Analytical Hierarchy Process to Assess the Supply Chain Risk for Improving Sustainability of Shallot Agribusiness in LowLand Area

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Abstract. Shallots are one of the potential horticultural commodities, but they face various risks that affect the performance of the supply chain for shallot agribusiness. To reduce potential risks, it is necessary to identify various types of risks with a priority scale. This study is to analyse various risks in supply chain flows and the involvement of various actors in shallot agribusiness in Majalengka Regency in the lowlands. The research was conducted using a descriptive survey method and data collection of 50 respondents through interviews and questionnaires. The collected data were analysed using the Analytical Hierarchy Process (AHP) model. The results showed that the risks that occurred in the lowlands were production risk (15.6%), price risk (14.2%), market risk (10.9%), environmental risk (8.7%), and distribution risk (8.6%). The actors involved consist of farmers, farmer groups, traders, middlemen, retailers, and consumers. The results of this study can emphasize to facilitate decision making in risk mitigation by paying attention to the priority scale.

Keyword: supply chain, shallot, risk, AHP model

1. Introduction
Shallots are a potential horticultural commodity. The community's need for shallots as a food flavouring material needs to be followed by an adequate supply [1] so that shallots are also a strategic commodity [2] and are an important vegetable crop in Indonesia[3] This plant can also be used as an ingredient in the production of drugs. only one for liver cancer drugs [4] as well as Dayak onion bulbs for the treatment of menopause [5].

Many people have cultivated this commodity intensively. However, there are still problems including slow production and this plant is still categorized as having low productivity [6]. Shallots are also categorized as horticultural crops that are susceptible to pests and diseases. Moreover, many farmers use pesticides inappropriately[7]. Besides, shallots still have a lot of indications of production risk [8] so it is necessary to take a risk priority mitigation strategy [9] As in the perishable food supply chain, there must be an effective risk mitigation strategy [10] Increasing healthy and quality seeds is also wrong. one alternative in shallot agribusiness [11]. Efficient supply chain channels are needed in shallot agribusiness [12] as well as increasing primary and supporting actors in the supply chain management of shallots [13].

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This condition shows that shallot agribusiness has the potential to be developed but problems still exist, one of which is low productivity and there are still many supply chain risk indications. Based on this description, the purpose of this study is to see the actors involved and identify the risk of the shallot supply chain so that it can make a mitigation priority scale. This study uses the Analytic Hierarchy Process (AHP) methodology, this approach can see the identification of supply chain risks [14] This methodology is also tried in the consideration of site selection in minimizing wind energy project risks [15].

This research is focused on the aspects of identifying the risk of the shallot supply chain, mitigating the priority scale, determining the actors involved with the AHP methodology so that it will become a comparison material for determining the priority scale of the main risk mitigation of the shallot supply chain.

2. Methodology

The method used in this research is descriptive. The data collection technique was carried out through surveys, in-depth interviews, and distributing questionnaires to respondents. Surveys and interviews were conducted to determine the actors involved in the shallot supply chain. The questionnaire was used to identify the types of supply chain risks on shallots.

This research was conducted in the lowlands of the Majalengka Regency from December 2019 to June 2020. The determination of the location was carried out by purposive sampling with the consideration that the area is the centre of shallot production.

Respondents in this study consisted of government experts, academics, and actors involved in the shallot supply chain (farmers, farmer groups, traders, retailers, and consumers) [16]. Respondents as experts were selected purposively with the following criteria:

a) Having expertise and experience in the field of the supply chain for agricultural commodities, especially shallots.

b) Know the general conditions of shallot farming starting from cultivation, post-harvest, and marketing of shallots.

c) Know the sources and types of risks faced by shallot supply chain actors.

The analytical method used in this research is the model Analytical Hierarchy Process (AHP). AHP was developed by Thomas Saaty[17] This is an effective method for dealing with complex decision-making [18]. This method is used to make decisions and determine the best alternative by considering various criteria [19].

AHP model through expert choice 11 software can be used to identify the risk of the shallot supply chain. The data processed for AHP analysis is in the form of data on the risks faced by each actor involved in the supply chain of shallots. Risk data is obtained from literature studies and in-depth interviews with several experts who are familiar with supply chain risks, both from government, academia, and practitioners.

The AHP working principle stages are as follows [14]:

1) Problem identification

The first stage to do is identify the problem in depth. The next process is the identification and selection of elements that will be included in the system components, such as objectives, actors, and alternatives in the AHP structure. This method is able to break down complex problems into sub-problems, classify these sub-problems based on domination relations, and build an orderly hierarchy[20]. The hierarchical structure of the shallot supply chain can be seen in Figure 1.
2) Creating a hierarchical structure
Based on literature studies and expert opinions, the hierarchical structure in this study consists of 4 levels including goals, actors/criteria, sub-criteria, and alternatives. The AHP process method involves the consideration of a hierarchical structure in the form of targets, criteria, and alternatives. [19] The goal is to identify risks of onion supply chain actors, Actors/criteria are actors involved in the shallot supply chain consisting of farmers, farmer groups, traders, retailers, and consumers. Sub criteria consist of fairness in profit sharing among supply chain actors, supply chain efficiency, and smooth flow of goods, money, and information. Whereas the alternatives are the types of risks that are often faced by shallot supply chain actors consisting of price risk, production risk, market risk, capital risk, technology risk, policy risk, quality risk, transportation risk, environmental risk, information risk, and storage risk.

3) Assessment of each level of the hierarchy
This assessment is carried out to find the elements that most influence the overall goal. The step taken is to assess the relative importance of two elements at a certain level about the level above it. The results of the assessment are made in the form of a matrix, namely the pairwise comparison matrix with size $n \times n$. Base scale 1 to 9 to assess the comparison of the importance of an element to other elements.

Table 1. Rating Scale.

| Comparison Scale | Define | Description |
|------------------|--------|-------------|
| 1                | Both elements are equally important | Two elements have the same influence greatly to the goals |
| 3                | Elements of a little more important than other elements | Experience and judgement slightly favor one element compared to other elements |
| 5                | Elements which one is more important than other elements | Experience and strong vote supporting one element compared to the other elements |
| 7                | One element is obviously more important than other elements | One very powerful element supported, and the domain has been in practice |
| 9                | One absolutely essential element than other elements | The evidence that supports one element against another element has the highest possible degree of confirmation strengthens |
| 2, 4, 6, 8       | The values between two adjacent values | Values considerations is given when there are two compromises between two |
options

4) Determination of element priority. Each level of the hierarchy needs to be compared in pairs to determine priority. The pair-wise comparison analysis helps to assign different levels of importance to criteria [21]. A pair of elements is compared based on certain criteria and weighs the intensity of preference between elements. Relationships between elements from each level of the hierarchy are established by comparing them in pairs. This relationship describes the relative influence of an element at a hierarchical level to each element at a higher level. The elements at this higher-level function as a criterion and are called properties. The result of this differentiation process is the priority vector or the relative importance of an element to each trait. Pairwise comparisons are repeated for each element in each level. Then the next step is to give weight to each vector with its priority properties. The pairwise comparison process starts at the top of the hierarchy (goal) which will be used to make the first comparison. Then from the level just below it (criteria), take the elements to be compared.

| Matrix Size | RI   | Matrix Size | RI   |
|-------------|------|-------------|------|
| 1           | 0    | 9           | 1.45 |
| 2           | 0    | 10          | 1.49 |
| 3           | 0.58 | 11          | 1.51 |
| 4           | 0.90 | 12          | 1.48 |
| 5           | 1.12 | 13          | 1.56 |
| 6           | 1.24 | 14          | 1.57 |
| 7           | 1.32 | 15          | 1.59 |
| 8           | 1.41 |             |      |

5) Logical consistency
In making decisions, an assessment that has high consistency is needed so that the results are accurate. Consistency is done to get authentic results in the real world. AHP measures the overall consistency of various considerations through a consistency ratio. The consistency ratio value must be 10% or less. If more than 10%, the assessment is still random and needs to be improved. The consistency ratio is calculated using the formula:

\[ CI = \frac{\lambda \ max - n}{n - 1} \] and \[ CR = \frac{CI}{RI} \] (1)

Where:
CI = Consistency Index
CR = Ratio Consistency
RI = Random Index
n = Size of The Matrix
3. Results and Discussion

3.1 shallot Supply Chain Actors
The actors involved in the shallot supply chain in the lowlands consist of farmers, farmer groups, middlemen, traders, retailers, and consumers. There are 7 shallot marketing patterns (Figure 3).

![Figure 2: Flow of shallot supply chain.](image)

In supply chain activities, farmer groups do not play a big role, but the traders do have a big role. The supply chain pattern is even more complex if it involves many traders and middlemen who come from the local area and from outside the region.

![Figure 3: Supply Chain Flow Pattern.](image)

3.2 Shallot Supply Chain Risks
Identification of shallot supply chain risks consists of objectives, criteria, sub-criteria, and alternatives. The aim is to identify the risks of shallots as contained in the hierarchical structure of the shallot supply chain (Figure 1).

Pairwise comparisons between criteria in identifying the risk of shallot supply chain actors can be seen in Table 3. According to experts from farmer groups, supply chain efficiency is a top priority. This condition can be seen from the supply chain pattern 1, namely by breaking the marketing chain from farmer groups to traders. Thus, the supply chain pattern is more efficient. Supply chain efficiency as a priority is also indicated by consumer assessments. The high evaluation from consumers is due to the efficient supply chain, which lowers the price received by consumers.
Farmers consider that the criteria for fairness of profit-sharing among chain actors are the top priority, followed by the smooth flow of goods, money, and information and finally supply chain efficiency. This rating is the same as that of the retailer. Such assessments occur because farmers and retailers feel that their share received is unequal compared to other supply chain actors. Moreover, farmers lack access to price and market information.

The smooth flow of goods, money, and information is a priority based on the traders’ assessment, then the fairness of profit-sharing between chain actors is a priority, because so far there is still an imbalance in profit sharing. The consistency index value below 10% indicates that the data is consistent.

Table 3. Comparison of Criteria in Lowland Supply Chain Identification.

| Criteria          | The Efficiency of The Supply Chain | The Smooth Flow of Goods, Cash Flow and Flow Information | The Fairness of Advantage Between Supply Chain Actors | Consistency Index |
|-------------------|------------------------------------|--------------------------------------------------------|-----------------------------------------------------|-------------------|
| Farmers           | 0.157                              | 0.249                                                  | 0.594                                               | 0.05              |
| Group of Farmers  | 0.493                              | 0.311                                                  | 0.196                                               | 0.05              |
| Traders           | 0.311                              | 0.493                                                  | 0.196                                               | 0.05              |
| Middleman         | 0.196                              | 0.311                                                  | 0.493                                               | 0.05              |
| retailers         | 0.157                              | 0.249                                                  | 0.594                                               | 0.05              |
| Consumers         | 0.540                              | 0.297                                                  | 0.163                                               | 0.01              |
| Academian         | 0.196                              | 0.493                                                  | 0.311                                               | 0.05              |
| Government        | 0.140                              | 0.528                                                  | 0.333                                               | 0.05              |

Table 4 shows the results of the synthesis of the risk identification of shallot supply chain actors. According to farmer, production risk has the largest assessment, followed by price risk, environmental risk, and storage risk. Production risk is a priority risk compared to other types of risk. This is because in the shallot production process there are many obstacles in the form of weather and climate, pests and diseases, quality of seeds, use of fertilizers and pesticides that are not following the needs based on the recommended dosage, and there is still a need for improvements in cultivation techniques according to standard operational procedures.

According to group of farmers, the five biggest risks are production risk, price risk, environmental risk, and market risk, and technology risk. Price risk is a priority because onion prices are volatile. When the price goes down during the peak harvest and when it is not during the peak harvest the price goes up. However, according to farmer groups in the lowlands, production risk is a priority due to frequent attacks by pests and diseases. Besides, environmental risks such as irrigation conditions, weather and climate also present risks.

According to Traders, the biggest risks are price than production risk, market risk, distribution risk and technology risk. The highest risk according to middlemen is production risk, price risk, distribution risk, market risk, and capital risk. The number of cutters is not more than 10%. Middlemen not only come from the local area, but also from outside the region such as Brebes Regency.

The five biggest risks according to retailers are production risk, price risk, market risk, capital risk, and distribution risk. Production risk is the biggest risk because the supply of shallots in the lowlands is not as much as the supply in the high and medium lands.

The consumer’s assessment consists of price risk, production risk, market risk, quality risk and distribution risk. According to academicians and government experts, the risk of production is the biggest risk.
Table 4. Risk Assessment among Shallots Supply Chain Actors in the Lowlands of Majalengka Regency.

| Kinds of Risk | Farmers  | Group of Farmers | Traders  | Middleman | Retailers | Consumers | Academian | Government |
|---------------|----------|------------------|----------|------------|-----------|-----------|-----------|------------|
| Price         | 0.132    | 0.136            | 0.171    | 0.143      | 0.146     | 0.150     | 0.128     | 0.143      |
| Production    | 0.169    | 0.166            | 0.135    | 0.148      | 0.159     | 0.139     | 0.165     | 0.144      |
| Market        | 0.094    | 0.098            | 0.125    | 0.099      | 0.122     | 0.114     | 0.139     | 0.135      |
| Capital       | 0.069    | 0.081            | 0.068    | 0.092      | 0.104     | 0.062     | 0.076     | 0.047      |
| Technology    | 0.103    | 0.089            | 0.082    | 0.069      | 0.077     | 0.055     | 0.083     | 0.072      |
| Policy        | 0.036    | 0.044            | 0.043    | 0.041      | 0.052     | 0.058     | 0.076     | 0.076      |
| Quality       | 0.075    | 0.063            | 0.079    | 0.068      | 0.074     | 0.096     | 0.084     | 0.071      |
| Distribution  | 0.057    | 0.072            | 0.101    | 0.123      | 0.082     | 0.083     | 0.071     | 0.119      |
| Environmental | 0.130    | 0.126            | 0.073    | 0.054      | 0.062     | 0.058     | 0.063     | 0.046      |
| Information   | 0.039    | 0.042            | 0.056    | 0.092      | 0.054     | 0.088     | 0.058     | 0.079      |
| Storage       | 0.096    | 0.083            | 0.067    | 0.081      | 0.069     | 0.097     | 0.058     | 0.068      |

Figure 4 shows an assessment of the five biggest risks, namely production risk (15.6%), price risk (14.2%), market risk (10.9%), environmental risk (8.7%), and distribution risk (8.6%). These five types of risk should receive greater attention. Price risk is caused by fluctuations in the price of shallots, inflation rates, bank interest rates, and distortion of information and supply. Production risks come from weather and climate, pests and diseases, quality of seeds, irrigation and human resources or farmers who carry out the process of shallot cultivation.

Sources of market risk are the market structure, fluctuations in shallot prices, shallot quality standards in the market and consumer demand. Distribution risk stems from poor packaging and transportation in the transportation of shallots, which causes the shallots to be damaged and experience shrinkage on the way to markets and consumers. The quality of shallots is very much influenced by the quality of the seeds, harvest and post-harvest handling and their distribution. Currently, shallots of poor quality are sold cheaply to retailers and many of them are thrown away, even though if there is processing the results can provide added value to the community. Apart from production risk, price risk and market risk, what needs to be paid great attention are environmental risk and distribution risk.
4. Conclusion

The actors of the shallot supply chain in the lowlands consist of six actors, namely farmers, farmer groups, traders, middlemen, retailers and consumers. The results of pairwise comparisons based on the AHP model analysis show that equity in profit sharing among supply chain actors is a priority at the farmer, retailer and middlemen levels. Supply chain efficiency is a priority at the farmer and consumer group level. The smooth flow of goods, money and information is a priority according to dealers, academic experts and government experts. The results of the identification of the supply chain of shallots based on consideration of the criteria and sub-criteria indicate that five types of the biggest risks need attention from various parties, both practitioners and academics and the government. The five risks are production risk (15.6%), price risk (14.2%), market risk (10.9%), environmental risk (8.7%) and distribution risk (8.6%).

Acknowledgments

The author would like to thank the Faculty of Agriculture, Singaperbangsa University and the Faculty of Agriculture, University of Majalengka, West Java, Indonesia for their support for the implementation of this research.

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