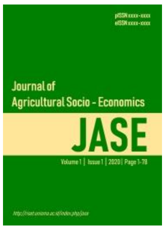

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FACTORS DETERMINING RICE PRODUCTION ON DRY SWAMP LAND FOOD ESTATE PROGRAM IN THE BERAMBAI MAKMUR VILLAGE, CENTRAL KALIMANTAN

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Abstract. Utilizing suboptimal swampland to boost national rice production is one alternative to increase food production. Berambai Makmur Village is a tourist village known for its food estate concept. Farmers in the village often face production challenges, leading to fluctuations in rice production, including delays in seed and fertilizer supplies and inadequate mechanization due to suboptimal use of production factors. However, empirical evidence on which production factors most strongly determine rice output in Food Estate-based dry swampland systems at the village level remains limited, particularly in studies that jointly consider technical inputs and farmers' socio-economic characteristics. This study provides village-level evidence from Central Kalimantan by quantifying the relative contribution of key production inputs and socio-economic variables to rice output under dry swampland cultivation. The purpose of this study was to analyze the factors that influence rice output in Berambai Makmur Village, Pangkalan Banteng District, West Kotawaringin Regency, Central Kalimantan. The study used a survey method, involving 30 rice farmer respondents who were members of farmer groups. The analysis used the Cobb-Douglas function in SPSS 27. The study found that farmers in Berambai Makmur Village use dry swamp land with good irrigation. This activity is carried out twice a year. The variables analyzed consisted of land area, seeds, urea fertilizer, phonska fertilizer, labor, education level, income, and risk and uncertainty dummies. The results indicate that production factors account for a substantial share of the variation in rice production. Simultaneously, land area, seeds, labor, urea fertilizer, phonska fertilizer, education level, income, and risk and uncertainty dummies influenced rice production. Partially, land area, seeds, labor, and income influenced production. Phonska and urea fertilizer had a positive effect, while education level and risk and uncertainty dummies did not influence rice production. Rice production in Berambai Makmur Village is in the Increasing Returns to Scale condition, indicating potential to increase production by optimizing production factors.

Keywords: Production Factors; Dry Swamp Land; Rice Production; Risk and Uncertainty; Returns to Scale

INTRODUCTION

Indonesia is known as an agricultural country, where the majority of the population relies on the agricultural sector for its livelihood. This sector plays a vital role in the national economy, providing food, industrial raw materials, and income for farmers. Among various agricultural commodities, rice is the primary commodity supporting national food security (Kharoh et al., 2023). Rice is therefore not only a strategic food commodity but also a socio-economic commodity because its availability and price stability influence household consumption and rural welfare.

Rice cultivation is one way to ensure national food security. It is increasingly directed toward utilizing suboptimal land, including swamplands, which remain widely available and can be managed for sustainable food production through improved water soil crop management and institutional support (Hatta et al., 2023; Sabran et al., 2025; Sari et al., 2025; Sulaeman et al., 2024). Utilizing suboptimal swampland to increase national rice production is therefore a strategic alternative in Indonesia, particularly in response to land conversion pressures and the need to strengthen production capacity outside conventional irrigated areas (Faoziyah et al., 2024; Fahmid et al., 2022). However, swampland rice systems face specific constraints, including water-table instability, soil acidity, and nutrient limitations, so production outcomes are highly sensitive to timely and appropriate input use and to the availability of supporting infrastructure, such as irrigation, drainage, and farm mechanization (Sulaeman et al., 2024).

Despite the growing emphasis on suboptimal land, national rice production has fluctuated over the past five years. According to Statistics Indonesia (2024), rice production shows fluctuations with an average annual production of 31.13 million tons of unhusked rice (GKG). The decline in GKG production began in 2022 (54.75 million tons) and reached 52.66 million tons in 2024. Such declines can affect food security, economic stability, and rural welfare. Fluctuations in production may reflect not only harvested-area dynamics but also farm-level constraints and risks, including climate variability, pest pressures, and volatility in input and output prices (Yu et al., 2022). These dynamics highlight the importance of strengthening production systems not only by expanding land use but also by optimizing farm-level production factors and improving farmers' capacity to manage uncertainty.

Central Kalimantan is one of the provinces selected for the Food Estate program, with a major focus on expanding and optimizing rice production. Food Estate development in this region began in mid-2020 as part of efforts to increase production capacity. As a flagship program, Food Estate implementation requires site-specific empirical evidence because outcomes can vary across locations due to agroecological conditions, infrastructure readiness, input access, and institutional support (Fahmid et al., 2022). Trends in harvested area, rice production, and productivity in Central Kalimantan Province over the past five years are presented in Table 1.

Table 1. Development of Rice Harvest Area, Production and Productivity in Central Kalimantan 2020-2024

Year	Harvest Area (Ha)	Rice Production (Ton GKG)	Productivity (tons/ha)
2020	143.275,05	457.952,00	3,20
2021	125.870,05	381.189,55	3,03
2022	108.226,80	343.918,80	3,18
2023	101.580,30	330.781,05	3,26
2024	110.804,62	378.178,03	3,41
Average	117.951,36	378.403,89	3,22

Source: BPS Central Kalimantan Province, 2020-2024

Rice production in Central Kalimantan has shown considerable variation, with an average productivity of 3.22 tons/ha. In 2020, rice production reached 457,952.00 tons (GKG), followed by a decline to 330,781.05 tons (GKG) in 2023 (Statistics Central Kalimantan Province, 2023), before increasing again to 378,178.03 tons (GKG) in 2024. Overall, harvested area declined from 2020 to 2023 and slightly recovered in 2024, while rice production followed a similar pattern. Meanwhile, productivity remained relatively stable. This pattern suggests that output fluctuations are closely linked to harvested-area dynamics and to farm-level constraints that affect production decisions and input use. Therefore, identifying which factors most strongly determine rice output at the farm level is essential to support more effective interventions under the Food Estate program.

At the district level, West Kotawaringin Regency ranks third in rice productivity, behind East Barito and Kapuas Regencies, with 3.3 tons per hectare in 2024 and a harvest area of 181 hectares. That reflects the relationship between harvested area and production, yet production performance depends not only on land area but also on how farmers utilize production factors. According to Statistics West Kotawaringin Regency (2019), Pangkalan Banteng District was the largest paddy rice-producing district in 2018, with a harvested area of 369.3 ha. However, high potential at the district level does not automatically translate into stable output at the farm level. Farmers' production performance is shaped by access to land, availability of inputs, labor, and financial capacity, as well as their ability to manage operational constraints and uncertainty.

Berambai Makmur Village is a tourist village known for its Food Estate concept, where swampy rice fields serve as the center of agricultural activity and a tourism attraction. Geographically, the village is characterized by lowland and swampy conditions, and the local community cultivates rice as a major livelihood activity. The village is also reported as the highest rice-producing village in Pangkalan Banteng District (Agricultural Extension Center, 2024). It highlights the strategic role of Berambai Makmur Village for local food supply and as a relevant case for evaluating Food Estate implementation at the village level.

However, farmers in Berambai Makmur Village face several constraints that may limit production performance. These include shrinking cultivated land due to conversion to non-agricultural uses, delayed distribution of seeds and fertilizers, limited mechanization, labor shortages dominated by elderly farmers, and production risks associated with weather variability, pests, and fluctuations in input and output prices. Such constraints are commonly observed in swampland rice farming and can reduce production performance when farm operations and input use are not timely and appropriate (Arsyad, 2014; Maftu'ah et al., 2016; Azwar et al., 2019). Consequently, optimizing production factors, such as seed use, fertilization practices, and efficient farm operations, is essential to improving output in swampland systems.

Although many studies have examined rice production factors and efficiency in different settings, empirical evidence remains limited on the determinants of rice output in food Estate-based dry swampland systems at the village level, particularly studies that jointly consider technical inputs, farmers' socio-economic capacity, and uncertainty aspects (Delaseh et al., 2020; Alamri et al., 2022; Azwar et al., 2019; Azis et al., 2024). This study addresses this gap by quantifying the relative contribution of key production inputs and socio-economic variables to rice output in Berambai Makmur Village.

Accordingly, the objective of this study is to analyze the factors influencing rice output in Berambai Makmur Village, Pangkalan Banteng District, West Kotawaringin Regency, Central Kalimantan. Using a survey of rice farmers and a Cobb–Douglas production function approach, the study assesses the role of land area, seed use, labor, urea fertilizer, phonska fertilizer, education level, income, and a pesticide price stability dummy. The findings are expected to provide evidence-based inputs to improve the effectiveness of Food Estate implementation by identifying priority factors for intervention to enhance rice production and support local food security.

METHODS

2.1 Research Location

The research location was Berambai Makmur Village, Pangkalan Banteng District, West Kotawaringin Regency, Central Kalimantan. The location was determined by purposive sampling, considering that Berambai Makmur Village is the highest rice-producing village, has unique topography with lowland and swampy areas, and is one of the villages implementing the Food Estate Program in Pangkalan Banteng District.

Figure 1. Location and Distribution of the Berambai Makmur Village Farmers Group

2.2 Population and Sample Determination

The study population comprised 128 rice farmers who are members of farmer groups in Berambai Makmur Village, distributed across five groups: Harapan Makmur, Sumber Rejeki, Tani Makmur, Lestari, and Sugih Waras. Primary data were collected in 2025 through structured interviews. Sampling used proportional random sampling to ensure each farmer group was represented according to its size. Within each farmer group, respondents were selected using random numbers from the official membership list. The total sample was set at 30 farmers, following the minimum sample size commonly used for statistical analysis in farm-level studies (Mahmud, 2011). The number of respondents selected from each farmer group was calculated using:

$$n_i = \frac{Ni}{N} \, x \, n \text{ .... (1)}$$

where n_i is the number of samples from farmer group i, *Ni* is the number of farmers in group i, *N* is the total population, and n is the total sample size (30). Respondents within each farmer group were selected randomly from membership lists. The determination of samples according to the proportions in the farmer group is presented in Table 2.

Table 2. Determination of the Number of Samples Based on the Number of Members of Farmer Groups in Berambai Makmur Village

No.	Farmer Group	Population	Number of Farmers (People)	Percentage (%)
1	Harapan Makmur	30	7	23,33
2	Sumber Rejeki	31	7	23,33
3	Tani Makmur	25	6	20,00
4	Lestari	22	5	16,67
5	Sugih Waras	20	5	16,67
	Quantity	128	30	100,00

Source: Primary data processed, 2025

2.3. Data Analysis and Model Specification

This study employed a quantitative approach supported by descriptive information from field observations. The determinants of rice output were estimated using a Cobb–Douglas production function in log-linear form with SPSS version 27. The unit of analysis is the rice farm household per cropping season. Rice output (Y) is measured as total paddy production (kg) per season, while input variables (seed, labor, urea fertilizer, phonska fertilizer, and income) are measured as total use per farm per season, and land area is measured in hectares.

The dependent variable was total rice production (kg). The explanatory variables included land area (ha), seed (kg), labor (HOK), urea fertilizer (kg), phonska fertilizer (kg), education level (years), income (IDR), and a risk and uncertainty dummy variable. Income (X_7) is included as a proxy for farmers' working-capital capacity to finance timely input purchase and farm operationsThe dummy variable was coded as 1 if input prices were perceived as relatively stable and 0 if input prices fluctuated. The Cobb–Douglas model was specified as:

$$\text{Ln } Y = Ln\, a + b_1\, LnX_1 + b_2\, LnX_2 + b_3\, LnX_3 + b_4\, LnX_4 + b_5\, LnX_5 + b_7\, LnX_7 + b_8\, D_1 \text{........ (2)}$$

where *Y* is rice production (kg); X_1 land area (ha); X_2 seeds (kg); X_3 labor (HOK); X_4 urea fertilizer (kg); X_5 phonska fertilizer (kg); X_6 education level (years); X_7 income (IDR), income (X_7) is included as a proxy for farmers' working-capital capacity to finance timely input purchase and farm operations ; The pesticide price stability dummy *(D_1)* was coded as 1 if farmers perceived pesticide prices as relatively stable during the most recent cropping season and 0 if pesticide prices were perceived as fluctuating; a is a constant; *bi* are parameters to be estimated; and ε is the error term.

2.4 Model Diagnostics and Returns to Scale

Prior to interpretation, the regression model was assessed using standard diagnostic tests, including multicollinearity (Variance Inflation Factor), heteroskedasticity, and residual normality testing. Returns to scale (RTS) was computed as the sum of estimated elasticities of the continuous input variables (the coefficients on the log-transformed variables), where RTS > 1 indicates increasing returns to scale, RTS = 1 constant returns to scale, and RTS < 1 decreasing return to scale. RTS was calculated as the sum of elasticities of continuous production inputs (land area, seeds, labor, urea, and phonska), excluding dummy variables.

RESULTS AND DISCUSSION

3.1 Descriptive Overview of Rice Farming

Rice cultivation in Berambai Makmur Village is carried out on dry swampland, supported by relatively good irrigation management. Cultivation is conducted twice a year and is generally semi-subsistence: farmers prioritize household consumption and sell the surplus to generate cash income. It shows that rice farming contributes to both household food security and local livelihoods. Based on interviews with rice farmers, the average rice production reaches 3,497 kg/ha, with an average cultivated area of 0.7 ha per farmer, indicating that the farm scale is relatively small and may constrain total output.

In terms of output prices, Inpari 32 grain is sold at approximately IDR 6,500/kg, and milled rice at IDR 13,000/kg. Catfish rice is sold at about IDR 7,000/kg (grain) and IDR 16,000/kg (milled rice). Overall, the price of rice offered by farmers ranges from IDR 13,000 to 16,000/kg. Rice farming in the village is also supported by government programs through subsidized fertilizers and seed assistance. However, fluctuations in output at the farm level suggest that production outcomes depend not only on the existence of input support, but also on farmers' operational capacity to access and use these inputs effectively and on time.

3.2 Determinants of Rice Output: Main Findings

The estimated coefficients, significance levels, and diagnostic statistics of the Cobb–Douglas model are presented in Table 3. The Cobb–Douglas regression results indicate that the model explains rice production variation strongly and is statistically feasible. The adjusted R^2 is 0.930, indicating that the included variables explain most of the variation in production among the sampled farmers. The model is also jointly significant (F = 49.012; Sig. < 0.001), indicating that land area, seed, labor, urea fertilizer, phonska fertilizer, education, income, and the pesticide price stability dummy collectively influence rice production. When assessed individually, however, the estimates show that rice production is primarily driven by farm scale and operational capacity, particularly land area, seed use, labor, and income. In contrast, fertilizers, education, and pesticide price stability do not show statistically significant effects in this sample.

Table 3. Results of Analysis of Biological Factors and Socio-Economic Factors Affecting Rice Production in Berambai Makmur Village

Independent Variables	Regression Coefficients	Value t_{value}	Significance
Land Area (X_1)	0.324	4.189	0.001 ***
Seeds (X_2)	0.197	2.046	0,053 *
Workforce (X_3)	0.258	2.559	0.018 **
Urea Fertilizer (X_4)	0.016	0.193	0.849 ns
Phonska Fertilizer (X_5)	0.106	1.408	0.174 ns
Education Level (X_6)	-0.040	-0.876	0.391 ns
Revenue (X_7)	0.222	5.301	0.001 ***
Dummy Risk and Uncertainty (D_1)	-.041	-0.696	0.494 ns
Constant	2.395	3.298	0,003
R^2 = 0.949			
R^2_{adj} = 0.930			
F_{hitung} = 49.012			<,001
Description:			

ns = insignificant at a confidence level of less than 90%

* = significant 0.1 at a confidence level above 90%

** = significant 0.05 at a confidence level above 95%

*** = significant 0.01 at a confidence level above 99%

Source: Primary data processed, 2025

Land area has a positive and highly significant effect on rice production (β = 0.324; Sig. < 0.001). That implies that a 1% increase in cultivated land is associated with a 0.324% increase in output, confirming that production remains scale-dependent. This result is consistent with the basic production economics view that land is a dominant input determining farm output (Karmini, 2018; Paul, 2024) and aligns with findings from Wulan et al., (2022), Alamri et al., (2022), Maksum et al., (2023), and Delaseh et al., (2020). In practical terms, this highlights that land conversion away from rice farming can directly reduce village-level production. Therefore, Food Estate interventions should not focus solely on intensification, but also on protecting productive rice land and improving effective land use through farmer-group coordination, so that available land can be utilized more efficiently.

Seeds use also shows a positive and significant relationship with production (β = 0.197; Sig. = 0.053). It indicates that a 1% increase in seed use is associated with a 0.197% increase in rice output. Farmers in Berambai Makmur Village use an average of 29.5 kg/ha, which falls within the recommended seeding rate range of 25 to 40 kg/ha (Pangerang, 2017; Government of Indonesia, 2022). However, farmers often use non-certified seed saved from previous harvests, which may reduce seed vigor and yield potential. This finding implies that seed availability and quality are critical, especially given under-reported delays in seed distribution. Thus, policy and managerial actions should prioritize strengthening seed logistics and encouraging the use of quality seed to help farmers achieve more stable establishment and output.

Labor has a positive and significant effect on production (β = 0.258; Sig. = 0.018), meaning a 1% increase in labor use is associated with a 0.258% increase in output. It suggests that timely and adequate labor remains crucial for swampland rice operations, such as land preparation, planting, water management, and pest control. Although some studies reported labor as insignificant (Delaseh et al., 2020; Wulan et al., 2022; Alamri et al., 2022; Maksum et al., 2023), the local context in Berambai Makmur Village, where older farmers dominate farming and mechanization, remains limited, and may make labor availability a binding constraint. That directly implies that improving output stability requires operational solutions: strengthening mechanization services (custom-hiring units), promoting labor-saving practices, and improving coordination among farmers during peak labor periods.

Urea fertilizer has a positive coefficient (β = 0.016) but is not statistically significant (Sig. = 0.849). That indicates that within the observed range of urea use, variations in urea quantity do not strongly explain differences in output across farmers. Farmers apply about 91.4 kg/ha, which is below the government recommendation (125 kg/ha) (Government of Indonesia, 2022). Field explanations suggest farmers intentionally reduce urea doses to avoid lodging. Therefore, the result indicates that fertilizer quantity alone, especially when applied conservatively, may not translate into measurable production gains without improvements in application timing, balanced nutrient application, and supporting crop management. The implication is that extension and program support should emphasize site-specific nutrient management and application practices rather than increasing urea quantity alone.

Phonska fertilizer also shows a positive coefficient (β = 0.106) but remains statistically insignificant (Sig. = 0.174). Average phonska use is 359.5 kg/ha, slightly below the recommended 375 kg/ha (Government of Indonesia, 2022). While farmers perceive phonska as more effective and tend to rely on subsidized supplies, the insignificant result suggests that differences in phonska quantity may not be the primary driver of production differences among farmers. Similar to urea, the effectiveness of compound fertilizer depends on timing, balance, and the interaction with swampland conditions. That implies that fertilizer programs should be complemented with practical guidance (dose, timing, split application) and field-based recommendations consistent with local soil–water constraints.

Education level has a negative coefficient (β = −0.040) and is not significant (Sig. = 0.391). It suggests that years of schooling do not directly translate into higher rice output in this study area. A plausible explanation is that production outcomes are more strongly constrained by access to land, capital, labor, and timely inputs than by differences in education, especially when education levels are relatively homogeneous (dominated by elementary graduates). The implication is that productivity improvement should rely more on hands-on extension, demonstration plots, and practice-oriented training rather than on the assumption that formal education alone increases output.

Income shows a positive and highly significant effect ($\beta = 0.222$; Sig. < 0.001), meaning that a 1% increase in income is associated with a 0.222% increase in output. That indicates that farmers' financial capacity is closely linked to production performance. Higher income can enable farmers to purchase inputs on time, hire labor, and pay for services, reducing operational delays that can lower output. This finding implies that policy efforts to increase production should also target financial access, such as seasonal credit, revolving funds within farmer groups, or input financing mechanisms that strengthen farmers' working capital capacity.

Finally, the Pesticide Price Stability Dummy (D_1) has a negative coefficient ($\beta = -0.041$) and is not statistically significant (Sig. = 0.494). It suggests that perceived pesticide price stability does not directly explain variation in production among farmers in this sample. The insignificant effect may indicate that price stability alone is insufficient to capture production risk, since risk also arises from pest incidence, weather variability, and input availability. Another explanation is adaptive behavior: farmers may adjust pesticide use or control practices regardless of price stability, reducing the measurable effect on output. The implication for future research is to strengthen risk measurement using more detailed indicators (pest incidence levels, frequency or timing of pesticide applications, or actual price variability), rather than relying on a single dummy variable. Overall, Table 3 indicates that land, seed, labor, and income are the most binding determinants of rice output in the study area, while fertilizer use, education, and pesticide price stability show weaker explanatory power; these patterns are further interpreted through the returns-to-scale results and their implications for Food Estate management in the next subsection

3.3 Returns to Scale and Implications for Food Estate Management

The estimated returns to scale for rice farming in Berambai Makmur Village is RTS = 1.042, indicating Increasing Returns to Scale. That means that proportional increases in the main production factors are associated with more-than-proportional increases in output; in other words, scaling up input use and operational capacity together can generate relatively larger output gains. This finding is important for the Food Estate program because it suggests that farmers may still operate at an inefficient scale due to constraints on land access, labor availability, and capital capacity.

Linking this result with the significant determinants identified in the model, the most actionable Food Estate priorities in Berambai Makmur Village include: strengthening land safeguarding and effective land use (given the strong land elasticity), ensuring timely access to quality seeds (given the seed effect and reported delays), addressing labor bottlenecks through mechanization services and operational coordination (given the labor effect and aging workforce), and improving farmers' working capital capacity (given the strong income effect). Meanwhile, fertilizer policies should shift emphasis from quantity alone to improving effectiveness through site-specific application guidance and extension support. Overall, these actions align with the increasing returns to scale condition, where improvements in operational capacity can unlock larger production gains under Food Estate dry swampland systems.

CONCLUSION

This study examined the determinants of rice production in Berambai Makmur Village, a Food Estate-based dry swampland area in Central Kalimantan, using a Cobb–Douglas production function. The model shows strong explanatory power, indicating that variation in rice output among farmers is largely associated with differences in production inputs and farmers' socio-economic capacity. The results confirm that production factors jointly influence rice output, while individually the most decisive determinants are land area, seed use, labor, and income. These findings imply that rice production performance in the study area is primarily shaped by farm scale and operational capacity, rather than by fertilizer quantity alone.

Urea and phonska fertilizers show positive coefficients but are not statistically significant under the observed conditions, suggesting that differences in fertilizer quantity do not explain much of the output variation among farmers, likely because effectiveness depends on timing, balanced application, and management quality in swampland systems. Education level is not a significant predictor of output, indicating that formal schooling differences do not directly translate into production gains under constraints related to land, labor, and capital. The Pesticide Price Stability Dummy is negative and insignificant, suggesting that perceived pesticide price stability alone does not capture the broader production uncertainties farmers face. The returns-to-scale result indicates increasing returns to scale

(RTS = 1.042), indicating that production gains remain attainable through simultaneous optimization of the key inputs.

Recommendations

Based on the significant determinants and the increasing returns-to-scale condition, Food Estate implementation in Berambai Makmur Village should prioritize interventions that strengthen farm scale and operational capacity. First, local stakeholders should safeguard productive rice land and improve land use to prevent output decline from land conversion, given the strong influence of cultivated area on production. Second, improving the timeliness and quality of seed supply should be prioritized, including strengthening seed distribution mechanisms and promoting the use of high-quality seed to support stable crop establishment. Third, labor constraints should be addressed through practical operational solutions, particularly by expanding mechanization services (equipment-sharing and custom-hiring units) and improving farmer-group coordination during peak operations to maintain timeliness in swampland rice farming.

Fourth, strengthening farmers' working capital capacity is recommended, as income significantly affects production and likely reflects the ability to finance timely inputs and operations. That can be pursued through seasonal credit schemes, revolving funds at the farmer-group level, or input financing mechanisms. Finally, fertilizer programs should shift emphasis from quantity alone to effectiveness, supporting site-specific nutrient guidance, appropriate timing, and balanced application so fertilizers can contribute more consistently to output under local swampland conditions. For future research, expanding the study to multiple Food Estate sites and improving risk measurement (beyond a single price-stability dummy) is recommended to capture production uncertainty better and strengthen the generalizability of results.

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