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The application of fuzzy FMEA and TOPSIS methods in agricultural supply chain risk management (Case Study: Kabupaten Paser)

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ABSTRACT

The preliminary research stated that there were several mayoral risks that occur in Paser Regency such as, process risks, legal and bureaucracy regulatory risks, demand risks, supply risks, and environmental risk that need to be carried out for further research. This purpose was to analyze the priorities for supply chain activities in XYZ Village, Paser Regency, with the Fuzzy FMEA method using Matlab 2009a software to obtain FRPN values, and carried out mitigation strategies to determine alternative of risk priority for supply chain activities using TOPSIS method to get preference value. The priority risk of the Farmer supply chain was the risk with the F17 code, namely drought which has an impact on land drought with an FRPN value of 749, the Processors supply chain player was the risk with the F30 code, namely Experiencing the destruction of the rice grains during the milling process with an FRPN value of 356, the Distributor supply chain player was a risk with the code F37, namely Uncertainty in the amount of market demand with an FRPN value of 364. The results of the mitigation strategy from the TOPSIS method were for farmers supply chain players, namely Participating in the Rice Farming Business Insurance Program (AUTP) (A1) with first ranking which had a value preference (Vi) of 0.7236, for Processors supply chain players, namely carried out Routine Machine Maintenance (A1) with a first ranking which had a preference value (Vi) of 0.6226, and for Distributor supply chain players, namely doing Forecasting of holes (A3) with first rating which had a preference level (Vi) of 0.6425.

ABSTRAK

Penelitian terdahulu menyatakan bahwa terdapat beberapa risiko mayor yang terjadi di Kabupaten Paser seperti risiko proses, risiko regulasi hukum dan birokrasi, risiko permintaan, risiko pasokan, dan risiko lingkungan yang perlu dilakukan penelitian lanjutan. Tujuan penelitian ini ialah untuk menganalisis risiko prioritas pada aktivitas rantai pasok pertanian yang ada di Desa XYZ, Kabupaten Paser, dengan Metode Fuzzy FMEA yang menggunakan bantuan software Matlab 2009a untuk mendapatkan nilai FRPN, dan melakukan strategi mitigasi untuk menentukan alternatif risiko prioritas pada aktivitas rantai pasok pertanian dengan menggunakan Metode TOPSIS untuk mendapatkan nilai preferensi. Risiko prioritas pemain rantai pasok Petani adalah risiko dengan kode F17 yaitu Kemarau yang berdampak pada kekeringan lahan dengan nilai FRPN sebesar 749, pada pemain rantai pasok Penggiling Padi adalah risiko dengan kode F30 yaitu Mengalami kehancuran pada bulir padi saat proses penggilingan dengan nilai FRPN sebesar 356, pada pemain rantai pasok Distributor adalah risiko dengan kode F37 yaitu Ketidakpastian jumlah permintaan pasar dengan nilai FRPN sebesar 364. Hasil strategi mitigasi dari metode TOPSIS adalah pada pemain rantai pasok Petani yaitu Mengikuti Program Asuransi Usaha Tani Padi (AUTP) (A1) dengan peringkat 1 yang memiliki nilai preferensi (Vi) sebesar 0.7236, pada pemain rantai pasok Penggiling Padi yaitu Melakukan Perawatan Mesin Secara Rutin (A1) dengan peringkat 1 yang memiliki nilai preferensi (Vi) sebesar 0.6226, dan pada pemain rantai pasok Distributor yaitu Melakukan peramalan permintaan (A3) dengan peringkat 1 yang memiliki nilai preferensi (Vi) sebesar 0.6425.

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1. Introduction

Indonesia, which is known as an agricultural country, certainly has a rapidly growing agricultural sector which contributes significantly to the country's economic growth. This can be seen in the increase in exports from 390.6 trillion in 2019 to 451.8 trillion in 2020, or an increase of 15.7%. Exports of agricultural products in January to July 2021 were also very large, reaching 282.86 trillion, an increase of 14.05 percent from 202.05 trillion in the same period in 2020. So far, this increase in agricultural exports is considered sufficient. satisfactory because it has a significant impact on improving welfare [1] By looking at these advantages, the agricultural sector must continue to be developed in order to help the country's economy and be able to compete with foreign countries.

According to [2], in order to realize a justice and sustainable green economy growth, East Kalimantan plans to realize "Kaltim Maju 2030" which focuses on the agricultural sector which will be the determinant of economic growth in East Kalimantan. Therefore, the East Kalimantan provincial government has determined a food crop-based industrial area in Paser Regency. Paser Regency is one of the regencies in East Kalimantan with a geographical location in the south of East Kalimantan Province which has potential in food crop agriculture and is predicted to become an industrial center that produces food products in 2030. The agricultural sector was the second sectors that give big contributes to GRDP in Paser Regency where paddy is the main food agriculture, seen from the area of rice cultivation in 2017 of 9,883 hectares of the total harvested area in Paser Regency with paddy production of 41,726 tons which makes the harvested area and paddy production higher than other food crops such as corn, sweet potatoes, and beans [3].

The agricultural sector cannot be separated from risks, especially the risk of the agricultural supply chain of rice food crops, in particular there were several obstacles faced by agricultural supply chain players in Paser Regency based on previous research that there were five major risks, namely process risks, legal and bureaucratic regulatory risks, demand risks, process risks, and environmental risks [2]. One way to produce good products in the supply chain of agricultural products, especially paddy, was to manage the risks that occur. Risk management was needed to control the risks that occur or may occur in food crop agricultural products in order to reduce losses that occur in order to create a supply chain that produces quality products with the appropriate quantity [4].

Fuzzy Failure Mode and Effect Analysis (Fuzzy FMEA) is one of the analytical methods that is widely used in research related to risk management which is considered to have the advantage of being more accurate, flexible, and easy to understand than Traditional FMEA [5]. The method used in risk mitigation is the Technique for Order Performance by Similarity to Ideal Solution (TOPSIS) because it has a simple and useful concept for ranking the alternatives used [6]. Based on these problems, this study was conducted to analyze the risks in agricultural supply chain activities in Paser Regency using the Fuzzy FMEA method, and carry out a mitigation strategy to determine alternatives for priority risk in agricultural supply chain activities in Paser Regency using the TOPSIS method.

2. Research Methodology

Data collectted was done by prepared and determined 2 types of data to be taken and used, namely primary data and secondary data. The primary data in this study were interviews and questionnaires, the interview aims to obtain information, causes, and efforts to determine risk priorities, and the questionnaire in this study refers to the risk of the mayor of previous studies which aims to obtain information related to the severity, occurrence, and detection of each existing risks and assessment of criteria and alternatives in the TOPSIS method assessed by expert judgment. According to [7], the criteria for selecting expert judgment are as follows:

a. Have experience in making assessments and making decisions based on evidence of expertise, such as positions or degrees, research, publications, positions, experiences, awards, and others.
b. Have a good image (reputation) in society.
c. Availability and willingness to participate.
d. Impartiality and inherent qualities such as self-confidence and the ability to make adjustments

According to the criteria, the expert judgment in this study was described as follows.

a. The head of the Farmers Group which has been established for more than 10 years, oversees about 18 farmers, owns the largest and most extensive land in XYZ Village.
b. Processor who cooperate with Farmers Group.
c. Rice Distributors who cooperate with Rice Grinders.

In this study, secondary data used were all major risk identifications in Paser Regency and several other risks taken from appropriate sources with this research. The identification of major risks in previous studies used are as follows [2]:

a. Process risk
    1) Inadequate irrigation
    2) Low quality rice seeds (not disease resistant) and their availability is not continuous
    3) Circulation of fake fertilizer
    4) Limited capital
    5) Discontinuous raw materials
    6) Lack of supporting equipment and machines
    7) Damage to supporting infrastructure (eg roads)
b. Legal and bureaucratic regulatory risks
    1) Regulations regarding rice planting procedures that are not in accordance with land conditions
    2) The price of rice or unhulled rice is contrary to the price standard set by the government
    3) Convoluted bureaucracy
    4) Expensive labor cost
    5) Regulations that are deemed less favorable to farmers

6) Less socialized insurance policies
7) Shrinking agricultural area due to the opening of oil palm plantations

c. Demand risks
1) Unstable paddy selling price
2) Abundance of agricultural commodities and fierce competition
3) Prices and demand for products are low during harvest season
4) Poor product quality lowers demand and selling prices
5) Harvest time coincides with other areas which causes abundant commodities and fierce competition
6) Reduced customer demand due to competing rice suppliers

d. Supply risks
1) Lower prices due to poor harvest quality
2) Fluctuating prices of raw materials and agricultural equipment

e. Environtmental risk
1) Unstable weather
2) Drought which has an impact on land drought
3) Flood
4) Poor quality of agricultural land
5) Resistance of pests and diseases to pesticides
6) Soil damage due to pesticide use
7) Waste from companies and plantations around agricultural land

At the research location, 3 supply chain players were assigned as respondents, namely the head of the farmer group, the processor, and the distributor. In the supply chain of a commodity there are two types of supply chain members, namely primary members and secondary members. Primary members are parties who are directly involved in production activities in the supply chain. The primary members in this supply chain are producers/farmers, collectors, and processors who are directly involved in production activities. Secondary members are parties that are not directly involved in production activities but have influence on business activities in the supply chain. Secondary members in the supply chain are distributors, retailers and direct consumers [8].

2.1. Fuzzy Failure Mode and Effect Analysis (Fuzzy FMEA)

According to [5], Fuzzy FMEA is a risk analysis method in a qualitative way based on opinions or judgments from experts to determine the risk of severity, occurrence, and detection using fuzzy linguistic language. Fuzzy logic replaces 10 point scale on FMEA into linguistic variables, if-then rules on Fuzzy FMEA are useful for generating RPN or FRPN outputs based on S, O, and D results that have been changed in the form of linguistic variables. The output of risk analysis using Fuzzy FMEA is in the form of Fuzzy RPN or FRPN values obtained from the results of the fuzzy function of the severity, occurrence, and detection values, then these values are used to determine the priority of the risk rating. The FRPN value will later be used as a reference in determine the risks that can be given corrective or preventive action. Regarding the existing steps, it is in line with the basic framework of the risk assessment stage, action plan, and monitoring and evaluation stage. The FRPN value in the Fuzzy FMEA framework is used as a measurement tool for the effectiveness of risk preventive measures and becomes a material for improvement of a process [5]. The working steps using the Fuzzy FMEA method are as follows:

a. *Fuzzification*

In Fuzzy FMEA, triangle and trapezoid patterns are used. The input variable membership function parameters can be seen in Table 1 below.

Table 1. Input variable membership function parameter**.**

Category	Curve Type	Parameter
VL	Trapezoid	[0 0 1 2.5]
L	Triangle	[1 2.5 4.5]
M	Trapezoid	[2.5 4.5 5.5 7.5]
H	Triangle	[5.5 7.5 9]
VH	Trapezoid	[7.5 9 10 10]

According to [9], the output value obtained from Fuzzy FMEA is the FRPN value which has a value range of 1-1000. The output variable function parameters can be seen in Table 2.

Table 2. Output variable membership function parameters**.**

Category	Curve Type	Parameter
VL	Trapezoid	[0 0 25 75]
VL-L	Triangle	[25 75 125]
L	Triangle	[75 125 200]
L-M	Triangle	[125 200 300]
M	Triangle	[200 300 400]
M-H	Triangle	[300 400 500]

Category	Curve Type	Parameter
H	Triangle	[400 500 700]
H-VH	Triangle	[500 700 900]
VH	Trapezoid	[700 900 1000 1000]

b. Fuzzy knowledge base creation
c. Implement the impliciation function
d. Composition of rules
e. Defuzzification
f. Priority risk ranking and determination

The order of RPN values as a result of risk analysis is known as risk priority or risk rating. The magnitude of the FRPN value that reflects the high and low degree of risk is used to determine the order of risk values in the context of risk analysis with fuzzy FMEA. The largest FRPN number becomes the priority for improvement to minimize the risk value, followed by a lower FRPN value [5].

2.2. Technique for Order Preference by Similarity to Ideal Solution (TOPSIS)

The decision-making process of a problem is the process of choosing the best option from a series of options. Many decision-making criteria are one aspect of a very complex decision-making problem where several actors or people involved in decision-making use several criteria and various options to evaluate, and each criterion has a certain weight value that seeks to give the desired result. Technique for Order Performance by Similarity to Ideal Solution (TOPSIS) is one of the MCDM strategies used to deal with problems in decision making that are optimized from problems that exist in decision making [6].

TOPSIS uses the distance between two points, also known as the Euclidean distance, to approximate the positive ideal solution and the furthest distance from the negative ideal solution to approximate the alternatives in obtaining the optimal solution. The positive ideal solution is defined as the sum of the best values obtained for each attribute that maximizes benefits while providing costs, while the negative ideal solution is defined as the sum of the worst values obtained for each attribute that maximizes benefits while providing costs. TOPSIS considers the positive ideal solution and the negative ideal solution by taking the relative closeness of the positive ideal solution [6]. The steps for working with the TOPSIS method are as follows:

a. Creation and assessment of alternative and mitigation strategy criteria from risk priorities
b. Creation and calculation normalized decision matrix

$$r_{ij}=\frac{x_{ij}}{\sqrt{\sum_{i=1}^{m}x_{ij}^2}} \quad (1)$$

c. Creation and calculation weight normalized decision matrix

$$Y_{ij}=w_{ij}r_{ij} \quad (2)$$

d. Calculation of positive ideal solution matrix and negative ideal solution matrix

$$A^+=\left(y_1^+,y_2^+,\dots y_n^+\right), \text{ and} \quad (3)$$

$$A^- = \left(y_1^-,y_2^-,\dots,y_n^-\right) \quad (4)$$

with: y_j^+ = - max y_{ij} , if j is benefit attribute
- min y_{ij} , if j is cost attribute
y_j^- = - min y_{ij} , if j is benefit attribute
- max y_{ij} , if j is cost attribute.

e. Calculation alternative distance with positive ideal solution matrix and negative ideal solution matrix

$$D_i^+=\sqrt{\sum_{j=1}^{n}(Y_i^+-Y_{ij})^2} \text{ , and} \quad (5)$$

$$D_i^-=\sqrt{\sum_{j=1}^{n}(Y_{ij}-Y_i^-)^2} \text{ .} \quad (6)$$

f. Determination of preference value

$$V_i = \frac{D_i}{D_i^- + D_i^+} \text{ .} \quad (7)$$

3. Result and Discussion

3.1. General Description of Agricultural Supply Chain

The object of this research was the agricultural supply chain in XYZ Village, especially the supply chain consisting of farmer groups, processors, and distributors. Based on the identification of risks that have been carried out in previous studies, the agricultural supply chain in Paser Regency has several major risks that occur. The agricultural supply chain management structure in XYZ Village was analyzed through the players who build the supply chain and the role of each member in the supply chain. The flow of products in the supply chain was divided into two types, namely rice grain from farmers to processors and rice from mills to distributors. The configuration of the agricultural supply chain can be seen in Figure 1 as follows.

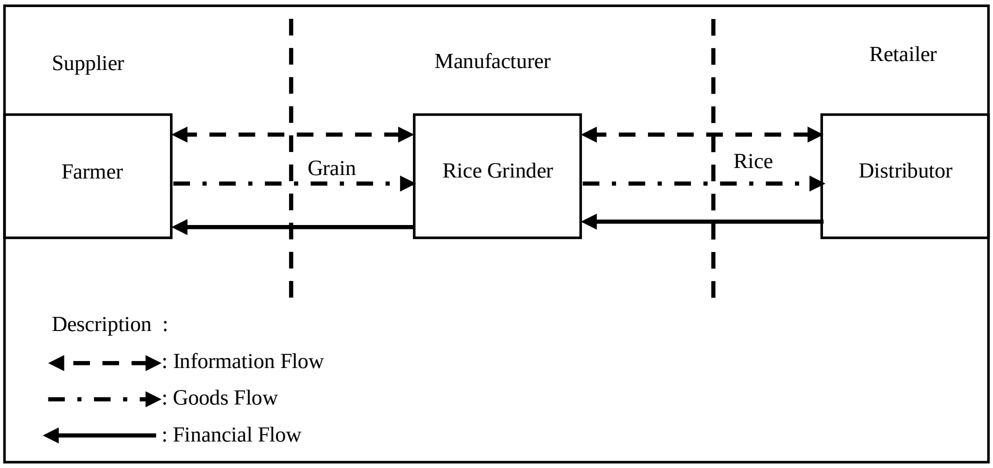

Figure 1. Agricultural supply chain configuration.

Identification of risks in the agricultural supply chain using secondary data from previous research, namely some risks that occur to farmers and processor, and risks obtained from interviews with several risks that occur to distributors. Based on the results of the literature study and interviews, data on the identification of risks that occur in the agricultural supply chain in Paser Regency, especially XYZ Village, can be seen in Table 3.

Table 3. Risk identification data**.**

Supply chain players	Risk	Source
Farmers	Inadequate irrigation	[2]
	Low quality rice seeds (not disease resistant) and their availability is not continuous	[2]
	Discontinuous raw materials	[2]
	Circulation of fake fertilizer	[2]
	Limited capital	[2]
	Regulations regarding rice planting procedures that are not in accordance with land conditions	[2]
	Convoluted bureaucracy	[2]
	Regulations that are deemed less favorable to farmers	[2]
	Less socialized insurance policies	[2]
	Expensive labor cost	[2]
	Shrinking agricultural area due to the opening of oil palm plantations	[2]
	Prices and demand for products are low during harvest season	[2]
	Harvest time coincides with other areas which causes abundant commodities and fierce competition	[2]
	Poor product quality lowers demand and selling prices	[2]
	Lower prices due to poor harvest quality	[2]
	Unstable weather	[2]
	Drought which has an impact on land drought	[2]
	Flood	[2]
	Poor quality of agricultural land	[2]
	Resistance of pests and diseases to pesticides	[2]
	Soil damage due to pesticide use	[2]
	Waste from companies and plantations around agricultural land	[2]
Processor	The price of rice or unhulled rice is contrary to the price standard set by the government	[2]
	Unstable paddy selling price	[2]
	Fluctuating prices of raw materials and agricultural equipment	[2]
	Reduced customer demand due to competing rice suppliers	[2]
	Lack of supporting equipment and machines	[2]
	Uncomfortable work environment	[10]
	Delays in the production process	[10]
	Experiencing the destruction of the rice grains during the milling process	Interview

Supply chain players	Risk	Source
	There is rice and packaging damaged during storage	[10]
	The quantity of rice that does not match the request	Interview
Distributor	Sudden receipt of orders	Interview
	Error in booking order	[11]
	Decrease in product quality when stored	[11]
	There are holding costs due to accumulation of inventory	[11]
	Uncertainty in the amount of market demand	Interview
	Excess inventory	[11]
	Lack of inventory	[11]
	Items damaged during the delivery process	Interview
	Damage to supporting infrastructure (eg roads)	[2]
	Late in delivering rice to customers	Interview
	Vehicle damaged during the delivery process	Interview
	There was a defective product during delivery	[11]

3.2. Fuzzy FMEA Data Process Result

The Fuzzy FMEA method aims to determine the priority risk of each risk that occurs in supply chain players. Data processing with this method is carried out computerized with the help of MATLAB 2009a Software so that it is easy to work with quite a lot of data, the output generated in data processing using this method is the Fuzzy RPN value where the FRPN value category, while the stages in data processing using the Fuzzy FMEA method are explained as follows.

3.2.1. Fuzzification

The formation of a fuzzy set or fuzzification is the first stage in the fuzzy FMEA method which aims to determine the membership function consisting of input and output. The input variables are crisp (firm) values of severity (S), occurrence (O), and detection (D) which have been changed to fuzzy approach values which can be seen in Table 1, membership function input parameters can be seen in Figure 2.

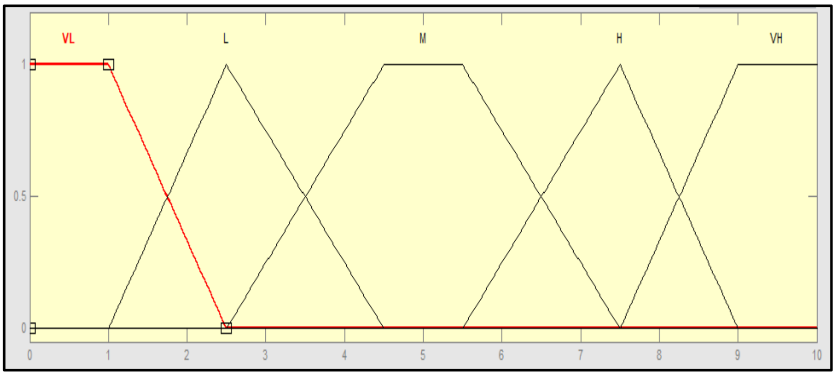

Figure 2. Membership function input parameters.

3.2.2. Formation of the fuzzy set

The next step after forming a fuzzy input set is then continued with the formation of an output set, namely FRPN which is fuzzy logic with a variable scale of 1-1000 where the FRPN category is divided into 9 categories which can be seen in Table 2. The results obtained are the highest FRPN value which will be a risk priority for mitigation. Membership function output parameters can be seen in Figure 3.

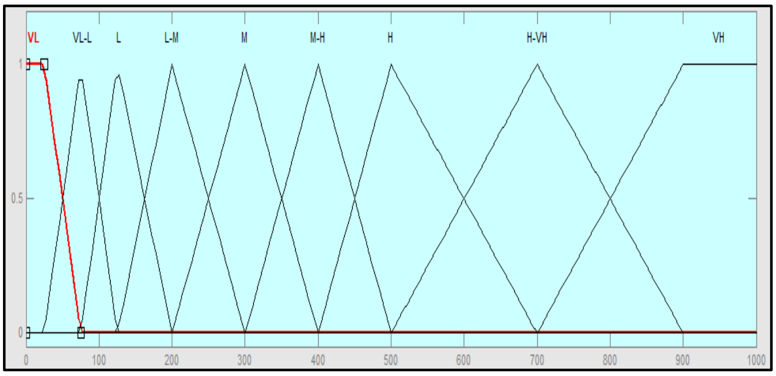

Figure 3. Membership function output parameters.

3.2.3. Fuzzy knowledge base creation

Fuzzy knowledge base creation or *rules based fuzzy* formulated in linguistic terms and formulated in the form of if-then rules. In the Fuzzy FMEA method, fuzzy rules are formed from a combination of input variables consisting of severity, occurrence, and detection. Rules based fuzzy means that the IF part comes from the variable input value and the THEN part comes from the variable output value. Rules based fuzzy produces 125 rules which can be seen in Figure 3.

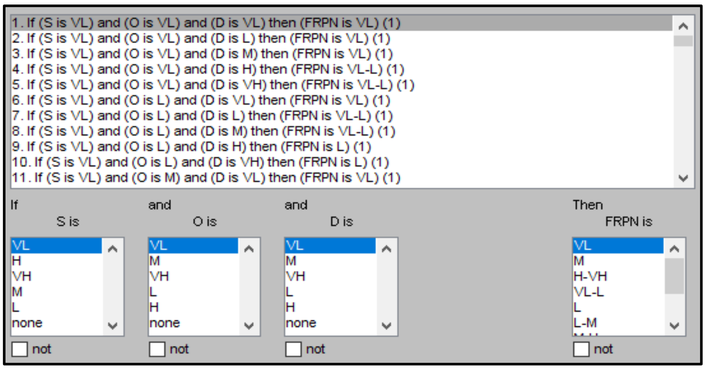

Figure 3. Fuzzy Rules.

3.2.4. Implement the impliciation function

Implement the impliciation function is a stage that describes the relationship between input and output variables. The fuzzy used in this data processing uses mamdani fuzzy where the implication function is an implication function of MIN. The results of one of the implications of risk inadequate irrigation with SOD values of 4, 3, and 2 are seen from Figure 4. Based on Figure 4, it can be seen that there are several regulations that have areas of implication. The areas of implication contained in risk Inadequate irrigation with an SOD value of 4, 3, and 2 contained in rules number 31, number 32, number 36, number 37, number 56, number 57, number 61, and number 62.

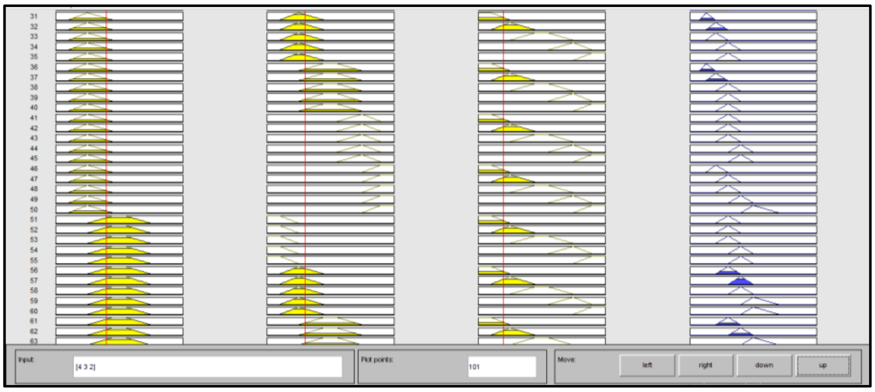

Figure 4. Implication area.

3.2.5. Composition of rules

Composition of rules used the maximum rule, which at this stage aims to unify the implications area into one composition with a value of severity 4, occurrence 3, and detection 2.

3.2.6. Defuzzification

Deffuzification is an affirmation stage that converts the output into a crisp number, the firm value is the Fuzzy Risk priority number. In risk Inadequate irrigation with an SOD value of 4, 3, and 2, the FRPN value of 318 obtained from data processing with the help of MATLAB 2009a software can be seen in Figure 5. Based on Figure 5, it is obtained that the output value of the Defuzzification is carried out with a firm value or FRPN of 318 for risk inadequate irrigation with a predetermined severity, occurrence, and detection value.

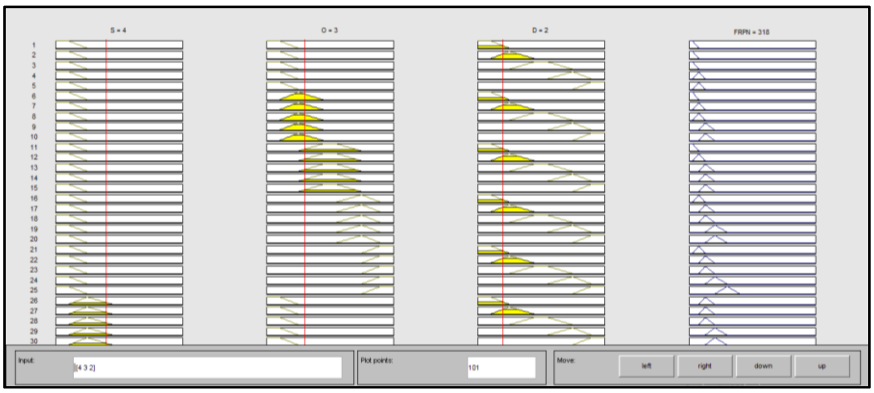

Figure 5. Inadequate irrigation risk FRPN value.

The ranking and determination of risk categories was carried out after data processing by sorting each FRPN value from the highest to the lowest based on each risk that exists in each agricultural supply chain player. The ranking and determination of the highest to lowest FRPN value categories by supply chain players Farmers can be seen in Table 4.

Table 4. Rating and determination of risk categories by Farmers**.**

No	Code	Risk	FRPN	Category
1	F17	Drought which has an impact on land drought	749	High-Very High (H-VH)
2	F16	Unstable weather	645	High-Very High (H-VH)
3	F13	Harvest time coincides with other areas which causes abundant commodities and fierce competition	601	High-Very High (H-VH)
4	F2	Low quality rice seeds (not disease resistant) and their availability is not continuous	404	Moderate-High (M-H)
5	F18	Flood	404	Moderate-High (M-H)
6	F3	Discontinuous raw materials	364	Moderate-High (M-H)
7	F12	Prices and demand for products are low during harvest season	364	Moderate-High (M-H)
8	F10	Expensive labor cost	356	Moderate-High (M-H)
9	F20	Resistance of pests and diseases to pesticides	356	Moderate-High (M-H)
10	F1	Inadequate irrigation	318	Moderate (M)
11	F4	Circulation of fake fertilizer	318	Moderate (M)
12	F8	Regulations that are deemed less favorable to farmers	318	Moderate (M)
13	F6	Regulations regarding rice planting procedures that are not in accordance with land conditions	258	Moderate (M)
14	F14	Poor product quality lowers demand and selling prices	258	Moderate (M)
15	F15	Lower prices due to poor harvest quality	258	Moderate (M)
16	F19	Poor quality of agricultural land	258	Moderate (M)
17	F5	Limited capital	207	Low-Moderate (L-M)
18	F9	Less socialized insurance policies	207	Low-Moderate (L-M)
19	F21	Soil damage due to pesticide use	205	Low-Moderate (L-M)
20	F7	Convoluted bureaucracy	155	Low-Moderate (L-M)
21	F22	Waste from companies and plantations around agricultural land	155	Low-Moderate (L-M)
22	F11	Shrinking agricultural area due to the opening of oil palm plantations	103	Low (L)

Based on the results of the ranking and determination of category risk by Farmers, the highest risk was from the type of major risk, especially environmental risk, namely Drought which has an impact on land drought (F17) with an FRPN value of 749 and was included in the High-Very High category. Priority risk that occurs to Farmers was defined as a lack of water relative to water needs for human, agricultural, economic, and environmental activities. Drought is inevitable and lasts for a long time until the rainy season arrives. It is included in the category of natural disasters because of the risk of drought. Specifications differ from other risks in that they can occur suddenly, but are gradual and easily ignored. When productive land experiences crop failure or decline in quality, the impact will be felt. Damage to land systems that are no longer used properly for land use, and damage to the agricultural sector are two more extreme consequences [12]. The ranking and determination of the highest to lowest FRPN value categories by supply chain players Processor can be seen in Table 5.

Table 5. Rating and determination of risk categories by Processor**.**

No	Code	Risk	FRPN	Category
1	F30	Experiencing the destruction of the rice grains during the milling process	356	Moderate-High (M-H)
2	F26	Reduced customer demand due to competing rice suppliers	356	Moderate-High (M-H)
3	F25	Fluctuating prices of raw materials and agricultural equipment	318	Moderate (M)
4	F28	Uncomfortable work environment	318	Moderate (M)
5	F24	Unstable paddy selling price	258	Moderate (M)
6	F27	Lack of supporting equipment and machines	258	Moderate (M)
7	F31	There is rice and packaging damaged during storage	258	Moderate (M)
8	F23	The price of rice or unhulled rice is contrary to the price standard set by the government	203	Low-Moderate (L-M)
9	F29	Delays in the production process	203	Low-Moderate (L-M)
10	F32	The quantity of rice that does not match the request	203	Low-Moderate (L-M)

Based on the results of the ranking and determination of category risk by the Processor, the highest risk was obtained from the process risk factor, namely Experiencing the destruction of the rice grains during the milling process (F30) with an FRPN value of 356 and included in the Moderate-High category. Rice milling is the process of converting grain into rice with a maximum moisture content of 13-14%. The milling process can generally be divided into two parts: the processing of unhulled rice into husked rice and the refining of rice which is converted into polished rice. Whitener and husker are two tools in the separation process. Rice grains are broken or crushed during the low milling process usually due to the large number of broken grains caused by the low moisture content of the grains, thereby increasing the number of broken rice grains during milling. As a result, the low water content in the grain during the game will have an impact on the quality of the final product [13]. The ranking and determination of the highest to lowest FRPN value categories by supply chain players Distributors can be seen in Table 6.

Table 6. Rating and determination of risk categories by Distributor**.**

No	Code	Risk	FRPN	Category
1	F37	Uncertainty in the amount of market demand	364	Moderate-High (M-H)
2	F34	Error in booking order	356	Moderate-High (M-H)
3	F41	Damage to supporting infrastructure (eg roads)	356	Moderate-High (M-H)
4	F39	Lack of inventory	318	Moderate (M)
5	F43	Vehicle damaged during the delivery process	318	Moderate (M)
6	F35	Decrease in product quality when stored	258	Moderate (M)
7	F36	There are holding costs due to accumulation of inventory	258	Moderate (M)
8	F38	Excess inventory	258	Moderate (M)
9	F42	Late in delivering rice to customers	258	Moderate (M)
10	F44	There was defective products returned by customers	207	Low-Moderate (L-M)
11	F33	Sudden receipt of orders	155	Low-Moderate (L-M)
12	F40	Items damaged during the delivery process	155	Low-Moderate (L-M)

Based on the results of the ranking and determination of the distributor's category risk, the highest risk from inventory activity was Uncertainty in the amount of market demand (F37) with an FRPN value of 364 and was included in the Moderate-High category. Uncertainty in the amount of market demand generally occurs due to the large number of competitors and changes in market demand as a result of certain events, the presence of competitors will cause demand to decline and with the influence of certain events such as a pandemic, demand will increase because many people keep a lot of rice stocks. for them to consume during the pandemic. With this, it will have an impact on the inventory system from distributors where when there is a lot of demand, the stock of goods is running low and sometimes it can't meet the demand from customers, and also when the demand is low, there will be a lot of inventory in the warehouse which will actually increase expenses with costs save from the rice stock.

3.3. TOPSIS Data Process Result

3.3.1. Creation and assessment of alternative and mitigation strategy criteria from priority risk

Determination of the weight of the criteria and alternatives was determined by the respondent using a predetermined scale. The assessment of the weight of the criteria for each supply chain player can be seen in Table 7.

Table 7. Criteria weight assessment**.**

Supply chain players	Benefit	Cost	Opportunity	Risk
Farmers	5	5	3	3
Processor	5	4	3	4
Distributor	5	5	3	3

The assessment of the alternative comparison matrix and the criteria for each supply chain player can be seen in Table 8.

Table 8. Evaluation of the comparison matrix**.**

Supply chain players	C1	C2	C3	C4
Farmers				
A1 Participate in the Rice Farming Business Insurance Program	5	4	4	3
A2 Drilling Well Construction	4	5	5	4
A3 Maintaining Product Quality	4	5	4	3
Processor				
A1 Performing Routine Machine Maintenance	5	3	3	4
A2 Maintaining Product Quality	5	5	4	4
A3 Collaborating with Other Business Actors	4	4	4	3

Supply chain players	C1	C2	C3	C4
Distributor				
A1 Doing Inventory Management	4	4	4	3
A2 Collaborating with Other Business Actors	5	3	4	2
A3 Doing Demand Forecasting	4	2	3	3

3.3.2. Creation and calculation normalized decision matrix

Making a weighted normalized decision matrix requires alternative rating scale data against the criteria used, namely the BCOR criterion which is calculated using Equation 1. An example of the calculation of the normalized decision matrix in Alternative 1 (A1) against Criterion 1 (C1) was as follows.

$$r_i = \frac{x_{ij}}{\sqrt{\sum_{i=1}^{m} x_{ij}^2}} = \frac{5}{\sqrt{5^2+4^2+4^2}} = 0.6623.$$

The whole results of the normalized decision matrix can be seen in Table 9.

Table 9. Normalized decision matrix.

Supply chain players	C1	C2	C3	C4
Farmers				
A1	0.6623	0.4924	0.5298	0.5145
A2	0.5298	0.6155	0.6623	0.6860
A3	0.5298	0.6155	0.5298	0.5145
Processor				
A1	0.6155	0.4243	0.4685	0.6247
A2	0.6155	0.7071	0.6247	0.6247
A3	0.4924	0.5657	0.6247	0.4685
Distributor				
A1	0.5298	0.7428	0.6247	0.6396
A2	0.6623	0.5571	0.6247	0.4264
A3	0.5298	0.3714	0.4685	0.6396

3.3.3. Creation and calculation weighted normalized decision matrix

The calculation of the weighted normalized decision matrix was calculated using Equation 2. An example of the calculation of the weighted normalized decision matrix in Alternative 1 (A1) against Criterion 1 (C1) is as follows.

$$y_{ij} = w_{ij} r_{ij} = 0.6623 \times 5 = 3.3113.$$

The whole results of the weighted normalized decision matrix can be seen in Table 10.

Table 10. Weighted normalized decision matrix.

Supply chain players	C1	C2	C3	C4
Farmers				
A1	3.3113	2.4618	1.5894	1.5435
A2	2.6491	3.0773	1.9868	2.0580
A3	2.6491	3.0773	1.5894	1.5435
Processor				
A1	3.0773	1.6971	1.4056	2.4988
A2	3.0773	2.8284	1.8741	2.4988
A3	2.4618	2.2627	1.8741	1.8741
Distributor				
A1	2.6491	3.7139	1.8741	1.9188
A2	3.3113	2.7854	1.8741	1.2792
A3	2.6491	1.8570	1.4056	1.9188

3.3.4. Calculation of positive ideal solution matrix and negative ideal solution matrix

The calculation of the positive ideal solution matrix and the negative ideal solution matrix are calculated using Equation 3 and Equation 4, in the positive and negative ideal solution matrix the positive ideal criteria are benefit (C1) and opportunity (C3) because the higher the value of this criterion, the more good, while the negative ideal criteria are cost (C2) and risk (C4) because the higher the value on this criterion, the worse it is. So that in the calculation for A^+ to C1 the highest weighted normalized decision value was sought, A^+ to C2 was sought the lowest weighted normalized decision value. For A^- to C1 the lowest weighted normalized decision value was sought and A^- to C2 was sought the highest normalized decision value. The whole results of the positive ideal solution matrix and the negative ideal solution matrix can be seen in Table 11.

Table 11. Positive ideal solution matrix and the negative ideal solution matrix.

Supply chain players	**C1**	**C2**	**C3**	**C4**
Farmers				
A^+	3.3113	2.4618	1.9868	1.5435
A^-	2.6491	3.0773	1.5894	2.0580
Processor				
A^+	3.0773	1.6971	1.8741	1.8741
A^-	2.4618	2.8284	1.4056	2.4988
Distributor				
A^+	3.3113	1.857	1.8741	1.2792
A^-	2.6491	3.7139	1.4056	1.9188

3.3.5. Calculation alternative distance with positive ideal solution matrix and negative ideal solution matrix

Calculation of alternative distance with positive ideal solution matrix and negative ideal solution matrix using Equation 5 and Equation 6. An example of calculating alternative distance on A1 to D^+ is as follows.

$$D_i^+ = \sqrt{\sum_{j=1}^{n}(Y_i^+ - Y_{ij})^2}$$

$$= \sqrt{(3{,}3113 - 3{,}3113)^2 + (2{,}4618 - 2{,}4618)^2 + (1{,}9868 - 1{,}5894)^2 + (1{,}5435 - 1{,}5435)^2} = 0.3974.$$

The whole results of alternative distances with positive ideal solution matrix and negative ideal solution matrix can be seen in Table 12.

Table 12. Alternative distances with positive ideal solution matrix and negative ideal solution matrix.

Supply chain players	**D^+**	**D^-**
Farmers		
A1	0.3974	1.0402
A2	1.0402	0.3974
A3	0.9876	0.5145
Processor		
A1	0,7809	1.2879
A2	1.2924	0.7735
A3	0.8359	0.9642
Distributor		
A1	2.0727	0.4685
A2	0.9285	1.389
A3	1.0331	1.857

3.3.6. Determination of preference value

Calculation of preference value in Equation 7. An example of calculating preference value in Alternative 1 (A1) is as follows.

$$V_i = \frac{D_i}{D_i^- + D_i^+} = \frac{1.0402}{1.0402 + 0.3974} = 0.7236$$

The whole results of preference value can be seen in Table 13.

Table 13. Preference value and alternative ratings**.**

Supply chain players	V_i	**Rating**
Farmers		
A1 Participate in the Rice Farming Business Insurance Program	0.7236	1
A2 Drilling Well Construction	0.2764	3
A3 Maintaining Product Quality	0.3425	2
Processor		
A1 Performing Routine Machine Maintenance	0.6226	1
A2 Maintaining Product Quality	0.3744	3
A3 Collaborating with Other Business Actors	0.5356	2
Distributor		
A1 Doing Inventory Management	0.1844	3
A2 Collaborating with Other Business Actors	0.5994	2
A3 Doing Demand Forecasting	0.6425	1

The results obtained for alternative priority mitigation strategies on priority risk by Farmer with code F17 which had an FRPN value of 749, namely Drought which has an impact on land drought was Participate in the Rice Farming Business Insurance Program (A1) with a first rating which had a preference value (Vi) of 0.7236, Maintaining Product Quality (A3) with second rating which had a preference value (Vi) of 0.3425, and Drilling Well Construction (A2) with a third rating which had a preference value (Vi) of 0.2764. The Rice Farming Business Insurance Program can overcome the risk Drought which has an impact on land drought because it provides protection against crop loss due to floods, droughts, and attacks by pests or plant-disturbing organisms. Farmers can use Rice Farming Business Insurance Program to file (claim) losses to carry out or continue agricultural activities because they have the necessary working capital to compensate for the risk in their fields. Related to this, the Ministry of Agriculture will continue to run the Rice Farming Business Insurance Program in 2021 to provide financial assistance to farmers as participants [14]. The results obtained for alternative priority mitigation strategies on priority risk by Processor with code F30 which had an FRPN value of 356, namely Experiencing the destruction of the rice grains during the milling process was Performing Routine Machine Maintenance (A1) with first rating which had a preference value (Vi) of 0.6226, Collaborating with Other Business Actors (A3) second rating which had a preference value (Vi) of 0.3744, and Maintaining Product Quality (A2) with third rating which had a preference value (Vi) of 0.5356.

The purpose of maintenance is to extend the useful life of the asset, meet product requirements and production plans in a timely manner. Avoiding maintenance that endangers workers, maintains quality at a level adequate to meet product requirements, and maintains smooth operations [15]. Performing Routine Machine Maintenance can overcome the risk of rice grain destruction during the milling process where the cause is the condition, setting, or configuration of the grinding machine is not compatible, the rice will break when milled, so it is necessary to carry out routine machine maintenance so that the grinding machine can work optimally.

The results obtained for the alternative priority mitigation strategy on priority risk by Distributor with code F37 which had an FRPN value of 364, namely Uncertainty in the amount of market demand was Doing Demand Forecasting (A3) with first rating which had a preference value (Vi) of 0, 6425, Collaborating with Other Business Actors (A2) with second rating which had a preference value (Vi) of 0.5994, and Doing Inventory Management (A1) with third rating which had a preference value (Vi) of 0.1844. Demand forecasting is the process of estimating the amount of demand for a particular good or service over a certain period of time and in a particular marketing area. Demand Management is an attempt to make the supply chain more capable of meeting demand. More specifically, management can be interpreted as an effort to actively anticipate that the customer demand profile will have a smooth pattern, so that its fulfillment is easy and efficient [16]. Forecasting demand at this distributor can be done in simple ways such as collecting sales data for the last few months, finding out the cause of fluctuating demand whether it is due to conditions such as a pandemic or rainy season, and finding out market conditions whether there are other rice competitors.

4. Conclusion

The results based on the analysis carried out, the results obtained that the priority risk on the Farmers supply chain player was Drought that has an impact on land drought with an FRPN value of 749 and was included in the High-Very High (H-VH) category caused by rainy weather and minimal absorption area, this results in a reduction in the area of rice planting land, decreased production, and crop failure, so that the mitigation efforts that can be done are for farmers to participate in the Rice Farming Business Insurance Program which had a preference value (Vi) of 0.7236. The priority risk for the processor supply chain player was experiencing the destruction of rice grains during the milling process with an FRPN value of 356 and was included in the Moderate-High (M-H) category due to low grain moisture content and poor grinding machine conditions, this results in decreased sales and the product quality was not good, so the mitigation effort that can be done was Performing Routine Machine Maintenance which had a preference level (Vi) of 0.6226. The priority risk for Distributor supply chain players was the uncertainty of the amount of market demand with an FRPN value of 364 and was included in the Moderate-High (M-H) category caused by competitors and unstable market demand, this results in inventory of goods in the warehouse due to low demand and stock of goods is running low due to soaring demand, so the mitigation effort that can be done was Doing Demand Forecasting which had a preference value (Vi) of 0.6425.

The results obtained in this study are useful for the food crop supply chain, especially in XYZ Village as an improvement material in the management of agricultural supply chain risks, for further research can conduct more complete research to consumers, can add criteria in mitigation strategies, and can use integration methods others that make it easier to carry out activities, risk assessments, and mitigation strategies that can be carried out.

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