Risk analysis model of sweet corn production using Z-score and value at risk methods

E Wahyuni, Kasmiati, ASutrisno, G Y Rahajeng
Department of Agribusiness, Faculty of Agriculture Borneo University, Tarakan, Indonesia
E-mail: etty30@borneo.ac.id

Abstract. Sweet corn is one of the food commodities produced by farmers in Indonesia. In sweet corn cultivation, farmers face the risk of production originating from fertilizers, pets and weather changes. Production risks include the decrease of quality and quantity of production and farmers experiencing losses. The purposes of this study were to identify sources of farming production risk, to analyze the probabilities and impacts of risk sources, to formulate the overcoming risk strategies risk of sweet corn farming production. A total of 50 corn farmers were involved. The collected data were analyzed by using descriptive analysis, probability and impact analysis, the Z-score and Value at Risk (VaR). The biggest source of risk was pest attack with a probability of 9.63% and an impact of Rp 562,102,64/hectare followed by fertilizer with a probability 6.55% and an impact of Rp 536,600,03/hectare and weather/climate change with a probability of 2% and an impact of Rp 337,150,10/hectare. The preventive strategies used to handle pest risk sources were land sanitation and mitigation strategies, namely the provision of pesticides and insect for grasshoppers. Mitigation strategy was used to handle fertilizer risk that improving farmers’ skills in fertilizing and giving the right type of fertilizer and dosage. As for climate/climate change, the preventive strategies used work making drainage, making high beds, watering and growing or accumulating roots.

Keywords: Risk Sources, Risk Analysis, sweet corn

1. Introduction
Sweet corn (Zea mays var. Saccharata) is a horticultural plant that has high sucrose content, low protein and fat so that it is widely preferred by Indonesians, especially for direct consumption. Sweet corn deserves to be a superior commodity for food crops because of its high demand and higher price than other maize varieties. Sweet corn farming can increase farmers’ income and welfare if it is cultivated effectively and efficiently[1],[2] stated that even though market demand is quite high, the current sweet corn production is still low because it is faced with various risks, one of them is the risk in the production process that comes from climate or weather change, the use of production inputs, the attack of pests and diseases. Farming in developing countries often face uncertainty because farmers do not know whether rainfall will be good or bad during the season, they do not know the price they will receive for their product, and whether their crops will grow without being infected with disease. Furthermore, [3] stated that the production risk comes from the uncertain natural growth process of plants or livestock with sources of risks related to weather and climate (temperature and rainfall), pests and diseases as well as other production limiting or reducing actors such as the presence of heavy metal or salinity in the soil. Production risk is very important for producers [4] who in this study are farmers. Sources of risk are predicted to increase along with technological developments, international trade, climate change, institutions and demographics [5].
The existence of risks becomes a consideration for farmers in allocating inputs and of course will affect the resulting output [6]. Farmers will consider reducing inputs that pose a production risk and conversely increasing inputs that can reduce risk so that there are variations in input allocation among farmers based on the level of production risk faced [5] such as the Philippine rice agricultural data model found that labor input reduces risk, whereas other inputs (area, fertilizer and materials) increase the risk.

Tarakan, especially North Tarakan, has agricultural potentials that need to be developed, such as secondary crops, namely corn and cassava. Harvested area for maize in 2016 was 94 hectares with a production of 1,225.4 tons, in 2017 the harvested area was 60 hectares with a production of 1,062.0 tons, in 2018 the harvested area was 100 hectares and production were 1,750.5 tons. The production of maize plants in North Tarakan District from 2016 to 2018 continued to experience fluctuations in the production of maize plants, which in 2017 experienced a decline in production and in 2018 experienced an increase. Changes in maize production that occur in North Tarakan District were influenced by several factors that cause irregular sweet corn production.

The aims of this research were to identify sources of risk, analyzed the probability and impact of risk sources, and formulate strategies that could be done to overcome the risk of sweet corn production.

2. Method

2.1 Location and Respondents

Tarakan city is located in the North Borneo with an average altitude of ± 18 meters above sea level, lies in the position between 3 ° 14’30”-3 ° 26’37” north latitude and 117 ° 30’50”-117 ° 4 0’12” East longitude. The area of Tarakan City is 657.33 km² with land area of 250.80 km² and sea area of 406.53 km². This research was conducted from November 2019 to May 2020.

![Figure 1. Map of study sites in Tarakan Island, North Kalimantan, Indonesia](image)

Black dot represents the study site

2.3 Data Collection Technique

50 respondents in this research were all corn farmers in the selected research location. The farmers had an age range of 29-71 years and 10 people predominantly in the age range of 53-58 years (20%), 22 people have completed elementary school (44%), while there were 35 people (74%) that has become corn farmers for 10 years. As many as 48 farmers (96%) planted corn on a land area of 0.5-1 ha, but only 10 people (20%) owned their own land while other farmers used borrowed land.

The data collection was done by using observation, interview and documentation methods. Methods of observation to keep records about the activities of the cultivation of sweet corn and risks faced by farmers. In the second stage, in-depth interviews were conducted with farmers to obtain more detailed information and data on production inputs, yields for each planting season, the amount of production damaged, and how farmers deal with the risks they face. The data collected was data for 3 planting periods, namely the period June-August, August-October and October-December.
2.4 Data Analysis Technique

Data analysis technique used was Probability Analysis, Value at Risk analysis and Risk Mapping. Probability analysis was used to determine the likelihood of the risk of using the data amount of production that was broken every period of the growing season of each source of risk. First thing to do was to calculate the average-risk events, then the standard deviation scores of events at risk, and continued to calculate the Z-score. The Z-score value obtained was then checked in the Normal Distribution Table (Z Distribution Table) available in Microsoft Excel to obtain the percentage level of the probability of each production period from risk sources.

The risk impact was analyzed using the VaR (Value at Risk) method to obtain the greatest value of the impact of the losses that may occur in each predicted planting period with a certain level of confidence (in this study the 95% confidence level was used). Data on the amount of production damage per period from risk sources are multiplied by the price and the average was calculated from 50 respondents. Then the standard deviation and VaR values were calculated.

The results of probability analysis (Z-score method) and impact value analysis (VaR) were used to create risk mapping, which was generally arranged based on the probability and impact of risk using a vertical axis that describes the probability of a risk and a horizontal axis that describes the impact of risk. These [7].

![Figure 2. Risk Map](image)

Based on the results of risk mapping, then an appropriate risk management strategy can be determined. There are two strategies that can be taken to manage risk, namely:

1. Risk avoidance (Preventive) will address risks in quadrants I and II. In handling risks using a preventive strategy, the risks in Quadrant I will shift to Quadrant III and the risks in Quadrant II will shift to Quadrant IV.

2. Mitigation Risks that are in the quadrant with a large impact are pursued using a mitigation strategy that can move to the quadrant that has a small impact. The mitigation strategy will handle risks in such a way that the risks in quadrant II will shift to quadrant I and those in Quadrant IV will shift to quadrant III.

3. Result

3.1 Source Risk Identification

One of the risks for sweet corn farming production are pests, fertilizers and weather / climate change.

1) Fertilizer

Fertilizer is a material that contains nutrients and nutrients for plants for plant growth and development. The fertilizer used by sweet corn farmers was 3.3 tons / hectare manure, fertilizer N 399 kg / ha, fertilizer P 133 kg / ha and fertilizer K 266 kg / hectare. This number is still below the recommended dosage, namely manure 3.57 tons / hectare, urea fertilizer 435 kg / hectare, phosphorus fertilizer 300 kg / hectare and SP-36 fertilizer 335 kg / ha (Ardila, 2013). Lack of
fertilizers or nutrients has created a risk of decreasing the quantity and quality of sweet corn production.

2) Pests
Pests are organisms that act as plant pests. Leaf worms, cobworms and grasshoppers were pests found in the research location. Leaf worms and grasshopper eat from the leaves to the stems while the cobworms eat the fruit cobs to form a tunnel.

3) Climate and weather changes
The research area often experiences unpredictable weather. For example, when it was supposed to be the dry season but a very high rainfall occurred. When rainfall is high, the population of pests and disease attacks also increases so that it affects the production of sweet corn. Meanwhile, during the dry season there is often a lack of water which causes the seeds to not germinate, plants that are still easily wilted and dry, and the flowering process is disrupted.

The following table presents data on sweet corn production and the amount of damage from each risk source:

| Planting Period | Production (Kg) | Total | Good | Pest | Damaged Fertilizer | Weather/Climate |
|-----------------|-----------------|-------|------|------|-------------------|-----------------|
| Period 1        | 1916,4          | 1530  | 116  | 124  | 146,8             |
| Period 2        | 1728            | 1233  | 126,4| 204,4| 164,4             |
| Period 3        | 1927,4          | 1591  | 127,2| 124  | 90,4              |

3.2 Probability and Impact of Production Risk
The probability of each risk based on the sequence is the probability that it is caused by pests, fertilizers and weather / climate changes as shown in the following table:

| No. | Sources of Production Risk | Probability (%) | Period 1 | Period 2 | Period 3 |
|-----|----------------------------|-----------------|----------|----------|----------|
| 1.  | Pest                       | 9,04            | 9,04     | 6,29     | 9,63     |
| 2.  | Fertilizer                 | 8,93            | 8,93     | 3,78     | 6,55     |
| 3.  | Weather/Climate Change     | 5,34            | 5,34     | 6,15     | 2,00     |

The highest risk probability value at each planting period came from pests with a value of 9.04 percent, 6.29 percent and 9.63 percent. Sources of fertilizer risk have a probability value of 8.93 percent in the first period, 3.78 percent in the second period and 6.55 percent in the third period. The risk probability caused by weather / climate change has a probability value of 5.34 percent in the first period, 6.15 percent in the second period and 2.00 in the third period. These results indicate that pests are a source of risk that is difficult for farmers to deal with, so the probability is always high at all planting periods. The source of the risk of fertilizers can still be overcome by farmers so that the probability value can decrease in the second planting period, but if farmers do not have the correct dosage and method of applying fertilizer, it could be that the damage from this source will increase. For the source of the risk of weather / climate change is the most difficult for farmers to predict, this is because the research area is an island so that the rainy and dry seasons are uncertain.

The impact of farmers’ losses caused by the occurrence of production risks can be calculated by making use of the probability calculation results as presented in the following table:
Impact of the highest risk in the first period was the risk of fertilizer with a value of Rp. 753,267, this means that the maximum loss borne by farmers due to fertilizer was IDR 753,267 / hectare with a confidence level of 95 percent. However, there was a 5 percent probability that the losses experienced by farmers would be greater than Rp. 753,267 / hectare. In the second period the highest risk impact was from the source of the risk of climate change or climate change, while in the third period it was the source of the risk of pests.

From the results of the calculation of the impact analysis of risk sources, it was found that the VaR value for each risk source was then carried out by mapping the production risk which aimed to show the position of the risk source so that more effective risk management can be carried out. The risk map shows an overview of the position of risk on a two-axis map, i.e. the vertical axis represents probability and the horizontal axis represents the impact. The probability that occurs was divided into two, namely high probability and low probability. Likewise, the impact of risk was also divided into two, namely a large impact and a small impact. The boundary between the probability was great and the probability of small as well as large and small impact impact can be determined by the value of middle limit derived from the average value of the probability and the average value of the impact, as presented in the following table:

Table 4. Median Value of Vertical and Horizontal

| Planting Period | Vertical | Median | Horizontal |
|-----------------|----------|--------|------------|
| Period 1        | 7,77     | 656,545|             |
| Period 2        | 5,41     | 471,590|             |
| Period 3        | 6,06     | 478,602|             |

In the first period, pests and fertilizers were a source of risk with a large probability, but pests have a small impact while fertilizers had a large impact. The weather / climate change was a risk with little probability and impact.

7,77

- Pest (9,04;595,666)
- Fertilizer (8,93;753,267)
- Weather/Climate Change (5,34;620,704)

656,545

Figure 3. Period 1 Risk Map

The second period, the risk of pests still had a large probability and a small impact, while the risk of fertilizer had a small probability and the impact remains large. For weather / climate change had a large probability and a large impact.
For the third period, the risk of pests and fertilizers had a high probability and impact, while weather/climate change had a small probability and a small impact.

3.3 Production Risk Management Strategy
The strategy for handling the production risks faced by sweet corn farmers can consist of two strategies, namely a preventive strategy and a mitigation strategy.

1) Source of pest risk
The preventive strategy is to sanitize the area for corn crop fields once a week. Mitigation strategies to deal with the problem of leaf worms, cobworms and grasshoppers by applying chemical pesticides and when attacking grasshoppers with a large population using insect nets.

2) Fertilizer
Preventive strategies to deal with sources of risk due to fertilizers by increasing farmers' skills regarding the type, dose and timing of fertilization, to suit the needs and recommendations for sweet corn plants.

3) Weather and Climate Change
Preventive strategies to overcome the problem of weather/climate change are to make drainage and making higher beds during the rainy season so that the corn plants are not flooded. Meanwhile, during the dry season, water the sweet corn when it is still seed and young so that the plants do not wither and die. As well as doing piling or rooting so that when the wind is strong the plants do not fall easily.

4. Conclusion
Risk mapping of the three periods of planting showed that pest is always the risk with high probability but can result in different impact which requires farmers to mitigate and prevent the bad impact towards the product. Fertilizer is considered as a risk that has different probability and big impact hence force the farmers to take preventive measure in order to minimize the damage. Meanwhile, weather/climate change is a risk that may bring different probability and impact as weather/climate is something unpredictable even though preventive measure still can be taken to mitigate the impact.

References:
[1] A. Meilin 2016 Performance and farming analysis of sweet corn through implementing integrated plant management (IPM) In irrigation land, Jambi province (land optimization with pattern of rice-rice-secondary / horticultural plants), Innov. Environ. Agric. Technol. Support. Sustain. Food Self-Sufficiency, pp. 511–519, doi: 10.5281/zenodo.3345584.
[2] D. Kahan and Food and Agriculture Organization of the United Nations 2008 *Farm business analysis using benchmarking*.

[3] A. M. Komarek, A. De Pinto, and V. H. Smith 2020 A review of types of risks in agriculture: What we know and what we need to know, *Agric. Syst.*, vol. 178, p. 102738, https://doi.org/10.1016/j.agsy.2019.102738.

[4] J. C. O. Nyankori, Sadoulet, Elisabeth, and Alain de Janvry 1996 Quantitative Development Policy Analysis . Baltimore MD: The Johns Hopkins University Press, 1995, xii + 397 pp, *Am. J. Agric. Econ.*, vol. 78, no. 1, pp. 251–253, doi: 10.2307/1243800.

[5] W. Mamilianti, N. Hanani, M. M. Mustadjab, and R. Asmara 2019 Risk preference of farmers and production input allocation of potato farming in tengger highland, Indonesia, *EurAsian J. Biosci.*, vol. 13, no. 2, pp. 1777–1783.

[6] R. A. Villano, C. J. O’Donnell, and G. E. Battese 2005 An Investigation of Production Risk, Risk Preferences and Technical Efficiency: Evidence from Rainfed Lowland Rice Farms in the Philippines, *Work. Pap. Ser. Agric. Resour. Econ.*, vol. 1, pp. 1–26.

[7] R. Kountur 2004 *Manajemen Risiko Operasional*. Jakarta: PPM.