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# Analysis Production and Technical Efficiency of Tilapia (*Oreochromis niloticus*) In Freshwater, Tasikmalaya

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**Abstract**
The fisheries subsector plays a significant role in the national GDP. In 2023, its contribution reached 2.66%, increasing from 2.58% in 2022. In the second quarter of 2024, the subsector contributed 2.54%, higher than the 2.34% recorded in the first quarter. One of its leading commodities is tilapia (Oreochromis niloticus), a freshwater species valued for its high economic potential and strong adaptability. In 2021, West Java reported the highest national tilapia production at 270,925 tons, with Tasikmalaya City contributing the largest share at 2,189 tons. This study analyzes the technical efficiency of tilapia farming in Tasikmalaya using the Cobb–Douglas Stochastic Production Function. The research was conducted from July - September 2024 in the districts of Bungursari, Kawalu, Purbaratu, and Cibeureum. Locations were selected purposive, and a snowball sampling technique yielded 52 respondents. The results indicate that seed and pellet feed exert a statistically significant effect on production, whereas bran, EM4, cultivation duration, and labor inputs do not show a significant influence. The technical inefficiency model demonstrates that farmer experience and education have a significant impact on efficiency. Experience contributes to technical inefficiency, while education mitigates it.

**Keywords:** Nile Tilapia, Production Inputs, Technical Efficiency.

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## 1. Introduction

The fisheries subsector contributes significantly to the national Gross Domestic Product (GDP). In 2023, the fisheries subsector contributed 2.66% to the total national GDP, an increase compared to 2022's 2.58%. Meanwhile, in the second quarter of 2024, the GDP contribution reached 2.54%, higher than the first quarter of 2024 at 2.34% (BPS, 2024). This achievement demonstrates the strategic role of the fisheries subsector in supporting natural resource-based national economic growth. Tilapia cultivation is one of the most widely developed activities. This species has a high growth rate, wide tolerance to various environmental conditions, omnivorous nature, and strong market demand as a consumption commodity (Eka, 2020). These characteristics make tilapia a commodity that has economic value and is relatively easy to manage in freshwater fisheries cultivation systems (Sibagariang *et al.,* 2020). In addition, tilapia cultivation provides significant economic contributions through efficient feed utilization, high reproductive capacity, and increasing market demand (Dailami *et al.,* 2021).

Data from 2021 indicates that West Java Province has the biggest tilapia production in Indonesia, totaling 270,925 tons. Indramayu Regency had the most output at the regency level with 52,202 tons, but Tasikmalaya City had the highest production at the city level, totaling 2,189 tons (BPS, 2023). Ten sub-districts serve as hubs for tilapia production in Tasikmalaya City, with total output rising from 2,127.56 tons in 2019 to 2,340.40 tons in 2022.

**Table 1. Tilapia Production in Tasikmalaya City in 2021-2022**

| No | Sub District | Production (Ton) | | | |
|---|---|---|---|---|---|
| | | 2019 | 2020 | 2021 | 2022 |
| 1 | Kawalu | 308.41 | 306.35 | 317.30 | 339.26 |
| 2 | Tamansari | 125.89 | 125.06 | 129.53 | 138.49 |
| 3 | Cibeureum | 299.86 | 297.86 | 308.51 | 329.85 |
| 4 | Purbaratu | 305.08 | 303.05 | 313.88 | 335.60 |
| 5 | Tawang | 37.84 | 37.59 | 38.94 | 41.63 |
| 6 | Cihideung | 26.93 | 26.75 | 27.70 | 29.62 |
| 7 | Mangkubumi | 251.32 | 249.64 | 258.57 | 276.46 |
| 8 | Indihiang | 198.91 | 197.59 | 204.65 | 218.81 |
| 9 | Bungursari | 400.61 | 397.94 | 412.17 | 440.69 |
| 10 | Cipedes | 172.71 | 171.56 | 177.69 | 189.99 |
| | **Total** | **2127,56** | **2113.39** | **2188.93** | **2340.40** |

*Source: opendata.tasikmalayakota.go.id (2023)*

Bungursari Sub District consistently recorded the highest production, reaching 440.69 tons in 2022, followed by Kawalu, Cibeureum, and Purbaratu Sub Districts, each producing over 300 tons. Conversely, Cihideung and Tawang Sub Districts produced less than 50 tons per year.

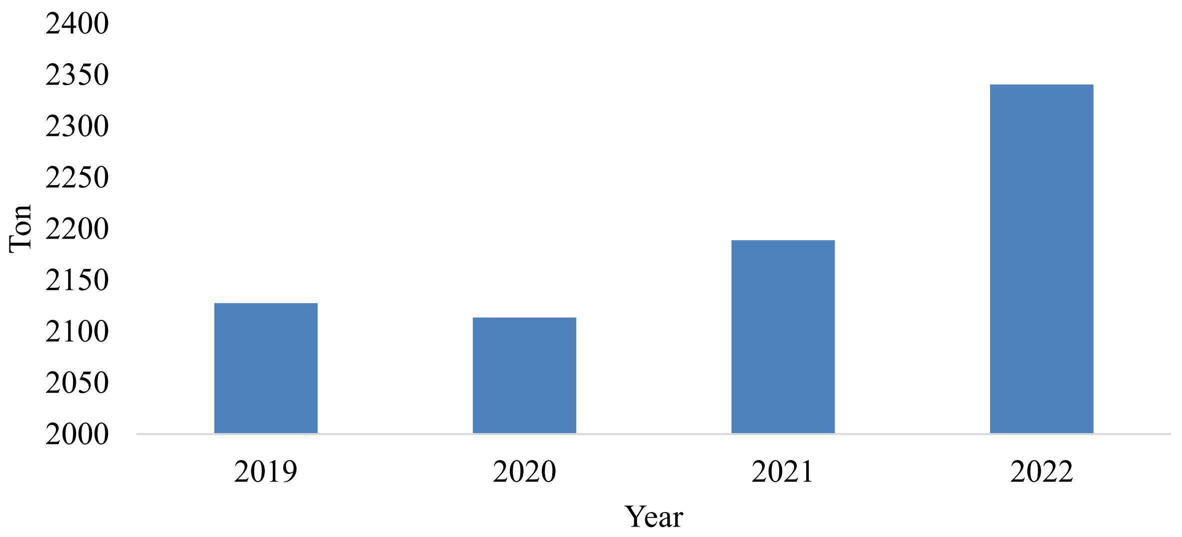


**Figure 1**. Graph of Total Tilapia Production in Tasikmalaya City
*Source: opendata.tasikmalayakota.go.id (2023)*

Tilapia production in Tasikmalaya City increased from 2021 to 2022, demonstrating the fisheries sector's tremendous potential, particularly in the freshwater fish farming subsector. However, the decline in production in 2020 was caused by technical inefficiency, a major contributor to low productivity in the agriculture and fisheries sectors, which is defined as a mismatch between input consumption and output produced during the production process. According to a recent frontier function analysis, many production units in the agriculture and fisheries sectors have yet to achieve optimal technical efficiency, resulting in actual productivity remaining below its maximum potential due to inappropriate or ineffective use of inputs in producing output. Empirical study in many locations has also discovered that characteristics like as production experience, entrepreneur education, and technology utilization all have an impact on technical inefficiency and productivity levels (Nurhanifa *et al,* 2020).

In the context of tilapia production, technical efficiency is significantly affected by the farmer's capacity to manage input combinations effectively. Decisions about the number and kind of inputs are critical for successful production, and farmer socioeconomic attributes such as age, education level, fisheries business experience, and family structure all have an impact on technical efficiency. Several recent studies have found that farmers with more formal education and aquaculture training achieve higher technical efficiency, while business experience is also an important factor in input optimization and efficient production management (Syabana *et al.* 2021). Based on this description, the purpose of this study is to assess tilapia production and technical efficiency levels in freshwater ponds. This approach is expected to provide a comprehensive view in identifying input management, so that production declines can be minimized in the future period.

## 2. Methods

### 2.1 Time and Study Site

This research was conducted in Bungursari, Kawalu, Purbaratu, and Cibeureum Sub Districts. The locations were selected purposively, using several considerations based on the desired criteria to determine the number of samples to be studied (Sugiyono, 2017). The consideration was that these four districts have an average annual production of more than 300 tons. The research took place from July to September 2024.

### 2.2 Respondents

The sampling technique used in this study was snowball sampling. According to Sugiyono (2017), snowball sampling is a sampling technique in which the sample size is initially small and then expanded through recommendations or referrals from previous respondents. This technique is used when the research population is difficult to identify directly, requiring the researcher to assist the initial informant in finding other respondents who meet the research criteria. The researcher began with three initial informants selected based on their suitability for the research characteristics, specifically tilapia fish farmers. Next, each informant provided referrals to other farmers with similar profiles. The sample development process was carried out in stages until saturation point was reached, when new respondents no longer provided additional information. Through this process, a total of 52 respondents were obtained as a research sample.

### 2.3 Analysis

An analysis of the production level and efficiency of tilapia farming was conducted using the *Cobb-Douglas Stochastic Frontier* production function model. This approach was chosen because it reduces the risk of multicollinearity between input variables, is homogeneous, and facilitates the derivation of multiple cost functions from the production function (Kumbhakar, 2002). Furthermore, its relatively simple function form, its ability to be transformed into a linear form, has been widely applied in agricultural and fisheries research due to its reliability in describing the relationship between input and output production.

Efficiency is generally divided into three main components: technical efficiency, allocative efficiency, and economic efficiency (Coelli *et al.,* 1998). This study focuses on technical efficiency, defined as the ability of a farming business to achieve the highest level of output from a combination of available inputs while optimally utilizing existing resources. In other words, a farming activity can be categorized as technically efficient if its production process is on the *frontier* production line or curve, indicating the maximum output that can be achieved based on the amount of input used. The general form of the *Cobb-Douglas* production function can be written as follows:

$$\mathbf{lnY = \beta_0+\beta_1 lnX_1+\beta_2 lnX_2+\beta_3 lnX_3+\beta_4 lnX_4+\beta_5 lnX_5+\beta_6 lnX_6 +(\mathit{vi} - \mathit{ui})}$$

Where:
Y : Tilapia fish production (kg)
$X_1$ : Tilapia fish seeds (kg)
$X_2$ : pellets (kg)
$X_3$ : Bran (Kg)
$X_4$ : EM4
$X_5$ : time
$X_6$ : labor
$\beta_0$ : Intercept or constant
$\beta_i$ : Estimator parameters, where i = 1,2,n
$vi - ui$ : *error term* (the effect of inefficiency in the model)
$vi$ : *noise effect*
$ui$ : the effects of technical inefficiency

The technical inefficiency model used in this study is based on the technical inefficiency effects approach as described by Coelli *et al.* (1998). In this model, the variables $vi - ui$ function as random components that reflect the level of technical inefficiency of a production process influenced by various internal factors. The greater the value of $ui$, the higher the level of inefficiency. Because $ui$ describes the deviation from the ideal production frontier, its value must not be negative and is assumed to follow a semi-normal distribution, namely $N (\mu i\ \sigma^2\ u)$. To estimate the distribution parameters of the technical inefficiency effects in tilapia cultivation, the following equation is used:

$$\mathbf{ui = \delta_0+\delta_1 Z_1+\delta_2 Z_2 +\delta_3 Z_3+\delta_4 Z_4+\delta_5 Z_5+\varepsilon}$$

Where:
ui : Technical efficiency effects
$\delta_0$ : Intercept or constant
$Z_1$ : Age (years)
$Z_2$ : Number of family dependents (people)
$Z_3$ : Experience (years)
$Z_4$ : Education (0 = no schooling; 1 = elementary school; 2 = middle school; 3 = high school; 4 = bachelor's degree)
$Z_5$ : Access to credit (0 = no; 1 = credit)
$\varepsilon$ : Residual elements (error)

The technical efficiency (TE) value ranges from 0 to 1, which is mathematically expressed as $0 \leq TE \leq 1$. The TE value has an inverse relationship with the level of technical inefficiency (vi – ui), the greater the inefficiency value, the lower the technical efficiency achieved. Technical efficiency measurements are generally carried out using a production function based on cross-section data, where the amount of input and output is considered constant in each observation unit. In this study, tilapia fish farmers are said to be efficient if the TE value is $\geq 0.7$, while TE $< 0.7$ indicates that the business has not achieved efficiency. The technical efficiency value is calculated using the following equation:

$$TE = \frac{y_i}{\exp(x_i\beta)} = \frac{\exp(x_i\beta - \mu_i)}{\exp(x_i\beta)} = \exp(-\mu_i)$$

## 3. Results and Discussion

### 3.1 Production Factors

Tilapia production levels are determined by the combination of various production inputs used by farmers. The main input components in this cultivation system include seeds, pellet feed, bran, EM4, harvest time, and labor. This study examined the extent to which all these input variables significantly influence tilapia production levels. The estimated effect of each input on production output is shown in Table 2.

**Table 2.** Results of Stochastic Frontier Production Function Estimation of Tilapia in Tasikmalaya City

| Variables | Coefficient | Std.Error | T-Ratio |
|---|---|---|---|
| Constant | 3.490 | 1.225 | 2.849 |
| Seeds | 0.457* | 0.090 | 5.061 |
| Pellet feed | 0.190* | 0.075 | 2.528 |
| Bran | -0.062 | 0.069 | -0.927 |
| EM4 | -0.241 | 0.337 | -0.713 |
| Harvest time | -0.078 | 0.280 | -0.277 |
| Labor | 0.149 | 0.642 | 0.232 |
| Sigma Square | 0.559 | 0.177 | 1.173 |
| Gamma | 0.139 | 0.239 | 0.232 |
| *Log likelihood function* | -59.238 | | |
| *LR test of the one-side error* | 9.399 | | |

*Source: primary data (processed). Note: significance level 5%*

Based on Table 2, two input variables significantly influence tilapia production levels: seeds and pellets. These variables indicate that feed is the largest cost component and the primary factor in achieving optimal growth and production efficiency, while the availability of quality seeds is the basic capital for initial growth. This finding aligns with Nurhayati *et al.* (2025), who explained that seeds and feed are dominant factors in increasing the productivity of aquaculture businesses. Feed quality and quantity significantly influence optimal cultivation productivity. This finding reinforces the role of feed as a dominant input in freshwater tilapia cultivation, in line with the importance of quality seeds in determining the initial growth potential of fish (Kirikanang *et al.*, 2022). The estimation results in Table 2 also show that the applied production function model demonstrates good fit. This is evident from the gamma ($\gamma$) value in the stochastic frontier model; a positive $\gamma$ value indicates the dominance of the frontier component and low random error variation ($v$).

In this study, a gamma value of 0.139 was obtained. This value indicates that variations in tilapia production output do not occur by chance, but are caused by technical inefficiencies at the farmer level. In addition, the sigma-squared ($\sigma^2$) value of 0.559, which is significant at the 95% confidence level, indicates that approximately 55.9% of production variations can be explained by differences in technical efficiency levels between farmers. The analysis results show that seeds, pellets, and labor have a positive and significant influence on tilapia production results. In contrast, bran, EM4, and maintenance duration have no significant effect. Of all production factors, seeds are the most influential variable with a coefficient value of 0.457, which is significant at the 95% confidence level.

Seed is the variable that shows the strongest influence on tilapia production, with a coefficient of 0.457 and significant at the 95% confidence level. This finding confirms the research of Pakage *et al.* (2014), which stated that seed is a key factor in increasing tilapia production. Pellet feed has a positive and significant effect, with a coefficient of 0.190. Thus, feed is the second most important factor after seed. The results of this study align with the findings of Yunus (2014), who emphasized that feed availability has a positive and significant contribution to the productivity of the aquaculture sector.

### 3.2 Technical Inefficiency Effects

To determine the difference in efficiency between tilapia fish farmers, an estimation of the factors that influence technical inefficiency was carried out. The estimation results are presented in Table 3.

**Table 3.** Results of the Estimated Technical Efficiency Effect of Tilapia Cultivation in Tasikmalaya City Using the Stochastic Frontier Model

| Variables | Coefficient | Std.Error | T-Ratio |
|---|---|---|---|
| Age | 0.118 | 0.100 | 1.173 |
| Number of family dependents | -0.011 | 0.021 | -0.514 |
| Experience | 0.429* | 0.222 | 1.930 |
| Education | -0.001* | 0.000 | -1.946 |
| *Dummy* credit (0 = no; 1 = credit) | -0.550 | 0.597 | -0.921 |

*Source: primary data (processed). Note: significance level 5%*

Table 3 shows that the variables of experience and education level have a significant effect on technical efficiency, with probability values below the 5% significance level. This finding indicates that technical inefficiency in tilapia cultivation in Tasikmalaya City is more influenced by internal factors of farmers such as age, dependents, experience, and education. Therefore, increasing technical efficiency can be achieved by strengthening the capacity of individual farmers, especially through education. This result is in line with the findings of Sumarno *et al.* (2015), which stated that production inefficiency is influenced by internal factors, namely formal farmer education, group institutions, and extension institutions.

The experience variable shows a positive and significant coefficient at the 95% confidence level, indicating that the greater the farmer's experience, the greater the technical inefficiency in tilapia cultivation. This confirms that the accumulation of practical knowledge through experience does not necessarily contribute positively to increasing technical efficiency. This finding is in line with the research results of Sidabutar *et al.* (2024) which stated that age has a positive effect on the level of technical inefficiency, meaning that the older the farmer, the higher the likelihood of technical inefficiency in production.

Meanwhile, the average age of tilapia farmers is 40 years, which is considered a productive age. This age group tends to be more receptive to information and technological updates, making it more ready to adopt innovations that support increased efficiency and productivity. The increasing inefficiency results from experience related to learning in fish farming, which is still minimal. This is also in line with the positive but insignificant coefficient on the age variable. Contrary to Sarie *et al.* (2023), age as a demographic factor is strongly correlated with motivation and technology adoption by farmers, which influences production efficiency and agribusiness productivity. Farmers in their productive years generally have a stronger response to innovation and greater energy to improve business performance.

The analysis results show that education level has a negative and significant effect at the 5% level of significance. This means that increasing a farmer's formal education level can reduce technical inefficiency. This finding indicates that formal education can have a direct impact on technical skills. This finding aligns with Sidabutar *et al.* (2024) who found that the length of formal education is negatively correlated with the level of technical inefficiency. The higher the respondent's formal education, the more efficient their farming practices.

## 4. Conclusion

The conclusion of this study indicates that seeds, pellets, and labor are production factors that significantly increase tilapia output. However, the use of bran, EM4, and the length of the rearing period did not significantly impact production. The experience and education of the farmers were shown to influence the technical inefficiency of tilapia cultivation in freshwater ponds in Tasikmalaya City..

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