Risk analysis and revenue distribution of cassava farming as an impact of climate change in Wonogiri Regency

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Abstract. The geographical condition of Wonogiri Regency is agro climatically suitable for the cultivation of cassava. The management of cassava cultivation certainly has risks that can occur from natural factors, such as climate, weather, floods, as well as pests and diseases, during the cultivation process, price risks, etc., and ultimately will have an impact on farmers' income. Cassava risk analysis due to climate change is an interesting topic to research because it can cause huge losses that affect farmers' incomes and income inequality of cassava farmers. The study aims to (1) identifies the impact of climate change on cassava farming, (2) analyze the income of cassava farmers as a result of climate change, (2) analyze the risks of cassava farming from the impacts of climate change. The research method used is a survey with purposive sampling in the determination of sub-districts and villages, selected Ngadirojo Subdistrict, cassava farmers took 60 farmers in simple random sampling. Data were analyzed with descriptive analysis, frequency analysis, revenue analysis, and risk analysis. The results showed that there was a 12.43% change in income due to climate change as measured by the delay in the growing season and product quality. There is a change in quality and quantity in three types of cassava market in Wonogiri Regency, namely (1) wet cassava market, (2) dry cassava market (gaplek), (3) industrial market that goes directly into the factory. Risk analysis obtained coefficient of variation (CV) of 0.503 which means that the average income risk faced by farmers is classified as risky in the low category (CV>0.5), with the lower limit value (La) showing Rp. 28,121.82 which means that in running a cassava cultivation business, farmers must dare to bear the risk of income of Rp. 28,121.82 (12.47%) in one period of cultivation.

1. Background
Cassava is a strategic commodity in supporting the food security of a region because it could be used as a substitute for staple food such as rice and corn, raw material for industry and livestock feed. During 2000-2015 the growth of cassava exports increased by an average of 109.18% and had an impact on the level of cassava productivity in Indonesia of 3.84% [1]. The high growth of production and export of Indonesian cassava is not sufficient for the demand of cassava in Indonesia, therefore Indonesia still imports cassava with a development that tends to increase by on the average of 41.26% per year and the number of imports of fresh and processed cassava increased to 987.5 tonnes in 2016. The import figure is estimated to increase next year when compared to the development of Indonesia’s cassava production [2].

Central Java Province is the third national producer of cassava after Lampung and East Java with an average harvest area of 15.17% or 163.88 thousand hectares [3]. One of the cassava producers in Central
Java is Wonogiri Regency. The cassava commodity in Wonogiri Regency is frequently associated with the fluctuation of cassava production which affects the agricultural production and the socio-economic of farmers. According to Wargiono et al., [4] cassava requires humidity of 65% and if the temperature is below 10°C the growth of cassava plants will be inhibited. Cassava plants are very well planted at an altitude of 150 meters above sea level with alluvial, Latosol, Podsolic, Grumosol and Andosol soil types with a minimum soil acidity level (pH) 5. The Wonogiri Regency area used for cassava cultivation is located at an average height of 100 to 275 meters above sea level and a tropical climate with an average temperature of 29.80°C, therefore the geographical of Wonogiri Regency are agro-climatically suitable for cassava cultivation. The management of cassava cultivation has a risk of either failure or success. Risk sources incurred from natural factors, such as climate, weather, floods, as well as pest and disease attacks, during the cultivation process, price risk, etc. would ultimately have an impact on farmers' income [5]. Analysis of the risk of cassava due to climate change is an interesting topic for investigating because it causes huge losses that affect farmers' income and income inequality to cassava farmers. The level of risk was analyzed by using risk analysis. The research objectives were (1) to identify the impact of climate change on cassava farming, (2) to analyze the income of cassava farmers as the impact of climate change, and (3) to analyze the risk of cassava farming from the impact of climate change.

2. Methodology

The research method used was a survey conducted in the Bengawan Solo watershed, Wonogiri Regency. The research location was carried out purposively taken in the largest order subdistrict based on the centre of cassava agribusiness production, therefore Ngadirojo Subdistrict was selected as the research location. Simple random sampling was used for sampling of the cassava farmers, data collection was completed with focus group discussion (FGD).

The data used were primary and secondary data. Data collection techniques were carried out by conducting observation, collecting of literature study and surveying following the distribution area of cassava management and interviewing with cassava farmers with structured questionnaires and interviews. Descriptive analysis was used to analyze the data, frequency analysis, income analysis and risk analysis. Analysis of the risk of cassava income could be known by calculating the coefficient of variation (CV) and the lower limit value (L). Calculating the value of CV is supposed to find the average value of the income of cassava (E) and the value of standard deviation (V). The calculation is formulated in the equation below (1)

$$\bar{E} = \sum_{i=1}^{n} \frac{E_i}{n}$$

Description:

- \( \bar{E} \) = Cassava average income (Rp)
- \( E_i \) = Cassava income at-\( i \) (Rp)
- \( n \) = Number of respondents

The next step is counting the value of standard deviation which following formula below (2)

$$V = \sqrt{\frac{\sum_{i=1}^{n} (E_i - \bar{E})^2}{n-1}}$$

Description:

- \( V \) = Standard deviation of cassava income
- \( \bar{E} \) = Cassava average income (Rp)
- \( E_i \) = Cassava income at-\( i \) (Rp)
- \( n \) = Number of respondents

Then, counting the value of income risk which following formula below (3)

$$CV = \frac{V}{\bar{E}}$$

Description:

- \( CV \) = Cassava income risk
- \( V \) = Standard deviation of cassava income
- \( \bar{E} \) = Cassava average income (Rp)
Description:
CV = Coefficient of income variation
V = Standard deviation of cassava income
E = Cassava average income (Rp)

The criteria used were if the CV value <0.5 means that the cultivation of cassava has a low risk and if the CV > 0.5 then the cultivation of cassava has a high risk. According to Husain et al. [6], the relationship between risk and income could be measured by a coefficient of variation that compares the risk borne by farmers and the amount of income. If the coefficient of variation goes down, then the possibility of risk borne will decrease. On the contrary, if the coefficient of variation rises, then the risk faced will increase. The lower limit (L) shows the smallest income value received by cassava farmers when coming through to the maximum risk. Counting the amount of the lower limit value which following formula below (4)

\[ L = E - 2V \]  

Description:
V = Standard deviation of cassava income
E = Cassava average income (Rp)
L = Lower limit value of income
If L≥0 means that the cassava farmers will not suffer losses. If the L value is negative, it means that farmers suffer losses equal to the result of the L value.

3. Result and discussion

Wonogiri Regency is one of the regencies in Central Java which is geographically located between 110°41' - 111°18' East Longitude and 7°32' - 8°15' South Latitude. The lowest altitude in Wonogiri Regency is Selogiri District with an altitude of 106 meters above sea level (masl) and the highest area is Karangtengah District with an altitude of >600 masl. Based on regional conditions, Wonogiri Regency is suitable for cultivating cassava because of accordance with the requirements for growing cassava plants. Altitude is good and ideal for cassava plants between 10-700 masl, while the tolerance is between 10-1,500 masl. The area of Wonogiri Regency is traversed by the Bengawan Solo watershed which is the largest river in Central Java Province with tributaries/sub-watersheds of Keduang, Wiroko, Solo Hulu, Temon, Kali Lanang, Kali Wuryantoro, Ngunggahan, Kresek, Oyo, and Walik. All of these tributaries flow into the Gajah Mungkur Wonogiri Multipurpose Reservoir and are upstream of Bengawan Solo.

The topography of Wonogiri Regency is mostly hilly land, with + 20% of the area being limestone hills, especially those in the southern area of Wonogiri. Most of the topography is uneven with an average slope of 30 degrees, therefore there are differences among the area that causes the conditions of natural resources to differ from one another. Only a small part of the area has fertility and potential for agriculture.

Climatic conditions are very important for life either for agriculture or plantations. Therefore, information about the weather consisting of rainfall, temperature, humidity is needed by agricultural land users to increase production. Based on the Meteorological Station of Wonogiri Regency, the air temperature in Wonogiri Regency in the dry season and the rainy season is a maximum of 36.5°C and a minimum of 18.26°C. This shows that the air temperature in Wonogiri Regency is suitable for the growth of cassava because the air temperature is above 10°C. The maximum humidity in the Wonogiri Regency area is 91% and a minimum of 80% with an average humidity of 85.3%. Rainfall in Wonogiri Regency is 1,488 mm/year with 106 rainy days/year. The number of rainy days in the dry season is 5 rainy days. The number of rainy days in the rainy season is 101 rainy days. Rainfall in Wonogiri Regency is close to optimal (1,500-2,500 mm/year) so it is suitable for the growth of cassava plants. According to Wargiono et al. [2], cassava requires rainfall of 150-200 mm at the age of 1-3 months, 250-300 mm at the age of 4-7 months, and 100-150 mm in the phase before and at harvest time. Cassava can be developed in almost all regions in Indonesia, both in the wet and dry seasons as long as the water is
available according to the needs of the plants for each growth phase. The appropriate rainfall for the growth of cassava is between 1,500-2,500 mm/year with an air temperature of at least 10°C. If the air temperature is below 10°C, it can cause plant growth to be slightly stunted and become stunted due to imperfect flower growth. Sunlight needed for cassava plants is around 10 hours/day, especially for leaf fertility and tuber development. Cassava varieties that are widely cultivated in Wonogiri Regency can be seen in the following graph:

Figure 1. Varieties of cassava in Bengawan Solo Watershed, Wonogiri Regency
(Source: Analysis of Primary Data, 2020)

Farm risk analysis, carried out by qualitative and quantitative approaches. The qualitative approach is based on subjective research from any decision making. Meanwhile, the quantitative approach is based on the expected return value as an indicator of the probability of investment and the measure of variance and standard deviation as an indicator of risk [7]. According to Yasa et al. [8], risk could be described as a potential adverse event due to uncertainty over the occurrence of an event. This uncertainty is a condition that can lead to risks arising from various activities, especially climate change. The changes observed were the retreating shift in cassava planting, causing a decrease in production (2.7%) and an impact on the income received. In addition, due to changes in high rainfall affect the quality of cassava products, which has an impact on the amount of income. The following is an analysis of the risk of income from cassava as a result of climate change.

Table 1. Risk of cassava income in a period.

| No. | Description                          | Amount          |
|-----|--------------------------------------|-----------------|
| 1.  | The highest income (Rp/kg)           | 12,000,000.00   |
| 2.  | The lowest income (Rp/kg)            | 1,100,000.00    |
| 3.  | Average income (E) (Rp/kg)           | 4,697,600.0     |
| 4.  | Variance (V_a²)                      | 5,583,111,682,051.28 |
| 5.  | Standard deviation (V_a)             | 2,362,860.91    |
| 6.  | Coefficient of variation (CV_a)      | 0.503           |
| 7.  | Value of lower limit (L_a)           | -28,121.82      |

Source: Analysis of Primary Data, 2020.

Based on Table 1, it is shown that the calculation results of all components obtained a coefficient of variation (CVa) of 0.503. The coefficient of variation indicates that the average income risk faced by
farmers was classified as "risky" (CV> 0.5) but in the low category. It because climate change involves cassava cultivation that did not require a lot of maintenance, therefore production costs could be reduced. Based on the results of research from Ekaria and Muhammad [9] who also analyzed the risk of cassava income, it showed a coefficient of variation (CV) of 0.35 due to relatively fluctuating selling prices and unstable production. The lower limit value (La) was obtained by a figure of Rp 28,121.82, which means that in running a cassava cultivation business, farmers must bear an income risk of Rp 28,121.82 in one planting season. The risk value was also influenced by climate change with delayed planting and the quality of the sweet potato does not meet the standard. This can affect the risk and the risk of affecting income, related to changes in quality and quantity in three types of cassava markets in Wonogiri Regency, namely (a) wet cassava market, (b) dry cassava market (gaplek), (c) industrial markets that go directly to factories. The various qualities and quantities cause the market to be reluctant to accept. Therefore, when the income from cassava farming poses a risk due to climate change, the cassava farmers will cover the lack of income from other sources outside of cassava. Income from these other sources can increase the total amount of income received by farmers. The following table is related to the risk of total farmer household income.

| No. | Description                     | Amount                   |
|-----|---------------------------------|--------------------------|
| 1.  | The highest income (Rp/kg)      | 92,016,000.00            |
| 2.  | The lowest income (Rp/kg)       | 3,250,000.00             |
| 3.  | Average income (E) (Rp/kg)      | 16,855,005.00            |
| 4.  | Variance (V^2)                  | 251,564,875,365,103.00   |
| 5.  | Standard deviation (V)          | 15,860,796.81            |
| 6.  | Coefficient of variation (CV)   | 0.94                     |
| 7.  | Value of lower limit (L)        | -14,866,588.61           |

Source: Analysis of Primary Data, 2020.

Based on Table 2, showing that the coefficient of variation of the total household income of farmers is 0.94, which means that the total income of the farmer household was at risk because the value exceeds 0.5. The high number was due to the risk of each household being different in the level of impact received and would affect farmers’ access to the cassava market. The various risk perceived by the farmers, then the farmers’ income would also vary and affect the total household income. It causes the total household income in every farmer will vary and more widely. This caused the coefficient of variation of total household income to become higher.

4. Conclusion and suggestion

The conclusions of this study are (1) the impact of climate change on cassava farming has been identified as providing a decrease in income, (2) analysis with the income of cassava farmers decreased by 12.43%, (3) income risk cassava farming due to climate change is quite large for farmers. Recommendation refers to the farmers that they must take the attitude of climate change, dare to take risks or counteract it with a cropping pattern strategy or switch to other, more advantageous in times of climate change.

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