Determinants of Production and Income Risks of Rainfed Lowland Farming: A Case Study in Maros Regency, Indonesia

Arifin[1]*, Muhammad Arsyad Biba[1] and Syafiuddin[2]

[1]Department of Agribusiness, Faculty of Agriculture, Animal Husbandry and Forestry, Muslim University of Maros, Indonesia; [2]Department of Agribusiness, Faculty of Agriculture, Muhammadiyah University of Makassar, Indonesia

Corresponding author: arifin.maros13@gmail.com

Abstract

Rainfed lowland farming production is generally lower than irrigated lowland rice due to area differentiation regional features. Rainfed lowland rice farming can only produce rice during the rainy season because lowland rice cannot be planted in the dry season. The purposes of this study are (1) to analyze the risk of production and income of rice farming in rainfed lowland farming and (2) to investigate the factors influencing the risk of rice farming in rainfed lowland farming. Data were collected from 100 respondents of rice farmers in four sub-districts in Maros Regency using the multi-stage cluster random sampling technique. The analysis of production and income risks were performed using multiple linear regression with the heteroscedastic method. The results have shown that rice farming in rainfed lowland farming poses a risk to production and income. The variables that significantly influence the rainfed lowland rice farming are land area, the number of seeds, the amount of urea fertilizer and the amount of pesticide. Farmers are required to manage risk by prioritizing the effectiveness and efficiency production factors as needed. Similarly the government is expected to assist farmers in maintaining the level of rice selling prices.

Keywords: income risk; production risk; rainfed lowland; rice farming

INTRODUCTION

Agricultural business is always characterized by high yield variability or risk (Adeosun and Opata, 2016; Wadu et al., 2019). Agricultural commodities have fluctuating prices for agricultural commodities and a segmented agricultural market due to local supply and demand conditions. Farmers are influenced by controllable (internal) and uncontrollable (external) factors causing risks or uncertainties (Lucas and Pabuayon, 2011; Arifin et al., 2019). Farmers become vulnerable to poverty due to these risks and uncertainties (Saleem et al., 2013).

Because agriculture is strongly influenced by nature, namely weather, pests, temperature, drought and flooding, the risk of agricultural production is greater than the risk of non-agriculture (Edeh et al., 2011; Singh et al., 2017; Magfira et al., 2020; Islam et al., 2021) Human resources, production inputs and natural factors can contribute to production risks (Rondhi et al., 2020). Production fluctuations are caused by production risks in the agricultural sector (Nurbudiati and Wulandari, 2020). Production problems are related to the nature of farming, which always depends on nature supported by risk factors, causing a high chance of failure

to produce and accumulating at the risk of low income received by farmers (Suharyanto et al., 2015). The risk can reduce production and farmers' income (Asbullah et al., 2017).

The increase in risk in agriculture can be seen with the in income fluctuation (Sulewski and Gajewska, 2014). The marketing activities of agricultural products can pose a price-related risk because the market price cannot be controlled by farmers. Price fluctuations are more common in agricultural products (Zakirin et al., 2013). Agricultural income issues depend on environmental problems, technological challenges, economics and structural changes in agricultural policies and institutions (Novickytė, 2018). Reducing income risks will improve farmer welfare, competitiveness and the ability to develop activities through innovation. Likewise, agricultural technological can have a positive effect on low-income farming communities.

Rainfed lowland rice farming is the second most productive farming practice, after irrigated rice field farming; however, the rainfed lowland rice productivity is still considered low (Kasno et al., 2016). Rainfed lowland rice farming production is generally lower than that of irrigated rice farming. The differences in the irrigated lowland rice and rainfed lowland rice production at national, provincial and local levels are due to farming area differentiation related to regional characteristics. Rainfed lowland rice farming can only produce rice during the rainy season (Reda et al., 2015). The arrival of the rainy season has a large effect on the activities of rainfed lowland rice farmers. Farmers can only grow rice in the fields during the rainy season. Meanwhile, the areas cannot be planted with rice during the dry season due to a lack of irrigation facilities and a decrease in river water discharge (Yartiwi et al., 2018). One of the activities that can be accomplished by adjusting the cropping pattern is planning of planting. A good cropping pattern will produce good production yields by maximizing the availability of water to meet the water needs of the cropping pattern (Dwiratna et al., 2016).

Rice production Maros Regency is 324,323.11 tons with a harvest area of 49,363 hectares and rice field productivity is 4.26 tons ha^{-1} (BPS-Maros Regency, 2019). Irrigated rice fields contributed 210,810.02 tons (65.4%) and rainfed lowland rice farming contributed 112,280.66 tons (34.6%). Rainfed lowland rice farming production in Maros Regency contributed to rice production in South Sulawesi by 5.60% and rainfed lowland rice farming production 1.90% (BPS-Statistics Indonesia Sulawesi Selatan Province, 2019). Although the contribution of rainfed lowland rice farming production remains small in comparison with irrigation rice production, a role in rice production in Maros and South Sulawesi Regencies.

Rice productivity can be increased by using balanced fertilization and high-yielding rice varieties. Climate change causes problems in agriculture, especially in rainfed lowland rice farming, where the source of water for production is highly dependent on rainfall, which is difficult to predict, making good planning is difficult (Hayashi et al., 2018). The potential contribution of rainfed lowland to increase rice production must be supported through the development of water resources infrastructure (Sulaiman et al., 2019).

Increasing land productivity is one of the determinants of rice farming sustainability in rainfed lowlands (Roy and Chan, 2015). The factors that contribute to the level of land productivity include planting area, high-yielding varieties, use of fertilizers and labor (Fitri and Mardhiah, 2018). Water is also an important factor in the efforts to boost rice production. Intensive use of water can support increased production yields (Rahmadiah et al., 2020). Anticipation of risks is pursued through plant cultivation, as well as cultivation techniques and management of rice plant nutrients (Lailiyah et al., 2017).

Maros Regency, one of the districts in South Sulawesi, has extensive rainfed lowland rice farming that contributes significantly to rice production. Identification of the factors that affect the risk of production of rainfed lowland rice farming in Maros Regency has never been carried out. Previous research related to the risk of rainfed lowland rice farming production in Maros Regency was still limited in terms of the location sample used, which was only one sample of the village. The novelty is the risk variable used to investigate the production risk related to the research location in four sub-districts and four villages. To identify the factors influencing the farming risk in rainfed lowland rice in Maros Regency, Just and Pope approach

was used. The purpose of this study was to analyze the risk of rainfed lowland rice farming production and investigate the factors that influence the risk of rainfed lowland rice farming.

MATERIALS AND METHOD

This research was conducted from September to November 2020 in four sub-districts, namely Lau (Soreang Village), Bontoa (Bontobahari Village), Marusu (Bonto Mate'ne Village) and Tompobulu (Tompobulu Village), in Maros Regency, South Sulawesi Province of Indonesia. The research locations with rainfed lowland rice fields in South Sulawesi were selected purposively. This study applied a quantitative approach with a survey method design. The primary and secondary data were collected with observation, recording and interviewing. The population in this study were 1,247 farmers who carried out rice farming on rainfed lowland rice fields at the research locations and 100 people were taken as respondents in four sub-districts using the multi-stage cluster random sampling technique. From each sub-district village was selected, namely in Lau (Soreang Village), in Bontoa (Bontobahari Village), in Marusu (Bonto Mate'ne Village) and Tompobulu (Tompobulu Village). Production and income risks were analyzed by determining the coefficient of variation. Production and income risks can be measured by the amount of variance and deviation standard (Mutisari and Meitasari, 2019). The mathematical coefficient of variation can be written as follows:

$$CV = \frac{\sigma}{\bar{X}}$$

$$\sigma = \sqrt{\frac{\sum x^2}{n}}$$

$$x = X - \bar{X}$$

The lower limit value of production and income was determined with the following formula:

$$L = \bar{X} - 2\sigma$$

Where:
CV = coefficient of variation in production and income
σ = deviation standard of production and income (variant)
$\bar{X}$ = average production and income
n = number of samples
L = lower limit of production and income

The decision was made by considering particular criteria (Asbullah et al., 2017):
1) The value of CV ≤ 0.50 or L ≥ 0 indicates that farmers avoid production and income risks in carrying out rice farming in rainfed lowland rice fields.
2) The value of CV > 0.50 or L < 0 indicates that farmers are at risk for production and income in carrying out rice farming in rainfed lowland rice fields.

A Just and Pope model approach and multiple linear regression analysis were utilized to determine the inputs on production risk. The function of production risk h(X)ε was estimated by regressing $\sigma^2 i$ to variable X. The next step was estimating the production function f(X) and the risk function h(X) together with the maximum likelihood approach by minimizing the number of squares of the two functions. The multiplicative heteroscedasticity model was applied by maximizing the likelihood function (Asmara et al., 2019; Chrisdiyanti and Yuliawati, 2019; Fadlilah et al., 2019). The regression models for the effects of the use of inputs on production and production risk were as the following.

Production function:
$$\text{Ln } Y = \ln \alpha_0 + \alpha_1 \ln X_1 + \alpha_2 \ln X_2 + \alpha_3 \ln X_3 + \alpha_4 \ln X_4 + \alpha_5 \ln X_5 + \varepsilon_1$$

Production risk function:
$$\text{Ln } \varepsilon_1{}^2 = \ln \beta_0 + \beta_1 \ln X_1 + \beta_2 \ln X_2 + \beta_3 \ln X_3 + \beta_4 \ln X_4 + \beta_5 \ln X_5 + \varepsilon_2$$

Where:
Y   = rice production (kg)
$\varepsilon_1{}^2$ = production risk (residual)
$\alpha_0; \beta_0$ = intercept
α_1- α_5; β_1- β_5 = regression coefficient (estimated parameter)
$\varepsilon_1; \varepsilon_2$ = error term (residual)

X_1 =   land area (ha)
X_2 =   the amount of seed (kg ha^{-1})
X_3 =   the amount of urea fertilizer (kg ha^{-1})
X_4 =   the amount of pesticide (L ha^{-1})
X_5 =   farming experience (year)

RESULTS AND DISCUSSION

The Characteristics of respondents

Farmer respondents have different characters and this condition influences making in running rainfed lowland rice farming. The characteristics of the respondents examined in this study include farmer's age, farmer education, cultivated land area and farming experience, which are presented in Table 1.

Table 1. Characteristics of respondents

No.	Variables	Number of respondents (people)	Proportion (%)
1.	Farmer's age		
	20 – 40 years	19	19
	41 – 60 years	68	68
	61 – 80 years	13	13
	Average (years)	50.5	
2.	Education level		
	Elementary school	71	71
	Junior high school	11	11
	Senior high school	17	17
	Bachelor	1	1
3.	Land size of farm		
	0.10 – 0.50 (ha)	62	62
	0.51 – 1.00 (ha)	24	25
	1.10 – 1.50 (ha)	13	13
	1.51 – 3.00 (ha)	1	1
	Average (ha)	0.32	
4.	Farming experience period		
	≤ 10 years	9	9
	10 - 25 years	23	23
	25 years or above	68	68
	Average (years)	19.9	

Based on age groups, rice farmers are dominated by productive age (Table 1). The productive age group can influence the success in managing and running the farm, especially in influencing the farmer's way of thinking and physical (Kurniati, 2014). Age greatly affects farmers' farming activities. Productive age is closely related to physical and decision-making abilities (Ibrahim et al., 2020). The husband, as the head of the household, serves as the main role and actor in farming activities.

The farmer's formal education level is classified as low. Formal education is an indicator of the quality of the workforce and the level of education generally affects people's way of thinking (Lailiyah et al., 2017). One measurement to support the optimal achievement of farmer work is the influence of the level of education and experience in participating in non-formal education, such as counseling and training. The higher the education level of farmers, the easier they are to receive and comprehend information, whether from newspapers, books, or extension officers (Safitri et al., 2020).

The most dominant size of arable land ranges from 0.10 to 0.50 ha, which is considered narrow, due to farmers' lack of capital to rent or purchase rice fields. Capital is highly important to obtain the whole or a part of livelihood, which is aimed at the activities in the agricultural sector (Magfiroh and Sofia, 2020). The farmers'

narrowest area of arable land 0.10 ha, while the widest is 2.00 ha. Many farmers cultivate their land but some others do not have any land and therefore, they cultivate other people's land by practicing a profit-sharing system. In the profit-sharing system, the harvest yields are shared between the landowner and smallholder equally.

Most of the farmers experienced in farming for 25 years and above. The rest have practiced farming activities for 10-25 years and 10 years, respectively. These data have proven that the farmers are experienced and have inherited the farming activities and business from their parents, through non-formal education, such as training and counseling from agricultural extension officers. In general, farmers with much experience in farming have better knowledge and skills in farming practices. Likewise, based on this experience, farmers can develop their farming (Mastrordianto et al., 2019).

Production risks and income of rice farming in rainfed lowland rice fields

Production and income risk can trigger fluctuations in production and income in business and therefore, it is necessary to calculate the amount of production risk and income to determine the most appropriate actions to overcome those challenges. The production and income risks of rice farming in rainfed lowland rice fields in Maros Regency can be seen from the coefficient of variation (Table 2).

Table 2. Production and income risks of rice farming in rainfed lowland rice fields in Maros Regency

Description	Production (kg)	Income (IDR)
Average (X̄)	1,242.35	4,532,981.20
Lower limit (L)	-702.15	-3,409,593.84
Standard deviation (σ)	972.25	3,971,287.52
Variant	945,272.73	15,771,124,573,070.60
Coefficient of variation (CV%)	0.78	0.88

The results of the lower limit (L) and the coefficient of variation (CV) of production and income are presented in Table 2. The value of the lower limit of production and income is negative, which is smaller than zero (L < 0), signifying that rice farming in rainfed lowland rice fields is at risk of production and income. Based on the decision making criteria, including the lower limit value and the coefficient of variation, farmers are at risk to production and income in carrying out rice farming in rainfed lowland rice fields.

However, the coefficient of variation is greater than 0.5 (CV > 0.5), exemplifying that rice farming in rainfed lowland rice fields is also at risk of production and income. The coefficient of variation in production is 0.78, which means that the opportunity for reduced production is 78% and the possibility to achieve stable production is very low. Meanwhile, the coefficient of variation in income is 0.88, which denotes that the opportunity to reduce income is 88% and the possibility to obtain stable income is very low. The coefficient of variation in production and income that is greater than 0.5 (CV > 0.5) indicates that the production and income of rice farming in rainfed lowland rice fields are at risk, based on the decision making.

Production and income risks experienced by the farmers in the research locations are due to the weather or erratic rainfall intensity and an increase in snail and rat populations attacking rice plants, which is the main cause of lack of production and crop failure. Data reported that a total of 2.11% hectares of rice fields were affected by flooding and 0.57% hectares of the areas experienced crop failure, while 0.46% hectares were attacked by pests and 0.05% hectares were struck by snails (BPS-Maros Regency, 2019; BPS-Statistics Indonesia Sulawesi Selatan Province, 2019). The decrease in production contributes to a decrease in farmers' income and an increase in income risk. The findings are in line with the report of previous study Mardliyah and Mirayana (2019) that the decline in production due to pests, plant diseases and weather occurring with excessive rainfall causes fluctuations in production and therefore, farmers must bear a large income risk. Plant pests, particularly rats and snails, attacking rice plants pose a threat to the majority of farmers.

Factors affecting the risk of rice farming in rainfed lowland rice fields

The factors contributing to the production of rice farming in rainfed lowland rice fields are demonstrated in Table 3. Variations in the independent variables, which include land area, the number of seeds, the amount of urea fertilizer, the amount of pesticide and farming experience, can explain 99% of the variation in rainfed lowland rice field production (Table 3). The independent variables of land area and farming experience have no significant effect on the production of rainfed lowland rice fields. The increase in land area does not result in a growth in rice production because rainfed lowland rice fields are limited in planting intensity, planting rice is only done once a year and production remains low. Rainfed rice fields can only be planted and produce rice during the rainy season (Yartiwi et al., 2018). Farming experience does not affect increasing rice production in rainfed lowland rice fields, this is related to the level of education of farmers. In general, the education level of farmers is low, dominated by primary school graduates, affecting the technology transfer in agriculture. Support for technology transfer relies on not only farming experience but also education level. Educated farmers understand the use of technology more easily and are more willing to accept innovations (Murdayanti et al., 2021). The coefficient for the number of seeds, the amount of urea fertilizer and the amount of pesticide are all positive, indicating that each additional production factor will increase the production of rainfed lowland rice fields.

Table 3. Factors affecting the production of rice farming in rainfed lowland rice fields

Variables	Regression coefficient	Standard error
Constant (C)	6.231***	0.929
Land area (X_1)	-0.167	0.118
Seeds (X_2)	0.217**	0.108
Nitrogen fertilizer (X_3)	0.283***	0.037
Pesticides (X_4)	0.562***	0.087
Farming experience (X_5)	-0.067	0.068
R^2		0.990
R-squared		0.980
F-statistics		899.269***

Note: *** = significant at 1%; ** = significant at 5%

Furthermore, the factors affecting the risk of rainfed lowland rice field production were estimated using the Least Square Method, with the risk of rainfed lowland rice field production (residual) serving as the dependent variable. The results of the analysis are presented in Table 4.

Table 4. Factors affecting the risk of rice farming in rainfed rice fields

Variables	Regression coefficient	Standard error
Constant (C)	43.401***	6.080
Land area (X_1)	-1.301**	0.566
Seeds (X_2)	-2.644***	0.606
Nitrogen fertilizer (X_3)	-0.441*	0.232
Pesticides (X_4)	-1.677**	0.508
Farming experience (X_5)	0.113	0.326
R^2		0.941
R-squared		0.886
F-statistics		146.131***

Note: *** = significant at 1%; ** = significant at 5%; * = significant at 10%

In general, the farmers in the research area grow rice using direct seeding, which uses more seeds than growing with transplanting. The farmers use direct seeding tools they design but the tools have a particular drawback, causing them to use more seeds. To save water and labor, the traditional farming practices with puddle transplantation can be replaced zero-till direct-

seeded rice (Kumar et al., 2015). The use of quality seed is one of the efforts to reduce the production risk in rainfed rice fields. This is consistent with the outcome of the previous study that increasing the use of quality seeds will, to a certain extent, increase the plant population, thereby increasing productivity and ultimately, reducing the production risk (Zakirin et al., 2013).

Farmers in the research area use nitrogen fertilizer, but not in the amount that is required. By increasing the use of nitrogen fertilizer within a certain limit, the production of rainfed lowland rice fields can be increased while the risk of production can be lowered. Zakirin et al. (2013) suggest that production will increase with the addition of nitrogen fertilizer to the recommended dosage.

These findings indicate that pesticide use has not reached the maximum usage requirement, implying that by increasing the amount of pesticide to combat pests and diseases in rice, production can be increased while the risk of production can be reduced. Suharyanto et al. (2015) and Lailiyah et al. (2017) advocate that rice farmers use pesticides as a preventive measure and in proportion to the level of pest attack. The control more directed at both anticipating and dealing with the risk of plant pest attack. If pests and diseases become more prevalent, appropriate pesticides are given in greater quantity to them (Mita et al., 2020).

CONCLUSIONS

Rice farming in rainfed lowland rice farming in Maros Regency is at risk of production and income. Factors that significantly influence the risk of farming are land area, the number of seeds, the amount of nitrogen fertilizer and the amount of pesticide. Farmers are required to manage the risk by prioritizing the effectiveness and efficiency with they use production factors as needed. Likewise, the government is expected to assist farmers in maintaining the level of rice selling prices.

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