Production risk of organic rice due to climate change in Magelang Regency, Central Java, Indonesia

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Abstract. Organic rice farming is a rice cultivation activity applies ecological principles without using chemical fertilizers and pesticides. The big challenge for organic rice farming is climate change in the form of high temperatures, drought, high rainfall which is difficult to predict. This situation have an impact on decline in production and income of organic rice farming. The objective of the study was to determine the income organic rice farming and analyzes the levels and factors affecting production risk of organic rice. The study was conducted in Magelang Regency with consideration that is a pilot project for organic rice farming in Indonesia and have farmer groups received organic certification. Respondents consisted of 75 organic rice farmers selected using simple random sampling methods. The data was taken through interviews based on questionnaires and documentation methods. Production risks were analyzed using the coefficient of variation and factors that influence production risk were analyzed using the Cobb-Douglass production function with Just and Pope approach. The results showed that the income of organic rice farming on an average land area of 3,690 m^2 was IDR 6,694,860. Organic rice farming has a low production risk category. Factors that affect the production risk are land area and labor.

1 Introduction

Rice is a commodity crop that is of strategic importance to the Indonesian nation. This is due to the fact that rice is the primary food of the Indonesian populace and is cultivated by the majority of farmers [1]. The government has implemented a variety of programs to increase rice production, in order to meet the increasing demand due to population growth. Intensification through the application of chemical fertilizers and pesticides has effectively increased rice production in Indonesia. However, the implementation of the intensification program is not effective enough because the use of inputs does not pay attention to the balance of the ecosystem [2]. If development only focuses on growth without considering

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environmental factors, the impact will be detrimental to the environment and threaten survival [3].

Organic farming is a form of agricultural development implemented in Indonesia by utilizing local resources that are environmentally friendly [4]. In the long run, organic cultivation of rice may increase rice production through improvement of the soil's physical, chemical, and biological qualities [5]. Organic rice farming that uses a combination of several compost fertilizers can reduce methane gas emissions and high rice yields [6]. Organic farming systems are ideal for rice cultivation as they require fewer inputs and yield high-quality rice [7]. Organic rice farming is a rice cultivation activity that uses an organic cultivation system, starting from treatment to obtain seeds, use of fertilizer, pest and disease control to post-harvest treatment, not the slightest involvement of chemicals, all must use biological or natural materials [8]. Even without using chemical fertilizers and pesticides, organic rice can produce higher production compared to organic rice as happened in Pringsewu Regency [9]. The same situation also occurred in Malang Regency, East Java[10], Boyolali Regency, Central Java [11], Cambodia [12], Chitwan District of Nepal [13] and the island of Mindoro, Philippines [14]. According to [2], there is a difference between farmers who have been conducting organic rice cultivation for a long time and those who are just starting this practice, organic rice production will also increase along with the length of time the farming has been carried out.

Magelang Regency is a region that is a pilot area for the development of organic rice cultivation in Indonesia and other Asian countries. The existence of the UPLAND project of the Ministry of Agriculture, which received funding from several international donors, has succeeded in developing organic rice with a large area 2,000 ha area cantered in Sawangan, Bandongan and Grabag Districts. Magelang Regency's organic agricultural products have so far been accepted in both domestic and international markets. This program uses an integrated approach that focuses on infrastructure development, through training and agricultural education.

Organic rice farming applies ecological principles without using chemical fertilizers and pesticides [15]. This causes plants to be more susceptible to pests and disease infections, so organic farmers must be more vigilant in controlling pests and diseases naturally. Another thing that can be a big challenge for organic rice farming is climate change in the form of high temperatures, drought, high rainfall [16] which is difficult to predict. This situation will affect organic rice production.

The objective of the research was to determine the income earned from organic rice cultivation and analyze the levels of risk and factors that influence the production risk of organic rice in Magelang Regency, Central Java.

2 Research methods

The research was conducted in Magelang Regency, based on the consideration that it is an area for a pilot project for the development of organic rice in Indonesia and other countries in Asia. The development of organic rice in Magelang is also supported by the existence of the Sawangan Organic Farmers Association (*GATOS = Gabungan Tani Organik Sawangan*). *GATOS* encourages farmers by providing seed assistance, training in organic fertilization, and purchasing their rice at advantageous pricing. A total of 75 organic rice farmers were selected using the simple random sampling approach, proportionately from five farmer groups. This study uses primary and secondary data. Primary data was obtained through interviews with respondents based on a questionnaire that had been prepared, while secondary data was obtained using documentation techniques.

The first objective is to determine the income earned from organic rice farming which is analysed descriptively based on the following formula [17].

$$NR = TR - TEC \quad (1)$$

$$TR = Y.P_Y \quad (2)$$

NR = Net Revenue (Income)
TR = Total Revenue
Y = Total organic production
P_Y = Organic rice price
TEC = Total Explicit Cost

Production risk is measured by the coefficient of variation, defined as the ratio of the standard deviation to the average value [18]:

$$CV = Sd(Y)/\bar{Y} \quad (3)$$

CV = Coefficient of variation
Sd(Y) = Standard deviation
$\bar{Y}$ = Average value

CV is $\geq$ 0.5, organic rice farming is at risk, or the farmer has the potential to suffer losses
CV is < 0.5 then organic rice farming is not at risk or farmers do not have the potential to suffer losses

Factor affecting Production risk are analysed with the Cobb-Douglas Production Function, using Just and Pope approach [19]. This involves first analysing the factors that effect of production through the Cobb-Douglas production function, which is then transformed into its natural logarithmic form as follows:

$$Ln\ Y = Ln\ b_0 + b_1\ Ln\ X_1 + b_2\ Ln\ X_2 + b_3\ Ln\ X_3 + b_4\ Ln\ X_4 + b_5\ Ln\ X_5 + \varepsilon_1 \quad (4)$$

Based on equation (4) the following Cobb Douglas production function approach Just and Pope can be formulated:

$$Ln(\varepsilon_1)^2 = Ln\ \theta_0 + \theta_1\ Ln\ X_1 + \theta_2\ Ln\ X_2 + \theta_3\ Ln\ X_3 + \theta_4\ Ln\ X_4 + \theta_5\ Ln\ X_5 + \varepsilon_2 \quad (5)$$

Information:

Y = Organic rice production
b_0, b_1, b_2, b_3, b_4, b_5 = coefficients of regression of factors that influence organic rice production
X_1 = land area (m^2)
X_2 = seed (kg)
X_3 = manure (kg)
X_4 = organic pesticides (l)
X_5 = labour (workday)
$(\varepsilon 1)^2$ = production risk
θ_0, θ_1, θ_2, θ_3, θ_4, θ_5 = coefficients of regression of factors that influence production risk

Variance analysis (F test) has been used to analyses the simultaneous impact of independent variables: land area, seeds, manure, organic pesticides, and labour on production risk, using the following hypothesis:

$H_0 : \theta_1 = \theta_2 = \theta_3 = \theta_4 = \theta_5 = 0$
H_1 : one of $\theta i \neq 0$ where i = 1,2,3,4,5

$$F_{Count} = \frac{\boldsymbol{R^2(k-1)}}{\boldsymbol{(1-R^2)(n-k)}} \quad (6)$$

Information :
R^2 = Coefficient of determination
k = Number of variables
n = Number of samples

Decision making:
F-Count > F-Table, then reject H_0 means the production factor (X) simultaneously affects the risk production of organic rice
F-Count < F-Table, then accept H_0 meaning that the production factor (X) simultaneously does not affect the risk production of organic rice.
To test the partial influence of each factor of production-on-production risk, t-test is used with the following hypothesis:
H_0 : $\theta i = 0$ means that factor of production i do not have a significant effect on the production risk of organic rice
H_1 : $\theta i \neq 0$ means the factors of production to-i has a significant effect on the production risk of organic rice

$$T\ count = \frac{\theta i}{S(\theta_i)} \quad (7)$$

Information :
θi = Regression coefficient
$S(\theta i)$ = Standard deviation of θi
Decision-making :
The t count exceeds the t table, then the null hypothesis (H_0) is rejected. The i-th production factor significantly influences the production risk of organic rice.
The count is less than the threshold in the table, then the null hypothesis (H_0) is accepted. The i-th production factor has no significant effect on the production risk of organic rice.

3 Results and discussion

3. 1 Profile of organic rice farmers

Sample farmers in this study were 75 organic rice farmers who had the characteristics as presented in Table 1. Table 1 shows that 85% of organic rice farmers are of productive age., namely in the range of 35-64 years [20]. Productive age farmers have strong physical condition, can run a good farming and are open to innovation. Organic farmers had significant potential to anticipate risks, maximise production, and advance their farming methods. In heavy organic rice cultivation activities, such as land preparation, planting and harvesting, farmers still use labour outside the family.

The degree of education influences the views and mindset of farmers, as education is a systematic process aimed at improving their knowledge, skills, and attitudes, therefore resulting in improvements in their standard of life [21]. In Magelang Regency, a majority (84%) of organic rice farmers had education at the junior high school and senior high school levels. More education among farmers correlates with a more developed thinking, encouraging them to make right decisions with more ease. As an example, the threat of climate change that may reduce productivity will be mitigated through using seeds that are resilient to extreme weather.

Since the establishment of the Sawangan Organic Farmers Association in 2012 and the subsequent organic certification from the Seloliman Certification Institute (LeSOS) in December 2013, organic rice production in Magelang Regency has been in significant demand among farmers. The introduction of organic rice cultivation began with the management of the farmer group, then followed by its members. The average experience of farmers in organic rice developing is 6.4 years, so it is included in the category of quite long.

A long farming experience affects the skills of farmers in organic rice cultivation, especially in plant maintenance, pest and plant disease control to reduce the risk of failure.

Table 1. Profile of organic rice farmers in Magelang Regency

No	Description	Number (people)	Percentage (%)
1.	Farmer age (years)		
	35 – 44	5	6.67
	45 – 54	20	26.67
	55 – 64	39	52.00
	65 – 74	10	13.33
	≥75	1	1.33
2.	Level of education		
	Elementary School	9	12.00
	Junior High School	49	65.33
	Senior High School	14	18.67
	College	3	4.00
3.	Experience in organic rice farming (years)		
	1– 3	16	21.33
	4 – 6	28	37.33
	7 – 9	15	20.00
	10 – 12	12	16.00
	>12	4	5.33
4.	Quantity of family members		
	1 – 2	3	4.00
	3 – 4	64	85.33
	5 – 6	7	9.33
	>6	1	1.33
5.	Land area of cultivated (m^2)		
	500 – 2,000	27	36.00
	2,001 – 3,500	24	32.00
	3,501 – 5,000	20	26.67
	5,001 – 6,500	2	2.67
	6,501 – 8,000	2	2.67

Most organic rice farmers (85%) in Magelang Regency have 3-4 family members. The quantity of family members will affect used of inside family labour to help in carrying out organic rice cultivation, so that it can reduce production costs, especially labour costs and is expected to increase income. However, the more family members will have an impact on increasing family expenses for food, clothing, education and health.

The land area for organic rice cultivation is 3,090 m^2 which is generally owned by the farmers themselves. The wider land utilized for farming, the more costs that must be incurred and of course the greater the income obtained. Nevertheless, the increase of farm land generally enhances production risk, as evidenced by rice farming in Central Lampung [22] and in semi-organic rice farming in Sleman Regency [23].

3.2 Organic rice farming income

The income is the difference between total revenue and total explicit costs. Total revenue is the multiplication of total production by the price per unit [17]. The explicit costs of organic rice farming including cost of seed, manure, liquid pesticide, outside family labour and tool depreciation cost based on an average land area of 3,690 m^2, are provided in Table 2.

Table 2. The explicit costs of organic rice farming in Magelang Regency

No	Description	Cost (IDR)	Percentage (%)
1.	Seed	240,373	6.94
2.	Manure	434,467	12.54
3.	Liquid pesticide	124,000	3.58
4.	Outside family labour	2,646,308	76.38
5.	Tool depreciation	19,325	0.56
	Amount	3,464,474	100.00

Based on table 2, the largest explicit cost is the cost of outside family labour, which is 76.38%. The high cost of outside family labour doe to the organic rice cultivation requires a lot of labour. In addition to land cultivation and harvesting, plant maintenance also gets a high proportion such as cleaning weeds, fertilizing and managing irrigation water. The number of outside family labour needed is 38 working days with wages of IDR 70,000 per working day. Manure also requires a fairly high cost because farmers only use manure without adding chemical fertilizers. Farmers need 621 kg of manure at a price of IDR 700/kg.

Table 3. Organic rice farming income in Magelang Regency

No	Description	Value (IDR)
1.	Total revenue	10,159,333
2.	Explicit costs	3,464,474
3.	Income	6,694,860

Based on Table 3. the income of organic rice farming is IDR 10,159,333 obtained from the multiplication of production of 1,451 kg with the price is IDR 7,000/kg. The income of organic rice in Magelang is IDR 6,694,860 for a land area of 3,090 m^2 or IDR 21,645,200/ha. This income is greater than the income of organic rice cultivation in Susukan District, Semarang of IDR 7,872,845 per hectare [24]. This condition is because organic rice in Magelang Regency is a pilot project for organic rice development in Indonesia so that it receives a lot of capital assistance for infrastructure and intensive training and agricultural education from the government.

3.3 Production risks of organic rice

The level of production risk of organic rice is measured using the coefficient of variation, which is the comparison between the standard deviation and the average production. According to Table 4, the coefficient of variation is 0.188 (18.8%) which means it is included in the low category (< 0.5) and farmers do not have the potential to suffer losses [18].

Table 4. The coefficient of variation of organic rice production in Magelang Regency

No	Description	Value
1.	Standard deviation of organic rice production (kg)	269.492
2.	Average organic rice production (kg)	1,432.267
3.	Coefficient of variation	0.188
4.	CV (%)	18.800

The production risk of organic rice is due to both internal and external causes. Production risk can occur due to limited use of inputs and unpredictable climate change. Climate change triggers pest or disease attacks that can cause crop losses [25]. Pests that attack organic rice and cause a lot of damage are brown planthoppers. Several regions in Indonesia, include the provinces Banten, West Java, Central Java, East Java, and North Sumatra often experience brown planthopper pest explosions, one of which is caused by seasonal factors. Stem rot disease also attacks organic rice plants, especially in the rainy season [26].

Climate change, shown through higher temperatures, drought, excessive rainfall, and flooding, can significantly affect rice production and food security, as is happening in China [16]. The same situation also occurs in Malaysia, that climate change presents a significant threat to rice production, which will ultimately impact food security due to the two are closely related [27].

3.4 Factors affecting of production risk

Factors affecting the production risk of organic rice were analysed utilizing the Cobb-Douglas production function with the Just and Pope approach [19], through the residual quadratic regression analysis of the previously analysed production function. Table 5 presents the findings from the analysis of the production function and risk function related to organic rice production in Magelang Regency.

Table 5. Production function and risks function of organic rice in Magelang Regency

No	Variables	Production function		Risk function	
		Coefficient	T count	Coefficient	T count
1	Constants	-1.814^{ns}	-0.812	6.140^{ns}	0.255
2	Land area	0.251^{ns}	1,410	-7,612***	-3,962
3	Seed	0.035^{ns}	0.570	-0.613^{ns}	-0.933
4	Manure	1,459***	2,834	4.425^{ns}	0.797
5	Organic pesticides	-0.468^{ns}	-0.941	-0.741^{ns}	-0.138
6	Labour	-0.403*	-1,807	10,145***	4,217
7	R-square		0.876		0.420
8	Adj R-square		0.867		0.378
9	F count		97,100		9,996

According to Table 5, the determination coefficient (R^2) of the production function is 0.876, indicating that 87.6% of the variation in organic rice production can be related to the production factors of land area, seeds, manure, organic pesticides, and labour, while the remaining 12.4% is explained for by other factors not included in the model, such as rainfall, air temperature, and soil fertility. All production factors, including land area, seeds, manure, organic pesticides, and labour, simultaneously show a significant influence on organic rice production at a 99% confidence level.

Manure provides a positive effect on organic rice production, indicated by a coefficient of 1.549; therefore, a 1% increase in manure usage, with all other variables held constant, could result in a 1.549% increase in organic rice production. The average used of manure by organic rice farmers in Magelang Regency is 621 kg, equivalent to 2 tons per hectare, which remains below the suggested standard. The use of 5 tons/ha of manure in organic rice farming can increase harvest yields by up to 10% [28]. Labor has a significant effect with a negative coefficient (-0.403), indicating that a 1% increase in labour will result in a 0.403% loss in organic rice yield. Farmers in Magelang Regency in cultivating organic rice use a lot of labour, both family and non-family labour as many as 25 working days.

The coefficient of determination (R^2) of 0.420 indicates that the variables of land area, seeds, manure, organic pesticides, and labour contribute to 42% of the production risk of organic rice, while the remaining 58% is due to other factors not included in the model, such as climate change manifested through increasing air temperatures, drought, heavy rainfall, and problems by pests and plant diseases and land status. Land ownership status also affects production risk, where the production risk on owned land is greater than on non-owned land (rental and profit sharing) [29].

Simultaneously, all production factors, including land area, seeds, manure, and organic pesticides, significantly influence the production risk of organic rice at a 99% confidence

level. This condition is in line with research [25] in rice farming in Kebunsari District, Madian Regency. The land area production factor provides a significant negative influence, indicating that an increase in land area will decrease production risk. This is in accordance with research [30], indicates that an increase in land utilized for organic rice production correlates with a reduced risk. the wider the land used for organic rice farming, the smaller the risk. The land use for organic rice cultivation in Magelang includes both owned and rented lands.

The factors of labour significantly influence production risk with a positive coefficient, meaning that the more labour used, the higher the production risk. The findings of the risk function research align with the production function, indicating that an increase in labour may reduce production while likewise increasing risk. The findings of the risk function research align with the production function, where if the workforce is added, it can decrease production, conversely it can increase risk. This situation is different from the research conducted by [31] and [25] that utilization of labour does not significantly impact production risk.

Seed production factors do not significantly affect production risk with a negative regression coefficient, meaning that if the use of seeds is increased, there is a tendency to reduce production risk. The seeds used by farmers are "*Menthik Wangi*" and red rice with an average use of 80/ha. Organic pesticides also do not significantly affect production risk with a negative coefficient, meaning that the addition of organic pesticides tends to reduce production risk. Farmers utilize liquid organic insecticides sourced from the *GATOS* cooperative, averaging 20 liters per hectare. Manure does not significantly influence production risk, and its coefficient is positive, indicating that an increase in manure usage relates with a tendency for production risk increasing. The same situation also occurs in rice farming in Bali Province [31] and West Tanjung Jabung Regency [32], where organic fertilizer does not significantly influence production risk. The mean application of manure by farmers in Magelang Regency is 2 tons per hectare, which remains below the recommended standard. The optimal use of manure for highest yield is 10 tons per hectare. [33].

4 Conclusion

The income earned from organic rice cultivation in Magelang Regency, based on an average land area of 3,690 m², was IDR 6,694,860. The production risk related to organic rice is low category, and farmers are do not have the potential to incur losses. Simultaneously, all the production factors include land area, seeds, manure, organic pesticides, and labour significantly impact production risk. The production factors that significantly influence production risk are land area, which has a negative coefficient, and labour, which has a positive coefficient. A larger land area correlates with a reduced production risk, while conversely, a smaller area increases production risk.

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