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THE ECONOMIC EFFICIENCY OF CYPRINUS CARPIO GROWOUT CULTURED IN RUNNING WATER POND*)

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Abstract

This study is estimating the production economic efficiency of running water pond, cultured-Cyprinus carpio growout. Primary data is analyzed using Cobb Douglas function approach. The result indicated that factors which significantly affected production were fish-seed, fish-feed, and labor. The efficiency analysis showed that actual Cyprinus carpio growout had not reached its efficient level, since input usage was below its optimum level, thus the maximum profit was not gained. To be able to gain more profit, according to the calculation under the optimum condition assumption, running water pond, cultured Cyprinus carpio growout had to reduce fish-seed usage while increasing fish-feed and labor usage.

Keywords: efficiency, economic of scale, Cyprinus carpio growout, running-water-system
JEL Classification: D24, D29

INTRODUCTION

As so far, fisheries development policy in Indonesia is still aimed to improve fish production with orientation to market, farmer's income improvement, creation of productive employment and support local revenue. Supporting by high potency of natural, human resources, and large market opportunity, the implementation of fisheries policy is able to push production fish culture (Kusumastanto, 2002).

Theoretically, the success of fish culture depends on the use of appropriate factors of production to yield optimal production and maximum profits. When the condition is fulfilled, then it will give incentive for farmers to increase economic of scale of the business activity in the future (Soekartawi, 2003). Empirically, the success is depending on availability of various factors of production in continuously manner and right quantity. Continuity of production actors usage will determine level of production related with economic efficiency of fish culture and in turn will yield maximum efficiency level (Hendrinawati, 2002; Marpaung, 2001). But in fact, farmers are often confronted with high price of production factors. Relative increase of production factors price expected will directly affect production cost and in turn will reduce economic efficiency level and the profits (Jangkaru, 2002).

Such conditions were also experienced by farmers in Regency of Bogor, partiu larly in Situ Daun Village, District of Ciampea, as center of Cyprinus carpio growout by using running water system (KAD). Confronted with increasing of production input factor prices, the farmers arecnot yet clearly known how to develop the business activity. This matter due to deter-

*) The paper is replication study that conducted at 2008 according to research in 2004

mination of optimum combination of production factors and product yielded in running water system, that cause inefficiency of production process and suboptimal profits level.

To the end, using Situ Daun village, District of Ciampea, Regency of Bogor, as a case study, this paper is aimed at estimating factors that affect Cyprinus carpio production in running water system; and analyzing economic of scale and economic efficiency of Cyprinus carpio growout in running water system.

METHODS

The research's location is in Situ Daun Village, District of Ciampea, Regency of Bogor. The Location was selected because it constitutes as one of production center of Cyprinus carpio growout in regency of Bogor, particularly using running water system (Dinas Perikanan Bogor, 2007). This research took place during April – August, 2008.

In this research, the samples are collected using purposive sampling method. By the method, respondents are selected intentionally to fulfill specific-purpose and by relying on rules or logics on basis of expected researcher's goals (Fauzi, 2001). The sample is pond unit for Cyprinus carpio growout activities in running water system. Total amount of collected sample is 40 pond unit that is obtained from 6 respondents (of 13 farmers as population), representing carp fish farmers that are directly involved in running water system, active farmers and at least has two years experiences. The consideration to select respondent is that the farmers has experience and knowledge in carp fish management in running water system.

The data sources are consisted of primary and secondary data. Primary data are obtained from interview with farmers according to list of questions that have prepared previously. The primary data are including respondent characteristics (age, education level, experience, occupation, and number of family responsibility), production level, and production factors that are used for one season and price level of production factors. The secondary data are obtained from documents, record, and report of relevant institution, namely Livestock and Fisheries Office of Bogor Regency and Village Head Office of Situ Daun.

In this research, Cobb-Douglas production function is used as analytical method. Cobb-Douglas production function is an equation or function that is consisted of two or more variables, namely dependent variable or explained variable (Y) and independent variable or explanatory variable (X) (Soekartawi, 2003; Beattie and of Taylor, 1999). In order to estimate factors that affect carp fish production level in running water system, it was assumed that the production level is affected by pond size, fish seed dispersion density, labor and feed.

Cobb-Douglas Production Function is used to estimate relationship between carp fish production for one season with estimated production factors. The estimation model of Cobb Douglas equation is:

$$Y = aX_1^{b1} X_2^{b2} X_3^{b3} X_4^{b4} e^u \quad (1)$$

To simplify the equation, Cobb-Douglas production function can be rewritten in linear form and processed using multiple regression. Then, the equation of Cobb-Douglas production function can be rewritten:

$$LnY = Lna + b_1 LnX_1 + b_2 LnX_2 + b_3 LnX_3 + b_4 LnX_4 + uLne \quad (2)$$

where :

$Ln\,Y$ = Natural Logaritmic of carp fish production (kg)

Ln X_1	=	Natural Logaritmic of pond size (m^2)
Ln X_2	=	Natural Logaritmic of fish seed density (kg)
Ln X_3	=	Natural Logaritmic of feed (kg)
Ln X_4	=	Natural Logaritmic of labor (man days/HKP)
a	=	*intercept* (constant)
bi	=	regresion coefficient or production elasticity of i^{th} number (production factors)
u	=	error (*disturbance term*)
Ln e	=	Natural Logaritmic of exponential value = 2,718

Parameter estimation of Cobb-Douglas production function is obtained using *Ordinary Least Square (OLS)*. OLS is a method to estimate the least estimation and based on assumption that the obtained regression coefficient is BLUE (Best Linear Unbiased Estimator) (Gujarati, 1995).

The fitness of model was tested using t and F statistical test. The t-statistic test is to capture how far each production factor (X_i) as dependent variable affect production (Y) as independent variable. The F-statistic test (simultaneous testing) is to capture simultaneous effect of production factors (X_i) on output (Y).

Analysis of return to scale was conducted to study either the business activities fall into decreasing return to scale, constant return to scale, or increasing return to scale. In the production function, there are three forms of return to scale in production process (Soekartawi, 2003) namely decreasing return to scale, constant return to scale, and increasing return to scale. It is called as decreasing return to scale if the sum of production elasticity is lower than one or (b_1+b_2+ ...$+b_n$...<1). It means that share of additional production factor is higher than share of additional production. It is constant return to scale if the sum of production elasticity is equal to one or (b_1+b_2+ ...$+b_n$...=1) which means that share of additional production factor is proportional with share of additional production. Whereas the increasing return to scale is happened if the sum of production elasticity is higher than one or (b_1+b_2+ ...$+b_n$...>1). It means that share of additional production factor will result larger share of additional production.

Soekartawi (2003) stated that production factor is efficiently allocated when maximum profits has achieved from production process. In the case, efficiency means economic efficiency. A business or activities can be said has achieved economic efficiency level when it achieve technical efficiency and price efficiency. Technical efficiency is related to the utilization of production factors, that is if the utilized production factors yield maximum production. It was said as price efficient (allocative) when the value of marginal product is equal to the price of production factor.

Profit is the difference between total output values and total input values used to achieve the output. The profit equation can be written as:

$$\prod = Py \cdot Y - \sum Pxi \cdot Xi \qquad (3)$$

where :

$\prod$	=	obtained profit values (Rp)
Y	=	weight of product (kg)
P_y	=	Unit price of the product (Rp)
X_i	=	i^{th} production factor (kg)
P_{x_i}	=	price of i^{th} production factor (Rp)
i	=	1, 2, 3, …, n

Maximum profit can be achieved when the first difference of profit equation on production factor variables is equal to zero, with assumption that P_y is not changing no matter amount of Y sold and P_x is not changing no matter amount of X_i used up. Mathematically, the equation can be written as follow:

$$\frac{d\Pi}{dX_i} = P_y \frac{dY}{dX_i} - P_{x_i} = 0 \quad (4)$$

$$P_y \frac{dY}{dX_i} = P_{x_i} \quad (5)$$

$$NPM_{x_i} = BKM_{x_i} \quad (6)$$

Where *NPMxi* denotes marginal product value of i^{th} independent variable (production factors), and *BKMxi* denotes Marginal Opportunity Cost of i^{th} independent variable (production factors). Maximum profits required that NPM value equal to BKM value of each production factor or the ratio between NPM and BKM must equal to one or mathematically can be expressed as (Soekartawi, 2003):

$$\frac{NPMx_1}{NPMx_2} = \frac{NPMx_2}{BKMx_2} = ... = \frac{NPMx_4}{BKMx_4} = 1 \quad (7)$$

In the analysis of economic efficiency, calculation value of the ratio marginal product value (NPM) with marginal opportunity cost (BKM) give three values namely higher than 1, equal to 1 and lower than 1. If the ratio value is equal to 1, the use of production factor is on optimum level. If the ratio for each production factor that is used in Cyprinus carpio growout is lower than 1, the optimum state has been achieved. While if the ratio is higher than 1, the optimum state is not achieved yet. To obtain optimum state, the use of production factors should be reduced or increased to obtain NPM and BKM ratio equal to 1.

RESULTS DISCUSSION

Cyprinus carpio growout in Situ Daun Village use running water system (KAD) as culture technique. Pond construction is square or called as ditch with various size, from 2 x 5 m^2 to 2 x 8 m^2. Height of pond is between 1 - 2 m, with water depth 0,8-1,5 m. Pond construction for Cyprinus carpio growout in Situ Daun village is made from masonry or concrete wall with thickness of pond's wall is 30 cm, arranged in vertical and slippery to avoid injury in fish body.

Cyprinus carpio growout in Situ Daun village use Cihideung and Cinangneng River as water source. The water channel for running water system is consisted of inlet and outlet, equipped with iron or bamboo grate to prevent fish running away and filter garbage which come into the pond. Process of water inflow from secondary channel to the fishpond is through inlet or *sekoneng* that made from bamboo or iron.

Before running water system can be used for fish culture, farmers prepare the pond by cleaning sand, moss, mud, bough stick and plastics which patch in pond wall and base. After cleaned, the pond is exposed to sun light for 2-3 days in order to kill existing fish disease.

In general, seeds are dispersed in morning or evening time when water temperature is not too hot. The average density of fish seed dispersion is 322,68 kg per season with range between 53 - 775 kg per pond unit. The seed is 100 gram per fish because on the weight the fish has ability to live in running water. Farmers buy fish seeds at the price of per fish or size per kg. For 1 kg of fish seed that consisted of 5 - 10 fishes, the price is between Rp. 11.000,- Rp. 12.000,- per kg.

In general, feed is applied three times that is in morning day (at 06.00), daytime (at 12.00) and evening (at 17.00), that is usually marked by many fish emerge in water level. The feed is applied manually by disperse evenly in water pond surface, gradually to avoid feed looses. Feed application is between 574-2.800 kg per pond unit with average feed application 1.342,63 kg per season at the average price Rp. 3.000,- per kg.

Harvesting is usually started at 19.00 WIB or at 03.00 WIB, depending on distance of order area. This is to provide fresh condition for fish transportation. In the other hand, harvesting can be total or selective, depending on market demand. Before fishes are harvested, the fishes are not feed for one – two days (called as *pemberokan*). The average of yield is 1.491,83, in the range between 726 - 3.500 kg per season. One kilogram of fish in consumption size is containing 2-3 fishes with weight between 700-800 gr per fish.

Production factors that are hypothesized to affect Cyprinus carpio growout in Situ Daun village are pond size (X_1), seed density (X_2), feed (X_3) and labor (X_4). According to analysis result from *Ordinary Least Square* (OLS) method, the estimated production function is as follow.

$$Ln\ Y = 0{,}315 + 0{,}060\ Ln\ X_1 + 0{,}152\ Ln\ X_2 + 0{,}409\ Ln\ X_3 + 0{,}627\ LnX_4 \quad (8)$$

Se : *0,260* *0,046* *0,063* *0,155* *0,282*

t-calc : *1,213* *1,289ns* *2,412*** *2,635*** *2,226***

R^2 = 0,615; R^2*-adjusted* = 0,571; *F –calc* = 13,976; *Prob.F* = 0,000; *DW* = 1,705

Note:

ns = not significant at 90% of significance level

* = significant at 90% of significance level

** = significant at 90% of significance level

*** = significant at 90% of significance level

From the estimated production function, equation (8), the determination coefficient R^2 = 0,615. It means that 60% of production variation in *Cyprinus carpio growout* using running water system can be explained by production factor namely pond size (X_1), fish-seed density (X_2), fish-feed (X_3) and labor (X_4), while the rest of 40% is explained by outside factors that not included in the model.

According to F-statistic test, the four independent variables (X_1, X_2, X_3, and X_4) simultaneously show significant difference on the dependent variable (*Cyprinus carpio* production/Y). However, due to t-statistic test (partial), three of the four variables (X_2, X_3, and X_4) that shows significant difference at 5% of significance level with positive sign, while pond size (X_1) does not show significant difference at 5% of significance level. The estimation result also shows that DW value = 1,705, that the equation model is not identified autocorrelation. Therefore, statistically and economically, the equation model is considered as valid and able to use for further analysis.

For analysis purpose, equation (8) can be rewritten as equation (9):

$$Y = 1{,}370 X_1^{0{,}060} X_2^{0{,}152} X_3^{0{,}409} X_4^{0{,}627} \quad (9)$$

Return to scale analysis was conducted to study either *Cyprinus carpio* growout at decreasing return to scale, constant return to scale or increasing return to scale. The condition of return to scale can be calculated from the summation of regression coefficient or elasticity of Equation (9). According to the equation, the sum value is 1,248 (E>1). It means that *Cypṙ nus carpio* growout using running water system is at increasing return to scale. In other words, if the four production factors (pond size, fish-seed, fish-feed and labor) simultaneously increase in given percentage, the fish production will increase with larger proportion.

Theoretically, the condition of increasing return to scale for the study location is at area I (point A), that is production elasticity higher than 1 (E>1). It means that output growth is higher than input growth, or farmers in Situ Daun vilage are not optimally use the inputs, therefore optimum condition as indicated by area II (decreasing return to scale) has not achieved yet.

The condition of increasing return to scale above reflect tendency that factor inputs increase (pond size, fish-seed, fish-feed and labor) simultaneously. The tendency is consistent for each independent variable. As indicated by estimation result of production factor function, each of production factor namely pond size (X_1), fish-seed (X_2), fish-feed (X_3) and labor (X_4) has regression coefficient or elasticity value positive that is 0,060; 0,152; 0,409 and 0,627 respectively.

From the regression coefficient value, (testing result of t-statistic as described at Equation (8) and Equation (9), ceteris paribus), each addition of pond size equal to 1% will improve fish production 0,060%. However, t-statistic result for the pond size does not show significant effect on the fish production. It means that effort to improve fish production by enlargement of pond size is not urgent, because need high cost and the effect is not significantly increasing production.

According to the result of Equation (8) and Equation (9), each additional 1% of fish-seed will increase fish production 0,152% and additional 1% of fish-feed, ceteris paribus, will improve fish production 0,419%. It was expected that the higher quantity of fish-seed and fish-feed usage, the faster growth of the fish and in turn the production. For labor usage, additional 1% of work hour will increase fish production 0,627%. The additional of work hours is assumed to intensify maintenance and management efforts and as the result will increase fish production.

From the estimation result of production function, it can be calculated the ratio of NPM and BKM for each production factor. In detail, the ratio described at Table 1.

From Tables 1, it can be seen that ratio of NPM and BKM for fish-seed (X2) is lower than 1, fish-feed (x3) and labor (X4) is larger than 1, that is 0,642 (for X2), 1,591 (for the X3 of), and 10,776 (for the X4). These conditions indicate that production factors usage is not in efficient manner (optimum condition is not reached). To be optimal, fish-seed need to be reduced, while labor and fish-feed need to be added, until the ratio of NPM and BKM from the three production factors is equal to 1. Optimal usage of production factors is described at Table 2.

According to Table 2 above, to achieve optimal allocation of production factor usage – in turn maximum profit – the usage of fish-seed factor production (X2) need to reduced to 207,039 kg per average of pond size, while fish-feed (X3) (and labor X4) need to be added by 2.135,547 kg and 854,037 HKP per average of pond size, respectively. The discussion above shows that *Cyprinus carpio* growout using running water system in Situ Daun village is not considering yet fish-seed dispersion with availability of pond size. The fish-seed are dispersed regardless of optimum for each pond size, and this is not followed up by sufficient fish-feed due to lack of labor usage. In order to achieve optimum condition, farmers need to reduce fish-seed dispersion and add labor and fish-feed usage (decreasing return to scale), that is a condition that a resource has been used efficiently.

Table 1: The ratio of NPM and BKM for *Cyprinus carpio growout* using running water system in Situ Daun village

Variable	Coefficient	NPM	BKM	NPM / BKM
Pond size (X_1)	0,060	77.673,530	75.000	1,036
Fish-seed (X_2)	0,152	7.378,795	11.500	0,642
Fish-feed (X_3)	0,409	4.771,729	3.000	1,591
Labor (X_4)	0,627	123.920,333	11.500	10,776

Source: primary data, proceed (2008)

Table 2: Alocation of Production factor usage by average of pond size for *Cyprinus carpio* growout using running water system in Situ Daun village

Variable	Optimal Input	NPM	BKM	NPM / BKM
Pond size (X_1)	12,531	75.000	75.000	1
Fish-seed (X_2)	207,039	11.500	11.500	1
Fish-feed (X_3)	2.135,547	3.000	3.000	1
Labor (X_4)	854,037	11.500	11.500	1

Source : primary data, proceed (2008)

Table 3: Profit at actual and optimal condition for *Cyprinus carpio* growout using running water system in Situ Daun village

Description	Actual		Optimal	
	Volume	Value (Rp)	Volume	Value(Rp)
Revenue				
- Production	1.491,825 kg	15.664.162,50	5.681,261 kg	59.653.240,50
Cost				
- Fish-seed	322, 675 kg	3.710.762,50	207,039 kg	2.380.952,70
- Fish-feed	1.342, 625 kg	4.027.875,00	2.135,547 kg	6.406. 642,46
- Labor	79,256 HKP	911.444,00	854,037 HKP	9.821.429,89
Variable cost		8. 650.081,50		18. 609.025,05
Profit		7.014.081,00		41.044.215,45

Source: primary data, proceed (2008)

Through calculation of optimal level of production factor usage, it can be calculated production at optimal condition. The extent of production factors usage will determine costs for *Cyprinus carpio* grow-out and in turn the farmer's profit. With analysis as discussed above, profit at optimal and actual condition are able to calculate. The comparison result of the analysis is shown at Table 3.

As shown at Table 3, production level at actual condition is equal to 1.491,825 kg per pond unit per season, requiring production cost Rp. 8.650.081,50 to yield revenue Rp.15.664.162,50 per pond unit and profit level Rp. 7.014.081,00 per pond unit. Input usage at optimal condition will produce 5.681,261 kg per pond unit per season, requiring production cost Rp.18.609.025,05 to yield revenue Rp. 59.653.240,50 per pond unit. With addition of fish-feed and labor to 2.135,547 kg per pond unit and 854,037 HKP per pond unit, the profit level at optimal condition is 41.044.215,45 per pond unit.

CONCLUSION

Production variation in *Cyprinus carpio* growout using running water system is explained by production factors namely pond size, fish-seed density, fish-feed and labor. Production factors variables which partially have significant effect on the fish production are fish-seed, fish-feed and labor. *Cyprinus carpio* growout using running water system at study area is at increasing return to scale or in other words if the four production factors (pond size, fish-seed, fish-feed and labor) simultaneously increase in given percentage, the fish production will increase with larger proportion. However production factors usage at Situ Daun vilage is sub optimal.

Considering that *Cyprinus carpio* growout using running water system at Situ Daun Village is at sub optimal condition, it is necessary to adjust production factors usage to achieve maximum profit level. It is by lowering quantity of fish-seed to avoid denser population and competing of food. At optimal condition, the fish-seed should be reduced per average of pond size, while fish-feed and labor usage should be increased per average of pond size and HKP per average of pond size. The quantity of fish-feed should be increased to provide better food intake and growth. At the same time, amount of labor usage must be improved to give better management (dispersion, fish-feed application, controlling and harvesting). Government, through Marines and Fisheries Office and other relevant institution, is expected to improve extension and training program by implementing optimal condition as this study. Also, government through the research institution (Marines and Fisheries Research Centre) must provide support, especially by conducting similar study but with more variables and more valid modelling.

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