The supply chain risk analysis using House of Risk method: seaweed commodity in Jeneponto case study

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Abstract. Seaweed development involves the supply chain activity related to sources of raw material, production, and distribution process, yet well organized. The risk opportunity in each those aspects becomes the main obstacle. This study discusses the risk of raw material supply, production, and distribution process at the seaweed commodity in Jeneponto, one of the centers of seaweed development center in South Sulawesi, Indonesia. The objective of this study was to design the proposed risk management occurred in the supply chain activity. The House of Risk is a method applied in this research, which is the integration between Failure Mode and Effect Analysis (FMEA) and the House of Quality methods. The result shows that the main risk prioritized was the lack of seed supply (8.53%), water contamination (7.82%), and the cost fluctuation by the company (8.09%). The proposed preventive action to prevent those risks was to give joint-managed nurseries establishment, drowning longline on forecast-based, and establish better communication with the company before collection.

1. Introduction
Jeneponto is a district, and one of center of seaweed development in South Sulawesi, Indonesia. It has 114 kilometers coastline and six sub-districts of seaweed producer. Data from Fisheries and Marine Services of Jeneponto show that seaweed production reaches 9,308 tons and increase yearly between 20%-200% at two sub-districts. However, this region can lose their profit up to 12 million rupiahs per hectare, which caused by problems on cultivation and degradation of seed quality [1,2]. The main activities in supply chain consist of upstream, internal, and downstream activities [3]. Upstream involves the raw material supply, internal consists the supply of procurement goods from the warehouse to the production process, and downstream which included the whole activity of distribution product to the customer [4–6].

The risk management process consists of three main processes: determination of the concept; risk assessment; and risk handling [7,8]. Some of the risk management analysis methods are the Failure Mode and Effect Analysis (FMEA) and House of Risk (HOR) method. FMEA is a procedure on evaluation design conducted to identify the production failure mode and to determine the effect of each those failures to the performance system. This method applied to obtain the general valuation effect of risk and the value of the frequency level of a risk agent, based on the criteria, which are severity, occurrence, and detection [9].
The House of Risk (HOR) is a risk management model of the supply chain to set a framework in managing the supply chain risk [10]. This HOR method focuses on preventive action to reduce the probability of a risk agent. The Bow-tie analysis is a diagram method used as risk control tools by creating a barrier of the occurred risk [11]. It refers to AS/NZS 4360 model recommended by ISO 31000. The Bow-tie analysis can studies further by including the barrier decay mechanisms and likely effectiveness evaluation from the control measures.

2. Methods
This research conducted in Jeneponto, South Sulawesi, and focuses on identifying the risk and effect, as well as designing the risk mitigation strategy for the optimal supply chain performance. The objects of this research were the farmers and collectors of seaweed in Tamalatea and Binamu sub-districts, with 33 respondents as the sample for primary data.

The risk identification conducted structurally from a hierarchy identification process to risk structure probability. The methods used for data collecting process are interview, observation, and brainstorming.

3. Result and discussion
3.1. Risk Identification and Agent
The risk identification conducted by outlining the supply chain steps through the seaweed commodity with the actions taken in terms of maintaining and followed activities on each phase presented in figure 1.

![Supply Chain Risk on Seaweed Commodity](image)

**Figure 1.** The supply chain process diagram of seaweed
The risk and severity on phase 1 presented in table 1 while the risk agent and identified the occurrence of those five risks above presented in table 2.

### Table 1. The risk and severity on phase 1

| Code | Risk                              | Severity |
|------|-----------------------------------|----------|
| E1   | Wrong planning of seed supply     | 6        |
| E2   | Limited seed supply               | 6        |
| E3   | Unable to purchase seed           | 6        |
| E4   | Difficulty in seed cropping       | 9        |
| E5   | Less quality and freshness of seed| 6        |

### Table 2. The risk agent and occurrence of phase 1

| Code | Risk Agent                                                                 | Occurrence |
|------|---------------------------------------------------------------------------|------------|
| A1   | Supply calculation not conducted                                         | 6          |
| A2   | Lack of farmer in terms of seed supply                                   | 8          |
| A3   | Unrelated location condition with seed from other location               | 8          |
| A4   | Limited quantity of supplied seed                                        | 8          |
| A5   | High cost of seed                                                         | 8          |
| A6   | Location of seed in different islands                                    | 9          |
| A7   | High temperature and low humidity during seed distribution               | 4          |

Phase 2 (Plantation and Maintenance) consists of 3 activities with eight risks. The risk and each level of severity presented in table 3.

### Table 3. The risk and severity of phase 2

| Code | Risk                                  | Severity |
|------|---------------------------------------|----------|
| E6   | Preparation of seed and its media takes time | 5        |
| E7   | The longline rope broke                | 5        |
| E8   | Infection of clam pests                | 8        |
| E9   | The seaweed dead                       | 8        |
| E10  | Low specific mass                      | 5        |
| E11  | Slow growth progress                   | 4        |
| E12  | Infection of weed                      | 3        |
| E13  | Seaweed falls from the longline rope   | 4        |

The identified risk agents of eight risks are nine occurrences and presented in table 4.
Table 4. The risk agent and occurrence of phase 2

| Code | Risk Agent                                                                 | Occurrence |
|------|----------------------------------------------------------------------------|------------|
| A8   | Less manpower for binding the seed on the longline rope                   | 5          |
| A9   | The longline rope need reparation                                         | 3          |
| A10  | The lifetime of the longline rope                                         | 4          |
| A11  | Inappropriate length of water plantation                                  | 5          |
| A12  | Water contamination                                                        | 7          |
| A13  | Overheated water temperature                                              | 7          |
| A14  | Low brightness of wastewater                                               | 5          |
| A15  | Over-slow wave                                                             | 6          |
| A16  | Break cause of rubbing during crop process                                 | 9          |

Table 3 (after cropping) consists of four activities. The identified risks are six, with each severity presented in table 5.

Table 5. The risk and severity of phase 3

| Code | Risk                                      | Severity |
|------|-------------------------------------------|----------|
| E14  | Low quality of drying process             | 6        |
| E15  | Unstable price                            | 6        |
| E16  | Low quality of seaweed                    | 6        |
| E17  | Weight decreased                          | 5        |
| E18  | Unstable distribution schedule             | 8        |
| E19  | Uncertainty of merchant profit            | 7        |

The risk agent identified with each occurrence for those six risks above presented in table 6.

Table 6. The risk agent and occurrence on phase 3

| Code | Risk Agent                                           | Occurrence |
|------|------------------------------------------------------|------------|
| A17  | Unstable weather condition                           | 6          |
| A18  | No agreements and definite pricing conditions        | 7          |
| A19  | High humidity                                        | 6          |
| A20  | Over period on supply                                | 5          |
| A21  | No agreements between merchant and factory           | 8          |
| A22  | Unstable purchasing quantity of seaweed              | 8          |
| A23  | Fluctuation on price by the company                  | 6          |
3.2. *The House of Risk Method*

The alternative designed mitigation presented in table 7.

**Table 7. The design for priority risk agent preventive action**

| Code | Risk Agent                              | Code  | Suggestion of Preventive Action                          |
|------|-----------------------------------------|-------|----------------------------------------------------------|
| A2   | Lack of farmer supplying the seed       | PA'1  | Procurement of seed field maintained in groups           |
|      |                                         | PA'2  | Purchasing seed from another district                    |
| A12  | Water contamination                      | PA'3  | Drowning the longline rope based on weather forecast     |
|      |                                         | PA'4  | Relocate the plantation area further                     |
| A23  | Fluctuation of purchasing cost by the company | PA'5  | Communicate with the company before purchase             |
|      |                                         | PA'6  | Hold the purchasing process until it stable              |

The difficulty level of each preventive action is presented in table 8.

**Table 8. Degree of difficulty**

| Code | Preventive Action                              | Dk Value |
|------|-----------------------------------------------|----------|
| PA'1 | Procurement of seed field maintained in groups | 4        |
| PA'2 | Purchasing seed from another district         | 3        |
| PA'3 | Drowning the longline rope based on weather forecast | 4        |
| PA'4 | Relocate the plantation area further         | 5        |
| PA'5 | Communicate with the company before purchase | 3        |
| PA'6 | Hold the purchasing process until it stable  | 3        |

3.3. *The Bow-tie Diagram*

Table 7 already showed the action that should be conducted by supply chain commodity of seaweed in Jeneponto to prevent the risks. The design of preventive measures is presented in figure 2.

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**Figure 2. Bow-tie diagram of existing preventive action**
4. Conclusion
There are 19 risks, and 23 risk agents occurred in the supply chain of seaweed commodity in Jeneponto. The seed preparation phase has five risks, plantation and maintenance have eight, and after the cropping process has six risks. From the House of Risk, it was obtained the risk agents with 3 top priorities: the lack of farmer who supplies the seed; water contamination; and fluctuation of purchasing cost by the company. Those three risk agents have the highest aggregate risk potential value that presents the effect of severity and high potential frequency to occur. The preventive actions for this issue are: communicate with the company before purchasing and collecting process; the procurement of seed field maintained in groups effectively; drowning the longline rope based on the weather forecast. Those actions have the highest preventive effectiveness level by considering the difficulty of the most top execution.

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