Assessment Of Risk As A Sustainable Coffee Supply Chain Strategyon Rural Area In Jember Regency

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ABSTRACT

Risk assessment is essential for effectively and efficiently evaluating and controlling risks in order to create a sustainable coffee supply chainThe goal of this research is to identify the factors that influence quality risk and risk mitigation in small-holder coffee. The ANP method is used to identify the cause of a problem in the smallholder coffee supply chain by taking into account the occurrence criteria (O), severity (S), and detection (D). Data is gathered through interviews with expert respondents and experts from farmers, cooperatives, agro-industries, researchers, and academics who have been involved in the coffee agro-industry for at least ten years. The analyses' findings reveal a structural model for identifying and prioritizing risks by identifying six factors and 16 sub-factors. According to the findings of this study, farmers' knowledge and skills in terms of cultivation techniques are the main risks of relative importance in the coffee supply chain and thus require attention. Mitigation efforts that can be taken include improvements to cultivation that focus on the management of pests and diseases of coffee plants, as well as technical education and training. Factors that prevent farmers from accessing and implementing training must be considered so that knowledge and skills can be effectively provided.

Keywords: *coffee, supply chain, risk assessment, strategy*

INTRODUCTION

Jember Regency is one of the centers of Robusta coffee. Robusta coffee production in this region in 2010 was 3,120 tons with a plantation area of 5,608 ha (Directorate General of Plantations, 2011). Silo District is one of the areas located on the slopes of the Raung mountain Jember which has a total Robusta coffee production of 788.58 kw with a harvested area of 2.133 Ha in 2020, consisting of 1314.30 Ha of mature plants and 279.34 Ha of immature plants. The projected demand for robusta coffee from Jember Regency increases from year to year. However, unbalanced supply and low quality cause farmers' income to decline. Various levels of fruit ripeness, stripping harvest technique, poor post-harvest handling, high physical contaminants, there are triggers low coffee quality. Other factors such as conflicts between production systems and environmental aspects are still ongoing, The emergence of social conflicts in the production system with the surrounding community.

Some of these phenomena can be an obstacle to the development of Agroindustry and Coffee supply chain in Jember. This condition is a risk and causes losses for every member of the coffee supply chain. Therefore, it is necessary to analyze the risk of coffee supply chain using the ANP and FMEA methods. The purpose of this study is to evaluate and control the risk of an effective and efficient robusta coffee supply chain, especially smallholder coffee in Silo District, Jember.

This research is divided into three steps, namely risk identification, risk analysis and formulation of risk control. Risk identification aims to determine the criteria that will be used as a reference in data processing using ANP (Analitycal Network Process). The risk identification stage is carried out using a Focus Group Discussion (FGD) approach. The risk assessment stage uses the ANP method and is used as a reference for risk control recommendations using WFMEA (Weighted Failure Mode and Effect Analysis). Risk control is the next stage after risk identification and grouping based on the level of risk.

The supply chain that requires a lot of processes, ranging from material suppliers, production, customer demand, transportation, warehousing, distribution, so it requires high assistance in its management. At each process in the supply chain, risks occur (Jaya, 2014).

The Small holder coffee business is currently developing, but faces various problems related to the low product, low productivity, comparing prices between farmers and agro-industries and increasing information on the need for inter-coffee needs in the supply chain (Putra et al, 2019).

These problems can cause problems with the supply of raw materials, prices, and supplies for farmers, traders and coffee agro-industries that can support the competitiveness of Small holder coffee coffee. Therefore it is necessary to anticipate and mitigate efforts to reduce these risks.

Risk is the uncertainty of future events, in other words, risks are those that occur both internally and externally that are negative towards the achievement of organizational goals in the future (Wu and Blackhurst, 2009). Risk also determines as an impact of environmental and financial processes that are issued (Wibowo et al., 2014). To avoid and reduce the impacts arising from risks there needs to be a mitigation scenario prepared based on the risk specifications associated with the Small holder coffee coffee supply chain.

Risk is the possibility of an event resulting in a loss when the event occurs for a certain period of time. Risks can be prevented if managed by transferring them to other parties, avoiding risks, reducing the negative impacts of risks, and accommodating the consequences of these risks (Fahrudin, 2015). Risk management is a systematic approach used to determine quality management policies, procedures and practices based on risk assessment, risk control, and risk evaluation (Sijabat, 2012). In general, risk management is a tool or instrument used to control or reduce risk (Darmawan, 2004).

The concept of Supply Chain Risk Management, in this study was adopted from the definition given by Ho et al. (2015) based on a study they have done from journal articles in the field of supply chain risk management. They define supply chain risk management as "collaborative efforts between organizations that use quantitative and qualitative risk management methods to identify, evaluate, mitigate, and monitor unexpected and micro-level events or conditions that may have a detrimental impact on each part of the supply chain". The purpose of supply chain risk management is to control, monitor and evaluate supply chain risk by optimizing actions to prevent disruption and recover quickly. Supply chain risk management also has a large influence on the stability of dynamic cooperation among supply chain partners and is thus very important for the overall performance of supply chain operations (Khan and Burnes, 2007). Giannakis and Papadopoulos (2016) stated that the process of risk management in the supply chain includes several things, namely: risk identification, risk assessment and priority setting, risk management actions, and risk monitoring.

According to Prawitasari (2020), the steps in the coffee quality risk modeling process are risk identification, risk assessment, and determination of risk mitigation alternatives. A good management decision in managing risks must begin with understanding and prioritizing the risks experienced by all members of the supply chain through identification. Identification of the source of risk, making decision-makers aware of the phenomenon that causes uncertainty (Astuti et al., 2013). Risk assessment requires the loyalty and accuracy of the entire supply chain (Hadiguna, 2012). FMEA is a powerful and effective analytical tool and has been widely used to assess the relative importance of risks, identify the causes and potential effects of risks and examine the potential correlations between identified risks (Giannakis and Papadopoulos, 2016). FMEA was first applied to aerospace industry research in the mid-1960s which focused on safety issues such as improving safety, preventing defects and increasing customer satisfaction (Mc Dermott et al., 2009). In its development, FMEA is also used in risk assessment in various industries (Liu et al., 2013). In the FMEA process, all potential failures are evaluated in three dimensions of risk: likelihood (Occurrence), severity (Severity) and the ability to detect (detectability). Then the Risk Priority Number (RPN) is calculated for each potential failure. A higher RPN score implies a greater risk (Curkovic et al., 2013).

In previous studies FMEA implementation for supply chain risk assessment has been widely carried out both industry and agricultural supply chains (Anin et al., 2015; Bradley, 2014 ;; Curkovic et al., 2013; Giannakis and Papadopoulos, 2016; Jaya et al., 2014; Slamet et al., 2017). Jaya et al. 2014) examines the most influential risk factors and determines their mitigation in the Gayo coffee supply chain using the Fuzzy AHP approach. Raab et al. (2013) developed a study for risk categorization, systematization, identification, and evaluation of failures in the context of implementing a proactive risk management system in the global value-added chain for fruits and vegetables. In their research, FMEA is used to identify product-specific risk categories, assess risks (based on supplier country, company and process steps) and to rank potential hazards using a risk priority number then a mitigation strategy is tested. Anin et al. (2015) also conducted a study evaluating pineapple supply chain networks in Ghana using the Pareto analytical model with FMEA. This approach is applied to identify risks, analyze risks and then classify based on the level of impact on operational activities. Mitigation strategies are then developed to deal with risks. They found that lack of good planting material, availability of skilled labor, fluctuations in electricity, pre-cooling facilities and ineffective cold chains were the main risks faced by most pineapple supply chain actors in Ghana. However, each commodity supply chain has different risks and risk factors. Therefore it is necessary to identify risks in the coffee supply chain.

Prawitasari (2020) states that risk analysis and evaluation is generally carried out using the Failure Mode and Effects Analysis (FMEA) method, which is a method used to identify potential failures of a product or service. The FMEA method assesses risk to eliminate or minimize the risk of failure, without considering the relationship of alternative interests to the control plan. So to calculate the weight of each risk and its relationship to risk control for each member of the supply chain actor, he uses the integration between the ANP and FMEA methods to build a Risk Potential Identification model in the Ijen Coffee Supply Chain in Bondowoso Regency.

Liu et al. (2013) state that the FMEA method has shortcomings, based on the summary of various risk measurement models from various articles. One of FMEA's weaknesses is that it does not consider the relative importance of the three risk dimensions, these three risk factors are considered to have the same importance. Different combinations of the three risk dimensions can also produce identical RPN values, for example, LOO (RPN_1 = 10 (S) x 5 (O) x 2 (D), RPN_2 = 1Qx2x5) which can lead to the conclusion that priorities for corrective actions are applied to two the risk component is the same (Xiao et al., 2011). Although the risk implications of the two events may be different due to different levels of severity and failure. The example shows that FMEA is not strong enough in the priority mode of failure. Therefore, an important role in the critical analysis is the proper assessment of the weight of risk factors because they can influence the failure mode ranking (Slamet, et al., 2017).

Some authors propose an alternative method to increase the significance of the RPN, which is to combine the traditional FMEA Method with Multi-Criteria Decision Making (MCDM). Chang et al. (2001) have applied gray theory to FMEA to improve product reliability and process stability during the product design and process planning stages. Braglia et al. (2003) presented a fuzzy technique for Order Preference with Similarity to the Ideal Solution (TOPSIS) approach to prioritizing failures in failure modes, effects and critical criticality analysis (FMECA). Seyed-Hosseini et al. (2006) propose an alternative multi-attribute decision-making approach called the Decision Making Trial and Evaluation Laboratory (DEMATEL) method to reprioritize failure modes in the FMEA system for corrective action. Liu et al. (2012) used the extended VIKOR method under a fuzzy environment to give priority to the FMEA method. The Analytic Hierarchy Process (AHP) combined with FMEA was applied in several cases by (Braglia, 2000; Chen and Wu, 2013; Davidson and Labib, 2003; Jaya et al., 2014; Zhong and Lin, 2013). In a further development, Slamet et al. 2017 in its publication applied the fuzzy ANP approach with FMEA for risk assessment in the coffee supply chain. This study proposes using this method to assess the risk of the Kopi Rakyatcoffee supply chain.

METHOD

Research framework: The research methodology consists of several sequential phases to assess coffee supply chain risk based on processes within the supply chain risk management framework. The first phase is the identification of supply chain risk, which is the basis of risk management to recognize future uncertainty. This phase identifies potential problems according to all members of the supply chain (Astuti et al., 2013). This study, integrating risk assessment for identification, fuzzy ANP to identify and determine the relative importance of coffee supply chain risk factors.

The second phase includes risk assessment using FMEA. All risks identified in the first phase are assessed in terms of the likelihood of their occurrence and the impacts or consequences that may result. Then proceed with the calculation of RPN based on three dimensions of risk.

The third phase of the RPN is calculated by weighting the risk factors obtained from the fuzzy ANP which gives a weighted RPN. The multiplication of these components enables the prioritization of risk factors to determine management actions that are deemed most appropriate to the coffee supply chain situation. The research framework is shown in Figs. 1

Data is collected based on in-depth interviews with expert respondents/experts representing members of the supply chain and come from farmers, traders, agro-industries, researchers, academics with qualifications that have been in the minimum 10 years in the coffee agro-industry. In this study, expert farmers were selected from the Farming Group of Sidomulyo Vilage, representing wholesale and retail supply chain managers at Silo District and researchers from the Coffee and Cacao Research Center and academics from the university. The questionnaire consists of two parts, the first part contains questions related to supply chain risks and the second part contains questions for risk assessment. An ANP survey was then conducted aiming to evaluate the comparison of perceived criteria for supply chain risk factors. Risk assessment is then measured according to supply chain risk criteria using FMEA.

Fuzzy logic is a logic that has a value of blurring or blurring (Fuzyness) between right and wrong. The purpose of the Fuzzy approach is to equate a notion of a set and problem to accommodate the type of obscurity in some problems in decision making (Badiru, Cheung 2002). Fuzzy Analytical Network Process: ANP introduced by Saaty in 1996, is a generalization of AHP (Saaty, 2008). The AHP model assumes a simple hierarchical relationship between decision levels. The ANP method allows for more complex interaction dependencies within clusters (internal dependencies) and between clusters (external dependencies) through the development of supermatrix (Chang et al., 2015; Dagdeviren et al., 2008). ANP uses the same method as AHP, which uses a fundamental comparison scale (1-9) to assess the preferences of decision-makers, except in the case of fuzzy representations, Triangular Fuzzy Numbers (TFN) is used (Mabanti and Kaur, 2008). The Fuzzy Set Theory (FST) was introduced by Zadeh (1965) to deal with uncertainties in the human valua tion process because of inaccuracy and obscurity. Decision-makers usually measure uncertain events and objects using unclear language, such as 'equal', 'sufficient', 'very', 'very strong', 'absolute' and 'significant level'. FST allows them to solve the problem of ambiguity involved in the process of linguistic assessment of data (Onut et al., 2011).

In this study, it is proposed to combine FST concepts with the ANP Method. Fuzzy ANP has been recognized as a well-accepted technique for adequately addressing the limitations of conventional ANP in the decision-making process (Buyukozkan et al., 2004; Dagdeviren et al., 2008; Shafiee, 2015; Valipour et al., 2015). The fuzzy set is then determined by the membership function which will assign each membership level object which ranges between 0 and 1 (Dagdeviren et al., 2008). Fuzzy triangle numbers (M), as shown in Fig. 2, defined as (1, m, u), where ls m su. Parameter 1 represents the smallest possible value, parameter m represents the most promising value and parameter u represents the largest value that represents a fuzzy event. The TFN membership function can be defined as follows:

$$\mu(xlrYi) = \begin{cases} 0 & x<l \\ (x-l)/(m-1) & l<x<m \\ (\mu-x)/(\mu-m) & m<x<\mu \\ 0 & x>\mu \end{cases} \qquad (1)$$

Fuzzy numbers can be given by the left and right that are appropriate for each level of membership:

$$M = \left[M^{t(y)}, M\hat{\ }r(y)\right] = \left[1 + (m-u)Y, u + (m-u)Y\right] \qquad (2)$$
$$y \in [0,1]$$

Where l (y) and r (y) represent the left and right sides of the fuzzy number, respectively. Definitions and detailed discussion of arithmetic operations on fuzzy triangles can be found in Kahraman et al. (Kahraman et al., 2002). Furthermore, in designing the relative importance scale to construct a pairwise comparison/evaluation matrix, TFN was used to improve the classical nine-point scaling design. Fuzzy linguistic scale regarding relative importance to measure relative weight (Kahraman et al., 2006) is given in Fig. 3 and Table 2.

In this paper, we use the fuzzy ANP method which will determine the important weighting of the nks in the coffee supply chain. Important elements of the integration of ANP and fuzzy set theory are as follows:

- Identify the coffee supply chain risk factors and sub-factors that will be used in the model.
- Structuring of the ANP model (targets, risk factors, risk sub-factors)

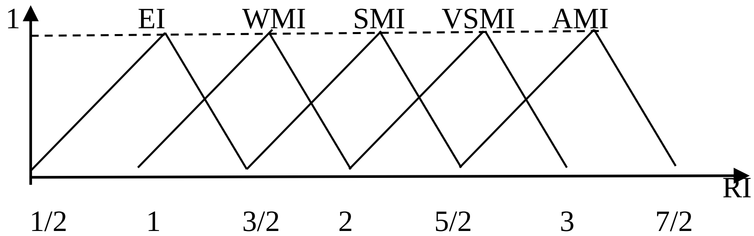
Determine the local weighting of risk factors and sub-factors using a paired comparison matrix (assumption: there is no dependency between factors). In this step, it is necessary to collect fuzzy numbers into crisp values using the Extent Chang Analysis method. Compared to other approaches, this method is easier and has been widely accepted to calculate the weighting of fuzzy aggregate importance for the evaluation matrix in pairs of fuzzy inputs (Mangla et al., 2014). The details of Chang's area analysis method calculation (Chang, 1996) are: if the area analysis value for the i-th object is represented by, $m_{gi}^1, m_{gi}^2, m_{gi}^3$ ... where (i = 1,2,3,4, ... n) and all, m_{gi}^j (j = 1,2,3,4, ...) is TFN (j = 1, 2, 3, ..., m), then the appropriate fuzzy synthetic level is represented as:

$$S_i = \sum_{i=1}^{n} M_{gi}^j \left[\sum_{i=1}^{n} \quad \sum_{r=1}^{m} \quad M_{gi}^j\right] \qquad (3)$$

The values for a particular matrix are then carried out to obtain

$$\sum_{j=1}^{m} M_{g1}^i$$

Figure 3 Linguistic scale of Relative Importance (RI)



(Slamet et al., 2017)

Figure 4 Representation of intersection between Ml and M2

$$\sum_{i=1}^{n}\sum_{j=1}^{m} M_{gi} = \left(\sum_{j=1}^{m} L_j, \sum_{j=1}^{m} M_j, \sum_{j=1}^{m} \mu_{i_i}\right) \qquad (4)$$

And the Fuzzy addition operation of M_{gi}^j ; j = 1,2,3, … m

Value are performed toobtain $\left[\sum_{i=1}^{n}\sum_{j=1}^{m}\sum_{g=1}^{l} \quad \right]$

$$\sum_{i=1}^{n}\sum_{j=1}^{m} M_{gi}^j = \left(\sum_{i=1}^{n} L_i, \sum_{i=1}^{n} M_i, \sum_{i=1}^{n} \mu_i\right) \qquad (5)$$

and then calculate the inverse of the vector in Equation ...

Formula 6

$$\left[\sum_{i=1}^{n}\sum_{j=1}^{m} M_{gi}^j\right] = \frac{1}{\sum_i^n u_i}, \frac{1}{\sum_i^n m_i}, \frac{1}{\sum_i^n l_i} \qquad (6)$$

Next, taking into account the minimum and maximum values for fuzzy numbers, the degree of probability for two fuzzy numbers M2 = (12, m., U2) .; ::, M1 = (11, m., U.) Represented as:

$$v\,[M_2 \geq M_1] = \sup\left[\min\left(\left(\mu_{M1}\right)(X), \left(\mu_{M2}\right)(Y)\right)\right] \quad \text{where} \quad (7)$$

$$x, y \in R \ and \ x > Y \ where \ X, y, R \ and \ X, Y$$

It is noted that, if x, Y and uMi (x) = uMi (y) = 1, then V (M2 ≥ CM1), because M2 and M1 are two convex fuzzy numbers, it satisfies the properties mentioned as:

$$v(M_2 \geq M_1) = 1 \ if \ m_2 \geq m_1 \qquad (8)$$

$$v(M_2 \geq M_1) = 1 \ if \ m_2 \geq u_1 \qquad (9)$$

$$v(M_2 \geq M_1) = hgt\,(m_1 \cap m_2) \qquad (10)$$

$$= \mu\, M_2(d)$$

where, d is the highest intersection point D between μM, and μM, (Fig. 4) and subsequently, D is given as: (formula 11)

$$v\ (M_2 \geq M_1) = hgt\ (M_1 \cap M_2) \quad (11)$$
$$= (i_1 - \mu_2) - (m_2 - \mu_2) - (m_1 - \mu_1)$$

We need both of values $v = (M_i \geq M_j)$ and $v = (M1 \geq M_2)$ to compare M_1 and M_2. Next, the level of probability for fuzzy convex numbers M_i (1 = 1, 2, 3, ..., m) calculated as:

$$v\ (M \geq M_1, M_2, M_3, \ldots, M_k) = v\ [(M \geq M_1)\ and\ (M \geq M_2)\ and \ldots and\ (M \geq M_k)]$$
$$= \min v\ (M \geq M_i), i = 1,2,3, \ldots, k \quad (12)$$

Assuming that fork $d(A) = \min v\ (S_i \geq S_2)$ d (A,) = min $v\ (S_i \geq S_2)$ = 1, 2, 3, …, n; however, the weight vector is given by:

$$W = (d\ (A_1), d\ (A_2))^T \quad (13)$$

where, A_1 (l, 2, 3, ..., n) are n elements. After being normalized, the normalized fuzzy weight vector is given as:

$$W = (d\ (A_1), d\ (A_2), \ldots, d\ (A_n))^T \quad (14)$$

While 'W' is a non-fuzzy number. After that, by using the fuzzy scale (Table 2), then determine the dependency matrix in each of the risk factors to other risk factors. The dependency matrix in this is then multiplied by the local weights of the factors determined in step 3, to calculate the interdependent weights of these factors.

Calculate the global weighting of risk sub-factors. The global sub-factor risk weighting is then calculated by multiplying the local weighting sub-factor by the interdependent weighting of the factors it has.

Weighted FMEA and RPN: FMEA is defined as "a systematic method for identifying and preventing product and process problems before they occur" (McDermott et al., 2009). The relative risk of failure and its effect in the F.tvlEA process is determined by three dimensions:

- Severity (S): consequences of failure
- Occurrence (0): probability or frequency of failures
- Detection (D): the probability of failure is discovered before the effect occurs

Using data and knowledge about processes and products in the coffee business, this study then assessed each mode and potential failure effect with the dimensions mentioned on a scale of 1-10 (with 1 being the best and 10 being the worst case). Then the Risk Priority Number (RPN) is determined for each mode and the potential failure effect by multiplying the dimension rating as shown below:

$$RPN = S \times O \times D$$

Traditional RPN has limitations, to overcome this we use a weighted RPN (WRPN) value, which is determined using fuzzy ANP multiplied by the RPN value (Equation 16). Next, WRPN values will be used to sort the failure mode:

$$WRPN = RPN \times W_{FANP} \quad (16)$$

Failure modes with higher WRPN values are assumed to be more important, thus higher priority will be given for corrective actions.

RESULTS AND DISCUSSION

The steps in the coffee quality risk modeling process are risk identification, risk assessment, and determination of risk mitigation alternatives. Based on in-depth interviews with experts, several criteria can reduce the quality of coffee beans.

Risk identification: The first and most critical step in the Supply Chains Risk Managament (SCRM) process is the identification of potential risks. Risks in the coffe supply chain have been identified in the literature review and expert interview stages and then validated with the actual situation of the coffee supply chain. This step involves identifying risks and factors in the coffee supply chain. Types of risks in this study include risks in the external environment, risks in the supply chain and internal risks (Lin and Zhou, 2011). Risks at the level of farmers and other members of the coffee supply chain can be grouped into six factors, namely: 1) Production risk (low coffee production due to poor cultivation practices, inappropriate management of pests and diseases, improper application of planting procedures, lack of technology and human risk); 2) Quality risks (inappropriate handling starts from the lack of supply of good quality agricultural inputs, processing and post-harvest activities); 3) Market risk (product volatility, uncertainty of inputs and demands and market competition); 4) Supply risk (inability to supply uniform product quality, loyalty in terms of supplier-buyer relations and continuity of supply quantities); 5) Distributtion and Storage risks (originating from poor infrastructure, failing to choose appropriate transportation and improper packaging and handling of storage). 6) Social and environmental risks (unexpected weather changes, governance Effectiveness/ regulations, socio-cultural and political conditions); Besides, the ANP potential risk model consists of three levels as shown in Figure. 5

The first level of this model aims to determine coffee Kopi Rakyatsupply chain risk weighting sub-factors. Second and third level factors and sub-factors are also related to objectives at the first level. The second level 1 factor is connected to the first level goal with a single directional arrow. While the other arrows on the second level represent deep dependence among factors. The inner dependence between markets, quality, environment, supply, production, and transportation, which is at this level is taken into account and with this, the effects of each other's factors are analyzed. Sub-factors related to factors are at the third level of the model.

Risk Assessment: After identifying the risks and structuring of the ANP Model, the degree of importance of each factor and sub-factors at the second and third level of the ANP Model is determined. Their local weights are then determined by conducting a pairwise comparison matrix conducted by the expert using the scale given in Table 2. For example, the expert is asked: "With respect to objectives, how important is the market compared to quality?" and the answer "weak is more important". Thus, the linguistic scale is placed in cells that are relevant to TFN (1, 3/2, 2). Similar questions are also asked to formulate all fuzzy evaluation matrices. The importance of factor weights is then calculated using the Extent Chang Analysis method using Eq. 3-15. The corresponding M_i value can be calculated through Eq. 3-6, then the probability level for two fuzzy numbers is calculated using Equation 7-12.

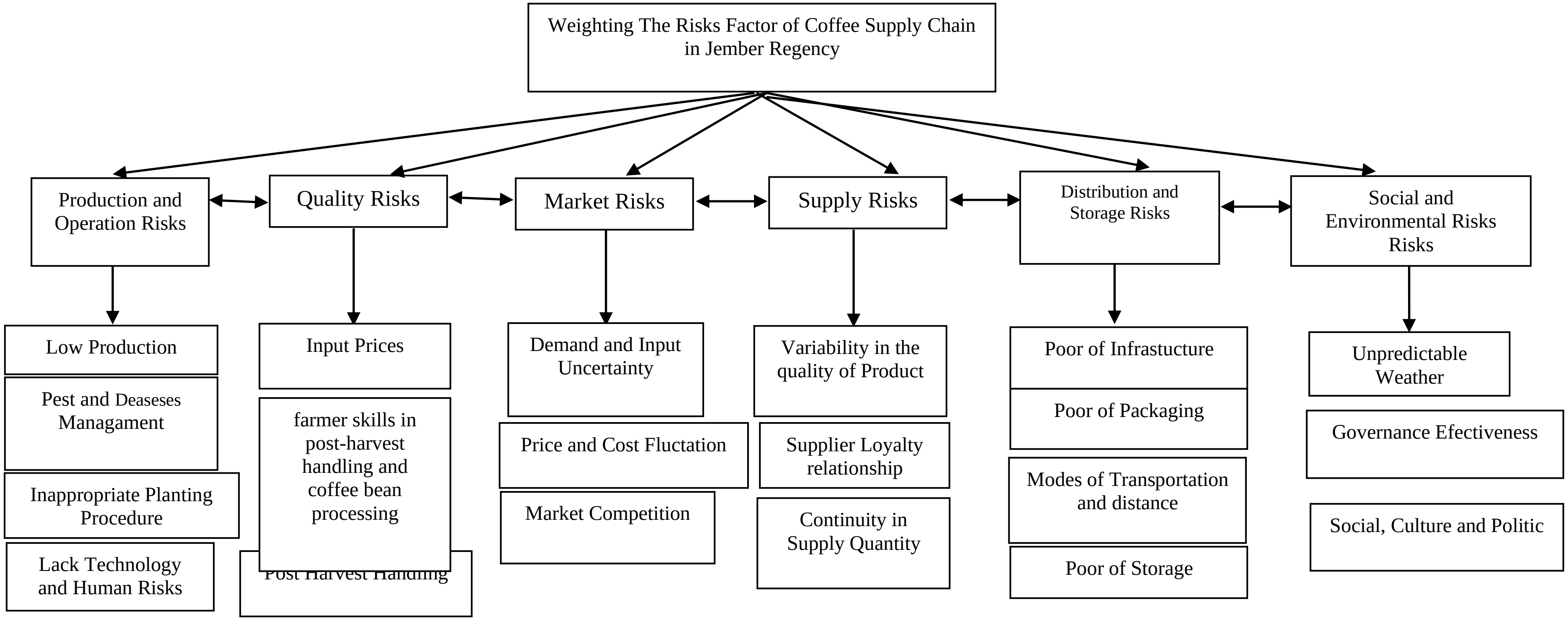


Figure 5. ANP Model Of Identification Potential Risk For Coffee Supply Chains in Jember

Table 1: Category of Risk factors and sub-factors

No	Risk Factor	Sub Factor	Sources (References)
1.	Production and Operation Risks	Low Production	Low production of coffee due to the poor agricultural practices
		Pest and Deaseses Managament	Pests and diseases have been shown to be very important factors in reducing yield and marketability of coffee (expert's opinion)
		Inappropriate Planting Procedure	Inappropriate procedure of planting causes flower of coffee had not been pollinated and therefore failed to develop into a fruit (expert's opinion)
		Lack Technology and Human Risks	Lack of technology and innovation, rural exodus and lack of training programs offarmer (expert's opinion)
		Farmer Knowledge in cultivation practice	Variation of personal skill and lack of knowledge off armer (Astuti *et al.*, 2013)
2.	QualityRisks	Input prices	Coffee quality is affected by availability of affordable inputs (expert's opinion)
		Post Harvest Handling	Inappropriate practices in harvesting, field handling, sorting, grading, postharvest treatments, and packing have a great impact on maintaining the optimum organoleptic, nutritional, and functional quality attributes of the coffee fruit (Sivakumar and Wall, 2013)
3.	Market Risks	Demand and Input Uncertainty	Variability and distortion of information about demand makes it difficult for retailers to expect long-term consumer demand (Anin *et al.*, 2015)
		Price and Cost Fluctuation	Fluctuations in product prices are caused by oversupply, reduced demand and other factors related to inflation, changes in interest rates, changes in currency values, etc. (Akcaoz, 2012)
		Market Competition	Competition with other fruits in availability, price and quality of products (expert's opinion)
4.	Supply Risks	Variability in the quality of Product	Branding of agriculture product is widely considered to be difficult because of the variability in quality of the product and irregularity of supply (Richards, 2000)
		Supplier Loyalty relationship	Failures in managing and maintaining loyal suppliers offers a number of disadvantages including inconsistent supplies, higher transaction costs, inefficiency and increased post-harvest losses (expert's opinion)
		Continuity in Supply Quantity	Shortage of shipment capacity, shortage of products in distribution center, lead time uncertainties and delay in delivery (Pujawan and Geraldin, 2009)
5.	Distribution and Storage Risks	Poor of Infrastucture	Agricultural supply chains increasingly face risks related to logistics and infrastructure, (e.g. access to asphalt road, lacking communication infrastructures), that affect the availability and timing of goods and services (Anin *et al.*2015)
		Poor of Packaging	Since coffees are highly sensitive to mechanical damage, proper packaging are needed to reduce damage, improve marketability and prolong shelf-life of coffee fruits
		Modes of Transportation and distance	Inappropriate use of transportation modes and long shipping distances, will cause quality degradation, increase transportation costs and problems along the supply chain (expert opinion) (expert's opinion)
		Poor of Storage	Due to the climacteric fruit characteristics, non-optimal temperature of storage will causes coffee can be ripened to the undesired level (Paull *et al.*, 1997)

		Poor of Storage	Due to the climacteric fruit characteristics, non-optimal temperature of storage will causes coffee can be ripened to the undesired level (Paull *et al.*, 1997)
		Unpredictable Weather	Non-extreme weather events (e.g., too much or little rainfall, or too high or low temperatures) often affect agricultural supply chains for a single production cycle (expert's opinion)
6.	Social and Environmental Risks	Government Effectiveness	Government policy and institutional risks have major direct and indirect impacts on shaping incentives and decision-making in agricultural supply chains (Astnti *et al.*, 2013)
		Social, Culture and Politic	changes in consumer attitudes, changes in trade relations, levels of farmers' welfare and health, risks related to security, etc. (Expert opinion)

Table 2. Local Weights And Pairwise Comparison Matrix Of Main Factor

Factors	Production	Quality	Market	Supply	Distribution	Social And Environment	Local Weights
Production	(1/2, 2/3, 1)	(1, 3/2, 2)	(1, 3/2, 2)	(2/3, 1, 2)	(1, 1, 1)	(1, 3/2, 2)	0.1887
Quality	(1/2, 2/3, 1)	(1, 1, 1)	(1/2, 1, 3/2)	(1/2, 2/3, 1)	(1/2, 2/3, 1)	(2/3, 1, 2)	0.1330
Market	(1, 1, 1)	(1, 3/2, 2)	(3/2, 2, 5/2)	(1/2, 1, 3/2)	(1, 3/2, 2)	(3/2, 2, 5/2)	0.2266
Supply	(2/3, 1, 2)	(1, 3/2, 2)	(1, 3/2, 2)	(1, 1, 1)	(112, 1, 3/2)	(3/2, 2, 5/2)	0.2069
Distribution	(2/5, 1/2, 2/3)	(1/2, 1, 3/2)	(2/3, 1, 2)	(2/5, 1/2, 2/3)	(1/2, 2/3, 1)	(1, 1, 1)	0.1187
Distribution	(2/5, 1/2, 2/3)	(1/2, 1, 3/2)	(2/3, 1, 2)	(2/5, 1/2, 2/3)	(1/2, 2/3, 1)	(1, 1, 1)	0.1187
Social And Environment	(2/5, 1/2, 2/3)	(2/3, 1, 2)	(1, 1, 1)	(1/2, 2/3, 1)	(1/2, 2/3, 1)	(1/2, 1, 3/2)	0.1261

Table 3. Weight Of Factors And Sub-Factors Based On Expert Assessment

Factors	Weights of factor	Sub-factors	Weights of sub-factors	Global weights
Production	0.1779	Low Production	0.1330	0.0237
		Pests and diseases	0.2266	0.0403
		Inappropriate planting procedure	0.1330	0.0237
		Lack of technology	0.1261	0.0224
Quality	0.1676	Input Prices	0.3333	0.0559
		farmer skills in post-harvest handling and coffee bean	0.3333	0.0559
		processing	0.3333	0.0559
Market	0.1965	Price and cost fluctuations	0.0970	0.0191
		Demand uncertainty	0.5584	0.1097
		Market competition	0.3446	0.0677
Supply	0.2080	Variability of product wuality	0.0970	0.0202
		Supplier loyalty	0.5584	0.1161
		Continuity of supply	0.3446	0.0717
Distribution	0.1219	Poor of infrastructure	0.2266	0.0276
		Packaging	0.1330	0.0162
		Modes of transportation and distance	0.1261	0.0154
		Storage during shipment	0.1187	0.0145
Social and environment	0.1280	Weather related risks and natural disruptions	0.4572	0.0585
		Governance Effectiveness	0.0857	0.0110
		Social, culture and politic	0.4572	0.0585

The minimum weight vector calculated is then operated to obtain the normal value and the weight vector using Eq. 14. As a result, weighting vectors for risk factors (eg, 0.2266, 0.1330, 0.1261, 0.2069, 0.1887 and 0.1187) were established (Table 3). In the same way, the importance of weights for subfactors has been calculated. All important weights calculated for factors and sub-factors are given in Table 4.

In the next step, the weights of the interdependent factors are calculated taking into account dependencies among the factors. Pairwise comparisons are used to analyze the impact of each factor on other factors to determine the dependency between these factors. Therefore, the following question is asked to experts "What is the relative importance of 'quality' when compared to "social and environmental" concerning market risks? "and the answer" Very more important "is changed to TFN (3/2, 2, 5/2) as stated in Table 5.

Table 4. The Interdependent Weights of Risk Factor

Factors	Respect to	Local Weights
Quality	Production	0.2224
Market		0.760
Supply		0.2114
Distribution		0.1681
Social and Environment		0.2203
Production	Quality	0.2611
Market		0.1046
Supply		0.2687
Distribution		0.2141
Socian and Environment		0.1253
Production	Market	0.1874
Quality		0.2713
Supply		0.0975
Distribution		0.1116
Socian and Environment		0.4152
Production	Supply	0.2351
Quality		0.2351
Market		0.2260
Distribution		0.1642
Socian and Environment		0.1668
Production	Distribution	0.1743
Quality		0.1766
Market		0.2233
Supply		0.7885
Socian and Environment		0.3253
Production	Social and Environment	0.2366
Quality		0.2365
Market		0.1673
Supply		0.2285
Distribution		0.1516

This dependency matrix for these factors is formed using the relative importance weights calculated from the previous step. Next, the matrix is multiplied by the local weights of the main factors in Table 4.

Then we calculate the weights of the interdependent factors. As for the results of these calculations are as follows:

$$\begin{bmatrix} 0.1668 \\ 0.1477 \\ 0.1784 \\ 0.2161 \\ 0.1318 \\ 0.1279 \end{bmatrix}$$

The results of weighting between factors indicate that there are significant differences when compared to weighting factors without regard to other factors as in Table 4. Weight changes from 0.1874 to 0.4152 for market factor weights, 0.1330-0.1676 for quality factor weights , 0, 024-0.1280 for social and environmental factors, 0.2069-0.2080 for supply weight, 0.1887 to 0.1777 for production; 0.1187-0.1219 for the distribution factor. Next, we calculate global weights for sub-factors by multiplying local weights by sub-factors with interdependent weights of each risk factor. After the weighted factors are verified and the weighted sub-factors are calculated, the risk rating is identified in this study by considering the RPN results from the FMEA process.

RPN value is a combination of product value from the severity, appearance, and detection. For risks related to "farmers' knowledge in cultivation practices", the severity is 7, the occurrence is 8, detection is 7, so the RPN value is 8 x8 x7 = 392. Example Sub-factor weighting, then calculated by multiplying the RPN value by weight sub-factor, for example, Ri from "farmers' knowledge in cultivation practices" and obtained values of 392x0,0559 = 20,2358. The overall results of each Ri are shown in Table 5 below.

A higher RPN weighting indicates a risk with a higher mitigation priority. To determine the focus of risk mitigation, the Pareto Principle is used with the idea that by reducing 20% of risk, we can produce 80% of risk mitigation benefits. While the RPN weighted cumulative weighted from the risk rating, shows the value of "Risk farmers' knowledge of cultivation practices is 21.9128%. This means that mitigation must focus on increasing farmers' knowledge and skills in terms of coffee cultivation techniques, so that the benefits of risk mitigation can be obtained entirely.

The results of this study are in accordance with the findings of Prawitasari (2020) who conducted a risk assessment on the Ijen Arabica coffee supply chain which showed that the quality risk in the farmer skills knowledge sub-factor is the factor that has the highest risk. , while supply risk in the Continuity of supply sub-factor is ranked second as a high-risk factor for the quality of Ijen arabica coffee in Bondowoso Regency. Likewise, the results of this study are in accordance with the findings of Yulian (2018) which assesses risk in the coffee supply chain in Bangsalsari, Jember Regency, the results of the WFMEA calculation show that quality risk ranks first with WRPN 222.45, and risk production is in second place with WRPN 116, 35.

Based on these risk categories, it can be interpreted that to control supply risk, risk needs to be avoided and quality risk must be carried out in the form of risk mitigation or needs to be eliminated. Efforts that can be made to control quality risk and supply risk are to motivate farmers to consistently apply good post-harvest handling techniques for coffee beans, as well as increase farmers' knowledge and skills in post-harvest handling and good coffee processing practices.

Technical training is one alternative to reduce risk priorities. If farmers have better knowledge and skills in terms of post harvest handling, they will also follow proper good practice post harvest handling procedures, be able to handle pests and diseases of coffee bean and can control coffee bean quality. Thus it will be able to achieve increased production and reduce coffee quality variability. Expanding knowledge and technology plays an important role in increasing production and detecting risks to future productivity arising from climate change. High coffee production is likely to guarantee the availability of raw materials and continuity of supply. Other efforts to increase production in the future are to encourage the involvement of private sector institutions and strengthen coordination between producers and management instructors. Coordination will combine business knowledge and skills to develop the ability of farmers to handle post-harvest products and create competitive advantage. Besides technical training for farmers, they can be equipped with life skills (for example, social and legal awareness) to increase farmers' awareness of how to become loyal suppliers in a coffee supply chain.

Table 5: Risk Assesment of Factor and Sub Factor

Factors	Sub-factors	O	S	D	RPN	Global weights	Wighted RPN	Rank
Production	Low Production	4	4	4	64	0.0237	1.5168	16
	Pests and diseases	5	5	6	150	0.0403	6.045	7
	Inappropriate planting procedure	5	7	6	210	0.0237	4.977	9
	Lack oftechnology	8	4	3	96	0.0224	2.1504	20
Quality	Input Prices	3	8	4	96	0.0559	5.3664	8
	farmer skills in post-harvest handling and coffee bean processing	8	7	7	392	0.0559	21.9128	1
	Postharvest handling	5	6	8	240	0.0559	13.416	3
Market	Price and cost fluctuations	3	4	3	36	0.0191	0.6876	18
	Demand uncertainty	4	2	3	24	0.1097	2.6328	12
	Market competition	5	6	5	150	0.0677	10.155	5
Supply	Variability of product wuality	8	6	5	240	0.0202	4.848	11
	Supplier loyalty	5	5	3	75	0.1161	8.7075	6
	Continuity of supply	6	6	6	216	0.0717	15.4872	2
Distribution	Poor of infrastructure	5	5	3	75	0.0276	2.07	14
	Packaging	5	5	4	100	0.0162	1.62	17
	Modes of transportation and distance	2	3	3	18	0.0154	0.2772	19
	Storage	5	6	6	180	0.0145	2.61	13
Social and environment	Weather related risks and natural disruptions	2	5	3	30	0.0585	1.755	4
	Governance Effectiveness	5	7	5	175	0.0110	1.925	15
	Social, culture and politic	4	4	5	80	0.0585	4.68	10

CONCLUSION

The development of the smallholder coffee supply chain, like other agricultural products, is strongly influenced by the potential for uncertain risks. In this study, an attempt was made by the Kopi Rakya tto develop a structural model to identify and prioritize risks, by identifying six factors and 20 sub-factors using FMEA and determining the relative weights using Fuzzy ANP, as the framework carried out in this study. This study has the following main points: First, this model shows the potential benefits of detecting high risk priorities in the Small holder coffee coffee supply chain systematically and effectively. Second, this study combines the FMEA and Fuzzy ANP methods to assess the risk of the Small holder coffee coffee supply chain which is difficult to find in previous studies. Fuzzy ANP methodology is very important in determining the importance of risk factor weights. Whereas the FMEA method can be used to assess risk factors in three dimensions: incidence, severity, and detection ability. Weights obtained from the ANP fuzzy method are then used as input to determine the weight of the RPN in multiplication with the RPN value of the FMEA technique. Risks are then sorted by weighted RPN value to determine priority risks that need to be reduced. The results of this study reveal that farmers' knowledge and skills in terms of cultivation techniques are the main risks inherent in the Small holder coffee coffee supply chain and thus require attention. Technical education and training is one alternative to reduce this risk. Factors that prevent farmers from accessing and implementing training must be considered so that the provision of knowledge and skills can be carried out effectively.

REFERENCES

Akcaoz, H, Risk *Management in Agricultural Production: Case Studies from Turkey. In: Risk Assessment and Management*, Zhang, Z. (Ed.). Academy Publisher, New York, USA., pp: 480-505. 2012

Anin, E.K., O.F. Alexander and D.E. Adzimah, *Managing supply chain risks: A perspective of exportable pineapple fresh fruits in Ghana*. Eur. J. Bus. Manag., 7: 59-71, 2015

Astuti, R., M. Marimin, Y. Arkeman, R. Poerwanto and M.P. Meuwissen, . Risks and risks mitigations in the supply chain of mangosteen: A case study. *Int. J. Opr. Supply Chain Mgmt*, 6: 11-25, 2013

Borodin, V., J. Bourtembourg, F. Hnaien and N. Labadie,. Handling uncertainty in agricultural supply chain management: A state of the art. Eur. *J. Oper. Res*., 254: 348-359, 2016

Bradley, J.R.,. *An improved method for managing catastrophic supply chain disruptions*. Bus. Horiz., 57: 483-495, 2014

Braglia, M., MAFMA: Multi-attribute failure mode analysis. *Int. J. Qual. Rehab. Manag*., 17: 1017-1033, 2000

Braglia, M., M. Frosolini and R. Montanari, *Fuzzy TOPSIS approach for failure mode, effects and criticality analysis*. Qual. Rehab. Eng. Int., 19: 425-443, 2003

Buyukozkan, G., T. Ertay, C. KahramanandD. Ruan, Determining the importance weights for the design requirements in the house of quality using the fuzzy analytic network approach. *Int. J. Intell. Syst*., 19: 443-461, 2004

Chang, B., C. Kuo, C.H. Wu and G.H. Tzeng, *Using fuzzy analytic network process to assess the risks in enterprise resource planning system implementation*. Applied Soft Comput., 28: 196-207, 2015

Chang, C.L., P.H. Liu and C.C. Wei, *Failure mode and effects analysis using grey theory. Integrated Manufactur. Syst*., 12: 211-216, 2001

Chang, D.Y., *Applications of the extent analysis method on fuzzy AHP*. Eur. J. Oper. Res., 95: 649-655, 1996

Chaudhuri, A., B.K. Mohanty and K.N. Singh, Supply chain risk assessment during new product development: A group decision making approach using numeric and linguistic data. *Int. J. Prod. Res*., 51: 2790-2804, 2013

Chen, P. S. and M. T. Wu, *A modified failure mode and effects analysis method for supplier selection problems in the supply chain risk environment: A case study*. Comput. Ind. Eng., 66: 634-642, 2013
Curkovic, S., T. Scannell and B. Wagner, *Using FMEA for supply chain risk management. Mod. Manag*. Sci. Eng., 1: 251-265, 2013
Dagdeviren, M., I. Yuksel and M. Kurt, *A fuzzy Analytic Network Process (ANP) model to identify Faulty, Behavior Risk (FBR) in work system*. Safety Sci., 46: 771-783, 2008
Davidson, G.G. and A.W. Labib, Leaming from failures: Design improvements using a multiple criteria decision-making process. Proc. Inst. Mech. Eng. *J. Aerospace Eng*., 217: 207-216, 2003
Giannakis, M. and T. Papadopoulos, Supply chain sustainability: A risk management approach. Int. *J. Prod. Econ*., 171: 455-470, 2016
Hadiguna, R.A., Decision support framework for risk assessment of sustainable supply chain. Int. *J. Logistics Econ*. Globalisation, 4: 35-54, 2012
Hallikas, J., I. Karvonen, U. Pulkkinen, V.M. Virolainen and M. Tuominen, Risk management processes in supplier networks. Int. *J. Prod. Econ*., 90: 47-58, 2004
Ho, W., T. Zheng, H. Yildiz and S. Talluri, Supply chain risk management: A literature review. Int. *J. Prod. Res*., 53: 5031-5069, 2015
Hu, A.H., C.W. Hsu, T.C. Kuo and W.C. Wu, *Risk evaluation of green components to hazardous substance using FMEA and FAHP*. Expert Syst. Appl., 36: 7142-1747, 2009
Ilangkumaran, M., P. Shanmugam, G. Sakthivel and K. Visagavel, Failure mode and effect analysis using fuzzy analytic hierarchy process. Int. *J. Prod. Qual. Manag*., 14: 269-313, 2014
Jaya, R., Machfud, Rahardja, S., Marimin. Analisis dan Mitigasi Risiko Rantai Pasok Kopi Gayo Berkelanjutan dengan Pendekatan Fuzzy. *J. Teknologi Industri Pertanian* 24 (1): 61-71, 2014
Kahraman, C., D. Ruan and E. Tolga, *Capital budgeting techniques using discounted fuzzy versus probabilistic cash flows*. Inf. Sci., 142: 57-76, 2002
Kahraman, C., T. Ertay and G. Buyukozkan, A fuzzy optimization model for QFD planning process using analytic network approach. Eur. *J. Oper. Res*., 171: 390-411, 2006
Khan, 0. and B. Burnes, Risk and supply chain management: Creating a research agenda. *Int. J. Logistics Manag*., 18: 197-216, 2007
Lin, Y. and L. Zhou, The impacts of product design changes on supply chain risk: A case study. Int. *J. Physical Distrib. Logistics Manag*., 41: 162-186, 2011
Liu, H.C., J.X. You, Q.L. Lin and H. Li, Risk assessment in system FMEA combining fuzzy weighted average with fuzzy decision-making trial and evaluation laboratory. *Int. J. Comput. Integrated Manufacturing*, 28: 701-714, 2015
Liu, H.C., L. Liu and N. Liu, *Risk evaluation approaches in failure mode and effects analysis: A literature review. Expert Syst. Appl*., 40: 828-838, 2013
Liu, H.C., L. Liu, N. Liu and L.X. Mao, *Risk evaluation in failure mode and effects analysis with extended VIKOR method under fuzzy environment. Expert Syst. Appl*., 39: 12926-12934, 2012
Mahanti, N.C. and P. Kaur, A fuzzy ANP-based approach for selecting ERP vendors. *Int. J. Soft Comput*., 3: 24-32, 2008
Mangla, S.K., P. Kumar and MK. Barua, *Prioritizing the responses to manage risks in green supply chain: An Indian plastic manufacturer perspective. Sustainable Prod. Consumption*, 1: 67-86, 2014
McDermott., RE., R.J. Mikulak and MR. Beauregard, *The Basic of FMEA. 2nd Edn., Productivity* Press, New York, USA, 2009
Ministry of Industry. *Coffee Geographical Indication Certificate*. Jakarta, 2017

Onut, S., U.R. Tuzkaya and E. Torun, *Selecting container port via a fuzzy ANP-based approach: A case study in the Marmara Region Turkey*. Transp Policy, 18: 182-193, 2011

Paull, R.E., W. Nishijima, M. Reyes and C. Cavaletto, *Postharvest handling and losses during marketing of coffee (Carica coffee L.). Postharvest Biol. Technol*., 11: 165-179, 1997

Perdana, T., The triple helix model for fruits and vegetables supply chain management development involving small farmers in order to fulfill the global market demand: A case study in Value Chain Center (VCC), *Universitas Padjadjaran. Procedia Soc. Behav. Sci*., 52: 80-89, 2012

Prawitasari, S. Assessment and risk mitigation of Arabica Ijen coffee supply chains. In *1st Borobudur International Symposium on Humanities, Economics and Social Sciences (BIS-HESS 2019)*). Atlantis Press., pp. 796-804, 2020

Pujawan, I.N. and L.H. Geraldin, House of risk: A model for proactive supply chain risk management. *Bus. Process Manage. J*., 15: 953-967, 2009

Raab, V., O.J. Hagan, F. Stecher, M. Furtjes and A. Brugger et al., *A preventive approach to risk management in global fruit and vegetable supply Chains*. WIT. Trans. Ecol. Environ., 170: 147-158, 2013

Richards, T., *A discrete-continuous model of fruit promotion, advertising and response segmentation. Agribusiness*, 16: 179-196, 2000

Saaty, T.L., The analytic network process. Iran. *J. Oper. Res*., 1: 1-27 2008

Seyed-Hosseini, S.M., N. Safaei and M.J. Asgharpour, *Reprioritization of failures in a system failure mode and effects analysis by decision making trial and evaluation laboratory technique*. Rehab. Eng. Syst. Safety, 91: 872-881, 2006

Shafiee, M., *A fuzzy analytic network process model to mitigate the risks associated with offshore wind farms*. Expert Syst. Appl., 42: 2143-2152, 2015

Sinha, P.R., L.E. Whitman and D. Malzahn, *Methodology to mitigate supplier risk in an aerospace supply chain. Supply Chain Manage*.: Int. I., 9: 154-168, 2004

Sivakurnar, D., M.M. Wall, *Coffee fruit quality management during the postharvest supply Chain*. Food Rev. Int., 29: 24-48, 2013

Slamet, A.S., Nakayasu,A, Astuti R, Rachman, N.M. Risk Assessment of Papaya Supply Chains: An Indonesian Case Study. *J. International Business Management* 11 (2): 508-521, 2017

Soto, S.W.E., R.E. Nadal, G.M.C. Araya and P.L.M. Aragones, Operational research models applied to the fresh fruit supply chain. Eur. *J. Oper. Res*., 251: 1-11, 2015

Tang, C.S., Perspectives in supply chain risk management. Int. *J. Prod. Econ*., 103: 451-488, 2006

Tang, 0. andM.S. Nurmaya, Identifying risk issues and research advancements in supply chain risk management. *Int. J. Prod. Econ*., 133: 25-34, 2011

Tsolakis, N.K., C.A. Keramydas, AK. Toka, D.A. Aidonis and E.T. Iakovou, *Agrifood supply chain management A comprehensive hierarchical decision-making framework and a critical taxonomy*. Biosyst. Eng., 120: 47-64, 2014

Valipour, A, N. Yahaya, M.N. Noor, S. Kildiene and H. Sarvari et al., A fuzzy analytic network process method for risk prioritization in freeway PPP projects: An Iranian case study. *J. Civil Eng*. Manag., 21: 933-947, 2015

Wibowo, R, Putu, L., Setyawati, I.K., Zainuddin, A. *Manajemen Pengambilan Keputusan Agribisnis Teori dan aplikasi*. Unej Press. Jember. 2017

Wu, T., & Blackhurst, J. V. (Eds.*). Managing supply chain risk and vulnerability: tools and methods for supply chain decision makers*. Springer Science & Business Media, 2009

Xiao, N., H.Z. Huang, Y. Li, L. He and T. Jin, *Multiple failure modes analysis and weighted risk priority number evaluation in FMEA*. Eng. Failure Anal., 18: 1162-1170, 2011

Yulian, N.F., Analisis Risiko Kopi Rakyat di Kecamatan Bangsalsari Jember, Universitas Jember, 2018

Zhang, F. and W. Zhang, *Failure modes and effects analysis based on fuzzy TOPSIS. Proceedings of the 2015 IEEE International Conference on Grey Systems and Intelligent Services (GSIS)*, August 18-20, IEEE,New York, USA., ISBN:978-l-4799-8374-2, pp: 588-593, 2015

Zhong, J. and Z.Y. Lin, *Risk management of international project based on AHP and FMEA. Appl.* Mech. Mater., 357: 2665-2670, 2013