has been able to handle these risks well so that mitigation proposals were not given, while other risk events need to be mitigated to reduce their severities.

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