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# ANALYSIS OF THE TECHNICAL EFFICIENCY OF AQUACULTURE POND ENTERPRISES IN TANI BARU VILLAGE ANGGANA DISTRICT KUTAI KARTANEGARA REGENCY

Analisis Efisiensi Teknis Usaha Tambak di Desa Tani Baru Kecamatan Anggana Kabupaten Kutai Kartanegara

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## ABSTRACT

Aquaculture pond farming is one of the main livelihood sources for coastal communities in Tani Baru Village. However, the efficiency of production input utilization and the factors affecting the efficiency of pond farming enterprises have noyt been clearly identified. Therefore, this study is important as a basis for improving the productivity and income of pond farmers. This study aims to analyze the level of efficiency of pond aquaculture enterprises and to identify the factors that influence the efficiency of pond farming businesses in Tani Baru Village, Anggana District. This study employed a survey method using purposive sampling to determine respondents based on the Slovin formula. Data were analyzed using the Data Envelopment Analysis (DEA) method with the Constant Return to Scale (CCR) and Variable Return to Scale (BCC) models,and the factors influencing efficiency were analyzed using Tobit regression analysis. The results showed that the average efficiency values in the CCR model were Technical Efficiency (TE) of 0.067, Allocative Efficiency (AE) of 0.693, and Cost Efficiency (CE) of 0.031. Meanwhile, in the BCC model, the results obtained were Technical Efficiency (TE) of 0.152, Allocative Efficiency (AE) of 0.642, and Cost Efficiency (CE) of 0.092. The results of the Tobit regression analysis indicated that business experience and land area had a significant effect on the efficiency of pond aquaculture businesses, whereas age and education did not have a significant effect.

**Keywords:** Efficiency, Data Envelopment Analysis (DEA), Tani Baru Village.

## ABSTRAK

Usaha tambak merupakan salah satu sumber mata pencaharian utama bagi masyarakat pesisir di Desa Tani Baru. Namun, Tingkat efisiensi penggunaan input produksi serta faktor-faktor yang mempengaruhi efisiensi usaha tambak masih belum diketahui secara pasti. Oleh karena itu penelitian ini penting dilakukan sebagai dasar dalam meningkatkan produktivitas dan pendapatan petambak. Penelitian ini bertujuan untuk menganalisis tingkat efisiensi usaha tambak serta mengidentifikasi faktor-faktor yang mempengaruhi efisiensi usaha tambak di

Desa Tani Baru, Kecamatan Anggana. Penelitian ini menggunakan metode survei dengan teknik purposive sampling dengan menentukan responden menggunakan rumus slovin. Analisis data menggunakan metode Data Envelopment Analysis (DEA) dengan model *Constant Return to Scale* (CCR) dan *Variable Return to Scale* (BCC) serta untuk menganalisis faktor-faktor yang mempengaruhi menggunakan analisis regresi Tobit**.** Hasil penelitian menunjukkan bahwa nilai rata-rata efisiensi pada model CCR yaitu Efisiensi Teknis (TE) sebesar 0,067, Efisiensi Alokatif (AE) sebesar 0,693, dan Efisiensi Biaya (CE) sebesar 0,031. Sementara itu, pada model BCC, hasil yang diperoleh yaitu Efisiensi Teknis (TE) sebesar 0,152, Efisiensi Alokatif (AE) sebesar 0,642, dan Efisiensi Biaya (CE) sebesar 0,092. Hasil analisis regresi Tobit menunjukkan bahwa lama usaha dan luas lahan berpengaruh signifikan terhadap efisiensi usaha tambak**,** sedangkan umur dan pendidikan tidak berpengaruh signifikan**.**

**Kata Kunci:** Efisiensi, Data Envelopment Analysis (DEA), Desa Tani Baru

## INTRODUCTION

Kutai Kartanegara Regency is a regency in East Kalimantan Province, boasting substantial fishery resources. Based on 2023 data, the area of public waters reached 79,406 ha, consisting of 19,217 ha of lakes, 22,302 ha of rivers, and 37,611 ha of swamps (Kutai Kartanegara Regency Central Statistics Agency, 2023). The area's fisheries potential is supported by various aquaculture communities, particularly tiger shrimp and milkfish ponds. Research by Hasyim et al. (2022) shows that the average tiger shrimp pond production is 1,590 kg per harvest season, or an average of 57 kg per harvest season per respondent, while milkfish production is 16,000 kg per harvest season, or an average of 600 kg per harvest season per respondent. These data indicate that the aquaculture business in Kutai Kartanegara Regency offers promising potential for development.

Tani Baru Village is located in Anggana District, Kutai Kartanegara Regency. This district is known as a center for aquaculture production, particularly for tiger prawns, which contribute significantly to the regional fisheries sector. In 2023, Kutai Kartanegara's capture fisheries production increased by 22% to 98,397 tons from 80,748 tons in 2021. The potential of aquaculture in Anggana District is known for its significant contribution to Kutai Kartanegara shrimp exports. (Kutai Kartanegara Regency Central Statistics Agency, 2024). With an area of 7,130 km2, the utilization of aquatic resources in Tani Baru Village is carried out through the development of pond cultivation businesses. The dominant commodities cultivated include tiger prawns and milkfish, which have economic value for coastal communities. This cultivation business is one of the community's main sources of income, with the aim of achieving maximum production results and improving the welfare of farmers. (Effendy et al., 2014).

The shrimp pond business in Tani Baru Village is still developed traditionally with relatively simple cultivation technology. This condition means that the efficiency level of the shrimp pond business is still unknown. Furthermore, issues related to the socioeconomic characteristics of the shrimp farmers have not been identified in detail. According to (Yulisti et al., 2021), measuring efficiency is necessary to determine optimal input usage and to improve performance and income. The shrimp pond business is influenced by several factors, namely the age of the shrimp farmer, the number of shrimp farms owned, the shrimp farmer's education level, the experience of the shrimp farmer, and the farmer's occupation. Therefore, a study is needed to determine the efficiency level of the shrimp pond business in Tani Baru Village. Based on this description, this study aims to analyze the levels of technical, allocative, and cost efficiency. It also aims to analyze the factors influencing the efficiency of the shrimp pond business in Tani Baru Village.

## RESEARCH METHODS

This research was conducted over a five-month period, from December to April. The location was Tani Baru Village, Anggana District, Kutai Kartanegara Regency, East Kalimantan. This study was quantitative. Data collection was conducted through direct interviews with respondents based on a pre-prepared questionnaire as a guideline. The data used consisted of two types: primary data obtained directly from respondents and secondary data derived from various supporting sources, such as data obtained from bibliographic data, journals, literature, and institutions or agencies.

Sugiyono (2020) states that sampling technique is a method used to determine the sample in a study. This study used probability sampling, a sampling method that provides each member of the population with an equal opportunity to be selected as a respondent. The sampling technique used was simple random sampling, ensuring that all fish farmers in the population had an equal opportunity to be included in the study sample (Sugiyono, 2020).

According to data from the Central Statistics Agency of Kutai Kartanegara Regency (2023), the number of fish farmers in Tani Baru Village, Anggana District, was 170. Therefore, the number of respondents in this study was determined using the Slovin formula with an error tolerance of 10% (Sugiyono, 2017). The sample size calculation is as follows:

$$n = \frac{N}{1+(Ne2)}$$
$$n = \frac{170}{1+170(0,10)}$$
$$n = \frac{170}{1+170(0,01)}$$
$$n = \frac{170}{1+1,7}$$
$$n = \frac{170}{2,7}$$
$$n = 62,96 = 63$$

Description:
N : Population Size
n : Sample size
e : Margin of error (10%)

Based on the sample size calculation, the minimum requirement was 63 respondents. However, to improve accuracy and strengthen the research results, the number of respondents in this study was increased to 100.

Furthermore, this study aimed to analyze the level of technical efficiency and to determine the levels of allocative and economic efficiency in each fishpond business unit in Tani Baru Village. The collected data were then analyzed using the Data Envelopment Analysis (DEA) method, which measures technical, allocative, and economic efficiency. In the DEA method, the basic measure of efficiency is determined by comparing total output to total input used in the production process. Furthermore, this study used an input-oriented DEA model, an approach that aims to minimize input use while maintaining the level of output produced (Susilo et al., 2022). Mathematically, technical efficiency (TE) is formulated as follows:

$$\text{Min } \theta$$

With constraints:

$$-\gamma i + Y\lambda \geq 0$$
$$\theta x i - X\lambda \geq 0$$
$$\sum_{j=1}^{n} \lambda j = 1$$

$$\lambda j \geq 0$$

Description:
θ = Technical efficiency level
λ = Comparative weight
$y_i$ = Output of pond business
$x_i$ = Pond business input
Y = Output matrix
X = Matrix input

The $\theta$ value is used to indicate the level of technical efficiency. A value close to 1 indicates efficient farming. Conversely, a $\theta$ value less than 1 indicates that input usage has not reached optimal conditions. Furthermore, DEA analysis uses two main models: the Constant Return to Scale (CCR) and the Variable Return to Scale (BCC) models.

The CCR (Constant Return to Scale) model assumes that changes in input will result in proportional changes in output. This model is used to measure overall technical efficiency. Mathematically, the input-oriented CCR model is formulated as follows:

$$\text{Min } \mathcal{W}i\mathcal{X}_i^*$$

With constraints:

$$-\gamma i + Y\lambda \geq 0$$
$$xi - X\lambda \geq 0$$
$$\lambda j \geq 0$$

$w_i$ = Input prices
$x_i$* = Optimal input (minimum cost)
$x_i$ = Input actual

Meanwhile, the BCC (Variable Returns to Scale) model assumes that changes in input and output do not always occur in equal proportions. This model is used to measure pure technical efficiency by taking into account business scale. The BCC model is an extension of the CCR model by adding the following constraints:

$$\sum_{j=1}^{n} \lambda j = 1$$

The addition of these constraints demonstrates that the BCC model takes into account business scale conditions, making it more appropriate for describing the conditions of pond businesses with varying land area and production capacity.
Next, economic efficiency (EE) is calculated using the formula:

$$EE = \frac{\mathcal{W}i\mathcal{X}i*}{\mathcal{W}i\mathcal{X}i}$$

And allocative efficiency (AE) is calculated as follows:

$$AE = \frac{EE}{TE}$$

Tobit regression is used to estimate factors influencing technical efficiency, allocative efficiency, and economic efficiency. The formula can be defined as follows (Tobin 1958) in (Susilo et al., 2022):

$$y_j^* = \beta_0 + \sum \beta_m X_{jm} + \varepsilon_j, \quad \varepsilon_j \sim N(0, \sigma^2)$$

$$y_j = \begin{cases} 1 & if \quad y_j^* \geq 1 \\ y_j^* & if \quad 0 \leq y_j^* \leq 1 \\ 0 & if \quad y_j^* \leq 0 \end{cases}$$

Description:
$\gamma^*_j$ : Latent variables that describe agricultural efficiency j;
$\beta_m$ : A vector of coefficients;
$x_{j\,m}$ : Vector of independent variables
$\varepsilon_j$ : It is an error term that is independently and normally distributed, with a mean of zero and a constant variance.

## RESULT

Respondent characteristics included gender, age, education, length of business, and pond area. Based on the research results, the average gender value was 0.8, indicating that the majority of respondents were male. The average age of respondents was 49.2 years, education level 1.48, length of business 20.1 years, and pond area 10.0 hectares. The statistical distribution of respondents is presented in the table below:

Table 1. Statistical Distribution of Respondents

| Variables | Description | Mean | Standard Deviation |
|---|---|---|---|
| Gender | 1 = Man, 0 = Woman | 0,8 | 0,3 |
| Age | Respondent's age (years) | 49,2 | 9,2 |
| Education | 1 = Did not finish elementary school, 2 = Elementary School, 3 = Junior High School, 4 = Senior High School, 5 = S1 | 1,48 | 0,9 |
| Length of business | Length of pond business (years) | 20,1 | 9,0 |
| Land area | Area of pond land (hectares) | 10,0 | 6,6 |

Source: Processed Research Data, 2026

### Efficiency Level of Fish Farming Business

The DEA analysis results show that the average values for technical efficiency (TE), allocative efficiency (AE), and cost efficiency (CE) in the CCR model are 0.067, 0.693, and 0.031, respectively. Meanwhile, in the BCC model, the average TE value is 0.152, AE is 0.642, and CE is 0.092. Most respondents fall into the 0–19% technical efficiency category, with 92 business units in the CCR model and 78 business units in the BCC model. The complete distribution table can be seen below:

Table 2. Distribution of Technical, Allocative, and Cost Efficiency Based on the CCR and BCC Models

| Efficiency Level (%) | CCR | | | BCC | | |
|---|---|---|---|---|---|---|
| <20 | TE | AE | CE | TE | AE | CE |
| 0 < 20 | 92 | 15 | 96 | 78 | 15 | 83 |
| 20 – 39 | 1 | 3 | 0 | 6 | 3 | 9 |
| 40 – 59 | 1 | 6 | 0 | 2 | 9 | 2 |
| 60 – 79 | 4 | 9 | 2 | 6 | 10 | 2 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 80 – 99 | 0 | 63 | 0 | 4 | 41 | 0 |
| 100 | 2 | 4 | 2 | 4 | 22 | 4 |
| Mean | 0,067 | 0,693 | 0,031 | 0,152 | 0,642 | 0,092 |
| Minimum | 0,000 | 0,000 | 0,000 | 0,001 | 0,000 | 0,000 |
| Maximum | 1,000 | 1,000 | 1,000 | 1,000 | 1,000 | 1,000 |

Source: Processed Research Data, 2026

**Factors that influence the efficiency of pond business**

The results of the Tobit regression model show that the CCR model obtained a chi² LR value of 7.85 with a Prob > chi² of 0.0974. The BCC model obtained a chi² LR value of 29.69 with a Prob > chi² of 0.0000. Partially, the variable of business length had a positive and significant effect on technical efficiency in the CCR and BCC models. The variable of land area had a positive and significant effect in the BCC model. Meanwhile, the variables of age and education did not significantly influence the technical efficiency of the pond business.

Table 3. Tobit Regression Model Estimates for Technical Efficiency (CCR and BCC)

| Variables | CCR (Koef.) | t CCR | BCC (Koef.) | t BCC |
|---|---|---|---|---|
| Age | -0,003 | -1,42 | -0,005 | -1,38 |
| Education | -0,001 | -0,24 | 0,010 | 1,15 |
| Year of Business | 0,007** | 2,82 | 0,016*** | 4,35 |
| Land Area | 0,001 | 0,51 | 0,014*** | 3,28 |
| Constant | 0,110 | 0,78 | -0,120 | -0,58 |
| LR chi² | 7,85 | | 29,69 | |
| Prob > chi² | 0,0974 | | 0,0000 | |
| Pseudo R² | -0,2733 | | 0,3907 | |
| Amount Sample | 100 | | 100 | |

Source: Processed Research Data, 2026

Description:

** = significant at α = 5%

*** = significant at α = 1%

## DISCUSSION

**Respondent Characteristics**

The majority of fish farmers in Tani Baru Village are male with an average value of 0.8 or around 80 percent of the total respondents. This condition indicates that pond business activities are still dominated by men as the main managers of the cultivation business. This finding is in line with Nawari et al. (2023) who stated that pond businesses in coastal areas are generally managed by men because they require quite intensive field activities in production management. The average age of respondents was 49.2 years, indicating that most fish farmers are in their productive age. According to Susilo et al. (2022), the productive age ranges from 15–65 years, so respondents still have sufficient physical ability and experience to carry out pond cultivation activities. Productive age is an important capital in supporting decision-making and the implementation of fisheries business activities. The average education level of respondents was 1.48, indicating that most fish farmers have a relatively low level of education. However, this condition does not always become an obstacle in managing pond businesses because most cultivation skills are acquired through field experience and a learning process passed down through generations. This is also supported by the Tobit regression results, which show that education level does not significantly influence pond business efficiency.

The average length of time respondents have been in business was 20.1 years, indicating that fish farmers in Tani Baru Village have considerable experience in running aquaculture businesses. High experience provides better knowledge of cultivation techniques, pond management, and handling various business risks. This is in line with the Tobit analysis results, which show that length of business has a positive and significant effect on pond business efficiency. Furthermore, the average pond area of 10 hectares indicates that pond businesses in Tani Baru Village are categorized as relatively large-scale. Larger land areas provide opportunities for farmers to optimize input use and increase production capacity. The results also show that land area has a positive and significant effect on efficiency in the BCC model, indicating that business scale is a crucial factor in increasing the technical efficiency of pond businesses.

**Efficiency of Fish Pond Business Based on CCR and BCC Models**

The results showed that the average technical efficiency (TE) value for the CCR model was 0.067 and for the BCC model, 0.152. These values indicate that most pond businesses in Tani Baru Village are still technically inefficient. The higher efficiency value for the BCC model compared to the CCR model indicates that pond business inefficiency is not solely due to the farmer's ability to manage production inputs but is also influenced by business scale factors. The BCC model measures pure technical efficiency by eliminating the influence of business scale, resulting in a higher efficiency value than the CCR model, which measures overall technical efficiency. Low technical efficiency indicates that the use of production inputs such as land area, labor, and production facilities has not been optimally utilized to produce maximum output. This condition is suspected to be related to the continued implementation of traditional pond cultivation systems in Tani Baru Village, which have limitations in technology application, cultivation management, and production process supervision. According to Yulisti et al. (2021), low technical efficiency reflects the suboptimal use of production factors, thus providing opportunities to increase output without having to increase the amount of inputs used. For allocative efficiency (AE), the average value obtained was relatively higher than technical efficiency, namely 0.693 in the CCR model and 0.642 in the BCC model. These results indicate that farmers are relatively capable of allocating input use based on price and production cost considerations. In other words, farmers are quite rational in determining the combination of available inputs. However, high allocative efficiency does not yet produce optimal business efficiency due to the still low technical capability in managing the production process.

The low cost efficiency (CE) values in both models, namely 0.031 in the CCR model and 0.092 in the BCC model, indicate that pond businesses have not been able to achieve a combination of technical and allocative efficiency simultaneously. Low cost efficiency indicates that costs incurred have not been able to produce optimal output. This condition indicates that increasing pond business efficiency requires not only controlling production costs but also improving the technical capabilities of farmers in managing aquaculture. This finding aligns with Rahmawati et al. (2021), who stated that cost efficiency is significantly influenced by the level of technical efficiency achieved by business actors.

**Factors Affecting the Efficiency of Fish Pond Business**

Tobit regression results indicate that length of operation has a positive and significant effect on pond efficiency in both the CCR and BCC models. These results indicate that the longer a farmer's experience, the higher the level of business efficiency achieved. Business experience enables farmers to have better knowledge in pond management, determining production times, addressing cultivation problems, and making informed decisions regarding the use of production inputs. Farmers with a long history of operation tend to have a better

understanding of pond environmental conditions and the business risks faced, thereby improving business management efficiency.

In addition to length of operation, land area also has a positive and significant effect on efficiency in the BCC model. This indicates that farmers with larger plots of land tend to have higher levels of efficiency than those with smaller plots. Larger plots allow for more optimal input use and provide opportunities for greater economies of scale. These results demonstrate that business scale plays a significant role in improving the technical efficiency of pond operations in Tani Baru Village.

Meanwhile, age and education variables did not significantly influence pond efficiency. This indicates that increased pond efficiency is more determined by practical experience in running a business than by age or level of formal education. Although most respondents were of productive age, their ability to manage a pond business was not directly influenced by age. Similarly, a relatively low level of education was not a major obstacle to pond management, as most aquaculture knowledge was acquired through years of field experience.

Overall, the research results indicate that increasing the efficiency of pond businesses in Tani Baru Village needs to focus on improving technical cultivation and business management skills, as well as optimizing business scale. These efforts can be achieved through technical cultivation training, outreach on pond management, and the implementation of more efficient aquaculture technologies, thereby increasing farmer productivity and income.

## CONCLUSION

Based on the results of research conducted in Tani Baru Village, Anggana District, Kutai Kartanegara Regency, as explained, the conclusions of this study are as follows:

1. The efficiency level of pond businesses in Tani Baru Village shows that the efficiency value using the BCC model is higher than that of the CCR model. The CCR model indicates that most pond businesses are not yet operating at optimal production scale, so inefficiency is caused not only by technical aspects but also by business scale factors. Meanwhile, the BCC model reflects relatively better pure technical efficiency, so efficiency improvements need to be achieved through technical management improvements and business scale adjustments.
2. The analysis of factors influencing efficiency shows that business years have a positive and significant effect on pond business efficiency in both the CCR and BCC models, while land area has a significant effect in the BCC model. Conversely, age and education level do not significantly influence pond business efficiency. This indicates that business experience and land scale are important factors in increasing pond business efficiency in Tani Baru Village.

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