A welfare study into capture fisheries in cirata reservoir: a bio-economic model

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Abstract. Capture fishery in inland such as reservoirs can be a source of food security and even the economy and public welfare of the surrounding community. This research was conducted on Cirata reservoir fishery in West Java, to see how far reservoir capture fishery can contribute economically in the form of resource rents. The method used is the bioeconomic model Copes, which can analyze the demand and supply functions to calculate the optimization of stakeholders' welfare in various management regimes. The results showed that the management of capture fishery using Maximum Economic Yield regime (MEY) gave the most efficient result, where fewer inputs would produce maximum profit. In the MEY management, the producer surplus obtained is IDR 2,610,203,099,- per quarter and IDR 273,885,400,- of consumer surplus per quarter. Furthermore, researches showed that sustainable management regime policy MEY result in the government rent/surplus of IDR 217,891,345,- per quarter with the average price of fish per kg being IDR 13,929. In open access fishery, it was shown that the producer surplus becomes IDR 0. Thus the implementation of the MEY-based instrument policy becomes a necessity for Cirata reservoir capture fishery.

1. Introduction

Public waters such as reservoirs have potential for the development of fish resources that can contribute to food security and even the economy and public welfare of local community [1,2,3,4,5,6,7,8]. Fishery activities in reservoirs become increasingly important in the secondary use of reservoirs, particularly in developing countries, as reservoir fisheries tend to provide a relatively affordable source of animal protein for rural populations [1]. Inland capture fisheries, including reservoir fisheries, generally provide ecosystem services (i.e., fish for food, livelihoods and recreation) for the people; therefore, they have an economic value [9]. Hence, reservoir fisheries play an important role in the economy of a country and the livelihoods of the people living around the reservoirs [8]. Included in the potential of fishery business in reservoirs is capture fishery [10]. Unfortunately, the potential of capture fisheries is pretty much neglected because it is considered as less potentially economic than the fishery businesses having been widely developed in reservoirs, especially floating cage culture fishery.
Cirata Reservoir is one of the public waters in West Java that has the potential to be used for fisheries in addition to its use in the hydroelectric power plant (PLTA) unit of Java and Bali. The main fishing activity in this reservoir is floating-cage aquaculture fishery. In addition, there are other fishing activities generally carried out by the local community. Just like any other general problem in developing countries, despite their high potential, capture fisheries in reservoirs receive less managerial attention [11]. This is also the case in the management of capture fisheries in Cirata Reservoir. The lack of management in the reservoir capture fisheries can be seen from various things, one of which is their open access, which means that all members of the society are entitled to use them without any restrictions or regulations. This has led to uncontrolled exploitation of fish resources, resulting in a drastic reduction in the production of capture fisheries in Cirata Reservoir during the period 2011-2015 [12]. The decrease of capture fishery production in Cirata was allegedly correlated with the decrease of water quality in the reservoir. It has also been revealed by [13], who found that there was abnormal growth of goldfish (slowing down)—which was unfavorable for the purpose of cultivation—due to the deterioration of the quality of the reservoir water. [14] stated that water condition greatly determines the abundance and spread of organisms in it, but every organism has different environmental needs and preferences for life, which are associated with its environmental characteristics. Thus, the decrease of water quality will cease the diversity of native or endemic fish in Cirata Reservoir, inhibit fish growth, cause diseases and pests for fish, and cause competition for the decreased amount of oxygen in Cirata Reservoir, which can lead to delayed growth of fish. The capture fisheries in Cirata has been in the overfishing state [12]. This problem can be an indication of uneconomical capture fishery activities in the reservoir as well as low performance in and contribution to the improvement of the welfare of the community, thus it does not receive proper managerial attention. This condition is like an endless loop of problems. In order to direct the attention of policy makers to sustainable fishery management, information on the role of capture fisheries in this case is important for the economic welfare of beneficiaries as well as the government as a representative of public ownership of fish resources in the reservoir. Such economic information is expected to be one of the important drives for the management to be aware of the purpose of increasing the economic welfare of the stakeholders who utilize fish resources in the reservoir.

This paper describes the performance of capture fishery in Cirata Reservoir by analyzing the welfare of the stakeholders (producers, consumers, and the government) from the surplus they obtained in the actual condition in capture fisheries, i.e., the status quo of no management or business as usual as well as sustainable and optimal regime management with Copes model. In the economics of fisheries management, the analysis of management strategies to maximize resources is a central issue, and the importance of consumer and producer surplus (CS and PS, respectively) as illustrated in [15] is also central in the total economic surplus. According to Green in [10], using a surplus approach to measure the benefits of natural resources is an appropriate measure because resource utilization is judged on the best alternative use. Furthermore, in this study, Copes model was also used to analyze optimal fish prices for the welfare of fishermen, consumers, and the government.

2. Methodology
The research was conducted in Cirata Reservoir that is located in 3 regencies of West Java, namely: Cianjur, Bandung Barat, and Purwakarta. The data collected consisted of two types, namely primary data and secondary data, both qualitative and quantitative. The primary data were taken using purposive sampling technique. The primary data were obtained from interviews with 300 fishermen who used gill nets, fishing lines, fishing nets, and fish pots, and from direct field observation. The data included the data relating to capture cost per unit fishing effort, catch per unit fishing effort, length and number of fishing effort units, and fish commodity price.
The secondary data were the data relating to production and time series capture effort. The data were obtained from several related institutions such as the Office of Marine Affairs and Fisheries of West Java Province, Livestock and Fishery Service of Cianjur Regency, Technical Implementation Unit of Cirata Reservoir, Office of Marine Affairs and Fisheries of Cianjur Regency, Regional Technical Implementation Unit (UPTD) of Cianjur Fishery, and other related institutions.

The first stage before the analysis of capture fishery welfare was the standardization of fishing gear. The standardization of fishing gear was done by considering the variety of fishing gear that was operated in the research area i.e., gill net, fish pots, cast net, fishing line, chart, and other fishing gear. The standardization technique used followed the one developed by King [16], with the following formula:

\[ E_{jt} = j_{jt} D_{jt} \]  
where

\[ j_{jt} = \frac{u_{jt}}{u_{st}} \]  

\[ E_{jt} = \text{standardized effort of fishing gear } j \text{ during time period } t \]

\[ D_{jt} = \text{fishing days of fishing gear } j \text{ during time period } t \]

\[ j_{jt} = \text{fishing power of fishing gear } j \text{ during time period } t \]

\[ u_{jt} = \text{catch per unit effort (CPUE) of fishing gear } j \text{ during time period } t \]

\[ u_{st} = \text{catch per unit effort (CPUE) of fishing gear being the basis of standardization} \]

In the analysis of Cirata capture fishery, after the fishing gear was standardized, an analysis of biological estimation parameters using Schaefer model was performed. The estimation of biological parameters r, K, and q was conducted to find out the maximum sustainable production function (MSY) value with the following formula:

\[ h_{MSY} = qKE - \left( \frac{q^2K}{r} \right) E^2 \]  

The equation above (3) was simplified into:

\[ h = \alpha E - \beta E^2 \rightarrow \alpha = qK, \beta = \frac{q^2K}{r} \]

The parameter values of sustainable production functions for coefficients \( \alpha \) and \( \beta \) were estimated in a regression analysis between catch per unit efforts (\( h/E \)) at various levels of fishing effort. The catch effort to achieve maximum sustainable production (\( E_{MSY} \)) was obtained by deriving the above catch effort (\( E \)) equation to obtain the following equation:

\[ \frac{\partial h}{\partial E} = \alpha - 2\beta E = 0 \]

\[ E_{MSY} = \left( \frac{\alpha}{2\beta} \right) \text{ or } E_{MSY} = \left( \frac{r}{2q} \right) \]

The sustainable catch on MSY or \( h_{MSY} \) level was:

\[ h_{MSY} = \left( \frac{\alpha}{4q} \right) \text{ or } h_{MSY} = \left( \frac{r}{4q} \right) \]
After obtaining the two values on this MSY level, the biomass level on MSY level was obtained to be:

\[
x_{\text{MSY}} = \frac{h_{\text{MSY}}}{qE_{\text{MSY}}} = \frac{(rK/4)}{q(r/2q)} = \frac{K}{2}
\]

(9)

Where

- \( h_{\text{MSY}} \) = Maximum sustainable yield (MSY)
- \( q \) = Catch coefficient
- \( K \) = Carrying capacity
- \( r \) = Intrinsic growth rate
- \( E \) = Catch effort level
- \( E_{\text{MSY}} \) = Catch effort level to reach MSY

After obtaining the sustainable production function (MSY), the optimization analysis of the fishery resource utilization was carried out using the Copes bioeconomic model to determine the bioeconomic balance of the fishery based on supply and demand [17]. In the microeconomic theory employed for the welfare analysis using the supply curve and demand curve, the actual supply curve is part of the marginal cost curve above the price received by the producer.

The demand curve of capture fishery products is strongly influenced by dependent variables such as price and income. The occurring prices are influenced by fish landing sites and other ship variables. In the static model study with changed prices used to determine the optimum level of fishery resource utilization, the price can be written as:

\[
P = m - nh
\]

(10)

The values of the demand function of the capture fisheries in Cirata for coefficients \( m \) and \( n \) were estimated using regression analysis between fish price and total fish production in Cirata. According to Fauzi [17], to determine a fishery supply curve, we must create a long-run marginal cost curve (LRMC) and long-term cost curve (LRAC). The mathematical equations for the LRAC and LRMC curves can be derived from equation [17]:

\[
TC = cE
\]

(11)

Information:

- TC = Total catch cost
- \( c \) = Average catch cost
- \( E \) = Catch effort level

By replacing effort \( (E) \) with catch \( (h) \), the formula becomes:

\[
E_{12} = -\frac{\alpha \pm \sqrt{\alpha^2 - 4\beta h}}{2\beta}
\]

(12)

With \( \alpha^2 > 4\beta h \)

The MEY point in the Copes model can be obtained from the intersection of the demand curve and the single ownership supply curve represented by the long-run marginal cost curve (LRMC). The solution was a graphical approach using the software Maple 16 so that \( h_{\text{MEY}} \) could be obtained. To obtain a capture attempt from MEY, then \( h_{\text{MEY}} \) is as follows:

\[
E_{\text{MEY}1,2} = -\frac{\alpha \pm \sqrt{\alpha^2 - 4\beta h_{\text{MEY}}}}{2\beta}
\]

(13)
The open access fishery point in the Copes model can be obtained from the intersection of the demand curve and the open access supply curve represented by the long-run average cost curve (LRAC). The catch in open access fishery was obtained from the curve, and the catch effort (EoA) of open access is as follows:

$$E_{OA1.2} = \frac{-a + \sqrt{\alpha^2 - 4\beta h_{OA}}}{-2\beta}$$  \hspace{1cm} (14)

By replacing a positive E value, the total cost can be written as the following function of output [17]:

$$LRAC = \frac{\delta TC}{\delta h} = \frac{c}{2\beta} \left( \alpha + \sqrt{\alpha^2 - 4\beta h} \right)$$  \hspace{1cm} (15)

The long-run marginal cost curve can be derived from the long-run average total cost curve on h [17]:

$$LRMC = \frac{\delta AC}{\delta h} = \frac{c}{\sqrt{\alpha^2 - 4\beta h}}$$  \hspace{1cm} (16)

The optimum profit in the utilization of capture fishery resources achieved in MEY condition is:

$$\pi_{MEY} = (m - n_h_{MEY})h_{MEY} - c.E_{MEY}$$  \hspace{1cm} (17)

The optimum profit in the utilization of capture fishery resources achieved in the open access condition is zero ($\pi = 0$), as shown below:

$$\pi_{OA} = (m - n_h_{OA})h_{OA} - c.E_{OA} = 0$$  \hspace{1cm} (18)

Where:
- AC = Average capture cost
- MC = Marginal capture cost
- c = Total cost per capture effort
- TC = Total capture cost
- MEY = Maximum Economic Yield
- OA = Open Access

The price variable of fish (p) is determined based on the average real price per year during the period 1995—2016 with the base price 2007 = 100. Furthermore, the long-run average cost curve and marginal cost curve in the consumer surplus and producer surplus can be obtained with the equations below:

$$CS = \int_0^{Q_0} P(Q)dQ - P_0Q_0$$  \hspace{1cm} (19)

$$PS(Q_0) = P_0Q_0 - \int_0^{Q_0} S(Q)dQ$$  \hspace{1cm} (20)

Where:
- CS = Consumer Surplus
- PS = Producer Surplus
- S(Q) = Supply function
- P(Q) = Demand function
- P_0 = Real price
- Q_0 = Catch/output
3. Results and Discussion

3.1. Maximum sustainable yield (MSY)

Fishery resources MSY conditions are the thresholds of the utilization of fish resources allowable without disturbing or destructing the sustainability to grow back. The utilization of fish resources in Cirata Reservoir in MSY condition and actual conditions can be seen in the figure below:

![Figure 1. The comparison of actual production with sustainable production value.](image)

As shown in the figure above, in the first quarter of 2011 through the last quarter of 2012 and in the first quarter of 2014, the catch exceeded the sustainable production value (MSY). The output limit was based on the Total Allowable Catch (TAC), where 80% of the production value was sustainable (MSY). Referring to figure 1, the utilization of fish in Cirata Reservoir reached almost the average of the actual catch of 2011 and exceeded the allowable catch amount (TAC). Thus, it could be categorized as overfishing.

On the other hand, the actual catch value that continued to decline annually as well as the low sustainable catch value basically describe the dynamics of fish resources in Cirata Reservoir which is a function of the exploitation itself and the condition of the aquatic habitat. The aquatic environment of Cirata Reservoir had long faced a problem, especially since its water had been used for massive fish farming with massive use of feed, which caused significant pollution. Thus, the environmental carrying capacity for capture fisheries dropped, and the sustainable catch dynamics lowered. The implication of the policy on this problem is the question of how the environmental carrying capacity can be improved to allow for the increase of stock capacity by improving the aquatic environment using physical, biological and other techniques. The reduction of the number of floating nets for the purpose of adjustment to the carrying capacity of the environment becomes a necessity for the development of capture fisheries, that can contribute to the economy of the local community as well as to the food security.
3.2. The optimization analysis of copes bioeconomic model for fishery management regime in Cirata Reservoir

The optimization of copes bioeconomic model suggests that this model has the advantage in that it is based on output or production rather than on input; it enables the use of elastic demand curves; it enables the analysis of economic surplus, producer surplus, consumer surplus, and government rent; and it allows the analysis of imperfect economic structures such as monopoly, monopsony, and public ownership (government) [15,17]. The net social benefit was evaluated using producer surplus and consumer surplus measures. According to Green in [17], using a surplus approach to measure the benefits of natural resources is appropriate because resource utilization is judged on the best alternative use. Thus, Copes bioeconomic model obtained the welfare effects of the perpetrators of the utilization of fisheries (producers) and consumers. The following is the model curve:

![Copes model optimization on fish resources in Cirata reservoir](image)

**Figure 2.** Copes model optimization on fish resources in Cirata reservoir (Y=Price (Rp), X= Catch (Ton)).

| Variable            | Management Regime |
|---------------------|-------------------|
| Production (h) (Ton)| MSY: 254.6150929  |
|                     | MEY: 188.0716294  |
|                     | OA: 252.03        |
| Effort (E) (Trip)   | MSY: 39201.70791  |
|                     | MEY: 19160.88192  |
|                     | OA: 35252.9708    |
| Profit (pi) Rupiah  | MSY: -847.280.297 |
|                     | MEY: 0            |

Based on the table, the results obtained in the Copes model for each management regime was not significantly different from the dynamics obtained in the GS model, the Gompertz model where the management of the MEY regime has the highest efficiency and more conservative biomass management.
3.3. Producer surplus, consumer surplus, and government surplus on capture fishery resources in Cirata Reservoir

The main principle in the Copes model is determining the bioeconomic equilibrium of fishery based on demand and supply. Surplus is derived from the demand and supply equations for the production of capture fishery resources in Cirata Reservoir. The producer surplus in capture fisheries is the utility advantage gained as a result of market price on the sellers' willingness to sell their goods, resulting in the number of profitable manufacturers selling at market prices higher than the prices of those willing to sell. The producers in question were fishermen/fish entrepreneurs. Meanwhile, consumer surplus refers to the utility advantage obtained by consumers because of the fact that market prices were lower than the consumer purchasing power per unit of goods. If the purchasing power of consumers per unit of goods is above the market prices or if the actual market prices are under the purchasing power of consumers, it means that the consumer gets utility profit. The assumption in this study was that the market was competitive, which means that the price was influenced by the market mechanism of demand and supply, thus the producers and consumers in the market could not affect the price and could only act as the recipients of the price.

3.3.1. Consumer surplus and producer surplus in open access fisheries management regime (Uncontrolled)

Open access or unregulated fishing means that the fishermen or fish farmers would compete to catch fish in Cirata Reservoir. Hence, more fish would be captured, which caused a decrease of fish prices due to the abundance of fish available. In the open access curve, the consumer surplus is greater than the producer surplus because in the open access fishery, every business that utilizes fishery resources will try to catch as many fish as possible.

![Figure 3](image.jpg)

**Figure 3.** Consumer surplus and producer surplus on open access fishery (Y=Price (Rp), X= Catch (Ton)).
Based on the figure above, the producer surplus was below the price of the equilibrium point and above the supply function, while the consumer surplus was in the area under the demand curve and above the equilibrium price. By plotting between the demand curve and open access supply curve, the value of producer surplus in open access fisheries was found to be IDR 0, while the value of consumer surplus was found to be IDR 491,776,746. Hence, the producer surplus value in the open access fisheries in Cirata Reservoir was not profitable at all (TC = TR), and the producers could even incur loss.

By determining the equilibrium point between the demand curve and the open access fishery supply curve in Cirata Reservoir, where the requested amount was equal to the quantity supplied, an open access point for the catch $h_{OA}$ was 252 Ton and the $P_{OA} = IDR 12,938,600$. Thus, the increase of average fish price per kg applied was IDR 12,938 per kg. In other words, the producers and the government did not generate profit at all. Meanwhile, the interview results showed that the average price at which fish were sold by fishermen or fish farmers was IDR 12,000-13,000 per kg. Thus, the actual condition was still in open access fishery condition.

3.3.2. Consumer surplus and government surplus in controlled fisheries management regime (MEY)

The application of MEY regulation in the capture fisheries in Cirata would cause the consumer surplus to decrease because the price would no longer be low. According to the law of demand, if the price rises, the demand decreases; meanwhile, producer surplus would increase because when the supply increases, the price also increases. Thus, in the long run, the controlled fisheries in Cirata Reservoir will benefit both consumers and producers because both consumers and producers will have sustainable capture fishery resources and obtain optimum economic benefits. The producer surplus resulting from the plotting between the demand curve and the marginal cost offering curve (MC) was IDR 2,610,203,099 per quarter, which means that the average surplus of every fleet or fishing gear was about IDR 914,651 per quarter while the consumer surplus as the region is under the demand curve and above the equilibrium price. The consumer surplus from the plotting between the demand curve and the marginal cost offer curve (MC) was IDR 273,885,400. By determining the equilibrium point between the demand curve and the controlled supply curve in Cirata Reservoir, where the demanded amount was equal to the supplied quantity, the balance of open access conditions for the catch $h_{MEY} = 188.07$ tons and the price $P_{MEY} = IDR 13,929,000$. 
As presented in the figure above, the results of the computation using the split in the Maple 16 program showed that the catch in the controlled fishery condition \( (h_{MEY}) \) was 188.07 tons per year. This means that if the catch is as much as 188 tons per year, an optimal advantage will be gained. Furthermore, if the catch of fish in Cirata Reservoir is below 188.07 tons per year, it gets less proficiency. And if the catch is above 188 tons per year, reduced profit to the point of break-even or no profit at all will be experienced in the open access condition i.e., 252 tons per year.

3.3.3. Government surplus

Government surplus may be generated from tax or levy imposed to the fishermen in Cirata Reservoir, both on input and output. In the actual condition, the average price of fish in Cirata Reservoir was around IDR 12,000-13,000 per kg, which means that the fishery management had yet to produce any government surplus. Furthermore, the government surplus could be obtained when the fish resources were utilized in the MEY condition. Thus, the application increased the average price of fish to IDR 13,929 per kg (price under optimum/ MEY condition). This would result in a government surplus of IDR 217,891,345 per quarter.

4. Conclusion

The Welfare Analysis using Copes bioeconomic model yielded a producer surplus value in open access fishery (Open Access) of IDR 0 per quarter and a consumer surplus value of IDR 491,776,746 per quarter. The balance point of open access condition for the catch \( h_{OA} = 252 \) tons and the price \( P_{OA} = IDR \)
12.938.600 per ton. This means, fishermen who sold fish at IDR 12.930 per kg would experience a break-even or would not generate any profit at all. The producer surplus in regulated fishery management (MEY) was IDR 2.610.203.099 per quarter, while the consumer surplus was IDR 273.885.400 per quarter. The equilibrium point of MEY regime for the catch $h_{MEY} = 188.07$ tons and the price $P_{MEY} = IDR 13.929.000$ per ton.

Thus, the application of controlled fishery management regimes (MEY) increased the average price of fish to IDR 13.929 per kg (price under optimum/MEY condition), which would give the government a surplus of IDR 217.891.345 per quarter. In the MEY management, the producer surplus was IDR 2.610.203.099 per quarter, which means that the producer surplus per fleet or per fishing gear was about IDR 914.651 per quarter, and the consumer surplus was IDR 273.885.400 per quarter. Furthermore, research shows that sustainable management regime policy through MEY implementation will result in government rent/surplus of IDR 217.891.345 per quarter, with an average fish price of IDR 13.929 per kg. In the fisheries under an open access condition, the producer surplus is IDR 0. Thus, the implementation of the MEY instrument-based policy becomes an appropriate management of capture fishery in Cirata Reservoir.

5. References

[1]. Abery N W, Sukadi F, Budhiman A A, Kartamihardja E S, Koeshendrajana S, and Silva de S S 2005 *J. Fish. Man. and Eco.* **12** 315–330

[2]. Béné C and Russell A J M 2007 Diagnostic study of the volta basin fisheries part 2 - livelihoods and poverty analysis, current trends and projections (Cairo Egypt: WorldFish Center Regional Offices for Africa and West Asia) p 66

[3]. De Silva S S and Amarasinghe US 2009 Status of reservoir fisheries in five Asian countries (Bangkok : NACA Monograph No. 2. Network of Aquaculture Centres in Asia-Pacific) p 116

[4]. Paul P and Basak N K 2015 *Indian J. of Applied Res.* **5** 56-58

[5]. Paul P and Sandipan C 2016 *Inter.J. Fish.Aqua. Sci.* **6** 59-76

[6]. Renwick M E 2001 Valuing water in irrigated agriculture and reservoir fisheries: A multiple use irrigation system in Srilanka (Colombo: Research report 51 International Water Management Institute)

[7]. Sugunan V, Welcomme R, Béné C, Brummett R, Beveridge M 2007 *Inland fisheries, aquaculture and water productivity. Water for food, water for life: comprehensive assessment for agricultural water* (London UK: Earthscan ed. Molden D., editor.) pp 459–484

[8]. Teame T, Natarajan P, ZelealemTesfay 2016 *Int. J. Fauna Bio.Stu.* **3** 105-113

[9]. Grantham R W and Rudd MA 2015. *Fish. Manag.and Eco.* **22** 458–471

[10]. Welcomme R L, Cowx I G, Coates D, Béné C, Funge-Smith S, Halls A and Lorenzen K 2010 *J. Phil. Trans. of the Royal Society B: Bio. Scie.s* **365** 2881–2896

[11]. Smith Laurence E D, Khoa S. Nguyen and Lorezen K 2005 *J. Water Pol.* **7** 359-383

[12]. Anna Z 2003 Dinamic embedded model economic interaction fisheries-pollution (Bogor : Bogor Agricultural Institute Disertation) (In Indonesia)

[13]. Komarawidjaja W, Sukimin, Sustrisno and Arman E 2011 *J. Env Tech. P3TL-BPPT.* **6** 268-273

[14]. Anwar N 2008 Physical and chemistry characteristics of aquatic and its relation to the distribution and abundance of fish larvae in the bay of palabuhan ratu (Bogor : Bogor Agricultural Institute Thesis) (In Indonesia)

[15]. Copes P 1972 *J. Manch. Sch. Soc. Econ. Study.* **40** 145-163

[16]. King M 1995 *Fisheries biology, assessment and management* (Great Britain: Fishing News Book)

[17]. Fauzi A 2010 *Fisheries economy* (Jakarta: Gramedia Pustaka Utama)(In Indonesia)
