Shallot supply chain analysis using rapid agricultural supply chain risk assessment method: case in Bantul Regency, Special Region of Yogyakarta, Indonesia

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Abstract. The supply chain of shallot commodities in Bantul Regency involves several business actors including farmers, middlemen, collectors, wholesalers, retailers, and small traders. In the process of each supply chain, risks will always be encountered. The risks in each tier of shallot supply chain certainly need to be identified and analyzed. The categories of each of these risks will determine the appropriate supply chain risk management steps based on the risk categories obtained. This study was conducted to analyze the risk of shallot supply chains in the three largest shallot producing sub-districts. The Rapid Agricultural Supply Chain Risk Assessment (RapAgRisk) method is used to carry out risk analysis, and the sampling method used was purposive sampling and snowball sampling. The results show that the farmer is the tier with most risks faced compared to the others. Excessive stock is the risk that requires adequate priority to manage, and it is faced by all levels of the shallot supply chain. Meanwhile, farmers are the weakest supply chain actors in bargaining power, and the small traders are the most vulnerable actors in the face of risks associated with quality damage and slow sales rate.

1. Introduction
Shallot is a horticultural commodity with a large amount of production in Indonesia. Based on data from the Ministry of Agriculture, the national production of shallots in 2017 reached 1.47 million tons. The provinces of Central Java, East Java, West Nusa Tenggara, and South Sulawesi are the largest red onion producing provinces with total production reaching 1.27 tons or 86.68% of national production [1]. Table 1 represents the number of horticulture crops from 2012-2017 (in tons).
Table 1. Vegetable Production 2012-2017 (in tons)

| No | Crops     | Year       |         |         |         |         |         |
|----|-----------|------------|---------|---------|---------|---------|---------|
|    |           | 2012       | 2013    | 2014    | 2015    | 2016    | 2017    |
| 1  | Shallot   | 964,221    | 1,010,773| 1,233,984| 1,229,189| 1,446,860| 1,470,155|
| 2  | Potato    | 1,094,240  | 1,124,282| 1,347,728| 1,219,277| 1,213,038| 1,164,738|
| 3  | Cabbage   | 1,450,046  | 1,480,625| 1,435,833| 1,443,227| 1,513,318| 1,442,624|
| 4  | Big chili | 954.63     | 1,012,879| 1,072,977| 1,045,200| 1,045,591| 1,206,272|
| 5  | Cayenne   | 702,252    | 713,502  | 800,409  | 869,954  | 915,993  | 1,153,159|

Meanwhile, according to data from the Yogyakarta Central Bureau of Statistics, the center of shallots production in the Special Province of Yogyakarta is dominated by the Bantul Regency area, followed by Kulon Progo Regency [2]. Production of shallot in every city/district in the Special Region of Yogyakarta could be seen in Table 2.

Table 2. Shallot Production In Yogyakarta Special Region (Quintal)

| City/Regency | Year       |         |         |         |         |         |
|--------------|------------|---------|---------|---------|---------|---------|
|              | 2012       | 2013    | 2014    | 2015    | 2016    | 2017    |
| Kulon Progo  | 24,722     | 21,505  | 36,483  | 39,921  | 38,342  | 52,729  |
| Bantul       | 92,191     | 73,270  | 83,921  | 44,789  | 79,047  | 79,102  |
| Gunung Kidul | 1,238      | 450     | 2,891   | 3,019   | 4,685   | 7,400   |
| Sleman       | 399        | 181     | 300     | 256     | 335     | 570     |
| Yogyakarta   | 0          | 0       | 0       | 0       | 0       | 0       |
| Total        | 118,550    | 95,406  | 123,595 | 87,985  | 122,409 | 139,801 |

Supply chain management has an important role in improving the quality of company services to customers. Risk management in the supply chain is related to the costs that must be incurred by the supply chain actors (tier) who are the risk owners. Therefore, supply chain actors need to identify and look for ways to manage the risks that will be faced. Each tier of the shallot supply chain has its own risks, although sometimes there is the same risk but with different levels of vulnerability on each tier. Depending on the logistics flows, the entities in the supply chain include producers, vendors, warehouses, transportation companies, distribution centers, and retailers [3]. Through risk identification, risk owners can effectively manage the risks to be faced so that they can reduce losses and damage that may occur [4]. One method that can be used to identify the risks is RapAgRisk.

RapAgRisk, which stands for Rapid Agricultural Supply Chain Risk Assessment, is a comprehensive system approach method to identify risks, risk exposure, potential failure severity, and options for risk management, both by supply chain participants (individual or collective) or by third parties (for example government). RapAgRisk was developed by the Agricultural Risk Management Team (ARMT) of the World Bank [5]. The initial step to be carried out in the assessment is to identify the risks faced by each supply chain actor based on risk categories which include weather-related risks, natural disasters,
biological and environmental risks, market-related risks, logistical and infrastructural risks, management and operational risks, public policy and institutional risks, and political risks.

Risk analysis is the next step following risk identification. This step is conducted to estimate the severity and probability of the occurrence of the risks that have been identified previously, to produce a risk matrix. Through the assessment of risk handling capacity ratings (by considering various parameters), the vulnerability assessment table will then be obtained. The steps for conducting Rapid Agricultural Supply Chain Risk Assessment in detail are presented in the document of World Bank on Agriculture and Rural Development Discussion Paper 47 under the title Rapid Agricultural Supply Chain Risk Assessment: A Conceptual Framework [5].

There are many types of research related to supply chain risk assessment. Various reviews on quantitative models for managing supply chain risk have also been carried out [6, 7]. As an illustration, a risk measurement method has been developed to establish a better supply chain of electronic devices and anticipate the risks that may be faced [8]. In the field of agriculture, reviews dan investigations on the supply chain have been quite adequate, especially for food products and fresh fruit [9, 10, 11, 12, 13, 14]. However, most studies still take no account of agricultural product characteristics such as perishability into the quantitative model of the supply chain. Thus, the risks could not be illustrated and calculated clearly in mathematical perspective [9]. However, a conclusion is agreed that the risks associated with the functioning of the supply chain negatively affect logistics performance [15]. A review on supply chain has even raised the possibility of implementing an environmentally friendly supply chain [16].

With the increasing emphasis on supply chain vulnerability, research to analyze and understand supply chain risk management has done. As an example, supply chain studies in Latin American countries conclude that the public sector can have a more effective role in increasing the access and performance of value chains from the supply chain by embracing an integrated risk management approach to the value chain [17]. This conclusion is in line with the results of other studies that reveal the role risk and risk management practices in the integrated supply chain success [18]. A review has even tried to track the progress in supply chain risk management for the agricultural food industry [19].

The supply chain of shallot commodities involves several tiers starting from farmers as producers to small traders in the market. Some of the risks associated with the shallot supply chain are related to weather risks, biological and environmental pests, operational management, market sales and demand, natural disasters, logistics, infrastructure, and government policies. This study aims to identify risks and assess the management capabilities of each shallot chains in one of the production centers in the Bantul region, Indonesia.

2. Methodology

2.1. Method of collecting data

Tiers identification in the shallot supply chain is carried out through supply chain tracking starting from farmers to small traders. Data obtained from each tier in the supply chain is in the form of general supply chain information, risk, probability of occurrence (probability) and the impact (severity) of each risk. Data was got by an in-depth interview with a snowball sampling technique and purposive sampling. The snowball sampling and purposive sampling techniques are included in the category of non-probabilistic or non-random sampling, where each element of the population does not have the same opportunity to
be sampled [20]. From the risk owner, detailed information is obtained regarding the events and risks that exist according to real conditions. The criteria for risk responders are supply chain players who really understand the risks in the supply chain, namely the risk owner.

2.2. Method of Analysis

The first step is to identify the risk of shallot supply chain based on the risk categories found in the Rapid Agricultural Supply Chain Risk Assessment method. These risk categories are risks related to weather-related risks, natural disasters, biological and environmental risks, market-related risks, logistical and infrastructural risks, management and operational risks, public policy and institutional risks, and the political risks.

Risk analysis is the next step done to estimate the severity (magnitude of the impact) and the probability of the risks that have been previously identified. The level used for severity and probability level is starting from one to five. Then, a risk mapping is conducted to produce expected loss ranking matrix which has 3 priority groups, namely priority-1 (high expected loss), priority-2 (medium expected loss), and priority-3 (low expected loss).

When the expected loss ranking matrix was obtained, risk management and vulnerability assessment were carried out to continuously study and improve the effectiveness of risk management. This study uses a scale of 1 to 5. Value 1 illustrates a condition where the capacity is partly effective but tends to be expensive and not sustain. Value 3 describes capacity that is effective but not affordable and not sustain. Value 5 means very effective and has a high possibility to be sustained. For value 2 and value 4, they describe the capacity between values 1 and 3, and between values 3 and 5 respectively.

In assessing the risk handling capacity rating, in order to get the right rating, it must consider various parameters such as availability, access, timing, affordability, responsibility, knowledge, effectiveness and sustainability. A more detailed explanation of these factors can be seen in Table 3.

| Table 3. Parameter for assessing risk management capacity ranking |
|---------------------------------------------------------------|
| **Capacity** | **Parameter** | **Remark** |
| Low | Availability | Risk management instruments such as insurance and financial markets are available |
| | Access | Risk management instruments can be accessed by risk owners |
| | Timing | There are efforts to prevent ex-ante risks and deal with ex-post risks that can be used at any time |
| | Affordability | The available risk management instruments don’t burden risk owners |
| | Responsibility | The responsibility for risk management arrangements lies in the private and public sectors |
| | Knowledge | There is adequate knowledge of the ability to handle risk |
| | Effectiveness | Risk management efforts indicate a positive impact on the risks faced |
| | Sustainability | The risk management efforts carried out can will sustain |
| High | | |

The end result is a vulnerability table from the set of risks that have been assessed. Vulnerability assessment tables for risky events in the supply chain are prepared based on expected loss ranking matrix and capacity to manage the risks. Through the results of the vulnerability table that is compiled, the information will be obtained about the vulnerability status of each risk along with estimates of the losses.
experienced and the level of capacity to manage risk. Thus, recommendations can be made for the right strategy to minimize supply chain risk in each tier.

3. Results and identification

3.1. Tier identification
Based on direct observations in three sub-districts acting as centers of shallot production, it can be seen that the shallot supply chain actors in the Bantul district include farmer, middleman, collector, wholesaler, retailers, and small traders.

3.2. Identification of shallot supply chains
Tracking in each tier of the shallot supply chain in Bantul Regency has identified 18 supply chain flows, as presented in Figure 2.

Furthermore, to identify the problem of the shallot supply chain, the supply chain with the longest tier is used as the basis for risk analysis. This is intended so that identification of supply chain risk can be carried out thoroughly without even missing one-tier. In this study, the two longest supply chains of the shallot commodity in Bantul Regency were obtained, as shown in Figure 3.

Figure 1. Shallot supply chain flow in Bantul Regency

Figure 3. The two longest supply chains of the shallot commodity in Bantul Regency.
3.3. Identification of supply chain risk
There are twenty-five risks in farmer tier that each category of risks can be divided into three-step of cultivation such as pre-cultivation stage, cultivation stage, and post-harvest stage. In the tier of middleman, there are seven risks that can be identified and the most of risks were related to marketing risk category, while the collector tier faces eight risks with the most of risks were related to marketing risk category.

In the wholesaler tier, there are four risks that can be identified and most of the risks were related to a marketing risk category. For the retailer, there are four risks that can be identified and most of the risks were related to a marketing risk category. Finally, the less risk found in the tier of small traders. In this tier there are three risks that can be identified and most of the risks were related to a marketing risk category.

3.4. Risk analysis and risk handling capacity of each tier
There are six risks with high expected losses category, eleven risks with medium expected losses category and eight risks with low expected losses category. The high expected losses category faced by the farmers are related to operational management category on pre-cultivation stage, logistics/infrastructure category on pre-cultivation stage, logistics/infrastructure category on cultivation stage, marketing category (selling price is lower than it should be), marketing category (delayed payment for farmer), government policy category on post-harvest stage (price protection policy for consumer that impact on low selling prices at the farm level).

For the middleman, there is only one risk with high expected losses marketing category namely loss due to falling prices, three risks with medium expected losses category and three risks with low expected losses category. There two risks with medium expected losses category and six risks with low expected losses category at the collector tier. The medium-risk includes the loss due to falling prices for the excessive stock in the market and the falling selling price due to quality decreases as perishable product. However, the analysis results faced by wholesalers, retailers, and small traders indicate that there is no high or moderate risk of expected losses category.

Furthermore, assessment results for the probability and severity of each risk in each tier are combined with an analysis of the opportunities for managing each risk to produce a vulnerability matrix that describes the capacity of each tier in managing the risks faced. Based on the results of the risk mapping and the capacity to manage risk for the farmer’s tier, it found that there are 5 risks that fall into the category of very vulnerable and 5 risks which include moderate or medium vulnerability. The risks included in the category of being very vulnerable to the medium vulnerability must be prioritized in
handling the risks for the farmer tier in order to minimize the losses experienced. While the low and limited vulnerability risk categories experienced by farmers can be categorized into acceptable risks where they don't cause significant loss.

At the level of middleman, there are only two risks that can be categorized into risks with moderate vulnerabilities, namely the risk associated with excessive stock in the market and the risk of incorrect estimates of yields. Both of these risks faced by the middleman's tier must be prioritized in the future when risk management efforts will be carried out. Meanwhile, other risk risks can be categorized into acceptable risks.

At the level of collector, there are two risks that are categorized as moderate vulnerability, namely the risk associated with excessive stock in the market and the quality decreases as a perishable product because of overstock. These risks have the highest level of vulnerability for collectors so they need to get priority in their risk management. The other risks included in low vulnerability and limited vulnerability are less potential to disrupt the supply chain, so these are acceptable and will not cause significant losses to the tier of collectors. Of the 4 risks faced by a wholesaler, only one needs to be prioritized in handling, namely the risks associated with excess stock in the market. The impact is low for the other 3 risks remaining.

Based on the risk vulnerability assessment matrix and risk managing capacity for the retailer, it found that there is one risk that falls into the category of moderate vulnerability, namely the risk due to slow sales rate. A large number of shallot retailers is one of the driving factors for this risk. Most retailers are found in traditional markets. Meanwhile, three other risks are included in the risk of low vulnerability which means that the risk is acceptable and does not cause significant losses.

With only a few kilograms (less than 5 kg) of shallot traded, small traders face directly to household consumers, both in traditional markets and in small shops in the village. As a perishable product, the effects of long trips of shallot in the supply chain on its quality cannot be ignored. When the shallot arrives at this tier, it results in a condition of quality that is no longer prime. Moreover, excessive supply in traditional markets as a result of a large number of small traders often results in unsold shallot being offered. According to risk vulnerability assessment calculated, it can be inspected that the three risks faced by small traders enter as medium vulnerabilities. So, all the risks faced by small traders are risks that can not be ignored. Small traders need proficiency in managing the three risks that they always face in day to day trading

4. Conclusion

In Bantul Regency, the risk faced by all levels of the shallot supply chain that requires adequate priority is the risk of the excessive stock. Meanwhile, farmers are the weakest supply chain actors in bargaining power, and the small traders are the most vulnerable actors in the face of risks associated with quality damage and slow sales rate.

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