Economic benefits of fisheries activities in Jatibarang Reservoir, Central Java

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Abstract. Inland fisheries are categorized as small scale fisheries. Those small-scale fisheries are frequently under-valued social and economically. Likewise with Jatibarang Reservoir that is included in it. Whereas the intensity of the use of the reservoir by the local community is very high. Although according to local wisdom, the use of Jatibarang Reservoir is only limited to handline fishing, it is thought to have a good impact on the economy of the community and the reservoir environment. The study was carried out during the period of 2018, with the aims to determine the economic impact of the fisheries sector even though there are restrictions on the types of fishing gear used in the Jatibarang Reservoir. By using the Contingent Valuation Method in estimating the value of consumer surplus through the use of several parameters such as annual income, expenditure and number of fishing days. The results show that the handline fishing activities in the Jatibarang Reservoir are still achieved the economic benefits or in other words, the net benefit value shows a surplus.

1. Introduction
Fisheries activities in reservoir waters consist of capture and cultivation fisheries. With all its complexity, reservoirs provide direct benefits to the surrounding community [1]. The developing fisheries sector is usually one of the sectors that take advantage of the existence of reservoirs, other sectors can be irrigation, recreation, water resources, and power generation, as a multipurpose function of a reservoir [2,3].

Capture fisheries in a reservoir are not only formed by the condition of existing fish resources which are then isolated due to the damming of land into a reservoir, but also by human activities that introduce a type of fish into the reservoir waters, known as stocking, restocking and introduction. In its development, the support for the condition and quality of reservoir waters also contributes to fluctuations in fisheries production.

Due to the need and utilization of the reservoir, the government and the community then realized that anticipatory steps were needed to make fish resources and the reservoir environment sustainable. Apart from efforts to restore resources through distribution, other activities limit or overcome overfishing, either through legal regulations or based on agreements in the community itself. Likewise, what happened in the Jatibarang Reservoir.

Jatibarang Reservoir is located in Semarang, Central Java. This reservoir is relatively new because it was only completed in 2014 and started operating in 2015. The Jatibarang Reservoir was built by damming the Kreo River (a tributary of the Garang River) located in West Semarang. Jatibarang Reservoir is located in four urban villages that are included in two sub-districts, namely Kelurahan Kandri and Kelurahan Jatirejo in Gunungpati District, as well as Kelurahan Kedungpane and Kelurahan Jatibarang which are part of Mijen District. It is estimated that 90% of the local population depends on
the Jatibarang Reservoir [1,4], the rest comes from users by other parties outside the local community [4].

This study aims to examine the value of the economic benefits of the fisheries sector in the Jatibarang Reservoir. Several studies have been carried out, such as the economic benefits of the tourism sector [5] [6], the economic value of tourism around the Jatibarang Reservoir [1] and the value of economic benefits in the provision of drinking water [5].

2. Materials and methods
The study was carried out at the Jatibarang Reservoir, which is located in Semarang, Central Java, during the 2018 periods through several stages of collecting data and information either directly or through enumerators in the research area. The collection of data and information includes direct random observation of 53 respondents who work around the reservoir, such as fishermen and recreational angler.

The economic benefits of fishery activities in the Jatibarang Reservoir are carried out by analysing the consumer surplus. Consumer surplus value is defined as the additional value received by individuals for the consumption of a good in excess of what is paid [7]. The Travel Cost Method (TCM) uses a regression analysis approach. The average travel cost used is the average of transportation costs, consumption while fishing, lodging, and other costs incurred by fishermen during fishing activities [8]. Furthermore, the consumer surplus is calculated as an acceptable economic measure of the benefits of fishing activities [8,9].

Estimation of consumer surplus value for fisheries follows the procedure commonly used in assessing recreational value [9], namely:

\[ WTP = a + bY + cT + dI + eD \]

Where WTP = Willingness to pay; Y = annual income; T = expenditure per day per person; I = investment in fishing equipment; D = average fishing days.

3. Result and discussion
3.1. Characteristics of reservoir beneficiaries
The users of Jatibarang Reservoir in the fisheries sector consist of fishermen and recreational angler. Anglers come from local communities and from outside the city. From the results of the interviews, it was found that about 90% came from the community around the reservoir and only 10% came from outside communities such as Surakarta, Yogyakarta, Magelang. Meanwhile, fishermen are come from residents surround the reservoir. Based on the age characteristics, the fishermen in Jatibarang Reservoir ranged from 20-56 years, and the age range that mostly engaged in fishing activities was 30-40 years old for local fishermen and 40-50 years old for outside fisherman (Figure 1a & 1b). In terms of age, it can be seen that the age of local fishermen is the productive age, with a living as fishermen. While related to local anglers, it appears that these ages that make fishing activities as entertainment or side activities. When viewed from the composition of education, fishermen in the Jatibarang Reservoir are dominated by primary school education (Figure 1c).
3.2. Fisheries productions

The catch of both fishermen and anglers who are active in the Jatibarang Reservoir is dominated by introduced fish. The catch includes 8 types of fish, namely hampala barb (*Hampala* sp), milkfish (*Channos Chanos*), tambaqui (*Colossoma* sp), snakehead murrel (*Channa striata*), gouramy (*Osphronemus gourami*), catfish (*Clarias* sp), tilapia (*Oreochromis niloticus*) and catfish (*Pangasius* sp), as well as reports on the presence of java barb (*Barbonymus gonionotus*). The catch was dominated by tilapia (68.23%), then milkfish (24.63%) and snakehead murrel (6.84%) (Figure 2). Catch composition is the same as the composition of the catch in other reservoirs, such as the Malahayu Reservoir [10,11] and Sempor Reservoir [12,13]. The high catch of tilapia and milkfish is due to the two types of fish that are often stocked in each stocking program [4].

![Figure 1. Local fisherman age (a); outside fisherman age (b); fishermen education (c) in the Jatibarang Reservoir.](image1)

**Figure 2.** Catch composition in Jatibarang Reservoir

The catch during the 9 month observation period ranged from 479-821 ind. or the equivalent weight of 293-658 kg (Figure 3). Monthly catch does not show any significant fluctuation except in June which tends to be low. Environmental conditions showed that there is no indication of the cause of the decline in catch. Aisyah *et al.* [14] stated that the 2018 period did not show anomalies of seasonal changes, which implied that the water level was in a stable condition. It also stated that the water residence period in this long (stable) period gave time for plankton to grow [15], so that it did not affect the catch in June 2018. On the other hand, the fishing trip shows that in that month there is a decrease in fishermen and angler activities due to the big day (Eid Al-Fitr).
3.3. Economic benefit / Consumer surplus

The dominant use of Jatibarang Reservoir is for recreation, while in the fisheries sector is for fishing activities by angler only. The economic value of fishing is needed to determine how much the benefits generated from the fisheries sector are. Conceptually, economic value is referred to willingness to pay (WTP) for goods and services produced by natural resources and the environment [16]. This economic value is obtained by using the current cost approach by measuring the relationship between costs incurred and the benefits obtained from fishing activities. Economic analysis is carried out to determine whether fisheries activities are appropriate or not.

Some information was obtained from direct observation, including the average catch per day for each fisherman, that is 3.12 kg with an average fish size of 30.2 cm so that total catch per year reach to 137.9 kg (Table 1). The time spent for fishing is around 5 hours, more tilapia caught compared to milkfish and the more profitable fishing location.

Table 1. Parameters used to estimate the economic benefits of fisheries in Jatibarang Reservoir.

| Variable                        | Average |
|---------------------------------|---------|
| Number of catch/day (ind.)      | 3.12    |
| Time for fishing (hours)        | 5.06    |
| Number of catch (tilapia)/day   | 2.00    |
| Number of catch (milky fish)/day| 0.80    |
| Average size of tilapia (cm)    | 28.1    |
Average size of milky fish (cm) 32.6
Number of fish brought home (ind.) 2.32
Percentage of fishing at least 1 fish 43.40
Percentage of fishing > 1 fish 41.51
Percentage of fishing using boat 1.89
Percentage of fishing on the banks side 98.11
Daily average
Average catch/day 3.12
Average size (cm) 30.2
Average fishing day per year 137.9

The function of WTP for fishing in the Jatibarang Reservoir is obtained by regressing the annual cost of income, the costs that must be incurred and the average fishing days. The equation obtained is as follows:

\[
WTP = 21.603 + 0.005Y - 0.61T - 0.013D
\]

\[
R^2 = 21.2\%
\]

\[
WTP = 31.31 - 0.357T
\]

\[
R^2 = 20.8\%
\]

The coefficient of determination (\(R^2\)) indicates that 20.8% of the variation in fishing benefits is explained by daily expenditure. The regression coefficient for daily expenditures is significant at the 5% confidence level, while for other variables it is not significant. Benefits obtained per day have a negative relationship with daily expenses. This means that if the expenditure increases, then the visit to the Jatibarang Reservoir to fishing will decrease because the benefits it get decreases by 0.35 units. Or in other words, that fishing activity provides relatively high benefits because it does not require high costs.

The average trip to the reservoir is around 10.93 km and individual expenses per day are around IDR 21.79 thousand per day. The net benefit value (consumer surplus) per day for fishing is above what they actually spend, which is IDR 23.52 thousand (Table 2). The value of economic benefits is the aggregate or the sum of WTP so that it can be obtained by multiplying the previously obtained consumer surplus value with the total visits during a year, which is around 45,000 fishermen. Based on these calculations, the value of economic benefits from fisheries in the Jatibarang Reservoir is IDR 1,058,562,723.00.

| Table 2. Expenditure Patterns, Value, and Use of Fishermen in the Jatibarang Reservoir. |
|-----------------|----------------|
| Variable        | Average        |
| Distance of travelling (km) | 10.93         |
| cost per trip (x IDR 1000)   | 58.67         |
| Number of people per trip    | 2.69          |
| Amount spent per person (x IDR 1000) | 21.79        |
| Days number per trip         | 1             |
| Amount spent of a person per day (x IDR 1000) | 21.79        |
| Consumer surplus per person per day (x IDR 1000) | 23.52        |

When compared with the value of economic benefits generated from other businesses, namely the economic value of boat tourism businesses, food and homestay businesses [1], the value of economic benefits from the fishing sector in the Jatibarang Reservoir is relatively low. In a study of other surplus uses outside the fisheries sector, it shows that the variable portion of expenditure never exceeds of 50%, except for expenditures for food business actors which reaches 61%, however this includes building rental costs for the next 3 years [1].
But if it is compares to the economic benefits of the fisheries sector between Jatibarang Reservoir and other reservoir, Jatibarang Reservoir gave a relatively lower than Malahayu and Djuanda Reservoir (Table 3). This is thought to be due to the higher income that Malahayu and Djuanda fishermen receive per person per year, because the use of varied fishing gear so that the catch is more than the fishing gear which tends to be selective.

### Table 3. The economic value of several reservoirs in Indonesia.

| Reservoir     | Numbers of Fishermen/day | Economic value (IDR)   |
|---------------|--------------------------|------------------------|
| Jatibarang *) | 150                      | 1,058,562,723          |
| Djuanda [17]  | 50                       | 44,099,462,963         |
| Malahayu [19]| 150                      | 3,539,180,000          |

Sources: *) this study

Based on the parameters that affect the WTP value, the following figure describes the change in each parameter to the WTP value. The regression results show that the WTP is significantly affected by the expenditure parameter. This can be seen from Figures 4a and 4b where if the parameters of income are low and expenditure is high, then the change in WTP will be more visible from changes in expenditure. Higher expenditure results in a lower WTP value so that the desire of fishermen to fishing will decrease. Likewise, if the two parameters of income and expenditure simultaneously change, where income decreases and expenditure increases, then the WTP value will continue to decline and even there will be a deficit (Figure 4c).

**Figure 4.** Effect of Change in the income (a); expense (b); and income and expenses simultaneously (c) on Willingness to Pay.
4. Conclusion

The fisheries sector in the Jatibarang Reservoir provides more economic benefits for the surrounding community. The economic factors that significantly influence fishing activities in the reservoir are expenditures. The consumer surplus obtained by using the travel cost model obtained a value of IDR 23,52 thousand/day and an economic benefit value of IDR 1,058,562,723. This consumer surplus value shows that the fishermen's willingness to fishing is quite large, which is balanced by the fish restocking throughout the year and restrictions on the use of other types of fishing gear other than handline only.

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6. Acknowledgement

This paper is part of the research on the impact of fish stocking in the inland water fisheries management area 434 at the Center for Fisheries Research in 2018. We would like to express our gratitude to Professor Dr. Husnah, M. Phill for guidance during the research and the Suko Makmur fishers group in assistance for data collection.