Journal of Industrial Engineering and Education

Risk Mitigation Supply Chain of Non-Edible Coconut for Sustainable Bioavtur Raw Material

Rahid Pambengkas [1] * and Choesnul Jaqin[2]

[1] Department of Industrial Engineering, Mercu Buana University, Jl Meruya Selatan, RT.4/RW.1, South Meruya, Kembangan, West Jakarta City, Jakarta 11610
[2] Department of Industrial Engineering, Mercu Buana University, Jl Meruya Selatan, RT.4/RW.1, South Meruya, Kembangan, West Jakarta City, Jakarta 11610

ABSTRACT

Coconut production in Riau Province, especially Indragiri Hilir Regency, is very abundant, but not all of it can be consumed by humans for various reasons, whether due to management, tree rot, aflatoxin fungi, and so on. The risk of the coconut supply chain from farmers to collectors to the company's warehouse is very ineffective due to mixed coconuts and coconuts being returned to farmers. This research aims to mitigate supply chain management risks faced when non-standard coconut is managed at SAF, especially in Indragiri Hilir Regency, Riau. The data analysis technique used in this research is the Analytical Hierarchy Process (AHP) which is followed by the application of the House of Risk (HOR) risk management model based on the FMEA (Failure Mode and Error Analysis) principle. This research found that there are 13 activity mapping points that have been determined using the SCOR method, including plan, source, make, delivery and return. Based on the results of research that has been carried out, the biggest risks based on FMEA calculations based on priority risk events using the Risk Priority Number (RPN) method, there are 6 risk events, including the absence of laws that specifically regulate coconuts. Based on the results of research that has been carried out, the biggest risk based on FMEA calculations is the absence of laws that specifically regulate coconuts. However, the solution that can be taken according to priority is for the Government to carry out an outreach and education program for farmers about how to dry copra properly and safely. Solutions that have been implemented include the government and other parties conducting studies, outreach and education programs for farmers about how to dry copra properly and safely. It is hoped that the management of the non-edible coconut supply chain can become a raw material for sustainable Bioavtur products.

ARTICLE INFO

Received 30 July 2023
Accepted 10 January 2024
Available online 22 April 2024

***Correspondence**

Rahid Pambengkas
pambengkas@gmail.com

Keywords:
AHP; FMEA; non-edible coconut; risk mitigation; supply chain management

1. Introduction

As a country rich in its natural resources, Indonesia has emerged as one of the world's leading coconut producers. In 2019, Indonesia successfully produced an impressive approximately 17.13 million tons of coconuts, an achievement that cannot be ignored. According to the World Atlas report, this coconut production officially ranks Indonesia as the largest producer in the world. However, from all corners of the country, the province of Riau plays a crucial role in contributing to this coconut production. In 2021, this province yielded around 395,000 metric tons of coconuts, covering an extensive land area of approximately 432,300 hectares. Indragiri Hilir Regency, situated within the Riau region, stands out as one of the areas with the most abundant coconut production. Nevertheless, what is intriguing to note is that despite the vast coconut output, not all of it is suitable for human consumption. Various reasons account for this, ranging from improper management to coconuts falling from trees in spoiled conditions, as well as aflatoxin fungus infections and other factors (Rizaty, 2021).

The countries that are destinations for Indonesian coconut exports include the United States, the Netherlands, South Korea, China, Japan, Singapore, the Philippines, and Malaysia. Most Indonesian coconuts are produced in the form of copra and other derivative products. The main coconut-producing areas in the country include Riau, Jambi, North Sulawesi, West Java, East Java, and North Maluku. As one of the largest coconut-producing countries, Indonesia has the potential to lead in the use of coconut as a raw material for Bioavtur. Therefore, a deep understanding of the dynamics of the global Bioavtur supply chain, especially in the context of coconut, is essential for designing sustainable, efficient, and adaptive strategies. Thus, this research aims to thoroughly investigate macro issues in the global Bioavtur supply chain and detail the risk phenomena in the supply chain of coconut as a raw material for Bioavtur. With this in-depth understanding, it is hoped that effective and sustainable solutions can be found to support positive transformation in the global aviation sector.

The type of coconut in this study can be grouped as waste, which accounts for 30% of edible coconuts every year. The researchers see great potential if coconuts that are not suitable for consumption (non-edible/non-standard) are converted into Sustainable Aviation Fuel (SAF). The high price of SAF, the environment/health is disturbed, and the potential for abundant material supply makes it possible for SAF to be developed more massively. However, there are also obstacles, including the absence of regulations that specifically allow non-edible coconuts for energy, which is a risk in itself if non-edible coconuts are managed into SAF without permission from the policy-making authority. In the language of the general public, which is easily understood is known as "waste". the four characteristics of non-standard coconuts are as follows: small; too old; sprouted; cracked and corroded. Coconuts with the above conditions are not sold raw but are usually sold after being processed into copra. Copra is dried coconut flesh. Copra is a very important coconut derivative product because it is the raw material for making coconut oil and its derivatives. Copra is divided into two, namely edible copra and non-edible copra. To make good (edible) copra you need a coconut that is around 300 days old and weighs around 3-4 kg. After the copra oil has been extracted, what remains is a by-product that contains high protein (18-25%) but is so high in fiber that humans cannot eat it. There are four types of copra processing techniques, namely sun drying, smoke curing or drying, and indirect heating. Meanwhile, non-edible copra is managed as a non-edible CNO.

Researchers see great potential if this type of coconut that is not suitable for consumption (nonedible/nonstandard) is converted into SAF. The high price of SAF, environmental/health concerns, and the potential for abundant material supply make it possible to develop SAF more massively. However, there are also obstacles including the absence of regulations that specifically allow Non Edible coconuts for energy which is a separate risk if these nonedible coconuts are managed into SAF without permission from the policy-making authority. According to Ferreira et al. (2018), a company should have proper Supply Chain Risk Management (SCRM) to survive in a risk-prone business environment to prevent potential losses. Research by Oliveira et al. (2019) on supply chain risk management in the environment with the Systematic Literature Review (SLR) method which consists of eight stages to evaluate and synthesize risks in the supply chain.

Then research by Vilko et al. (2019) regarding risk management capabilities in multimodal maritime supply chains with Failure Mode Effect of Analysis (FMEA) to analyze risks. Research by Dadsena et al. (2019); Toppel & Trankler (2019); Thons & Stewart (2019); Ceres et al. (2019) said that risk mitigation strategies use 3 main characteristics in designing mitigation strategies, namely implementation costs, strategies, and the probability of risk occurrence and risk mitigation measures based on three mitigation indicators, namely (1) Cost-based risk and optimization (2) Measure and ensure significance in reducing risk, and (3) Measure and ensure the possibility of high-cost efficiency. Handayani & Yusuf (2022), in their research, conducted a risk analysis using the FMEA (Failure Mode and Effect Analysis) and AHP (Analytical Hierarchy Process) methods. Hasibuan et al. (2021) in their research analyzed data by utilizing the House of Risk approach. Risk evaluation in the industrial supply chain combines the SCOR-FMEA method. Risks classified as High and Priority are further analyzed with Fishbone Diagram and 5W1H as a reference for the preparation of risk mitigation strategies for the sustainability of the industrial supply chain. Yunita et al. (2022) provided research results in the form of a relationship model between the speed of movement and sustainability in the integrated national poultry industry supply chain.

The speed of movement variable drives the sustainability of the integrated national poultry industry supply chain with customer sensitivity being an important key factor to improve the sustainability of the poultry industry supply chain. Hasibuan & Thaheer (2019) showed the results of a study in which 16 risks to the FFB supply chain were identified. Risks are grouped into 1) risks that are immediately handled; 2) risks that are considered to be handled; and 3) risks that are temporarily recorded (documentation). Risks characterized as immediately addressed and considered to be addressed are risks that shortly are considered to affect the supply of FFB raw materials for the industry. Within the next five years, successful mitigation of these risks has been developed. With this risk management, it is calculated that the supply of FFB to the mills in the Rokan Tandun district can be secured. As a result of observations carried out in the field, several obstacles were found, including the ineffectiveness of the non-edible coconut supply chain managed by industry in Indragiri Hilir Regency due to several causes. One of the reasons is the absence of tools for sorting edible and non-edible coconuts. Apart from that, there is also copra in poor condition because it is dried using sulfur.

This research was conducted at one of the coconut processing industries in Indragiri Hilir Regency. Production for 6 months in 2022 will experience an increase in edible coconut production. Meanwhile, non-edible coconuts, including small, rotten, dry and moldy coconuts, experienced a decrease in yield. The latest research uses the Supply Chain Operations Referee (SCOR) approach for risk mapping in the coconut supply chain. Meanwhile, to analyze failure risk modes and determine the weight of events using the Failure Mode and Effect Analysis (FMEA) method to see the level of risk in the coconut supply chain. The relationship between supply chain risks that influence them uses the Analytical Hierarchy Process (AHP) method followed by the implementation of the House of Risk (HOR). This research aims to Mitigate Supply Chain Management Risks faced when non-standard coconut is managed into SAF, especially in Indragiri Hilir Regency, Riau.

2. Literature Review

In this section, we will discuss literature reviews that are close to this research as research references. The reference matrix for this research can be seen in Table 1.

Table 1. Literature Review

No	Research's Name/Year	Title	Method	Research Object
1	Azevedo et al., (2019)	Urban solid waste management in developing countries from the sustainable supply chain management perspective: A case study of Brazil's largest slum	Sustainable Supply Chain Management (SSCM)	• Urban waste from an SSCM perspective in developing countries • Sustainable waste management in real life in slum settlements
2	Anggrahini et al., (2018)	*Manajemen Risiko Kualitas Pada Rantai Pasok Industri Pengolah Hasil Laut Skala Menengah*	• Delphi • House of Risk (HOR) • Manajemen Kualitas Rantai Pasok • Supply Chain Operations Reference (SCOR)	• Management of marine products • Temperature changes • Deviations in product quality • Food safety • Risk event • Risk agent • Risk Mitigation
3	Hasibuan et al. (2021)	*Analisis risk supply chain management untuk mendukung keberlanjutan rantai pasok*	• (SCOR) Supply Chain Operations Reference • FMEA. • Fishbone Diagram • 5W1H • HOQ dan HOR	Product returns due to: • Spoilt • Expire • Bocor • Double Order

2.1 Plantation Industry

Law of the Republic of Indonesia Number 18 of 2004 concerning Plantations states that Plantations are all activities that cultivate certain plants on land and/or other growing media in a suitable ecosystem, process and market goods and services from these plants, with the help of science and technology, capital and management to realize welfare for plantation business actors and the community. Plantation companies are plantation business actors of Indonesian citizens or legal entities established under Indonesian law and domiciled in Indonesia that manage plantation businesses on a certain scale. Meanwhile, the plantation product processing industry is a handling and processing activity carried out on plantation crops aimed at achieving higher added value.

2.2 Supply Chain

A supply chain is an integrated process in which several parties work together to obtain raw materials, various raw materials (Haudi et al., 2022). A supply chain is a tangle of companies that work together to create and deliver a product to the end user (Handayani & Yusuf, 2022). The supply chain is a set of activities of a network of facilities and distribution options that include all interactions between suppliers, distributors, companies, manufacturers, and consumers. In a supply chain, there are generally three types of flows, namely the flow of goods, cash flow, and information flow (Fatorachian et al., 2021).

2.3 FMEA

FMEA is a method of evaluating the possibility of a failure of a system, design, process, or service to make handling steps (Nastiti & Masduqi, 2023). In FMEA, every possible failure that occurs is quantified to prioritize handling (Andiyanto et al., 2020). FMEA (*Failure Mode and Effect Analysis*) is a tool that systematically identifies the consequences or consequences of failures or processes, and reduces or eliminates the chance of failure, FMEA (*Failure Mode and Effect Analysis*) (Kurnia et al., 2021). RPN (*Risk Priority Number*) is the result of S x O x D where there will be different RPN (*Risk Priority Number*) numbers on each tool that has gone through the process of analyzing the cause and effect of errors, on tools that have the highest RPN (*Risk Priority Number*) numbers the team must prioritize these factors to take action or efforts to reduce risk numbers through corrective maintenance actions. The RPN (*Risk Priority Number*) value of each potential problem is then used to compare the causes identified during the analysis (Wiyatno & Kurnia, 2022). In general, the RPN (*Risk Priority Number*) falls between the specified limits. Corrective actions can be proposed or taken to reduce the risk.

2.4 HOR

HOR is a needs-based risk management model that focuses on every preventive action to identify which risk events become dominant risks, which will then receive actions for mitigation or risk management (Enderzon et al., 2020). The House of Risk is a sustainable method in risk analysis. Its application uses the principles of FMEA (Failure Mode and Error Analysis) to quantitatively measure risk, combined with the House of Quality (HOQ) model to prioritize risk factors that need to be addressed first and then select the most effective actions to reduce potential risks caused by these factors. The HOR model underpins risk management with a prevention focus, aiming to reduce the likelihood of risk events. Therefore, the initial step is to identify risk events and risk factors. Typically, one risk factor can lead to more than one risk event. Adapting from the FMEA method, the applied risk assessment is the Risk Priority Number (RPN), consisting of three factors: the probability of occurrence, the level of severity of the impact, and detection.

2.5 AHP

Analytical Hierarchy Process (AHP) is a decision support model developed by Thomas L. Saaty. The Analytical Hierarchy Process (AHP) deals with multifactor or multicriteria problems, organizing them into a hierarchy or unity. A hierarchy represents a complex problem in a multi-level structure consisting of goal levels, factor levels, criteria levels, sub-criteria levels, and the final level of alternatives. The hierarchy breaks down a complex problem into groups, making it more structured and systematic (Ridhawati et al., 2017). The Analytical Hierarchy Process (AHP) is a quantitative technique developed for cases with various levels of analysis. The AHP method is conducted through pairwise comparisons, calculating weighting factors, and performing an analysis to generate relative priorities among the existing alternatives (Hardono et al., 2023; Makhmudah et al., 2021). The Analytical Hierarchy Process (AHP) is considered a simple and flexible method that accommodates creativity in problem-solving (Herjanto, 2018).

2.6 Government regulations related to the plantation and agriculture industry.

Law of the Republic of Indonesia Number 22 of 2019 concerning Sustainable Agriculture Cultivation System states that Agriculture is the activity of managing biological natural resources with the help of technology, capital, labor, and management to produce agricultural commodities which include food crops, horticulture, plantations, and/or livestock in an agroecosystem. Sustainable Agriculture Cultivation System is the management of biological resources in producing agricultural commodities to meet human needs in a better and sustainable manner by preserving the environment. Government Regulation of the Republic of Indonesia Number 26 of 2021 concerning the Implementation of the Agricultural Sector states that Plantation Company is a business entity incorporated under Indonesian law and domiciled in the territory of Indonesia, which manages Plantation Business on a certain scale. Meanwhile, Government Regulation of the Republic of Indonesia Number 24 of 2015 concerning the Collection of Plantation Funds also regulates the operation of the plantation industry.

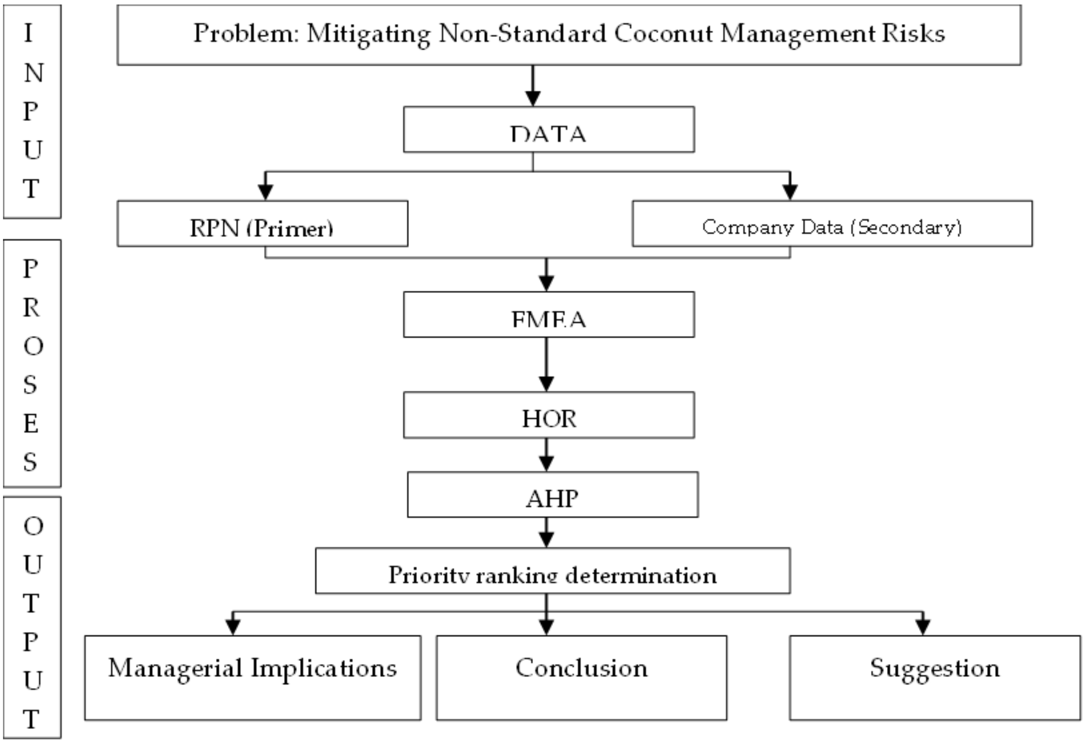

Figure 1. Conceptual framework

3. Methodology

The research method used in this research is a case study. A case study is part of a qualitative method that wants to explore a particular case in more depth by involving the collection of various sources of information. This research uses a type of mixed research (mixed methodology). Mix methodology is used to produce more comprehensive facts in examining research problems because researchers have the validity to use all data collection tools according to the type of data needed (Zulkarnaen et al., 2023).

In this study, data was taken from direct observation of the supply chain. The sources of information from this research are employees of the Plantation Service of Indragiri Hilir Regency and a team of experts who are experts in the field of waste management to develop strategies. Data collection is done through documentation techniques, interview techniques, and questionnaire techniques. The samples used in this study were employees who were directly related to the supply chain. Interviews were conducted with 1 person from the Indragiri hilir Regency Plantation Office and 3 expert team who are experts in the field of waste management. While the questionnaire was given to the coconut waste management industry. As for the questionnaire indicators, they consist of:

1. Instrumental Input
   Law of the Republic of Indonesia Number 39 of 2014 Regarding Plantations provides a general framework for plantation management, but there is no specific law governing coconut cultivation, from planting methods to processing and distribution.
2. Environmental Input
   Supplies from farmers are still mixed, with no sorting except based on market demand, which distinguishes prices solely based on visual experience. As a result, prices can suddenly become high when the market desires, making them uncontrollable and subject to sudden drops. This condition makes it difficult for farmers to maintain supply stability, especially for non-edible copra to be converted into non-edible CNO.
3. Raw Input
   There is a lack of coconut sorting equipment, and some copra is in poor condition due to sulfur-based drying methods.
4. Output
   Sustainable non-edible coconut supply chains compliant with regulations encompassing the three pillars: profit, people, and planet.
5. Outcome
   There are no specific regulations that permit the use of non-edible coconuts for energy, which poses its own risks if non-edible coconuts are managed for SAF without authorization from policy authorities.

The activity mapping of the SCRM method in waste management can be seen in Table 2.

Table 2. Activity mapping of the SCRM method in waste management

Process	Activities
Plan	Planning with coconut harvesting
	Calculation of needs
Source	Purchasing raw materials
	Receiving and storing raw materials
	Checking received raw materials
	Receiving orders from customers
Make	Processing coconut into food products
	Packaging production products
	Delivering finished goods to retailers
Deliver	Update finished product availability
	Delivery of products to customers
Return	Returning products to suppliers
	Handling finished product returns from customers

The data analysis technique used in this research begins with mapping the problem (risk analysis), namely the House of Risk using the FMEA (Failure Mode and Error Analysis) principle. Next, the RPN calculation is carried out and problem solving (solution) is carried out. After that, the solution that has been determined is then reassessed until a ranking is obtained, this uses the Analytical Hierarchy Process (AHP) method.

4. Results

FMEA is used as a comparison of measuring instruments in analyzing variables in this study carried out on risk variables, namely Occurance, Saverity, and Detection, where the variable measurement or measurement scale on this variable is through an ordinal scale approach, namely distinguishing the categories of risk variables based on their level or order. FMEA is used as a comparison measuring tool in analyzing the variables in this research on risk variables, namely Occurance, Severity and Detection, where the measurement of variables or measurement scales on these variables is through an ordinal scale approach, namely distinguishing categories of risk variables based on their level or sequence (Sjarifudin & Kurnia, 2022). In detail these factors will be described through the Failure Mode and Effect Analysis (FMEA) method. In detail, these factors will be described through the *Failure Mode and Effect Analysis* (FMEA) method can be seen in Table 3, and the FMEA Analysis after being sorted can be seen in Table 4.

Table 3. FMEA analysis before sorting

Failure Mode	Cause of failure	Severity Rating	Occurance Rating	Detection Rating	Risk Priority Number
Instrumental input	No law specifically regulates palm oil.	8	8	2	128
Environmental input	The supply from farmers is still mixed, there is no sorting.	7	6	2	84
Raw input 1	No tools to sort coconut	7	7	2	98
Raw Input 2	There is copra in poor condition due to sulfur drying.	6	6	3	108
Output	Uncertainty of conditions that cause risks to arise in supply chain activities	8	6	2	96
Outcome	No regulation specifically allows Non Edible coconut for energy.	8	5	2	80

Table 4. FMEA Analysis after being sorted

Failure Mode	Cause of failure	Severity Rating	Occurance Rating	Detection Rating	Risk Priority Number
Instrumental input	No law specifically regulates palm oil.	8	8	2	128
Raw Input 2	There is copra in poor condition due to sulfur drying.	6	6	3	108
Raw input 1	No tools to sort coconut	7	7	2	98
Output	Uncertainty of conditions that cause risks to arise in supply chain activities	8	6	2	96
Environmental input	The supply from farmers is still mixed, there is no sorting.	7	6	2	84
Outcome	No regulation specifically allows Non Edible coconut for energy.	8	5	2	80

From the data from the FMEA (Failure Mode and Effect Analysis) analysis, the RPN (Risk Priority Number) value is obtained from the largest to the smallest. The largest RPN value is obtained in the cause of failure "There is no law that specifically regulates palm oil" with a value of 128. So, from the results of the largest RPN (Risk Priority Number) value, improvements are then made to reduce these problems. Furthermore, a team of experts in their respective fields provides solutions to the existing problems. This is then analyzed by the researchers and can be seen in Table 5.

Table 5. Solutions to existing problems

Failure Mode	Cause of failure	Solution
Instrumental input	No law specifically regulates palm oil.	The government can form a working team consisting of experts, academics, and stakeholders related to palm oil.
Environmental input	The supply from farmers is still mixed, there is no sorting.	Sorting and assessing the quality of coconuts so that sorting can be carried out according to type
Raw input 1	No tools to sort coconut	The government can establish partnerships with private companies and universities that have expertise in agricultural technology development.
Raw Input 2	There is copra in poor condition due to sulfur drying.	The government can conduct extension and education programs for farmers on good and safe drying methods for copra.
Output	Uncertainty of conditions that cause risks to arise in supply chain activities	Strong cooperation between companies and suppliers is key to addressing risks in the supply chain.
Outcome	No regulation specifically allows Non Edible coconut for energy.	The government can develop policies and regulations specifically governing the use of non-edible coconuts as an energy source through a consultation process with stakeholders, including farmers, coconut producers, the energy industry, and relevant experts.

Based on AHP calculations, it is found that the priority values can be seen in Table 6.

Table 6. Solutions to existing problems

Failure Mode	Solution	Priority	Ranking
Instrumental input	The government can form a working team consisting of experts, academics, and stakeholders related to palm oil.	0.095	6
Environmental input	The government can work with farmers, experts, and industry associations to develop clear guidelines and standards for coconut sorting and quality assessment.	0.167	3
Raw input 1	The government can establish partnerships with private companies and universities that have expertise in agricultural technology development.	0.157	4
Raw Input 2	The government can conduct extension and education programs for farmers on good and safe drying methods for copra.	0.238	1
Output	Strong cooperation between companies and suppliers is key to addressing risks in the supply chain.	0.234	2
Outcome	The government can develop policies and regulations specifically governing the use of non-edible coconuts as an energy source through a consultation process with stakeholders, including farmers, coconut producers, the energy industry, and relevant experts.	0.152	5

Based on the results of the AHP calculation, the ranking for problem-solving solutions is obtained as follows:

1. The government can conduct outreach and education programs for farmers on proper and safe drying methods for copra.
   a. Pro: Outreach and education programs for farmers on proper and safe drying methods for copra can help improve the quality of the copra produced. Better copra quality will have a higher market value.
   b. Con: Implementing outreach and education programs requires costs and resources, including instructor personnel, educational materials, and training locations. This can be an additional burden on the government.
   c. Benefits: Improved agricultural product quality and increased income for farmers.
   d. Consequences: Budgetary costs for education and outreach programs.
2. Strong cooperation between companies and suppliers is key to mitigating risks in the supply chain.
   a. Pro: Strong cooperation between companies and suppliers can enhance efficiency in the supply chain, ensuring the smooth flow of goods and information.
   b. Con: Overreliance on specific suppliers can make companies vulnerable if those suppliers encounter issues or change their business strategies.
   c. Benefits: Better risk management in the supply chain.
   d. Consequences: Potential over-dependence on specific suppliers.
3. The government can collaborate with farmers, experts, and industry associations to develop clear guidelines and standards for coconut sorting and quality assessment.
   a. Pro: Developing clear guidelines and standards for coconut sorting and quality assessment can help improve the quality of coconut products. This can enhance the competitiveness of coconut products in both domestic and international markets.
   b. Con: Developing guidelines and standards requires significant time, effort, and resources. The government may need to allocate a budget for this project.
   c. Benefits: Increased consumer trust in coconut products and strengthened collaboration in the coconut supply chain.
   d. Consequences: The need for effective monitoring and enforcement of established standards.
4. The government can form partnerships with private companies and universities with expertise in agricultural technology development.
   a. Pro: Such collaboration can help farmers and agricultural producers increase their productivity, yielding more output with fewer inputs.
   b. Con: Partnerships like these can lead to dependence on private companies, which may have different economic interests than the government or farmers.
   c. Benefits: Providing additional resources and knowledge to farmers.
   d. Consequences: The need for strong regulations to address conflicts of interest and other issues in these partnerships.
5. The government can develop policies and regulations specifically governing the use of non-edible coconut as an energy source through consultation with stakeholders, including farmers, coconut producers, energy industries, and relevant experts.
   a. Pro: This can create new opportunities in the energy and agricultural industries, supporting economic growth.

   b. Con: Developing new policies and regulations requires time and resources, which can be an additional burden on the government.
   c. Benefits: Utilizing previously untapped natural resources, reducing potential waste, and promoting more sustainable resource use.
   d. Consequences: The need for strict monitoring and oversight to ensure sustainable exploitation of non-edible coconut and avoid environmental harm.
6. The government can establish a working team consisting of experts, academics, and relevant stakeholders in the coconut industry.
   a. Pro: Experts and academics can provide scientific insights and the latest research to enhance coconut planning quality.
   b. Con: Forming a diverse team can slow down decision-making due to varying perspectives and interests that need synchronization.
   c. Benefits: Decision-making based on input from various stakeholders has the potential to be more sustainable and support more sustainable development.
   d. Consequences: If not managed effectively, forming a team involving diverse stakeholders can lead to conflicts and delays in the planning process.

5. Discussion

Based on the results of the research that has been carried out, this research found that there were inconsistencies in the problems which became the main findings. These main findings influence the risk analysis of the supply chain for non-edible coconut as a sustainable bioavtur raw material, including:

1. The local government does not yet have a law that specifically regulates coconut farming. Based on the FMEA results, this is a supply chain risk whose assessment is the first priority. So the government must immediately form a working team consisting of experts, academics and stakeholders related to coconuts.
2. There are no regulations that specifically allow non-edible coconut for energy. This aims to ensure that the sorted coconuts, called non-edible coconuts, get permission from the local government to be used as raw material for sustainable Bioavtur. Therefore, the government can develop policies and regulations that specifically regulate the use of non-edible coconut as an energy source through a consultation process with stakeholders, including farmers, coconut producers, the energy industry and related experts.
3. There is copra in poor condition because it is dried using sulfur. The aim here is that drying copra with the new system can reduce the condition of copra which is suitable for use as raw material for sustainable bioavtur. Therefore, the government can carry out outreach and education programs to farmers about good and safe drying methods for copra, for example taking advantage of the hot season in the Indragiri Hilir Regency area.
4. There are no tools for sorting coconuts when selecting coconuts from coconut farmers which are sent to suppliers. So there is a risk of disrupting the supply chain which will experience work twice. Therefore, the government can establish partnerships with private companies and universities that have expertise in developing agricultural technology. This sorting tool can detect the quality of coconut which could potentially pose a supply chain risk in coconut management.
5. Uncertainty in weather conditions causes risks to arise in supply chain activities. The erratic weather conditions in Indragiri Hilir Regency create a risk that the supply chain will not deliver according to plan. Therefore, strong cooperation between companies and suppliers is key in overcoming risks in the supply chain. This means that the harvested coconuts are stored in the farmer's warehouse first, waiting for good weather conditions.
6. Supplies from farmers are still mixed, there is no sorting of coconut after harvest. When the coconut plantations are harvested, the harvest will be collected and weighed. Therefore the government can work together with

farmers, experts and industry associations to develop clear guidelines and standards on grading and assessing the quality of coconuts.

The principle of this supply chain is that the use of non-edible coconut can be used as a useful raw material for the world of aviation. The raw materials produced must meet standards for reducing emissions of harmful substances when used by aircraft (Nuryadin et al., 2023). The manufacture of Bioavtur raw materials has fulfilled the wishes of agencies and the government to create Bioavtur raw materials that are environmentally friendly, thereby reducing environmental pollution and reducing unhealthy air pollution. This research also uses several references to previous research articles with the same research object, namely the evaluation of coconut processing on plantations in Indonesia, however there are differences in the research location and use of coconut types, both edible coconut for food needs and non-edible coconut for non-food or alternative needs. utilization of coconut processing waste.

6. Conclusion

In this section, we will discuss the conclusions from this research that have been produced due to the improvement process. This research found that there are risks in supply chain management that have gone through the SCOR mapping stages consisting of the plan, source, make, delivery, and return stages. This SCOR method is very good in mapping supply chain risks which is connected to further analysis in the form of Fishbone diagrams. Based on the results of research that have been carried out, the biggest risks based on FMEA calculations based on incident risk priorities using the Risk Priority Number (RPN) method, there are 6 risks in the supply chain management of non-edible coconut as raw material for sustainable bioavtur.

Based on the results of research that has been carried out, the highest RPN value is 128 with "instrumental input" failure mode, namely the biggest risk based on FMEA calculations is that there is no law that specifically regulates coconuts. Nevertheless, the solution that can be taken is according to priority with rank 1 based on AHP calculations, namely "raw input 2", namely The government can carry out outreach and education programs to farmers about good and safe drying methods for copra. This is because the solution that can be resolved shortly is the problem related to copra. Having outreach and education programs for farmers about good and safe drying methods for copra can help improve the quality of the copra produced. Better copra will have a higher selling value on the market. However, carrying out outreach and education programs requires costs and resources, including instructors, educational materials and training locations. This could be an additional burden for the government. The benefits of this program are improving the quality of agricultural products and increasing farmer income. With the consequence of budget costs for education and extension programs.

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To Cite This Article: Pambengkas & Jaqin (2024). Risk Mitigation Supply Chain of Non-Edible Coconut for Sustainable Bioavtur Raw Material. *Journal of Industrial Engineering and Education*, 2(1), 1-13.