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# DESIGN OF SYSTEM ANALYSIS AND MITIGATION OF SUPPLY CHAIN RISK WITH FUZZY FMEA (FAILURE MODE AND EFFECT ANALYSIS) METHOD AND AHP (ANALYTICAL HIERARCHY PROCESS) IN THE BROCCOLY INDUSTRY IN LEMBANG

Najah [1], Ari Yanuar Ridwan [2], Budi Santosa [3]

[1] Telkom University
[2] Telkom University y
[3] Telkom University

Abstract. The importance of awareness for the need of risk management in companies is increasing, one of them is in broccoli vegetable industry. Supply chain management of agricultural products is different from supply chain management in general, considering agricultural industry has perishable properties, with a variety in shape in size. Therefore, it is vulnerable and usually become the risk of loss for the company. The intention of this research is to identify and formulate the risk mitigation strategies that occur in the company. The method used in research is fuzzy FMEA which functions as a tool to measure the agreed priorities and AHP is used as a tool to determine the weight of supply chain risk mitigation strategies. This research that carried out in the field and interviews with experts showed 13 risk events and 25 risk causes that is divided into each process plan, source, make, and deliver. For mitigation strategy, there are 11 alternatives that are divided into each process.

Key Word : Supply Chain Risk, Broccoli Vegetables, Risk Mitigation, Fuzzy FMEA, AHP

## 1. INTRODUCTION

Supply chain has an important role in the activities of the company starting from the supply of raw materials to the delivery of products to consumers. Every activity carried out on the supply chain is certainly not inseparable from uncertainty that can cause risk, where this risk can cause delays in supply chain activities, so it is necessary to identify risks in each of its supply chain activities [1]. Awareness of the need for risk management for a company is becoming increasingly important, one of which is in the agro-industry sector. Agroindustry is a horticultural commodity that has a high commercial value because horticulture products are always consumed at all times [2] and generally horticulture products are rapidly decaying, runny and damaged if they are not immediately processed and consumed, so immediate treatment is needed to overcome them. According to Suharjito et al. (2010) supply chain management of agricultural products is different from non-agricultural products because (1) agricultural products are generally perishable, (2) planting, growth, and harvesting have different processes and

[1] Corresponding Author, Email: najahfaruk@student. telkomuniversity.ac.id

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depend on climate and season, (3) varying shapes and sizes of harvests and (4) agricultural products are camba, so handling in agricultural products becomes more difficult [3].

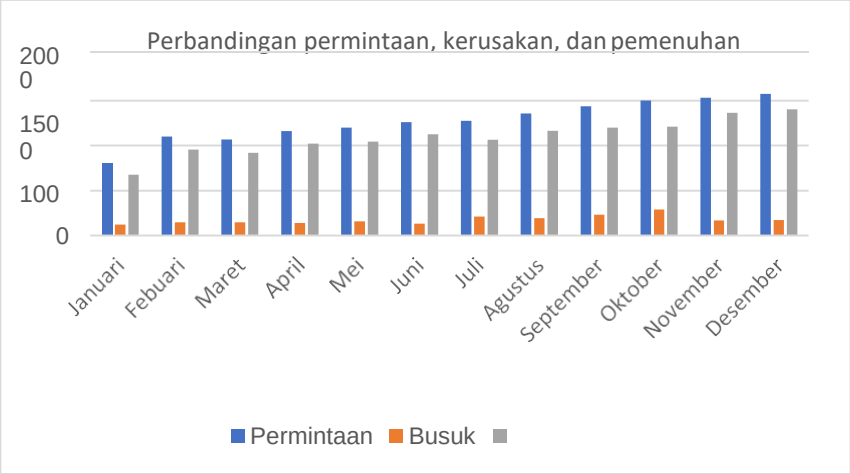


Figure 1. Comparison of demand, damage and fulfillment

Figure I. above explains the comparison between the demand for vegetables with the number of rot and fulfillment of requests every month. Based on the picture above, it can be seen the demand for broccoli vegetables, the amount of damaged vegetables and the demand for broccoli vegetables fulfilled every month by the company. Based on the picture above, it can be seen that every month the demand for broccoli vegetables increases and on every request there is decay which in the end fulfilling the demand for broccoli vegetables cannot be maximally fulfilled. With so many requests, the company must compensate for the increase in the quality of vegetables in meeting high consumer demand, not only in terms of quantity that must be considered, but in terms of quality of vegetables also need to be considered. Therefore, a risk management is needed to determine the possible risks that arise and can control and minimize the risks that may occur.

The company has not yet identified risks that might occur in every business activity in the company. Based on this, in this study risk identification and risk agents can trigger a risk, as well as a proposed strategy that can be applied to mitigate the probability of the emergence of risk agents in a company's supply chain using the fuzzy FMEA method and Analytical Hierarchy Process ( AHP). Identification of risks and sources of risk uses the Supply Chain Operations Reference (SCOR) model which consists of five dimensions, namely plan, source, make, deliver and return. In addition to identifying and mitigating risks, it is necessary to design a monitoring system to monitor risks in graphical form. A monitoring system that is able to briefly describe the condition of the company allows the company to make informed decisions accurately [4].

## 2. BASIC THEORY

### *2.1. Supply Chain Management*

Supply Chain Management or Supply Chain Management (SCM) is a series of activities which include coordination, scheduling and control of procurement, production, inventory

and delivery of products or services to customers that include the administration daily, operations, logistics and processing of information from the customer to the supplier [5] . Supply chain management is defined as a series of approaches used to integrate suppliers, producers, warehouses and stores effectively so that inventory can be produced and distributed in the right amount, to the right location, and at the right time so that the overall cost of the system can be minimized while trying satisfying the needs[6] .

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### *2.2 Risk*

#### *2.2.1 Risk Definition*

According to Muslich (2007) Risk is all things that can cause losses to the company. According to Djohanputro (2008), the risk is interpreted as uncertainty which has known the probability of occurrence or uncertainty that can cause loss or loss.According to Marimin and Maghfiroh (2010), supply chain risk can be defined as the losses studied in terms of the possibility of occurrence, the side of possible causes, and the consequent side in the supply chain of a company and its environment. In a supply chain, if one actor experiences a problem in the supply chain, it will affect directly or indirectly to partners in the supply chain network [7] .

#### *2.2.2 Risk Management*

Supply chain risk management focuses on how to analyze and manage risk. In general, Risk Management is defined as the process, identifying, measuring and ensuring risk and developing strategies to manage risk [8] . According to Hopkin in Saniatusilma and Suprayogi (2015) risk management is carried out through four processes, namely [9]:

1. Risk identification

2. Risk evaluation

3. Risk control

4. Response to Risk .

### *2.3 Supply Chain Operation Reference (SCOR)*

Supply Chain Operation Reference (SCOR) is a model for mapping supply chain activities to companies. In its application, the Supply Chain Management system has several basic components that must be met before the system can run [9] . In Paul's book (2014) there are five basic components of Supply Chain Management including [10]:

1. Plan is the process of making a plan and then implementing it.

2. Source is the process of ordering, sending, receiving, and transferring raw materials, sub-assemblies, goods and or services to fulfill requests.

3. Make is the process of adding value to the product.

4. Deliver y is a process to fulfill the demand for goods and services.

5. Return is the process of moving goods back from consumers to deal with product defects / damage and handling of grazing, namely the purchase of products to suppliers.

### *2.4 Fuzzy Failure Mode And Effect Analysis (FMEA)*

FMEA method is a structured procedure to identify and prevent as much as possible modes of failure (failure mode) with a priority scale. Failure Mode and Effect Analysis (FMEA) is a methodology for analyzing potential unwanted problems early in the development cycle to

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take action and resolve problems [11] . According to Crow (2002), FMEA is implemented to identify potential forms of failure, determine their impact on production, and identify actions to reduce failure [12] . The final result of the FMEA method is the Risk Priority Number (RPN) or priority risk number. RPN is a value calculated based on information obtained relating to the Potential Failure Modes , Effect and Detection . The value of RPN is calculated based on the multiplication of three quantitative rankings, namely the effect or influence, cause, and detection in each process or known as S, O, D multiplication ( severity, occurance, detection)[3] .

### *2.5 Risk priority number (RPN)*

Risk priority number (RPN) is a mathematical system that translates a group of effects with serious severity , so that it can create a failure related to these effects ( assurance ), and has the ability to detect failures ( detection ) before reaching consumers.RPN is a multiplication of occurance (O) rating, severity (S) and detection (D)

RPN = Severity x Occurance x Detection

RPN values range from 1-1000, with 1 being the smallest possible risk of design. The value of RPN can be used as a guide to find out the most serious problems, with the highest indication of numbers requiring serious treatment priorities [11] .

### *2.6 Analytical Hierarchy Process ( AHP)*

AHP method is one method used for decision making that uses several variables with a multilevel analysis process (Irawan et al., 2017) . The Analytical Hierarchy Process ( AHP) is basically designed to rationally capture people's perceptions that are closely related to certain problems through procedures designed to arrive at a preference scale among various kinds of alternatives. This analysis is shown to make a model of a problem that does not have a structure, usually set to solve measurable problems (quantitative), problems that require opinion (judgment) as well as in complex or unforeseen situations, in situations where statistical data is very minimal or non-existent at all and only qualitative in nature based on perception or experience [13].

## 3. ANALYSIS AND DISCUSSION

### *3.1 Overview of Supply Chains*

Supply chain mapping is done to know the overview of supply chain activities performed by the company in general. Mapping aims to find out the entities involved and to know the flow of material or goods, and the flow of information in the supply chain activities of the company. Supply chain activities performed by the company can be seen in Figure 2. Based on the image can be seen for the flow of goods or materials on the activity supply chain vegetables started from suppliers of production facilities, farmers supplier seedlings, farmers suppliers of vegetable products to the customers. The flow of information that occurs on the entities in the supply chain of broccoli is made in two directions. Information exchange by farmer supplier of seedlings with PT. XYZ is done continuously and occurs every day and the information exchange company with modern customer also happens every day.

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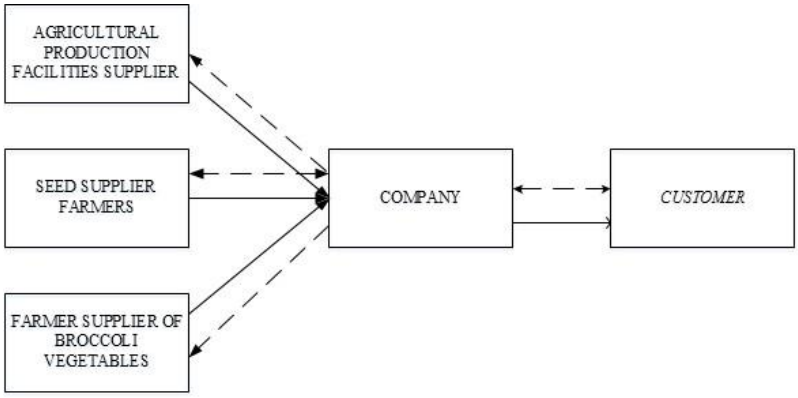


Figure 2. Supply Chain Overview

Flow of goods/materials

Flow of information and data

### *3.2 Supply Chain Risk Analysis*

To assess the impact of supply chain risk a company must identify not only the direct risks to its operations but also the potential causes or sources of risk in each relationship throughout the supply chain (Christopher et al., 2002). In risk identification, the data obtained comes from direct observation and interviews with experts / experts who are considered competent in their field. This data collection was conducted by interviewing experts who were respondents in this study. When doing risk identification, each process is grouped using the SCOR model to find out every risk that occurs from each process. The results of risk identification are 13 riks events and 25 risk causes.

Furthermore, the result of riskidentification are measured using fuzzy fmea by assessing the severity, occurance, detection of each risko by giving questionnaires to respodents who have been previsiously determined. After obtaining severity, occurance, and detection values, a calculation is then performed to find the RPN value to determine risk priorities.

Tabel 1. Risk Identify and Risk assessment

| Process | Sub Process | Risk Event / Risk Event | Causes of Risk | S | O | D | RPN | Rank |
|---|---|---|---|---|---|---|---|---|
| *Plan* | Production Planning | Inaccuracy in Determining Production Amount Plans | Fluctuating demand | 8 | 7 | 5 | 280 | 1 |
| | | | Error calculating forecast demand | 4 | 6 | 5 | 120 | 5 |
| | | | Delay in information from consumers | 5 | 7 | 5 | 175 | 4 |
| | Material requirements planning | Determination of the Amount of Material Purchases Not Right | Fluctuating demand | 4 | 4 | 6 | 96 | 6 |
| | | | Delay in information from consumers | 7 | 7 | 5 | 245 | 2 |

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| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Capacity Planning | Incorrect Capacity Determination | Delay in information from consumers | 6 | 8 | 5 | 240 | 3 |

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| Process | Sub Process | Risk Event / Risk Event | Causes of Risk | S | O | D | RPN | Rank |
|---|---|---|---|---|---|---|---|---|
| *Source* | Order Expenditure to *Supplier* | Error order specifications to *suppliers* | Not careful in making orders | 3 | 2 | 4 | 24 | 5 |
| | Delivery of raw materials by suppliers | Late Delivery of raw materials | Delivery outside the seed harvest period | 8 | 7 | 6 | 336 | 2 |
| | Acceptance of Raw Materials | The amount of raw material received is not in accordance with the request | The unavailability of raw materials in terms of quantity | 7 | 8 | 6 | 336 | 2 |
| | | | Error in the number of orders received by suppliers | 3 | 4 | 4 | 48 | 4 |
| | | | Difficulties in getting raw materials | 7 | 6 | 5 | 210 | 3 |
| | Raw material inspection | Changes in the Quality of Raw Materials | Disruption of Raw Material Supply due to uncertain weather | 8 | 7 | 7 | 392 | 1 |
| *Make* | Harvest | Decrease in the amount of crop | Unpredictable weather | 8 | 7 | 4 | 224 | 4 |
| | | | Too late or exceed the harvest time | 8 | 7 | 6 | 336 | 3 |
| | | | the quality of seeds / fertilizers / pests is not good | 8 | 7 | 7 | 392 | 2 |
| | | | High pest attacks | 8 | 7 | 4 | 224 | 4 |
| | | | Broccoli is scattered at harvest | 4 | 3 | 5 | 60 | 7 |
| | | | Rotten broccoli | 5 | 7 | 6 | 210 | 5 |
| | | | Land productivity decreases | 5 | 4 | 6 | 120 | 6 |
| | Post-harvest | Broccoli grade down | Postharvest handling that is not right | 9 | 7 | 7 | 441 | 1 |
| | Weighing | Packaging weight is not according to request | Error in weighing | 4 | 3 | 5 | 60 | 7 |
| | Storage | Broccoli is damaged during temporary storage | Packaging is broken | 3 | 2 | 7 | 42 | 8 |
| | Delivery schedulin | Delivery scheduling | Errors in product delivery scheduling information | 3 | 2 | 4 | 24 | 6 |

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| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| *Delivery* | g | error | Error collecting product shipments | 5 | 4 | 4 | 80 | 4 |
| | Product Delivery | Broccoli vegetables are returned by the customer | Broccoli vegetables received by the *customer are* not according to specification s | 7 | 8 | 7 | 392 | 1 |
| | | | Broccoli vegetables are damaged during the shipping process | 6 | 7 | 5 | 210 | 2 |
| | | | | | | | | |

| Process | Sub Process | Risk Event / Risk Event | Causes of Risk | S | O | D | RPN | Rank |
|---|---|---|---|---|---|---|---|---|
| | | Delay in sending broccoli vegetables to customers | Demand beyond production capacity | 4 | 6 | 8 | 192 | 3 |
| | | | Transportatio n accident | 7 | 5 | 2 | 70 | 5 |

From the results of calculations on the risk-causing plan process which is a top priority is the fluctuating demand in the risk of inaccuracy in the number of production with a value of 280 RPN , the score process which is a priority is the disruption of raw material supply due to the change in quality of raw materials with value RPN 392, to process the make that a top priority is post-harvest handling is less precise on kejadia n risk grade broccoli down to the value of the RPN 441 and in the process deliver the priority risks are broccoli received does not match the specification of the occurrence of the risk of broccoli returned by the consumer with an RPN value of 392.

### *3.3 Mitigation Strategy Analysis*

Next step after knowing the priority of risk is to determine alternative strategies for mitigating existing risks. In this stage use the Analytical Hierarcky Process (AHP) method . To determine the risk minimization strategy, experts are needed in this field. The experts used are parties from the company. In the initial stage, alternative strategies were identified that might be in accordance with the results of each risk cause of each process, then formulated into a questionnaire to prioritize risk mitigation strategies. Respondents assessed and filled out a comparison questionnaire in pairs to determine the level of importance. To be able to be weighted using AHP, the existing alternative strategies are changed in the form of AHP hierarchy which is arranged into three levels of hierarchy, based on (1) level 1 is the goal, which is the goal of conducting mitigation strategies, (2) level 2 is criteria, the criteria are the causes of risk from each process, and (3) level 3 is an alternative to the strategy of each process. The AHP hierarchy that has been compiled can be seen in Figure 3 :

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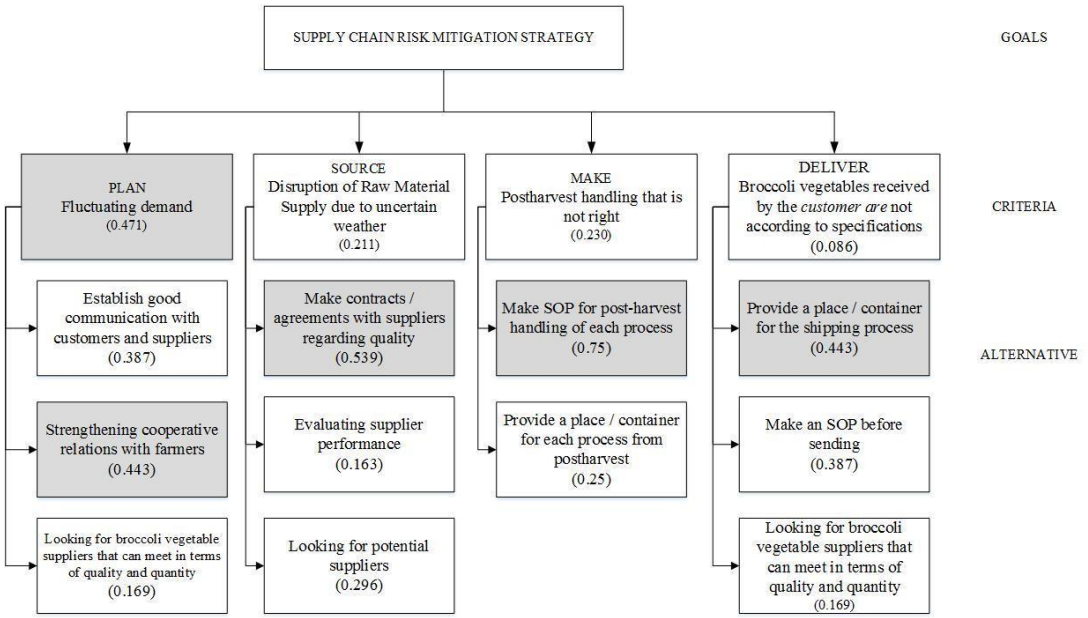


Figure 3. AHP Hierarchy structure

After compiling the hierarchy the next stage is paired data collection conducted by distributing questionnaires. The assessment used is using pair-wise comparison judgment metrices (PCJM). Based on the calculation method of AHP, a comparison is made at each level of the level, to level 2 compared to the level of interest among the causes of the risk of plan, source, make, deliver. At level 3 compared between mitigation alternatives for each process from the AHP calculation, it can be seen that the priority criteria is a plan with a value of 0.471. and for the most important alternative strategy is to strengthen the relationship of cooperation with farmers when the demand soars with a value of 0.443 . For source alternative make a contract / agreement with the supplier regarding quality with a value of 0.539, make process that is, making postharvest SOPs of each process with a value of 0.75, and delivering the main alternative is to provide a place / container for the delivery process with a value of 0.443.

### *3.4 Monitoring System Design Analysis*

The monitoring system in this research is a support system that is needed to provide a brief description of the conditions of the supply chain of each process. As a support system, the designed monitoring system is the application of a supply chain risk measurement system for

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companies that has been designed in the form of web-based applications. The picture below is the initial display of the monitoring system:

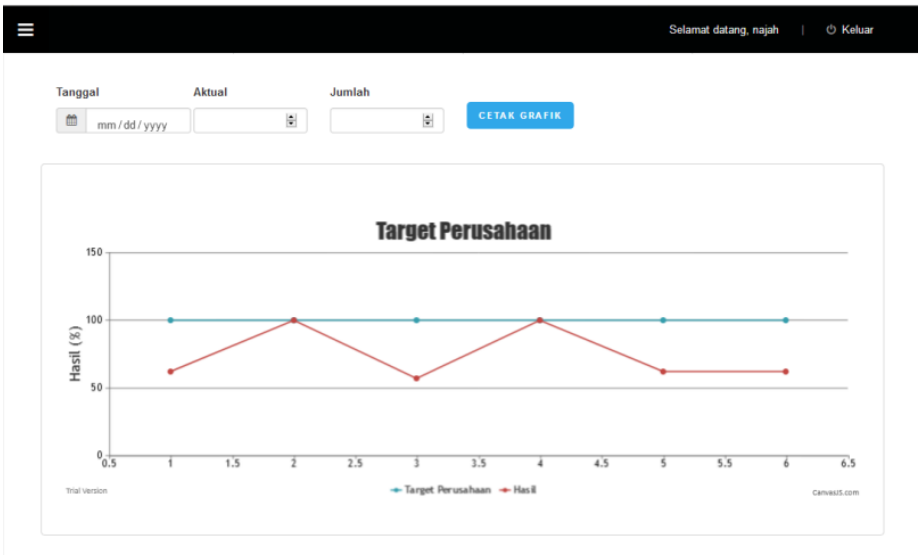


Figure 4. User Interface dashboard

Dashboard that contains a graph of the results of the calculation between the actual value and the target value divided and multiplied by 100% then compared with the target of the company every day and on the dashboard the user can choose the date, month and year according to his needs to see the grading chart , this dashboard works for companies to find out the achievement and conduct monitoring, whether it is in accordance with the company's target or not, if not then the company can take decisions or actions to change or reduce these risks. To be able to display the dashboard the user must fill in any risks that occur, provide an assessment of the risk to determine the priority of risk. The results of these risk priorities

users will measure or assess the achievements that occur in the field.

## 4. CONCLUSION

Based on the results of the study it can be concluded that there are 13 risk events and 25 risk causes that are divided into each process plan , source , make , deliver . From the risks identified, the experts / experts are given the value to determine the risk priorities that must be mitigated, in the plan that has the highest RPN value, there are the causes of risk, namely fluctuating demand with a value of 280 , for the source of the highest risk interruptions in the supply of raw

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material0073 due to the weather with a value of 392, the make process contained in post-harvest handling is not quite right with the value of 441 and deliver the highest causes of risk there in broccoli received does not match the specifications of the value of 392. Risks that have the highest value are made mitigation strategies designed by experts to reduce or avoid risk, in the plan processthere are two alternative strategies, the source process has 3 alternatives, make there are 2 alternatives, the deliver process has 3 alternatives. At level 2 which has the highest importance value lies in the plan with a value of 0.471.

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