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Factors Affecting Hybrid Coconut Farming Production in Indragiri Hilir Regency, Riau Province (Cobb-Douglas Production Function Approach)

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Abstract. Coconut is one of the leading plantation commodities in Riau Province, especially in Tempuling Sub-district, Indragiri Hilir Regency. Hybrid coconut farming supports the local economy and improves farmers' livelihoods. This study aims to analyse: (1) the profile of farmers and the characteristics of their farming, (2) the use of production factors, costs, income, and farming efficiency, and (3) the factors that influence hybrid coconut production. The research used a survey method with 53 farmers as respondents. The data analysed includes both primary and secondary data, using descriptive qualitative and quantitative approaches, along with the Cobb-Douglas production function. The results show that most farmers manage their farms on a relatively large scale with sufficient capital, supported by family labour, and the average age of hybrid coconut trees is 9.8 years. The production cost is IDR 13,152,120 per year, with revenue of IDR 55,510,189 and income of IDR 42,358,068 per year. The farming efficiency (RCR) is 4.2. The Cobb-Douglas model shows that the R^2 value of 0.759 indicates that 75.90% of the variation in production is explained by six input factors: land area (X1), number of productive trees (X2), labour (X3), lime (terusi) (X4), salt (X5), and pesticides (X6). However, only land area (X1) has a statistically significant effect. This shows that even though inputs are used, their effectiveness varies, and optimizing land use remains the key to increasing productivity in hybrid coconut farming.

1. Introduction

The plantation subsector plays a strategic role in agriculture because it contributes to people's income through farming activities. In Sri Lanka, for example, plantations are still an important source of production and employment (1). Among the leading commodities, coconut is an important source of livelihood, raw material for industry, and a high-value export commodity (2)(3). In Indonesia, coconut plantations are widespread and involve millions of small and marginal farmers, contributing significantly to the local economy. Meanwhile, coconut farming in other agricultural countries like India and Sri Lanka also helps create jobs and reduce rural-to-urban migration (4)(5).

Indonesia is one of the largest coconut producers in the world, with smallholder plantations playing a significant role (2). Riau Province is recorded as the largest coconut-producing region in the country, with a production of 407.7 thousand tons or 14.45% of the national total, and a planted area of 442.8 thousand hectares or 13.35% of the national total (6). This advantage is supported by coastal topography and peatland areas (7), as well as sufficient and well-distributed rainfall (8), suitable for coconut growth. Coconut cultivation is found in almost all districts and cities in Riau Province. Detailed distribution data is presented in Table 1.

Table 1. Coconut Land Area, Production, and Productivity in Riau Province, 2025

No	Regency	Land Area (Ha)	Production (Ton)	Productivity (Ton/Ha)
1	Kuantan Singingi	529	491	0.93
2	Indragiri Hulu	1,260	376	0.30
3	Indragiri Hilir	341,070	312,019	0.91
4	Pelalawan	26,037	33,716	1.29
5	Siak	106	41	0.39
6	Kampar	1,674	476	0.28
7	Rokan Hulu	962	488	0.51
8	Bengkalis	6,092	3,329	0.55
9	Rokan Hilir	4,602	3,451	0.75
10	Kepulauan Meranti	33,057	29,747	0.90
11	Pekanbaru	10	7	0.70
12	Dumai	498	287	0.58
	Riau	415,897	384,428	0.92

** Central Bureau of Statistics Riau Province (2025) (9)*

Based on Table 1, Indragiri Hilir Regency is the leading coconut producer in Riau Province. The coconut plantation area in this regency reaches 341,070 hectares, or about 82.01% of the total coconut area in Riau. Its coconut production is also dominant, totaling 312,019 tons or around 81.16% of the province’s total production. This advantage is closely related to the fact that most people in Indragiri Hilir Regency rely on coconut farming for their livelihoods, either as farmers or in related businesses. In addition, the land in this area is mostly peat soil, which has characteristics that support optimal coconut growth. On the other hand, the area with the lowest contribution in terms of coconut area and production is Pekanbaru City, with only 10 hectares of coconut land and a production of 7 tons. This shows that coconut cultivation is highly concentrated in Indragiri Hilir Regency compared to other regions in Riau Province.

In Indragiri Hilir Regency, there are two main types of coconut cultivated by farmers: (1) local coconut, commonly known as "kelapa dalam," and (2) hybrid coconut. Kelapa dalam is widely grown and found in all sub-districts, while hybrid coconut is only cultivated in certain areas. Sub-districts, such as Concong, Gaung, and Kateman, do not grow hybrid coconuts. One of the key areas for hybrid coconut development is the Tempuling Sub-district. In 2024, this area ranked fourth in hybrid coconut plantation, covering 3,153 hectares. This area recorded production of 5,910.40 tons, with a productivity rate of 1.87 tons per hectare. This figure shows the significant contribution of Tempuling to the total hybrid coconut production in Indragiri Hilir Regency. Figure 1 presents the data on land area and hybrid coconut production in Tempuling.

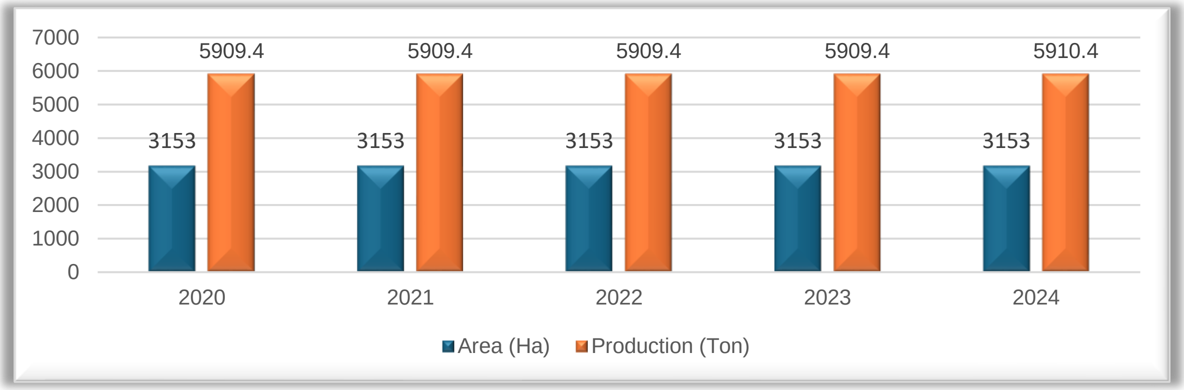

Figure 1. Land Area and Production of Hybrid Coconut in Tempuling Subdistrict, 2020-2024 (10)(11)

Based on Figure 1, the land area and production of hybrid coconuts in 2022–2023 showed no significant increase or decrease. However, in 2024, although the land area remained the same as the previous year, there was a slight increase in production, from 5,909.4 tons to 5,910.4 tons. This increase may indicate improvements in farming practices or farmers' more efficient use of inputs. Although the growth is relatively small, it suggests that land productivity still has the potential to be improved in the future.

One of the main problems in hybrid coconut farming is the low productivity in some areas, even though they have large land areas. This issue concerns land size and how efficient inputs such as fertilizers, labor, the number of trees, and cultivation technology are used (12)(13). Inaccurate input allocation and limited access to production facilities hinder optimal yields. The average technical efficiency of coconut farming is only 72.94%, meaning there is still a 27.06% potential to increase productivity (14). Other challenges include limited land, lack of financing (15), price uncertainty, declining soil fertility (16), and inadequate agricultural infrastructure and market access (17)(18). The research objectives are to analyze:

- The profile of hybrid coconut farming in Tempuling sub-district, Indragiri Hilir Regency.
- The use of production factors, production costs, income, and efficiency of hybrid coconut farming in Tempuling sub-district, Indragiri Hilir Regency.
- Production factors of hybrid coconut in Tempuling sub-district, Indragiri Hilir Regency.

2. Research Methods

This study used a survey method. A survey is a common data collection technique in social sciences to understand attitudes, behaviors, and population characteristics (19). Data was collected through questionnaires and interviews to improve efficiency and avoid duplication of information (20). The study used primary and secondary data and was conducted over six months, from May to December 2024.

2.1 Sampling Techniques

The population in this study includes all hybrid coconut farmers in Tempuling Sub-district, Indragiri Hilir Regency. The research location was selected using simple random sampling, as it met the required data collection standards. Tempuling consists of 5 villages and 3 sub-villages, but samples were only taken from 4 villages and 3 sub-villages, since some areas do not have hybrid coconut farmers. The selected locations are: Karya Tunas Jaya Village, Mumpa Village, Teluk Kiambang Village, Teluk Jira Village, Sungai Salak Sub-village, Pangkalan Tujuh Sub-village, and Tanjung Pidada Sub-village. The sample size in each area was 5% of the total population of active hybrid coconut farmers, resulting in 53 samples.

2.2. Data Analysis

a) Hybrid coconut farming profile

The farm profile includes information on farm size, capital, and labor. Data collected from hybrid coconut farmers were tabulated and processed using Microsoft Excel, then analyzed descriptively. This descriptive analysis presents an overview of the research, and the variables used in the study. It serves as an important first step to understanding the real conditions in the field before conducting further analysis.

b) Use of Production Factors, Production Costs, Income, and Efficiency of Hybrid Coconut Farming

- Use of Factors Production

The farm profile includes information on farm size, capital, and labor. Data collected from hybrid coconut farmers were tabulated and processed using Microsoft Excel, then analyzed descriptively. To identify the production factors, a quantitative descriptive analysis was also used, focusing on key variables such as land size, number of trees, labor, capital, fertilizers, pesticides, and farming tools. This approach helps to explain how each factor contributes to the productivity of hybrid coconut farming.

- Production Cost

Agricultural production costs are generally divided into material costs, labor, and machinery (21). This study analyzes production costs based on fixed and variable costs (22)(23). The production level does not affect fixed costs, such as depreciation, rent, and permanent staff salaries. Meanwhile, variable costs change depending on the production volume, such as raw materials and direct labor. The formula for calculating production costs refers to (24):

$$TC = TFC + TVC \quad \text{.......... (1)}$$

Explanation:

TC = Total Cost (IDR/Ha/Year)
TFC = Total Fixed Cost (IDR/Ha/Year)
TVC = Total Variable Cost (IDR/Ha/Year)

In this study, the costs calculated as fixed costs are equipment depreciation costs. To calculate equipment depreciation, the following formula is used:

$$D = \frac{NB-NS}{MP} \quad \text{..........(2)}$$

Explanation:

D = Depreciation (IDR/Year)
NB = Purchase Value (IDR/Year)
NS = Residual Value (IDR/Year)
MP = Usage Period (Year)

Total variable costs are the total costs farmers incur in the form of production factor input costs.

$$TVC = X_1.PX_1 + X_2.PX_2 + X_3.PX_3 \quad \text{.......... (3)}$$

Explanation:

TVC = Total Variable Cost (IDR/Ha/Year)
X_1 = NPK Fertilizer (Kg/Ha/Year)
P_1 = Price of NPK Fertilizer (IDR/Kg/Ha)
X_2 = Pesticide (Kg/Ha/Year)
P_2 = Price of Pesticide (IDR/Kg)
X_3 = Labor (HOK/Ha/Year)
P_3 = Labor Wages (IDR/HOK)

- Farming Income

Income in farming consists of total income (gross income) and profit (net income). Total income is calculated by multiplying the amount of hybrid coconut production by its selling price, which is formulated as:

$$TR = Y.Py \quad \text{.......... (4)}$$

Explanation:

TR = Total Revenue (IDR/Ha/Year)
Y = Production of Hybrid Coconut (Kg/Ha/Year)
Py = Price of Hybrid Coconut (IDR/Kg)

Profits are obtained by subtracting all production costs, including labor costs, from total revenues (25). The formula used to calculate profits is:

$$\pi = TR - TC \quad \text{..........(5)}$$

Explanation:

π = Profits (IDR/Ha/Year)
TR = Total Revenue (IDR/Ha/Year)
TC = Total Cost (IDR/Ha/Year)

- Efficiency

The efficiency of hybrid coconut farming is obtained using the RCR (Return Cost Ratio) formula, which the formula can describe:

$$RCR = \frac{TR}{TC} \quad (6)$$

Explanation:

RCR = Revenue Cost Ratio
TR = Total Revenue (IDR/Ha/Year)
TC = Total Cost (IDR/Ha/Year)

Criteria:

RCR > 1: Farming is declared efficient and feasible to be operated, because revenue is greater than costs.
RCR = 1: Farming is at the break-even point; revenue is equal to costs.
RCR < 1: Farming is inefficient and not feasible to operate, because costs are greater than revenue.

c) Production Factors of Hybrid Coconut

This study uses the Cobb-Douglas production function approach to analyze the influence of production factors on the total coconut output. This model makes it possible to measure the relative contribution of each input, such as land area, number of productive plants, labor, terusi, salt, and pesticides, to total production. By using the Cobb-Douglas model, it can be seen how efficiently the inputs have been used. Cobb-Douglas Production Function:

$$Y = A \cdot X_1^{\beta 1} \cdot X_2^{\beta 2} \cdots X_n^{\beta n} \quad (7)$$

Explanation:

Y = Output (coconut production)
A = Constant (total factor efficiency)
$X_1, X_2, ..., X_n$ = Production input (land area, number of productive plants, labor, terusi, salt, and pesticides)
$\beta_1, \beta_2, ..., \beta_n$ = Production elasticity of each input

The Cobb-Douglas production function can be transformed into a linear logarithmic form to make it easier to analyze. This transformation allows estimation to be done using the OLS (Ordinary Least Squares) regression method through the natural logarithm as follows:

$$\ln Y = \ln A + \beta_1 \ln X_1 + \beta_2 \ln X_2 + \ldots \beta_n \ln X_n \quad (8)$$

Analyzing the influence of several inputs on hybrid coconut production per hectare per year, the inputs used include land area (X_1), number of productive plants (X_2), labor (X_3), terusi (X_4), salt (X_5), and pesticides (X_6).

$$\ln Y = \ln A + \beta_1 \ln X_1 + \beta_2 \ln X_2 + \beta_3 \ln X_3 + \beta_4 \ln X_4 + \beta_5 \ln X_5 + \beta_6 \ln X_6 + \varepsilon \quad (9)$$

Explanation:

Y : Hybrid coconut production (kg/ha/year)
X_1 : Land area (ha)
X_2 : Number of productive plants (tree)
X_3 : Labor (HOK)
X_4 : Terusi (Kg/year)
X_5 : Salt (Kg/year)
X_6 : Pesticide (Liters/year)
ln A : Constant (intercept)
ε : Error term (factor not included in the model)
βi : Elasticity coefficient of each input

- Coefficient of determination (R^2)

The coefficient of determination (R^2) is used to measure how much influence the independent variable has on the dependent variable, expressed as a percentage (Gujarati, 2001).

The R^2 value ranges from 0 to 1. The closer to 1, the greater the influence of the independent variable on the dependent variable. Conversely, if it approaches 0, the influence is smaller.

- F-Test (Simultaneous Test)

The F-test is used to examine whether all independent variables together have a significant effect on the dependent variable. This test helps determine the overall significance of the regression model.

Hypotheses:

H_0: $\beta_1 = \beta_2 = ... = \beta_k = 0$ → All independent variables together have no significant effect on the dependent variable.

H_1: At least one $\beta_i \neq 0$ → There is a significant effect of the independent variables on the dependent variable.

Formula for F-test:

$$F = \frac{R^2 / k}{(1 - R^2)/(n - k - 1)} \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots . (10)$$

Where:

R^2 = Coefficient of determination
k = Number of independent variables
n = Number of observations

Decision Rule:

- If the significance value (p-value) < 0.05, then H_0 is rejected. This means that all independent variables together significantly affect the dependent variable.
- If the significance value (p-value) > 0.05, then H_0 is accepted. This means that all independent variables together significantly affect the dependent variable.

- t-Test (Partial Test)

The t-test is used to determine whether each individual independent variable has a significant effect on the dependent variable.

Hypotheses:

H_0: $\beta_i = 0$ → The independent variable Xi has no significant effect on the dependent variable.
H_1: $\beta_i \neq 0$ → The independent variable Xi has a significant effect on the dependent variable.

Formula for t-test:

$$t = \frac{b_i}{SE(b_i)} \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots (11)$$

Where:

b_i = Estimated coefficient for variable Xi
SE (b_i) = Standard error of b_i

Decision Rule:

- If the significance value (p-value) < 0.05, then H_0 is rejected. This means the independent variable significantly influences the dependent variable.
- If the significance value (p-value) > 0.05, then H_0 is accepted. This means that all independent variables significantly affect the dependent variable.

In this study, the F-test was applied to determine whether all production factors, such as land area, number of productive plants, fertilizer, salt, pesticides, and tools, have a joint influence on coconut production. Meanwhile, the t-test was used to evaluate the significance of each input variable individually. These statistical tests provide a clear understanding of which production inputs significantly contribute to output, both partially and simultaneously. The results of the F-test and t-tests support the assessment of input efficiency and guide recommendations for improving hybrid coconut farming productivity.

3. Results and Discussion

3.1. Hybrid Coconut Farming Profile

The hybrid coconut farming profile analyzed in this study includes farm scale, capital, and labor, aiming to describe the overall condition of hybrid coconut farming in the Tempuling District. The farming profile of hybrid coconut farmers in Tempuling is described as follows:

a) Farm Scale

The scale of farming reflects the level of income, labor requirements, and production output. Generally, the larger the farm scale, the higher the income, labor needed, and production results. In hybrid coconut farming in Indragiri Hilir Regency, land size is typically measured by the number of tree rows, with 30–40 trees per row. On average, 1 hectare comprises 4–5 rows of coconut trees. In the Tempuling District, farm scale is categorized into two groups: medium (0.5–1 ha) and large (>1 ha). The detailed distribution of farm scale can be seen in Table 2.

Table 2. Distribution of Hybrid Coconut Farm Scale in Tempuling District, 2024

No	Farm Scale (Ha)	Amount	Percentage (%)
1	Medium (0,5 - 1)	2	3.77
2	Large (> 1)	51	96.23
	Total	53	100.00

Table 2 shows that most hybrid coconut farmers in Tempuling District have large-scale farms (>1 ha), with 51 farmers or 96.23% falling into this category. This means that hybrid coconut farms in this area are generally quite large. (26) This condition is different from Vijayakumar's findings; many coconut farmers in various regions are smallholders with fragmented land, which limits their collective bargaining power and poses challenges for maintaining economic sustainability. (27) Small-scale farmers still mainly carry out coconut cultivation through integrated farming systems. Therefore, the situation in the Tempuling District can be seen as having a strong potential for developing coconut farming on a more economically viable scale than other areas.

b) Farming Capital

Farming capital reflects the farmer's ability to provide funds to run hybrid coconut farming activities. This capital is usually used to clear land, buy seedlings, and hire additional labor to speed up the land preparation process. The amount of capital needed depends on the type of farming. The distribution of hybrid coconut farmers' capital in Tempuling Sub-district is shown in Table 3.

Table 3. Capital Distribution of Hybrid Coconut Farmers in Tempuling Sub-district, 2024

No	Farming Capital (IDR)	Amount	Percentage (%)
1	3.000.000 - 6.000.000	14	26.42
2	7.000.000 - 10.000.000	15	28.30
3	11.000.000 - 14.000.000	8	15.09
4	15.000.000 - 18.000.000	12	22.64
5	19.000.000 - 22.000.000	3	5.66
6	23.000.000 - 25.000.000	1	1.89
	Total	53	100.00

Table 3 shows that most hybrid coconut farmers in Tempuling Subdistrict had working capital ranging from IDR 7,000,000 to IDR 10,000,000, which accounts for 28.30% of the total sample. Meanwhile, only one farmer (1.89%) had the highest capital, between IDR 23,000,000 and IDR 25,000,000. This finding suggests that most farmers started their business with relatively low capital. This is likely because land cultivation began 7 to 10 years ago, when the IDR value was lower than today. As a result, the capital needed in the past was not as high as it would be now. This indicates that many farmers began farming gradually and rely more on capital from previous harvests rather than significant initial investments.

c) Labor

(28) Coconut farming is a significant source of income and employment for many households, especially in Malaysia and Sri Lanka. (29)(30) It supports the livelihoods of small and marginal farmers, with many individuals depending on coconut farming as their main source of income. (31) Most farming households are small (1–4 members) and are dominated by adult male farmers, although female farmers are also starting to get involved.

Labor refers to individuals capable of doing work to meet their needs. In farming, labor includes family labor (TKDK) and hired labor (TKLK). In hybrid coconut farming in Tempuling Subdistrict, most farmers rely on family labor, with an average of around 9 to 10 people involved. This indicates that family participation remains the primary source of labor. (32) Family-based farming, which relies on internal labor, can be highly efficient, especially in areas with high population density and well-developed rural infrastructure. The distribution of labor can be seen in Table 4.

Table 4. Distribution of Hybrid Coconut Farming Labor (HOK) in Tempuling District, 2024

No	Work Stages	TKDK		TKLK		HOK	Wages/HKP (IDR)
		Amount	Labor Time	Amount	Labor Time		
1	Soil Cultivation	4.32	8.00	-	-	11.43	-
2	Planting	2.13	8.00	-	-	13.28	-
3	Fertilization	1.58	8.00	-	-	9.45	-
4	Weeding	1.38	8.00	-	-	2.75	-
5	Spraying	-	-	0.55	2.87	3.57	125,472
6	Harvesting	-	-	1.21	8.00	8.08	616,352
	Total	9.42	32.00	1.75	10.87	48.57	741,824

Based on Table 4, the average use of family and hired labor in hybrid coconut farming in Tempuling Subdistrict is 48.57 workdays (HOK). One HOK is equal to 8 hours of work. Labor wages are calculated based on the number of coconuts harvested, with a rate of IDR 50 per coconut. The average total wage per farming ground is IDR 741,824 per HKP. The activity that requires the most labor is land preparation (4.32 HOK), while the least is harvesting (1.21 HOK). This indicates that land preparation demands more labor than other farming stages. (33)(34) Coconut farming is labor-intensive and requires skilled workers, but the availability and cost of labor remain significant challenges in several countries, including the Philippines and India.

d) Age of Hybrid Coconut Plants

(35)(36) Coconut trees go through a long period before bearing fruit. Hybrid (dwarf) varieties usually mature earlier than "kelapa dalam" (traditional) ones. The age of hybrid coconut trees affects their productivity; knowing the tree's age helps farmers decide the proper care and treatment, as shown in Figure 2.

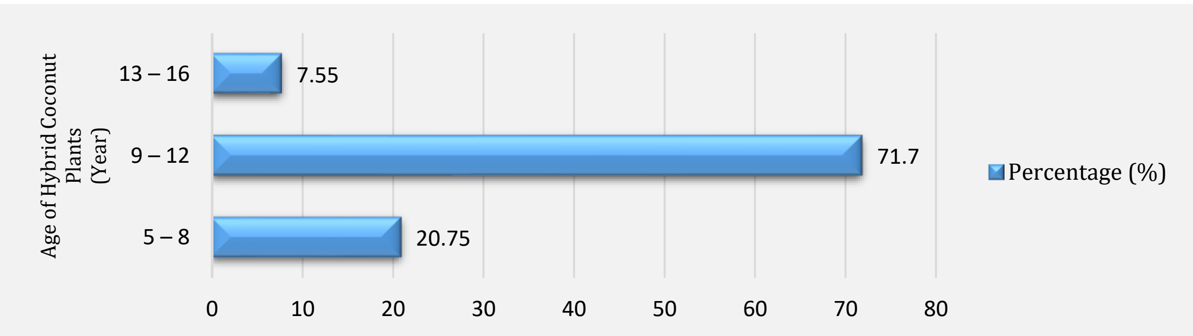

Figure 2. The Age Distribution of Hybrid Coconut Plants in Tempuling Subdistrict, 2024

Based on Figure 2, the average age of hybrid coconut trees in Tempuling Subdistrict is around 9.8 years, or approximately 10 years. Most trees are between 9–12 years old, while the fewest are in the 13–16-year range. This indicates that most hybrid coconut trees in the area are still in their productive phase. (37) The productivity of mature coconut trees depends on genetics, environment, and management, with older trees typically yielding less due to aging.

3.2. Hybrid Coconut Farming

a) Use of Production Factors

Production factors are all essential components provided to crops to support their growth and ensure good yields. These include land, capital, fertilizers, labor, and pesticides. However, this section focuses only on fertilizers and pesticides, as land, capital, and labor have been discussed earlier. The details of their use are presented in Table 5.

Table 5. Use of Hybrid Coconut Farming Production Factors (Fertilizers and Pesticides) in Tempuling District, 2024

No	Production Factors	Unit	Average
A	Fertilizer		
1	Salt	Kg/Cultivated/Year	343.40
2	Terusi	Kg/Cultivated/Year	34.79
3	NPK	Kg/Cultivated/Year	21.06
4	Urea	Kg/Cultivated/Year	54.72
B	Pesticide		
1	Rodokson	Liter/Cultivation/year	2.42
2	Paratop	Liter/Cultivation/year	27.43
3	Ledatop	Liter/Cultivation/year	11.43

Fertilizer use plays a vital role in boosting hybrid coconut production. Common fertilizers include salt (343.40 kg/cultivated/year), terusi (34.79 kg), NPK (21.06 kg), and urea (54.72 kg). To manage pests and diseases, farmers apply pesticides such as Rodokson (2.42 liters), Paratop (27.43 liters), and Ledatop (11.43 liters) per cultivated/year. (38)(39) Hybrid coconut trees are highly vulnerable to pests like rhinoceros beetles and red palm weevils, which can severely reduce yields, and additional challenges such as declining soil fertility, aging trees, and climate change. Therefore, adaptive strategies such as using drought-resistant coconut varieties and improved agronomic practices are crucial to maintaining productivity (40)(41).

b) Production Costs, Income, and Efficiency of Hybrid Coconut Farming

(42) Coconut cultivation is key in supporting the agricultural economy, especially in regions like Kerala, India, where it significantly contributes to farm income. Consequently, hybrid coconut farming is a farmer's effort to manage inputs efficiently to maximize earnings. Furthermore, the analysis of hybrid coconut farming includes production inputs, costs, yield, prices, revenue, income, and farm efficiency (RCR), as shown in Table 6.

As shown in Table 6, the average production cost of hybrid coconut farming in Tempuling Subdistrict is IDR 12,835,982/cultivated/year. Of this, 15.49% (IDR 1,987,804) is fixed cost, including land rent and equipment depreciation, while 84.51% (IDR 10,848,178) is variable. Land rent accounts for IDR 1,839,623 (92.55%), and depreciation of tools such as harvesting hooks, machetes, and grass cutters is IDR 148,182 (7.45%). Meanwhile, variable costs include seedlings (IDR 2,098,113 or 19.34%), fertilizers (IDR 4,936,023 or 45.50%), pesticides (IDR 2,563,727 or 23.63%), and labor wages (IDR 1,250,314 or 11.53%). High labor costs and the lack of skilled workers are significant economic constraints, while the high cost of inputs like fertilizers and fungicides also affects profitability (43)(44).

The average production of hybrid coconut farms in Tempuling Subdistrict is 5,760 kg/year, with an average selling price of IDR 2,423/kg. This results in an average gross revenue of IDR 55,510,189/year. (7) suggest that increasing production can be achieved by replanting aging plantations and expanding cultivation into new areas. After deducting production costs, farmers earn a net income of IDR 42,674,270/year, indicating that hybrid coconut farming is profitable in this region. (45) Coconut farming is the primary income source for approximately 6.6 million Indonesian farmers. However, (46) highlights that smallholders often struggle with limited bargaining power and poor access to affordable credit and inputs. Moreover, (47)(48) emphasize that price instability and uncertain markets significantly affect coconut farming profitability due to fluctuating supply-demand dynamics and the lack of reliable market forecasting.

Table 6. Costs, Income, and Efficiency of Hybrid Coconut Farming in Tempuling District, 2024

No	Explanation	Unit	Amount	IDR/Unit	IDR/Cultivated/Year	Percentage (%)
1.	Fixed Cost				1,987,804	15.49
a	Farm Lease				1,839,623	92.55
b	Depreciation Costs	IDR/Year			148,182	7.45
2.	Variable Cost	IDR/Year			10,848,178	84.51
a	Seeds	Tree	419.62	5,000	2,098,113	19.34
b	Fertilizer				4,936,023	45.50
	Salt	Kg	343.40	2,800	1,022,194	20.71
	Terusi	Kg	34.79	60,000	2,700,021	54.70
	NPK	Kg	21.06	18,000	490,774	9.94
	Urea	Kg	54.72	15,000	723,033	14.65
c	Pesticide				2,563,727	23.63
	Redoxon	Liter	2.42	75,000	243,984	9.52
	Paratop	Liter	27.43	70,000	1,509,548	58.88
	Ledatop	Liter	11.43	60,000	810,196	31.60
d	Labor		16.04		1,250,314	11.53
3.	Total Cost	IDR/Year			12,835,982	100.00
4.	Production	Kg	5,760			
5.	Price	Rp	2,423			
6.	Revenue	IDR/Kg			55,510,189	
7.	Profits	IDR/Year			42,674,207	
8.	Efficiency					4.3

Hybrid coconut farming in the Tempuling District has been proven efficient, with an RCR of 4.3, meaning that every IDR 1 production cost generates an IDR 4.3 in net income. However, (16) notes that high costs, a lack of skilled labor, and market price fluctuations may threaten its economic feasibility. Meanwhile, (49)(50) states that hybrid coconuts are very efficient in yield, quality, faster maturity, and nutrients.

3.3. Production Factors of Hybrid Coconut

The factors affecting hybrid coconut production were analyzed using multiple regression based on primary data collected from coconut farmers. The analysis was conducted using SPSS version 30.0, and the resulting regression model was transformed into a Cobb-Douglas production function. This model includes one dependent variable (Y: coconut production) and six independent variables: X_1: Land area, X_2: Number of productive plants, X_3: Labor, X_4: Terusi, X_5: Salt, and X_6: Pesticides. The Cobb-Douglas production function derived from the regression is:

$$\text{Ln } Y = \text{Ln } 4.598 + 0.250 \text{ Ln } X_1 + 0.065 \text{ Ln } X_2 + 1.292 \text{ Ln } X_3 + 0.110 \text{ Ln } X_4 - 0.009 \text{ Ln } X_5 - 0.035 \text{ Ln } X_6$$

The production function can be obtained as follows:

$$\text{Ln } Y = 4.598 \cdot X_1^{0.250} \cdot X_2^{0.065} \cdot X_3^{1.292} \cdot X_4^{0.110} \cdot X_5^{-0.009-} \cdot X_6^{-0.035}$$

a) Coefficient of determination (R^2)

The coefficient of determination (R^2) of 0.759 means that 75.90% of the variation in hybrid coconut production can be explained by six main input variables: land area, number of productive plants, labour, lime application (terusi), salt, and pesticides. This shows that the regression model is quite strong in explaining how these production factors affect output. However, the remaining 24.10% is influenced by other variables not included in the model.

Some of these may include superior seedlings and additional fertilizers, which could also significantly affect hybrid coconut production.

b) F-Test (Simultaneous Test)

The simultaneous test result shows that the F-calculated value is 24.118 at a 95% confidence level (α = 0.05). Using the p-value approach, where sig. < α, the null hypothesis (H_0) is rejected, and the alternative hypothesis (H_1) is accepted. This means that, together, the input variables—land area, number of productive plants, labour, lime application (terusi), salt, and pesticides—significantly affect hybrid coconut production in Tempuling District. This finding highlights the essential role of production inputs. In other words, without these inputs, the production process would stop, and output would be zero.

c) t-Test (Partial Test)

Based on the analysis results, variable X_1 (land area) significantly affects hybrid coconut production. Meanwhile, the other variables—X_2 (number of productive plants), X_3 (labor), X_4 (lime/terusi), X_5 (salt), and X_6 (pesticides)—did not show a significant effect in this model. These findings differ from a study (51) conducted on smallholder coconut farms in Johor, Malaysia. Using the Cobb-Douglas production function to analyze technical efficiency, their study found that coconut production responded positively to increased use of fertilizers, fungicides, and cultivated land area. Moreover, transportation, education, and farming experience significantly influenced technical efficiency. The detailed results are presented in Table 7.

Table 7. Hybrid Coconut T-Test in Tempuling District, 2024

	Coefficient	Standard Error	t Stat	P-value
Intercept	4.598	1.047	4.393	<0.001
X1	0.250	0.248	1.008	0.019
X2	0.065	0.167	0.390	0.098
X3	1.292	0.375	3.447	0.451
X4	0.110	0.094	1.166	0.250
X5	-0.009	0.189	-0.046	0.964
X6	-0.035	0.104	-0.336	0.738

- Land Area (X_1) on Hybrid Coconut Production (Y)

Based on Table 7, the variable ln X_1 (land area) has a p-value of 0.019. With a 95% confidence level (α = 0.05), this indicates that land area (ln X_1) significantly affects hybrid coconut production in Tempuling District. The significant influence of land area can be attributed to the relatively large average landholding size among the sample farmers, which is 3.31 hectares. Although the land size managed by each farmer is relatively similar, the number of coconut trees planted differs due to variations in planting distance and density. Even smaller plots can sometimes accommodate more trees if spacing is optimized. This highlights the importance of land size and planting patterns in determining productivity. According to (52)(53), land area is crucial in coconut production, as it determines planting space and yield potential. Larger areas allow for more trees and, in turn, higher harvest potential. In line with this, (54) emphasizes that sustainable coconut plantation development is essential to maintain ecological balance. Land use should also consider long-term environmental sustainability alongside productivity goals.

- Number of Productive Plants (X_2) on Hybrid Coconut Production (Y)

Based on Table 7, the variable ln X_2 (number of productive trees) has a P-value of 0.098 at a 95% confidence level (α = 0.05), indicating that it does not significantly affect hybrid coconut production in Tempuling District. This finding contrasts with studies by (55)(56), which found a direct relationship between the number of productive trees and yield. Although hybrid coconuts tend to produce more fruits, the number of productive trees alone is not the main factor determining yield. Tree quality, cultivation techniques, and production cycles also play key roles. Some trees may appear productive but are old or in non-fruiting phases, and productivity per tree can vary widely.

- Labor (X_3) on Hybrid Coconut Production (Y)

The P-value for ln X_3 (labor) is 0.451 at a 95% confidence level (α = 0.05), indicating that labor does not significantly affect hybrid coconut production in Tempuling District. This is likely because coconut farming generally requires limited labor. Activities such as fertilizing are done only when productivity declines, and land is cleaned occasionally, only when weeds become too dense. Thus, labor input tends to be irregular and not intensive, making its impact on output relatively low.

- Terusi (X_4) on Hybrid Coconut Production (Y)

The P-value for ln X_4 (lime application or "terusi") is 0.250 at a 95% confidence level (α = 0.05), indicating that it does not have a significant effect on hybrid coconut production in Tempuling District. This may be because some farmers apply lime or fertilizer based on recommended practices, while others only use it when productivity declines. As a result, whether lime is applied, coconut trees still produce fruit, though the quantity and duration of production may vary. Therefore, the impact of lime application on overall yield is inconsistent.

- Salt (X_5) on Hybrid Coconut Production (Y)

The P-value for ln X_5 (salt) is 0.964 at a 95% confidence level (α = 0.05), indicating that salt application does not significantly affect hybrid coconut production in Tempuling District. This is likely due to varying soil conditions across the region—farmers typically apply salt only when the soil requires it. On average, salt is used to help maintain plant health rather than boost yield. In other words, coconut trees still bear fruit regardless of salt application, although the production timing may differ. According to (57), salt stress can negatively affect coconut yields, as salinity influences plant growth and productivity.

- Pesticide (X_6) on Hybrid Coconut Production (Y)

The P-value for ln X_6 (pesticides) is 0.738 at the 95% confidence level (α = 0.05), indicating that pesticide use does not significantly affect hybrid coconut production in Tempuling District. This is likely because pesticides are applied only when pest or weed infestation occurs. Their role is more preventive than productivity-enhancing. If pests are promptly controlled, unaffected trees continue to produce typically. According to (58), Integrated Pest Management (IPM) is recommended to reduce excessive pesticide use while ensuring effective pest control.

4. Conclusions

The results of the study indicate that: (1) Hybrid coconut farming in Tempuling District is on average large-scale, with a business capital of around IDR 10,962,264, using an average of 13 family workers and four outside workers, and an average coconut age of 9.8 years. (2) Total production costs reach IDR 13,152,120/year, revenue of IDR 55,510,189/year, and income of IDR 42,358,068/year, with a business efficiency (RCR) of 4.2. (3) The coefficient of determination (R^2) value of 0.759 indicates that 75.90% of production variation is explained by six main inputs (land area (X1), number of productive plants (X2), labor (X3), provision of lime (terusi) (X4), salt (X5), and pesticides (X6)). However, only land area (X1) significantly affects hybrid coconut production.

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