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Resource use and Profit Function Estimation of Swampland Rice Farming in South Kalimantan, Indonesia

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ABSTRACT

We report here the analysis of factors those influence the production and profitability of swampland rice farming in South Kalimantan Indonesia. Four sub-districts which represented 2 major swamp agroecology (tidal and monotonous swamp) were purposively selected. Two analyses, i.e., stochastic frontier production function and Cob-Douglas profit function unit-output-price alighted from Cob-Douglas production function were applied to investigate the factors affecting the resource use and profit of swampland rice farming. We found that rice production is significantly positive affected by seed, fertilizer, and labour. In line with that, the increase of input price leads to a decrease in farmer profits, the lower the welfare level of the farmers. The prices in the study area are unstable due to the lack of transport infrastructure. We suggest the improvement of transport infrastructure is needed to assure farmer welfare and agricultural development. The government assistance in term of credit provision and machinery access is expected.

Keywords: production function, profit function, rice farming, swamp agriculture

INTRODUCTION

Current global condition reveals that food security is important to stabilize economic and politic. Thus, local specific development is needed in securing and maintaining economic development. This development should meet the geo-bio physic condition and local resource to guarantee the sustainable development.

Agricultural crops sector has considerably important roles in agricultural and economic development in Indonesia. It plays significant contribution to GDP, food provision, and employment. Even though agriculture's contribution to the total GDP is only 13.6%, however this sector absorbs 38.9% of the labour force [7].

Improved food security is one of the objectives of national development in Indonesia. As rice is the staple food in Indonesia, the increase food security is sought through intensify rice production. Rice is mainly produced from rice field which is previously converted from wetlands. Therefore, to fulfil the rice reserves, the area of wetland must be maintained or increased to a certain level. However, the island of Java experienced the steadily shrinking rice production because of land conversion to non-agriculture purpose. This conversion is caused by high population growth and fast economic transformation [4]. Land conversion has extended to approximately 100,000 ha per year. Around 79.3 % of conversion occurs in Java Island [4], where 60 % of national rice is produced [11]. This state is also exacerbated by land erosion and sedimentation [15].

On the other hand, Indonesia has approximately 33.4 million hectares of tropical swampland which 6 million hectares potentially used for agriculture [17]. Among them, 1.8 million hectares already developed for agricultural used [18]. The choice of swamp as a new source of agricultural growth,

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particularly food crops, due to several advantages of the swamp land as follows [17]: (1) the abundance of water, (2) relatively flat topography, (3) near to the river to maintain proper water circulation, (4) possibility to provide ideal acreage of land holding for proper mechanization of 2.0 hectares per household.

Specifically, South Kalimantan has 17,828 hectares of swamp where about 80% is dominated by acid sulphate soil. This area has economic value if they are managed well [2]. This potency can be used for rice cultivation that will contribute to the national rice production and play an important role as rice supplier for the global market.

The swamp is considered as marginal and fragile land. The swamp farming requires specific technique and input, which may differ to the common farming practice in Java Island or other type of wetlands. The farming practice should meet the feasibility of economic and ecologic to achieve sustainable farming. Thus, the limited resource should be allocated efficiently.

Indeed, swamp agriculture has become a centre of attention. Therefore, several studies have been carried out to assess swamp potency for agricultural and its socio-economic status, i.e: [21], [22], and [23]. The studies focused on resource allocation have been carried out by [24] and [25]. However, those studies only covered one swamp typology, either tidal or monotonous swamp. In addition, they only focused on resource allocation, while the profit assessment was neglected.

It is, therefore, interesting to explore the allocation of input use of rice farming that provides optimum benefit to the farmer. This result provides policy recommendation for further swamp development as an alternative food basket in South Kalimantan. In details, the study aims are: (1) to analyse the production factors that affect rice yield in the swamps of South Kalimantan, (2) to analyse the factors that influence the profit rate on swamp rice farming in South Kalimantan.

RESEARCH METHODOLOGY

Kalimantan Island, also known as Borneo Island, has a large scale of swampland rice farming. There are approximately 6 million hectares of swampland in Kalimantan (Radjagukguk (1992) cited in [19]), and most of them are tidal and monotonous swampland. Swampland has been utilized since the 1900s and was widely opened in the 1970s [19]. Therefore, farmers in the area have long experience in dealing with rice cultivation in a specific environment and any obstacles therein.

The study was conducted in South Kalimantan, which is located in the southern part of Kalimantan (Borneo) Island. Geographically, South Kalimantan is located between 114^{o}19'13" – 116^{o}33'28" East Longitude and 1^{o}21'49" – 4^{o}10'14" South Latitude. Its area is 37,530.52 km^2 (6.98% of Kalimantan Island). The climate is tropical with temperature ranged between 21.6^{o}C – 34.3^{o}C, the humidity between 51.2% - 99.1% monthly, and the precipitation accounted 30.1 – 1641.9 mm. Furthermore, the province consists of two main geographical natures, i.e.: lowland includes peatlands and swamps in the western, southern, and along the river basin; and mountainous area in the centre. The population was 3,695,124 people or 1.50% of the total Indonesian population. Moreover, the population density was 98.46 people per km^2, lower than that of country density (131.18 people per km^2). The rate of population growth was 1.45% (1990-2000), lower than that of the national level (1.49%) [6]. According to [1], from 975,141 of total household heads, around 45% are farmers. Rice is the main commodity in South Kalimantan and it uses almost 90% of agricultural land [6]. So far, South Kalimantan experiences production surplus and play important role as food basket in Kalimantan Island.

This study covered two swamp agroecosystem, i.e.: tidal swamp and monotonous swamp. The tidal swamp is a swamp where the water surface is influenced by water movement of regular fluctuation caused by tidal movement [20]. In South Kalimantan, it can be found in the coastal and river basin area of Banjar District and Barito Kuala [1]. Monotonous swamp (locally known as *rawa lebak*) is swamp formed in the inland valley where the water comes from upstream river or rain [17]. It is commonly found in the inland area of the northern part, like the Hulu Sungai Utara District and Hulu Sungai Tengah District [1].

Two sub-districts (Banjar and Aluh-Aluh) in Banjar District were purposively selected to represent the tidal swamp agroecology, while monotonous swamp is represented by Sub-District of Babirik and Sungai Pandan in Hulu Sungai Utara District. Around 60 rice farmers were randomly selected from each sub-district, so 240 farmers were involved in this study as respondents.

The study used Cob-Douglas stochastic production function to estimate the factors affecting rice production. The model has been broadly used to estimate the production function as well as technical efficiency (see [3], [12], [13], and [16]). This model was estimated by maximum likelihood (MLE) to estimate the best performance of rice farming conducted by farmers (see [9] and [8] for general model explanation). The model is written as follows:

$$Y = \beta_0 + \beta_1 \ln X_1 + \beta_2 \ln X_2 + \beta_3 \ln X_3 + \beta_4 \ln X_4 + v_i - u_i \tag{1}$$

Where, Y = rice yield (kg), X_1 = amount of seed (kg), X_2 = amount of fertilizer (kg), X_3 = amount of pesticide (litter), X_4 = amount of labour (man-days), β_0= intersep, β_j = coefficient parameter estimator of j=1,2,3...4, and $v_i - u_i$ = error term of (u_i) infficiency effects.

The Cob-Douglas equation also used to estimate factors which affect the profit rate. According to [14], equation (1) can be derived into unit-output-price (UOP) as follow:

$$\ln \pi^* = A^* \sum w_i \alpha_i \times \sum Z \beta_j \tag{2}$$

To simplify, the equation (2) can be written into natural logaritmic as follow:

$$\ln \pi^* = A^* \sum \alpha i \times \ln w^*{}_i \times \sum \beta_j \times \ln Z_j \tag{3}$$

$$\ln \pi^* = \ln A^* + \alpha_1 \ln w_1^* + \alpha_2 \ln w_2^* + \alpha_3 \ln w_3^* + \alpha_4 \ln w_4^* + \alpha_5 \ln w_5^*$$
$$+ \beta_1 \ln Z_1 + \beta_2 \ln Z_2 + e0 \tag{4}$$

Where: π^* = normalized short-term profit (IDR), A* = intersep, W_1 * = normalized seed price (IDR), W_2 * = normalized fertilizer price (IDR), W_3 * = normalized pesticide price, W_4 * = normalized labour cost (IDR), W_5 * = normalized tool and equipment cost (IDR), Z_1 = land area cultivated (hectare), Z_2 = labour use (man-days), α_i* = parameter of input i = 1, 2, …, 5 , β_j* = parameter of fixed output j = 1, 2; e0 = error term.

All actual prices and costs were normalized by the price of unhusked rice.

RESULT AND DISCUSSION

Socio-Economic Characteristic of Respondent

The socio-economic characteristic of the respondents is presented on the Table 1.

Table1. *Socio-economic characteristic of the respondents (N=240)*

Variables	Average / frequency	Minimum	Maximum	Standard error
Age (year)	46.70	31.00	67.00	10.50
Family dependents (person)	0.95	0.00	4.00	2.88
Land holding (hectare)	1.80	1.10	4.20	1.52
Farmer experience (year)	9.80	10.00	44.00	9.81
Formal education (year)	8.15	6.00	12.00	2.41
Informal education	- Yes (40.70%) - No (59.30%)			
Farmer group membership	- Yes (60.00%) - No (40.00%)			

Source: *field survey, 2015.*

On average, the farmers' age ranged from 31 to 67 years old, which are in productive age. This indicates that farmers have the possibility to work and more active in their fields. The existence of family dependent, which ranged from 2 – 4 persons per household, would encourage them. The farmers also own long experience in farming, approximately more than 10 years. They also underwent a mid-education level, with at least finished their basic school. These productive, experienced and mid-educated farmers are the asset for further agricultural development.

The survey further indicates that about 40.7 % farmers received informal education. According to [10], informal education has a significant impact on the rise yield and profit. Meanwhile, the farmer who joins the farmer group was only 60 %. If all farmers join the farmer groups, it will have a positive impact on farmer income. The farmers who receive informal education at farmer field school (FFS) could transfer their knowledge to other members easily.

The Estimation of Stochastic Production Function

The estimation describes the best performance of the farmer at the level of the existing technology. Table 2 shows the estimated parameters of frontier production function and its significance value.

Table2. *The estimation of stochastic frontier production function of swamp rice farming in South Kalimantan*

Variables	Parameter estimation	Standard Error	t-Rasio
Amount of seed (X1)	0.2437**	0.1886	12.9170
Amount of fertilizer (X2)	0.2717**	0.1501	18.1000
Amount of pesticide (X3)	0.6337	0.1649	0.3841
Amount of labour (X4)	0.4312*	0.1581	2.7267

Note: ** *significant on α = 1 %;* * *significant on α = 5 %;*

Source: *field survey, 2015.*

Partially, it can be seen that all parameters have positive signs as expected. The use of seeds and fertilizer significantly affected the rice yield at the significance level of α=1%, while labour significantly affected at the level of α=5%. On the other hand, pesticide had no effect on rice production.

The estimated parameters of the stochastic frontier production function show the elasticity of the production potential of the inputs used. As presented in Table 2, the elasticity of the potential production of seed, fertilizer, pesticides and labour were 0.2437; 0.2717; and 0.4312; respectively. Those figures show that in this study area, the addition of seeds, fertilizers, pesticides or labour by, for example, 10% addition of any input while others are assumed constant, the rice productivity would rise in the study area. However, the increase would relatively small at 2.4 %, 2.7%, and 4.3% caused by additional of seed increase, fertilizers, and labour use, respectively.

These results confirm the study of [3], [12], [13], and [24], where all parameters have positive direction. However, they have differences in the significance level. Similar to our study, the seed also has a significant effect on the yield in the study of [12] and [13]. In addition, it should be emphasized that the fertilizer and labour has significant roles on the yield in our study.

Our result implies that the addition of seed, fertilizer, and labour will increase the yield. However, the possibility to increase those input use encounters some challenges. In general, the seed used are indigenous seed. This seed usually comes from the previous harvest. As the consequence, without proper breeding, the seed quality will degrade after years and the yield will decline. Therefore, the introduction of improved seed should be considered. The improved seed should be resistant to pest attack, able to hold the extreme condition on the swamp area (i.e.: acidity, salinity, drought, and high level of water flooding), and fit to the consumer preference.

The fertilizer provision confronts several challenges. The fertilizer for the small farmer is subsidized and the availability is limited. The addition of subsidized fertilizer is also not the best decision as it may lead to the overuse of chemical substance and harm the swamp ecosystem. Therefore, the use of organic fertilizer is advisable. According to [17], the use of organic fertilizer in swamp agriculture will increase the yield considerably.

The addition of labour use is a rather difficult in application, as the lack of labour is a major issue in the area. Most of the households rely on family labour for the farming work. Even though the labour has a positive impact on profit and yield, the household finds difficult to acquire hired labour especially on planting and harvesting time. The introduction of mechanization could be the solution, but it needs the further comprehensive study related to its impact and compatibility.

The Effect of Inputs Price on Profit Rate

The profit function is presented in two models. First is using OLS (Model I), and the second model with the method of seemingly Unrelated Regression (SUR). The results of the analysis of these two models are presented in Table 3.

Table3. *The estimation profit function of rice farming in South Kalimantan*

Variables	Model I (OLS)		Model II (SUR)	
	Parameter Estimate	Pr > |t|	Parameter Estimate	Pr > |t|
Intercept	9.3416	<.0001	9.5336	<.0001
Seed price	-0.5232	0.1653	-0.7950	0.0311
Fertilizer price	-1.1028	0.0033	-1.1815	0.0014
Pesticide price	-0.8185	<.0001	-0.8653	<.0001
Labour price	-0.8459	0.0236	-0.8291	0.0219
Equipment price	-0.0741	0.4312	-0.0733	0.4200
Land (ha)	0.4730	<.0001	0.3990	<.0001
Labour use (man-days)	0.2637	0.0034	0.2260	0.0089
DM	0.3838	0.0389	0.4840	0.0077
R^2	0.8331		0.9247	
F value	39.32		17.07	

Source: *Field survey, 2015.*

Table 3 shows the estimation of the two models used. Each model has significant F-value at 99% of confidence level. This indicates that the model specification (for both dependent and independent variables) is considered to be accurate and reliable. The F-value specifies that all the independent variables (input price) in the model jointly affect the independent variable (profit rate). The coefficient of determination (R^2) of each model is greater than 80%, which indicates that the two models are able to explain the total variation of the dependent variable (profit) with a high proportion.

The estimation on the profit function Model I (OLS) shows that the F-value is very significant (39.23). The coefficient of determination (R^2) is 83.33%, which means independent variables are able to explain the diversity of approximately 83.33% of the total quantity of profit (UOP), while the remaining 16.672% is explained by other factors which are not included in the model. Compared to the Model I, Model II has significant F-value of 17.07 and coefficient of determination of 92.25%, greater than the model I. This indicates that the use of the Model II will give a more reliable estimation.

Based on the unbiased parameter estimation, in this case is standard error criteria, Model II has better estimation than Model I. It is proved from the lower standard error on Model II compare to that of the Model I for all of the parameters calculated, so it gives more significance level. This fact implies that the SUR prediction gives better results than OLS. Hence, further analysis and discussion use the result of the Model II (SUR).

Variable of normalized seed price has a negative coefficient, which means that its price reduces the profit rate. The coefficient of the seed price is -0.7949 at the significant level of 99%, which means that the increase of seed price by 10% causes a decline in profits of 7.95%. The normalized fertilizer price and normalized pesticide price also have a negative relationship to the profit rate. The coefficient of fertilizer and pesticide price are -1.181 and -0.8653, on that order, at the significance level of 99%. This implies that if any increase in fertilizer price or pesticide price by 10% causes a decline in profit of 11.81% or 8.651%, respectively. Normalized labour cost also has a negative correlation to the profit level. Labour price coefficient are and -0.8291 at the significant level of 99%. This means that any increase in labour price by 10% caused a decline in profits of 8.29%. Normalized equipment cost not-significantly affects the profit rate due to the lower contribution on farming business. Most of farming practices are conducted traditionally, which requires simple tools and handmade equipment.

The price stability is a major problem in the area. The infrastructure in the swamp area is relatively at the insufficient status. The roads are usually flooded in the rainy season, and the canal is dry in the dry season. These problems causes the transport cost of certain input may rise over time. As a result, the profit uncertainty on the farmer level is high. For this reason, the improvement of transport is essential factor in assuring farmer profit and further rural development.

The study also reveals that land variables significantly affect the profit rate at a confidence level of 99%. This shows that the more farmers use the land, the more rice harvested as well, so that the total farmer profit will be greater. This implies that the farmer has the possibility to increase their land holding through buying, renting, or crop sharing. This is also supported by the availability of large potential swampland in South Kalimantan. It should be noted that the increase of land use needs more capital and labour. Hence, the ease of credit is necessary to provide additional inputs and machinery.

CONCLUSION AND RECOMMENDATION

Based on the physical relationship between input and output, it can be explained that rice production is significantly affected by seed, fertilizer, and labour. In line with that, the price production factor also affects the profits of rice farming, so the higher increase of price will lead to a decrease in profits and farmer welfare. These facts are explained on the estimation result where all normalized input price has a negative effect on profits. The addition of land use and labour has a positive impact on the profit. It is also suggested that government supports farmers in particular with regard to the provision of input, for example the provision of subsidized (organic) fertilizers, and pesticides as well as ease in credit accessibility. The improved infrastructure is also required to assure the price stability.

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