Willingness to pay estimation of microhydro power plant user for hydrological ecosystem services in North Buton Wildlife Reserve Area

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Abstract. One of community empowerment programs implemented by the Ministry of Environment and Forestry is the construction of a Micro Hydro Power Plant (MHP) for communities around forest areas. One of the environmental services provided by forests is hydrological benefit in the form of water source to drive MHP turbines. The existence of the perceived benefit will trigger public awareness to participate in preserving forest functions. Rewards for benefits generated from forests can be manifested through efforts to conserve water resources jointly between the community and the party that manages the area. In this regard, this research is conducted to determine the willingness to pay of MHP users around the North Buton wildlife reserve to maintain the MHP unit and support forest resource conservation activities. This study employs the contingent valuation method (CVM) to calculate the willingness to pay value. The results show that MHP users are willing to pay IDR 2,611. for each kWh of electric power. The willingness to pay is influenced by the amount of electricity consumption and the amount of income of the respondent. If it is calculated based on the volume of water used, the total willingness to pay for environmental water service is IDR 414.- per 1 liter per second.

1. Introduction
The ability of forests to regulate water management is one of the environmental services produced by forests. Environmental services from forests are essential as the water supply for domestic use and irrigation [1]. However, because environmental services are often considered a public good, people consume them free [2]. Environmental services provide benefits, including reducing energy demand, increasing land value, avoiding drainage maintenance costs, regulating and controlling air pollution, preventing flooding, which is generally not valued in monetary terms [3]. The value of environmental services can be quantified through economic calculations.

The utilization of water resources from forests can be in the form of surface water or groundwater. The flowing surface water can be used to generate electricity by means of a water current rotating a turbine which in turns activates the generator to produce electricity. The potential of water to drive turbines for generating electricity tends to decrease in quantity due to changes in forest ecosystems [4]. Thus, the continuous use of water environmental services without paying attention to conservation factors will decrease the quality and quantity of these water environmental services [5].
Communities living around forest areas, especially conservation areas, interact more intensely with the forest [6], [7] resulting in increased pressure to the forest gradually change the forest ecosystem. One of the strategic efforts to reduce ecosystem degradation is by increasing community awareness of the importance of forests benefits to produce environmental services [8]. The process of raising awareness can be carried out through forest conservation programs involving the community living adjacent the forest. Water use fees can be potential and reliable as a source of income to finance nature conservation programs [9]. The community has a strong and consistent desire to support conservation efforts for the environmental services they enjoy [10].

One of the community empowerment programs implemented by the Ministry of Environment and Forestry by optimizing the benefit of water services in the last 5 years is the construction of a Micro Hydro Power Plant (MHP) for communities around forest areas. From forestry interests, development of MHP can be used as an instrument to enhance community participation in protecting and preserving the function of the forest. The rational of this concept is that operational of MHP depends on the availability of sustainable water flows which is mostly affected by the catchments area and forest condition. The operation of the MHP can continue only if two conditions are created, namely: 1) the source of driving energy in the form of water is continuously available which can be produced if the forest is maintained and 2) the MHP unit is well maintained by the community independently. Point one can be realized if the community is willing to actively participate in maintaining and preserving forest functions, while point two can be implemented if the MHP users are willing to pay the maintenance costs and are willing to jointly manage the operations of the MHP. In this regard, this research is conducted to determine the willingness to pay MHP users around North Buton Wildlife Reserve to maintain MHP units and support forest resource conservation activities. In order to maintain the sustainable use of water environmental services from forests, payment for environmental services scheme is needed [11].

2. Methodology
2.1. Study area
The research is conducted in Wowonga Jaya Village, North Kulisu Sub District, District of North Buton, Southeast Sulawesi. This village is adjacent to the North Buton Wildlife Reserve area. The map of the research location is shown in Figure 1.
2.2. Data collection
In this study, series of respondent interview are conducted employing questionnaires and a recording device to collect primary data. Respondents are head of households using MHP electricity. Respondent characteristics consist of age class, education, income, and the number of family members. The willingness to pay is questioned directly to the respondent how much they are willing to pay for the electricity used every month. The value of WTP per kilo Watt hours (kWh) is obtained by dividing the value of WTP obtained from interviews with the average of total electric power used by the household.

2.3. Data analysis
This study employs the contingent valuation method (CVM) to calculate the WTP value of MHP users. Data and information obtained in this study will be analyzed qualitatively and quantitatively. Data processing and analysis are done using the IBM SPSS version 22 program. Factors that affect WTP are analyzed by multiple regression analysis.

2.3.1. Estimating the average and total value of the WTP. The average value and total value of the WTP can be calculated using the following formulas [12]:

\[ EWTP = \frac{\sum_{i=1}^{n} Wi}{n} \]

Notes:
EWTP = Average value of WTP
Wi = the amount of WTP that is willing to be paid
i = respondent who is willing to pay
n = number of respondents

\[ TWTP = \sum_{i=1}^{n} WTPi \left( \frac{ni}{N} \right) P \]

Notes:
\( \sum \) TWTP = Total WTP
WTPi = sample i individual WTP
ni = number of samples that are willing to pay the amount of WTP
N = Number of samples
P = Total population of MHP users
i = Respondent i who is willing to pay (i = 1,2,…, n)

2.3.2. Factors affecting WTP. To justify the determining factors of WTP value, a linear regression analysis is carried out using SPSS version 22.0 software. In this analysis, the dependent variable is WTP, and the independent variable is the socio-economic characteristics of MHP users.

2.3.3. Calculating the value of water. In this study, the economic value of water used in the MHP unit is also calculated. The calculation of the economic value of water is approached by the equation of the relationship between the electrical power produced (watts) and the required water discharge (liters/second).

\[ P = g \times h \times Q \times e \]

Notes:
P = Power (kWh)
g = Earth's gravity (9.8 m/s²)
h = difference in elevation (m)
Q = Discharge (m³/s)
e = turbine efficiency (%)
Economic value of water per liter is calculated by dividing the WTP value per kWh by the water amount (litter per second) to produce certain amount of electricity power.

3. Results and discussion

3.1. Characteristics of respondents

The characteristics of the MHP user respondents in Wowonga Jaya Village are presented in Table 1.

| Characteristics of Respondents | Frequency | Percentage |
|-------------------------------|-----------|------------|
| Age Class                     |           |            |
| 20-30                         | 2         | 7          |
| 31-40                         | 10        | 33         |
| 41-50                         | 11        | 37         |
| >50                           | 7         | 23         |
| Education                     |           |            |
| No School                     | 1         | 3          |
| Elementary School             | 20        | 67         |
| Junior High School            | 4         | 13.5       |
| Senior High School            | 4         | 13.5       |
| University                    | 1         | 3          |
| number of family members      |           |            |
| <3                            | 2         | 7          |
| 3-4                           | 11        | 36         |
| 5-6                           | 12        | 40         |
| >6                            | 5         | 17         |
| Income (IDR)                  |           |            |
| <1,000,000                    | 1         | 3          |
| 1,000,000-1,999,999           | 10        | 33         |
| 2,000,000-2,999,999           | 10        | 33         |
| 3,000,000-3,999,999           | 5         | 17         |
| >4,000,000                    | 4         | 14         |
| Electricity consumption (watts) |         |            |
| <20                           | 7         | 23         |
| 21-40                         | 4         | 13         |
| 41-60                         | 2         | 7          |
| 61-80                         | 5         | 17         |
| 81-100                        | 6         | 20         |
| >100                          | 6         | 20         |

The study found that the age of the respondents are dominated by 41-50 years (40.7%). The rest are 31-40 age class (37%), 14.8% age class >50 and 7.4% age class 20-30. Most of the respondents' education level is still low, namely only 67% elementary school education and no school (3%), the rest is junior high school (13.5%), senior high school (13.5%), and university (3%). The number of family members of the respondent is mostly 3-6 people in one head of the family. Most of the respondents' income is IDR 1,000,000 - <3,000,000 per month. This income is generated from coconut, cashew, coffee, cocoa, nutmeg, clove plantations, and fishing businesses.

The power consumption of each respondent's household varies according to the amount of electrical equipment used. The average electricity consumption of each household is 69 watts (0.069 kW). The consumption of electrical power comes from a variety of electronic equipment in the form of light bulb, television, radio tape. MHP users who use electricity above 100 watts generally use more electrical equipment and with greater power.

3.2. Willingness to pay

The result of the analysis of willingness to pay of MHP users on average is IDR 2,611 per kWh of electric power used. The average number of respondents' WTP for electric power is higher than the State Electricity Enterprise (Perusahaan Listrik Negara) tariff, which is IDR 900-1,400 per kWh, this
indicates that electricity for the community in Wowonga Jaya Village is an important requirement. The electricity supply before the MHP came from a generator set which of course required a higher cost for each kWh of electric power.

The value distribution of willingness to pay varies, starting from IDR 575 to IDR 7,500. The value of willingness to pay is dominated by IDR 1,000-2,000 per kWh (Figure 2). Users who are willing to pay above IDR 3,000 are consumers who before the existence of MHP used personal generator sets running on gasoline or diesel fuel. This is understandable because the cost to generate electricity from a household generator set reaches 3 liters of fuel for 6 hours of use with a generator power of 700 Wh. Consumers who are willing to pay between IDR 1,000-3,000 are consumers who previously subscribed to electricity from electricity providers sourced from generators. Meanwhile, consumers who are willing to pay less than IDR 1,000 is a household that does not use much electricity. The following in Figure 2 shows the distribution of willingness to pay of MHP consumers.

![WTP electricity power](image)

**Figure 2.** Distribution of willingness to pay

The results of multiple regression analysis using the stepwise method show that the factors that influence the WTP of MHP users are the amount of power consumption and household income (Table 2). MHP users with high income are willing to pay more for each use of electric power. High incomes encourage households to consume more electricity [13]–[15].

| Model | Unstandardized Coefficients | Standardized Coefficients |
|-------|-----------------------------|---------------------------|
|       | B | Std. Error | Beta | t | Sig. |
| 1     | (Constant) | -1937.415 | 358.162 | -5.409 | .000 |
|       | Household Income | .002 | .000 | .935 | 13.926 | .000 |
| 2     | (Constant) | -3140.545 | 556.327 | -5.645 | .000 |
|       | Household Income | .003 | .001 | 1.668 | 5.916 | .000 |
|       | Electricity Consumption | -34.484 | 12.950 | -.751 | -2.663 | .013 |

Dependent Variable: Willingness to pay
The results show that the willingness to pay MHP users are dominant at 1300KVa electric power which was influenced by the amount of electric power consumption and the amount of income of the respondents.

3.3. The value of water

Based on the amount of electric power generated by the turbine, it can be determined the amount of water used to produce the power. The electric power generated from MHP is determined by several factors such as gravity with a value of 9.8 m/s², height difference, water discharge, and turbine efficiency. The efficiency of the turbine made by BP2LHK Makassar is assumed to be 60%. At the research location, the height difference (head) between the inlet and outlet of the turbine is 27 m with an average power consumption of 69 watts (0.069 kW)/household generated by 0.43 liters/second of water. With the value of WTP per kWh of IDR 2,611,- and 1 kWh requires 6.3 liters/second of water, the value of water per liter per second is IDR 414,-. Thus, the willingness to pay MHP users for each liter of water is IDR 414,- per second. Before the MHP was built, the community thought that water from the North Buton Wildlife Reserve Area is free of charge. However, after the MHP is built and an economic valuation of water services is carried out, this can provide an understanding that water services as a forest resource provide high value to the community. This will make the community appreciate the existing water services, so that it has implications for public awareness to take part in preserving the forest.

4. Conclusions

Willingness to pay of micro-hydropower plants users around the North Buton Wildlife Reserve, which is IDR 2,611, per kWh, is influenced by the amount of electricity consumption and household income. Meanwhile, the amount of the MHP user's willingness to pay for every liter per second water is IDR 414. The value of water services from the forest can provide an understanding to the surrounding community that water from the North Buton wildlife reserve area is valuable for the community so that it can trigger their awareness to participate in conserving the forest.

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