Sustainable risk mitigation in manufacturing company

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Abstract. Companies that are not aware of any risk events and sources of risk that occur in the company, will not be able to formulate an appropriate strategy in mitigating risk. This research aims to identify, measure and plan risk mitigation strategies related to sustainable risk. Sustainable risk is related to risks from environmental, economic and social aspects. This research takes a case study in one of the manufacturing companies in Indonesia. This study uses the Failure Mode and Effect Analysis (FMEA) method to identify events and sources of risk and the House of Risk (HOR) to analyze and design risk mitigation. This research identified 14 risk events and 39 sources of risk that occurred in the company. By using the HOR method, 15 priority sustainability risk mitigation actions were obtained.

1. Introduction

Companies that are not aware of all forms of risks in the business world will not be able to formulate the appropriate strategy in competing with other competitors in the business world. Companies are required to be able to find ways to handle demands with high standards expected by customers and to ensure their position remains safe in the market. On the other hand, risks that arise can sometimes be predicted and mitigated [1]. If the company is not able to mitigate any risks arise, then certainly the company will be displayed from the dynamics of the business world because the future of the company depends on how good the ability and responsive of the company to encounter the changes in the external environment [2].

The traditional approach often chosen by companies caused more susceptible to risk than sustainable approaches. Evidently, global warming, the depletion of non-renewable resources, various dangerous diseases and others arise as a result of traditional approaches [3], [4]. In addition to government regulations, manufacturing companies are required to change the pattern of traditional systems to systems that are aware of environmental sustainability [5], [6]. To change the traditional system to a more modern system, manufacturing companies need to change the company's orientation, from low cost products to more sustainable ones [7], [8]. Smith & Ball [9] said that a sustainable society and a manufacturing company system cannot be with one another. Thus, the instability of manufacturing companies caused by the risks that occurred, is able to disrupt the social and social order system. The presence of risk management aims to provide a strategic solution for the company in mitigating any potential risks that can create losses for the company [10].

It is realized that the external uncertainties of the business world originated by political problems, economic, social and cultural instability and rapid changes in technological and information aspects are a central problem of every company. Risk management for some companies is still considered to be inconsistent in its application [11]. In addition, risk management related to sustainability has been
highlighted lately. Understanding sustainable risk can help companies to increase supply chain availability [12], [13]. The issue of sustainability has become a serious concern among researchers, starting from the evaluation of sustainability risk in terms of economic aspects [14], [15], [16], social [14], conceptual framework for sustainable risk management [17]. Xu et al. [18] said that there is a lack of an integrated framework in assessing and evaluating sustainability risks by considering the triple bottom line (environmental, social and economic). The increasing concern for global sustainability in the industrial world requires stakeholders to immediately take the right policies. For this reason, a complete risk of sustainability is needed.

This study aims to propose an integrated framework in mitigating sustainable risk in one manufacturing company in Yogyakarta, namely PT. Yogya Presisi Tehnikatama Industri (YPTI). To fill in the deficiencies discovered by Xu et al. [18] in assessing and evaluating sustainable risk, the assessment aspects used in this study include environmental, social and economic aspects (triple bottom line). Torres-ruis and Ravindran [19] added that environmental aspects were still under-explored in terms of identifying risks to company activities. The company is engaged in Checking Equipment, Parts, Plastic Injection and Mold Making. Moreover, the results of the literature review and discussion with the company showed that there was no literature that has examined the company related to sustainable risk mitigation using the triple bottom line. Meanwhile, the results of preliminary observations at PT. YPTI showed that there were still work accidents that affected the environment in the company, inefficient use of energy and often a lack of functional air supply for the company. Occurrence of risks in the social aspect that was, excessive work time required by companies, employee wages provided were often not in accordance with the standards of UMR Yogyakarta and others. In addition, the occurrence of risk on economic aspects found in PT. YPTI, was the company’s revenue target has not been achieved in recent years, the production costs exceed the company's target. Therefore, to maintain the existence of the company and ensure that the company is able to achieve competitive advantage in both national and international levels, it is necessary to conduct research related to sustainable risk management.

2. Research Method
The number of companies engaged in the same field makes the competition is very tight therefore it can result in decreased revenue due to reduced orders from customers. In addition, as the manufacturing companies that have a lot of potential risks, the company itself must carry out effective management in order to be able to achieve competitive advantage. The object of this research is one manufacturing company located in Yogyakarta, PT. Yogya Presisi Tehnikatama Industri (YPTI). The selection of research sites is due to the company, PT. YPTI, which was established on September 9, 1999, is one of the companies which is able to penetrate the international market in a relatively short period of time. Starting from attending overseas exhibitions to selling products that are able to penetrate the domestic market, in addition, in 2018, the YPTI company succeeded in becoming a supplier of spear parts for the needs of various companies in Indonesia, including: Astra Daihatsu Motor, Coca Cola Bottling, Sari Husada, Toyota Astra Motor, PLN, PT. Dirgantara Indonesia and others. Engaged in Checking Fixture, Spare Parts, Plastic Injection, and Mold Making it makes PT. YPTI consistently to improve company management.

2.1. Data collection
There are several stages of data collection in this study such as, (1) a review of previous studies consisting of various sources and references. In addition, direct observations were conducted at the research location, to review and assess all activities carried out throughout the company activities of PT. YPTI; (2) identified risk events and sources of risk events. The identification process used a set of open and closed questionnaires. In addition, interviews were implemented with operators in the production department, supervisors, division heads, and managers regarding events and sources of risk that occurred in the company; (3) after the process of identifying events and sources of risk, a focus group discussion (FGD) were held with company superiors related to the risk mitigation process. FGD aimed to obtain information through interaction between groups to obtain certain agreements [20], [21]. In addition, the
FGD was conducted to determine the ability and willingness of the company in implementing risk mitigation for any risks that occur.

2.2. Data analysis
Data that has been obtained through a series of data collection processes was processed and analyzed. There were several steps in data processing in this study, consist of: (1) the results of identification of events and sources of risk, an assessment was analyzed using by the Failure Mode and Effect Analysis (FMEA) methods. FMEA can be used to evaluate and measure risk factors systematically, without the need of complicated statistical methods [22]. In this section, the weighting of the probability of occurrence and severity was calculated based on the results of identification through questionnaires; (2) calculations were carried out using the house of risk (HOR) approach. This approach consists of two parts [23], which are the first phase or HOR phase 1 to calculate the Potential Aggregate Risk (ARP) to be able to determine priorities in the process of handling risk agents [24]. In addition, to determine the correlation between sources of risk and risk events that have been identified, and finally the determination of risk evaluation using Pareto diagrams. While the second phase or HOR phase 2 was designing mitigation strategies, determining the correlation of mitigation strategies with risk agents, calculating the total effectiveness and the results of the degree of difficulty assessment, calculating the effectiveness to difficulty ratio and determining the mitigation strategies to reduce the probability value of the emergence of a risk source based on the effectiveness value to the highest difficulty [25].

3. Result and Discussion

3.1. Risk event and risk agent identification results
Based on the results of the distribution of research questionnaires and the results of interviews that have been conducted, the risk events, severity values, sources of risk and the value of occurrence of each risk obtained at the manufacturing company PT. YPTI as shown in tables 1 and 2 as follows.

| Code | Risk Event                                                                 | Severity |
|------|---------------------------------------------------------------------------|----------|
| E1   | Accidents that occur in the company and can affect the environment (for example, production machine operators or company staff) | 4        |
| E2   | Inefficient use of energy for production and shipping activities           | 4        |
| E3   | Excessive product waste produced by the company                            | 2        |
| E4   | Vulnerability caused by rising temperatures due to climate change          | 2        |
| E5   | Disturbances caused by natural disasters such as hurricanes, floods, storms, earthquakes or volcanic eruptions | 5        |
| E6   | Lack of water supply for company activities                                | 3        |
| E7   | Excessive work time; imbalance of work time with the lives of company employees | 5        |
| E8   | Labour issues related to population growth                                  | 2        |
| E9   | Antimonopoly claims (claims incurred against companies that violate inter-company competition laws, for example pricing that is detrimental to consumers) | 1        |
| E10  | Patent infringement (commercial use of an inventor who has patented his work without the knowledge of the patent owner) | 1        |
| E11  | Claim return of raw materials from suppliers                               | 5        |
| E12  | Company profits do not match the target                                    | 5        |
| E13  | Unpredictable and sustainable variance in fuel prices                      | 3        |
| E14  | Production costs exceed the company's target plan                           | 4        |
Table 2. Result of identification of risk agent

| Code | Risk Agent                                                                                           | Occurrence |
|------|------------------------------------------------------------------------------------------------------|------------|
| **Environmental**                                                                                       |            |
| A1   | Lack of K3 Education and Training in the company                                                   | 4          |
| A2   | Lack of awareness in using PPE                                                                      | 5          |
| A3   | K3 SOP is inadequate and not strict in application                                                  | 4          |
| A4   | Non-compliance in implementing SOP                                                                  | 5          |
| A5   | Lack of education and training in the use of energy to employees                                    | 4          |
| A6   | Production machines and transportation equipment that is not environmentally friendly               | 3          |
| A7   | Inefficient production machinery                                                                   | 2          |
| A8   | the absence of special techniques for recycling factory waste                                       | 3          |
| A9   | The company’s buildings and facilities do not use materials that are resistant to temperature changes | 2          |
| A10  | Lack of plants / trees around the company                                                           | 3          |
| A11  | The occurrence of natural disasters that are not detected                                           | 2          |
| A12  | Buildings and facilities are not specifically designed to withstand natural disasters               | 2          |
| A13  | drought in the surrounding environment                                                              | 3          |
| A14  | Prolonged dry season                                                                               | 2          |
| A15  | There was a jam in the water transport car                                                          | 3          |
| **Social**                                                                                              |            |
| A16  | Customer demand suddenly                                                                          | 5          |
| A17  | Changes in production schedules to meet target customers                                            | 5          |
| A18  | There was forced labour hours to meet company targets                                               | 4          |
| A19  | Population growth increased dramatically                                                           | 2          |
| A20  | The number of productive ages exceeds the capacity needs of the company                             | 3          |
| **Economy**                                                                                             |            |
| A21  | Monopolistic market shares holistically                                                             | 2          |
| A22  | Unfair market competition                                                                          | 3          |
| A23  | Weak law enforcement                                                                               | 2          |
| A24  | Lack of accountability                                                                             | 2          |
| A25  | Legitimacy is legally unclear / weak                                                                 | 3          |
| A26  | Weak Government intervention in supporting patent rights                                             | 2          |
| A27  | The quality of raw materials is not up to standard                                                  | 5          |
| A28  | Miscommunication occurs with suppliers                                                             | 4          |
| A29  | Raw materials are mixed with foreign materials                                                      | 4          |
| A30  | Marketing strategy is not on target                                                                 | 4          |
| A31  | Product quality is not up to standard                                                                | 5          |
| A32  | A strike occurred by an employee                                                                    | 4          |
| A33  | The company's internal management is not up to standard                                              | 4          |
| A34  | The instability of world fuel prices                                                                | 4          |
| A35  | Dependence on imported fuel                                                                         | 4          |
| A36  | Geopolitical tensions occur between countries, especially oil-producing countries                   | 5          |
| A37  | An increase in inflation                                                                           | 3          |
| A38  | Raw material costs are increasing                                                                   | 4          |
| A39  | The production machine is constantly damaged                                                         | 4          |

Based on the results shown in table 1, there were 14 risk events that occurred at PT. YPTI. Of the 14 risk events, there are 6 risk events in the environmental aspect category, 2 risk events in the social aspect category and 6 risk events in the economic aspect. From each of these risk events, the highest severity value is found in E5 risk events, namely disruptions caused by natural disasters such as hurricanes, floods, storms, earthquakes, or volcanic eruptions, E7 excessive work time (such as work time imbalances with the life of a company employee). In addition, from economic factors, there are 2 highest
severity values, including E11 (claim return of raw materials from suppliers) and E12 (company profits are not in line with the target). In addition, Table 2 shows the results of the identification of risk sources, amounting to 39 sources of risk with occurrence value. The highest occurrence value in environmental aspects is A2 and A4, social aspects are A16 and A17, and economic aspects are A27, A31 and A36. The next step processed with the House of Risk (HOR) approach to design mitigation actions optimally. Thus, any risks that interfere with the stability of the company can be minimized or even eliminated to achieve competitive advantage.

3.2. House of Risk (HOR)
In this section, data management is carried out using the house of risk (HOR) approach, where this approach is divided into two parts, namely in the first stage, data management is carried out with house of risk phase 1 with the aim of calculating the potential aggregate risk (ARP) in order to be able to determine priorities in the process of handling risk agents. Whereas HOR phase 2 aims to design a risk mitigation action against each prioritized risk.

3.2.1. House of Risk (HOR) phase 1
Based on the ARP value that has been obtained through the calculation of HOR phase 1, it is determined that the priority factor is to use Pareto. According to Caesaron & Tandianto [26] the source of making Pareto diagrams is based on the cumulative percentage of ARP value of risk sources. The results of the Pareto diagram can be shown in Figure 1.

![Figure 1. Diagram Pareto](image1.png)

![Figure 2. Risk map before mitigation priorities](image2.png)
Risk evaluation uses the Pareto diagram as shown in Figure 1, with the principle of 80:20 which means 20% of risk agents were a priority for risk mitigation. Based on the results of risk agent priorities as shown in figure 1 showed as much as 39.68% where with this percentage were carried out the design of mitigation strategies that were able to influence improvement by 60.32% other risk agents. Another consideration chosen by the company was because the company wanted to be more focused in carrying out risk mitigation actions. After that, a risk map was made to determine the risk conditions before being mitigated as shown in Figure 2.

3.2.2. House of Risk (HOR) phase 2
From the ARP calculation results in HOR phase 1, a number of risks was mitigated. The highest ARP value was a source of risk that must be immediately mitigated. The priority sources of risk for mitigation with the proposed mitigation strategies can be seen in table 3 as follows.

| No | Risk Agent                                                                 | Mitigation action                                                                 | Code |
|----|----------------------------------------------------------------------------|----------------------------------------------------------------------------------|------|
| 1  | Lack of education and training in the use of energy to employees           | • Carry out education and training on the use of environmentally friendly energy  | PA1  |
|    |                                                                            | • Collaborate with consultants on energy use                                     | PA2  |
| 2  | Unconscious employee about K3 in the company                              | • Conduct OHS training and training regularly                                     | PA3  |
|    |                                                                            | • Giving punishment                                                               | PA4  |
| 3  | The quality of raw materials is not up to standard                        | • Termination of employment contracts and looking for more selective suppliers    | PA5  |
|    |                                                                            | • Determination of standard raw materials from suppliers                         | PA6  |
| 4  | Non-compliance in implementing SOP in PT YPTI                             | • Provision of punishment for those who violate                                   | PA7  |
|    |                                                                            | • Conduct regular audits at the company                                           | PA8  |
| 5  | Customer demand suddenly                                                   | • Reinforce the work agreement                                                    | PA9  |
| 6  | The production machine is constantly damaged                              | • Production machine renewal                                                     | PA10 |
|    |                                                                            | • Preventive maintenance                                                          | PA11 |
| 7  | The company's internal management is not up to standard                    | • Renewal of company internal SOPs                                              | PA12 |
|    |                                                                            | • Improvement of the company’s internal management system                        | PA13 |
| 8  | The cost of raw materials has increased                                   | • Hedging with suppliers                                                          | PA14 |
|    |                                                                            | • Filing up raw materials                                                         | PA15 |

Correlation of mitigation strategies with risk agents was implemented to determine the extent of handling strategies correlated with risk agents. The correlation was conducted by the expert PT YPTI through focus group discussions. The measurement of correlation of risk management strategies with risk agents used 4 scales, namely 0, 1, 3, 9, which showed that sequentially there was no correlation, weak correlation, moderate correlation and high correlation. In addition, the total effectiveness and assessment of degree of difficulty were calculated. Table 4 and 5 shows the results of HOR phase 2.

Table 4. Table HOR phase 2
Based on the calculation of house of risk phase 2, the mitigation action management strategy was obtained based on the highest ETD ranking. After that, the following was a picture of the risk map after the priority of mitigation has been applied and the sequence of priority risk management strategies.

**Figure 3.** Risk map before mitigation priorities

**Table 5.** Table HOR phase 2

| Code | Risk Mitigation |
|------|-----------------|
| PA7  | Provision of punishment for those who violate |
| PA3  | Conduct OHS training and training regularly |
| PA1  | Carry out education and training on the use of environmentally friendly energy |
| PA2  | Collaborate with consultants on energy use and K3 |
| PA5  | Termination of employment contracts and looking for more selective suppliers |
| PA13 | Improvement of the company's internal management system |
| PA4  | Giving punishment |
| PA9  | Reinforce the work agreement |
| PA12 | Renewal of company internal SOPs |
| PA11 | Preventive maintenance |
| PA6  | Determination of standard raw materials from suppliers |
| PA14 | Hedging with suppliers |
| PA15 | Piling up raw materials |
| PA6  | Determination of standard raw materials from suppliers |
| PA10 | Production machine renewal |

4. Conclusions

Based on the results of data collection and analysis conducted in this study, it was concluded that PT. YPTI Yogyakarta, encountered 14 risk events with severity values for each risk event and 39 causes for risk events (risk agents) with occurrence values related to the company's sustainability risk. In addition, mitigation action strategies for the causes of risk events related to sustainability should be prioritized in handling through HOR phase 2, namely (A4) (ARP= 275) non-compliance in implementing company SOPs with mitigation strategies, providing punishment for violating (PA7) and conducting routine audits in companies (PA8); (A5) (ARP=348) lack of education and training in energy use for employees, with mitigation action strategies, the extensive education and training on the use of environmentally friendly energy (PA1) and work with consultants in the matter of efficient energy use (PA2); (A1) (ARP= 312) Unconsciousness of the importance of OHS education and training in companies with mitigation action
strategies. Conduct OHS training and training on a regular basis (PA3) and punishment (PA4); (A33) (ARP= 244) the company's internal management did not meet the standards with the mitigation strategy for internal SOP renewal (PA12) and improvement of the company's internal management system (PA13); and finally, (A38) (ARP= 240) the cost of raw materials increased with its mitigation action strategy of hedging with suppliers (PA14) and piling up raw materials in company warehouses (PA15).

For further researchers, it is recommended to add other factors from the aspect of sustainability for future studies related to the sustainability risks of manufacturing companies, as well as broaden the scope of risk identification that involves the entire manufacturing supply chain activities.

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