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Evidence for Mangrove Restoration in the Mahakam Delta, Indonesia, Based on Households' Willingness to Pay

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Abstract

Mangroves provide multiple benefits for local communities' livelihoods. However, in the Mahakam delta mangroves have declined considerably. This study examines the factors affecting households' willingness to pay (WTP) for mangrove restoration in three villages in the Mahakam delta and determines whether a mangrove restoration project would be viable and should be implemented in the study area or not. The contingent valuation method was applied through a double-bound dichotomous choice format to estimate the WTP for mangrove restoration. The results showed that over 80% of perception of respondents considered the benefits of mangroves were essential that associated with their livelihoods. Local residents tended to be willing to pay more for mangrove restoration when they acknowledged the benefits of mangroves and when they felt that the sustainability of mangrove ecosystems was their responsibility. The benefits transfer method was also used to estimate the costs and benefits of an ongoing mangrove restoration project in the study area. The benefits provided by mangroves, as estimated based on households' WTP, clearly outweighed the costs for the mangrove restoration project. We conclude that mangrove restoration should be implemented in the study area by increasing local communities' awareness and responsibility to protect and manage the mangrove a sustainable.

Keywords: mangroves, restoration, contingent valuation method, double-bounded dichotomous choice, willingness to pay, cost-benefit analysis

1. Introduction

Mangroves grow in the intertidal zones between land and sea in the sub-tropics. Mangroves are highly productive and promote ecological diversity in coastal environments as well as supporting socioeconomic activities (Nagelkerken et al., 2008; Barbier et al., 2011). Mangroves provide valuable ecological services including acting as nurseries for fish and crustacean (Kairo, Wanjiru, & Ochiewo, 2009) and offering carbon sequestration (Lee et al., 2014; Alongi & Mukhopadhyay, 2015). Mangroves also protect coastal areas from tidal waves (Everard, Jha, & Russell, 2014) and filter suspended solids (Gautier, 2002). Mangroves are found in 123 countries, covering a global area of 152.360 km^2 (ITTO, 2012). Asia is the center of origin of mangroves. Indonesia has the largest area of mangrove growth in the world and is home to some of the world's largest species of mangroves. Over 22.6% of the world's mangroves originated in Indonesia (Giri et al., 2011). Spalding, Kainuma, and Collins (2010) noted that mangroves in Indonesia cover approximately 30,000 square kilometers and comprise 45 out of the 75 species of true mangroves found globally.

East Kalimantan is the province with a second-largest area of mangroves in Indonesia. Mangroves in this province cover 364,254.98 hectares, equaling over 11% of Indonesia's total mangrove area (Hartini, Saputro, Yulianto, & Suprajaka, 2010). Most of East Kalimantan's mangroves originated from the Mahakam delta. Located at the mouth of the Mahakam River, the delta forms a unique fan-shape that includes 46 small islands in the coastal area of the Makassar Strait (Sidik, 2009). It is one of the most suitable environments for natural mangrove development in Indonesia. Currently, mangroves in the Mahakam delta cover approximately 29,600 hectares.

The area of mangroves has declined significantly worldwide as a result of economic development, population pressure and industrial and urban development (Polidoro et al., 2010). The Mahakam delta has also suffered the same fate. The degradation of mangrove areas in the Mahakam delta occurred primarily because of shrimp pond expansion and, to a lesser degree, urban and industrial development. From 1992 to 1996, there was a 3.67% a decrease in mangrove area, and from 1996 to 2009, there was a further 20.52% decrease (Bappeda Kukar, 2010). Mangroves carry out multiple functions that are important for humans. Declines in mangrove area could lead to less income for local people (*e.g.* lower fishery yields and unproductive brackish ponds). From 2011 to 2014, fishery yields in the Mahakam delta area declined continuously from 28,222 tons to 18,492 tons, while brackish pond production has continually decreased from 18,615 tons to 17,445 tons (BPS, 2015).

Previous studies have been carried out in the Mahakam delta (*e.g.* Storms, Hoogendoorn, Dam, Hoitink, & Kroonenberg, 2005; Persoon & Simarmata, 2014; Effendi, Kawaroe, Mursalin, & Lestari, 2016). However, studies that focus on assigning value to non-market resources in this area are scarce. The economic value of mangrove ecosystem services should be evaluated to assist with the future management and conservation mangrove ecosystems. Economic valuation can support the formulation of policies by attaching and the economic value of the preservation of biological resources (Christie et al., 2006). The economic valuation of mangroves involves constructing a hypothetical market because the majority of the ecosystem service functions performed by mangroves provide indirect value and do not imply marketed resources. Thus, identifying the economic value of mangrove ecosystem services is difficult. Therefore, we used the contingent valuation method (CVM) to solve this problem.

The CVM, which uses a questionnaire-based approach, has been widely applied to determine willingness to pay (WTP) for non-marketed assets or services (Hanemann, Loomis, & Kanninen, 1991). In this study, WTP refers to the maximum amount of the willingness of individual to pay or sacrifice to procure the benefits of mangrove restoration. There are various means of framing the WTP question commonly used in CVM studies, such as payment cards and dichotomous choice (DC). The DC comprises two formulas: the single-bound model, in which individuals can "accept" or "reject" a bid, and the double-bound model, in which an individual accepts the first bid and a second, higher bid is offered. Previous studies have also examined the value of WTP for mangrove restoration. Utilizing the single-bound model, Tuan, My, Anh, and Toan (2014) estimated the WTP for mangrove restoration in Thi Nai Lagoon, Vietnam within the context of climate change. Stone, Bhat, Bhatta, and Mathews (2008) also investigated factors that influenced households' WTP for mangrove restoration among three subsistence groups on the west coast of India. The application of the single-bound model for non-market valuation has been commonly used to assess programs for natural resource assessment (Gelo & Koch, 2015).

This study applies the double-bound model to estimate WTP for mangrove restoration in the Mahakam delta. Calia and Strazzera (2000) explain that the single-bound model has lower survey costs according to respondent group size when the interview is conducted face-to-face or over the telephone, especially when the targets of the interview are part of a specific respondent. Unlike the double-bound model, the single-bound model only offers one question to determine whether a bid is "accepted" or "rejected", so little time is required to complete interviews. However, CVM analysts prefer the double-bound model to the single-bound model. They argue that the double-bound model provides more information to better estimate an individual's true WTP and produces less biased WTP estimates than the single-bound model (Hanemann, Loomis, & Kanninen, 1991; Calia & Strazzera, 2000; Gelo & Koch, 2015). Using Monte Carlo analysis, Calia and Strazzera (2000) found that the double-bound model was more effective than the single-bound model because it resulted in more accurate point estimates of parameters and central tendency measures of WTP, with smaller confidence intervals for mean and median WTP. Hanemann, Loomis, and Kanninen (1991) also demonstrated that the double-bound model provides more information than the single-bound model. The double-bound model produces less biased estimates of WTP and asymptotically more efficient than the single-bound model for CVM.

Considering these points, we decided to use the double-bound model to determine households' WTP for mangrove ecosystem restoration in the Mahakam delta. We also investigated the factors influencing WTP, including sociodemographic characteristics and the perception of the local community and examined the costs and benefits of a mangrove restoration through a cost-benefit analysis (CBA).

We hypothesized that higher bids would have a negative effect on respondents' WTP. Further, restoration program preferences and those with a perceived responsibility toward mangrove restoration were expected to have a bigger probability of answering "yes" to WTP bids. Occupation and residential status were expected to have a positive effect on answering "yes" to WTP bids.

2. Method

2.1 Study Area

The study was conducted in the Mahakam Delta, which is located on the eastern coast of Kalimantan Island between 0°19′-0°55′ S and 117°15′-117°40′ E. The area includes Kutai Kartanegara District in East Kalimantan Province. The delta was formed by the deposition of suspended solids and consists of 46 small islands that formed over time as the result of deposition. The access of Mahakam delta is 5200 km^2 and divided into a terrestrial area at 1500 km^2, the delta front at 1000 km^2 and prodelta at 2700 km^2 (Sidik, 2009; Persoon & Simarmata, 2014). The Mahakam delta has one of the highest levels of biodiversity in Indonesia, including more than 260 bird species, 86 freshwater fish, and 86 plants. The delta contains 20 true mangrove species from at least seven families. Creocean (2000) reported that nipa palm (*Nypa fruticans*), covering 60,000 hectares, grows throughout the study area, which is one of the most widely distributed mangrove species in worldwide. The proboscis monkey, which is endemic to East Kalimantan, also occurs in this area. Currently, mangrove covers approximately 29,600 hectares of the Mahakam delta. True mangrove species include bakau (*Rhizophora* spp.), pedada (*Sonneratia alba*), api-api (*Avicennia* spp.), tancang (*Bruguiera* spp.) and nipa palm. The Mahakam delta consists of five sub-districts, including 20 villages with a total population of 99,347 individuals and 28,609 households. The local community members mainly work in fishing, fish farming and related trades (*e.g.* processing of fishery products) and, to a lesser degree, as government officers and private employees.

2.2 Data Collection

Data collection was conducted from April to June in 2016 by face-to-face interviews with respondents. We select three villages in the study area based on the highest number of households in a village. Surveys were carried out in three villages: Tani Baru, Muara Pantuan and Muara Badak. Of the 380 questionnaires that were distributed, 364 were completed. The sample from three villages was purposively selected based on the socio-demographic characteristics of respondents. We designed the questionnaires by conducting a pre-test with 30 respondents to ensure that respondents had sufficient information and understanding to answer all questions in the questionnaire. The questionnaire was composed of three parts. In the first part, respondents were provided with a summary regarding mangroves in the Mahakam delta and the problems associated with inappropriate resource utilization and lack of mangrove management. Information about the impact of mangrove degradation was also included in this section. In the second part, respondents were asked if they would be willing to pay for mangrove restoration according to five bid levels (see Table 1). In the second section, respondents were also asked to indicate how important they felt that different mangrove functions were to their livelihoods. In the third (final) section, respondents were asked to provide demographic information including sex, age, number of household members, residence status, occupation, education level and income.

Table 1. Double-bounded CVM offer prices

First bid	Second higher bid	Second lower bid
10000	20000	5000
20000	30000	10000
30000	40000	20000
40000	50000	30000
50000	60000	40000

Note. 1 USD was equivalent to 13,000 IDR at the time of the study.

2.3 Analytical Techniques

Bishop and Heberlein (1979) first introduced the double-bounded questionnaire to determine WTP. This approach requires respondents to answer either "yes" or "no" to the offer price in a hypothetical market (Venkatachalam, 2004). This approach was then modified by Hanemann (1985), who introduced the double-bounded dichotomous choice method (DBDC). In this approach, each respondent is presented with two bids. The amount of the second bid depends on the reply to the first bid. The second bid B_i^u is a certain amount higher than the first bid ($B_i < B_i^u$) if the individual responded "yes" to the first bid. However, the amount of the second bid B_i^d is smaller than the first bid ($B_i^d < B_i$) if the individual responded "no" to the first bid. Four possible outcomes are obtained when each respondent is presented with two bids: (a) both answers are "yes"

(π^{yy}); (b) both answers are "no" (π^{nn}); (c) a "yes" followed by a "no" (π^{yn}); and (d) a "no" followed by a "yes" (π^{ny}).

The likelihood of these responses occurring can be described by the following formulas, assuming a utility-maximizing respondent (Hanemann, Loomis, & Kanninen, 1991):

$$\begin{aligned}\pi^{yy}(B_i, B_i^u) &= \Pr\left\{B_i \le \max WTP \, and \, B_i^u \le \max WTP\right\} \\ &= \Pr\left\{B_i \le \max WTP \middle| B_i^u \le \max WTP\right\} \Pr\left\{B_i^u \le \max WTP\right\} \\ &= \Pr\left\{B_i^u \le \max WTP\right\} \\ &= 1 - G(B_i^u;\theta)\end{aligned} \quad (1)$$

Because with $B_i^u > B_i$, $\Pr\left\{B_i \le \max WTP \middle| B_i^u \le \max WTP\right\} \equiv 1$. Similarly, with,

$B_i^d > B_i$, $\Pr\left\{B_i^d \le \max WTP \middle| B_i \le \max WTP\right\} \equiv 1$. Hence,

$$\pi^{nn}(B_i, B_i^d) = \Pr\left\{B_i > \max WTP \, and \, B_i^d > \max WTP\right\} = G(B_i^d;\theta) \quad (2)$$

When a "yes" is followed by a "no", then $B_i^u > B_i$ and,

$$\pi^{yn}(B_i, B_i^u) = \Pr\left\{B_i \le \max WTP \le B_i^u\right\} = G(B_i^u;\theta) - G(B_i;\theta) \quad (3)$$

moreover, when a "no" is followed by a "yes", then $B_i^d > B_i$ and,

$$\pi^{ny}(B_i, B_i^d) = \Pr\left\{B_i \ge \max WTP \ge B_i^d\right\} = G(B_i;\theta) - G(B_i^d;\theta) \quad (4)$$

Provided a sample of N respondents, the log-likelihood function of this model can be given as,

$$\ln L^D(\theta) = \sum_{i=1}^{N}\left\{d_i^{yy} \ln \pi^{yy}(B_i, B_i^u) + d_i^{nn} \ln \pi^{nn}(B_i, B_i^d) + d_i^{yn} \ln \pi^{yn}(B_i, B_i^u) + d_i^{ny} \ln \pi^{ny}(B_i, B_i^d)\right\} \quad (5)$$

Where, d_i^{yy}, d_i^{nn}, d_i^{yn}, d_i^{ny}, are binary-valued indicator variables. The maximum likelihood estimator for the DBDC model, $\hat{\theta}^D$ is the solution to equation $\partial \ln L^D(\hat{\theta}^D) / \partial\theta = 0$.

In the DBDC model, the mean WTP is calculated using an integration technique as under:

$$Mean\,WTP = \int_L^U (1 + e^{\beta_0 + \beta_1 \log T + \beta_2 C})^{-1} dT \quad (6)$$

Where, U and L represent the upper and lower limits of the integration, respectively, the probability of answering "yes" is expressed as: $(1 + e^{\beta_0 + \beta_1 \log T + \beta_2 C})^{-1}$, and the median is as expressed follows:

$$Mean\,WTP = \exp\left(\frac{-\hat{B}_0 - \hat{B}_2\overline{C}}{\hat{B}_1}\right) \quad (7)$$

Where, T = bid, C = socioeconomic variables, β_0 = a constant, and β_1 and β_2 are parameters. We screened and removed zero protest bids. Finally, estimation of parameters was carried out using the LIMDEP software package (NLOGIT version 5).

3. Results

3.1 Sociodemographic Characteristics

Table 2 presents the sociodemographic characteristic of the respondents. On average, respondents in the study area are the male, with an average of 78%. The mean actual age is 31-40 years, implying that the average households in the study area are in the productive life phase. Regarding family size, we found that respondents who three members were the domination in the study area. The data shows that 33% of occupation type is fish farmers and residence status in the study area is dominated by the immigrant (68%). Respondents have only a primary school, implying that they work for earn a living without any education background. The respondents with incomes of IDR 2-2.9 million are most prevalent in the study area. We also asked respondents how they would like to participate in mangrove restoration; the options were: planting mangrove seedlings, monitoring plant progress and protecting the mangrove area. Thirty-six percent of respondents chose planting seedlings and 64% chose the other options. Furthermore, 90% of respondents agreed that the protection of mangroves was their responsibility. 43% of respondents assess that mangroves provide the benefit as a nursery ground for aquatic organisms. Of the 364 respondents who were interviewed, 313 respondents (86%) were willing to pay for mangrove restoration.

Table 2. Sociodemographic characteristic of respondents

Variables	Description	Mean	Std. Dev
Sex	1 if the respondent is male; 0 if female	0.78	0.41
Age	1 = below 20; 2 = 20-30; 3 = 31-40; 4 = 41-50; 5 = 51-60; 6 = over 60)	3.32	1.01
Family size	Family size of respondents	2.94	1.54
Occupation	1 if the respondent is fish farmer; 0 if otherwise	0.33	0.47
Residence status	1 if the respondent is indigenous; 0 if immigrant	0.32	0.47
Education	1 = never; 2 = primary school; 3 = secondary school; 4 = high school; 5 = university degree	2.27	1.06
Income (Million IDR)	1= less than 1; 2 = 1-1.99; 3 = 2-2.99; 4 = 3-3.99; 5 = 4-4.99; 6 = more than 5)	3.24	1.49
Planting of mangrove seedlings	1 if respondent wants to participate in planting of mangrove seedlings, 0 if otherwise	0.36	0.48
Responsibility	The responsibility of the local community to mangrove restoration. 1 if respondent agrees, 0 is disagree	0.90	0.29
Nursery	1 if mangrove benefit as nursery ground; 0 if otherwise	0.43	0.49
The number of samples[a]	1 if the respondent willing to pay; 0 if not willing	0.86	0.34

Note. [a] not included in variables used in the logistic regression model.

3.2 Perceptions Regarding Mangrove Benefits

Table 3 depicts the responses of respondents to the questions regarding the relative importance of mangrove ecosystem functions associated with their livelihoods. The respondents were asked to respond to six questions about mangrove ecosystem functions on a five-point scale ranging from 1 = not very important to 5 = very important. The results revealed that over 80% of respondents assessed the benefits of some mangrove-related ecosystem functions associated with their livelihoods as “important” or “very important”. However, 0.27%-28% of respondents responded that mangrove functions were neither important nor unimportant depending on the question.

Table 3. The importance of mangrove ecosystem functions

Mangrove Function	Not very important	Not important	Neither	Important	Very important
Timber and plant product	0.82	3.02	17.58	69.23	9.34
Coastal protection and erosion control	0.27	0.82	0.27	34.34	64.29
Water purification	0.27	1.92	7.69	51.10	39.01
Carbon sequestration	0.27	0.55	9.07	66.48	23.63
Fisheries	0.27	0.27	3.02	34.89	61.54
Tourism	0.27	3.85	28.57	46.70	20.60

Note. values are % of total individual responses.

3.3 Individual WTP

Table 4 summarizes the bids and responses to the WTP questions. The proportion of ‘yes’ responses to base bid (BD) and upper bound (UB) ranged from 57.97% for IDR 10000 to 14.04% for IDR 50000. An identical pattern was recognized for the proportion of ‘yes’ responses to BD and the proportion of ‘no’ responses to UB ranged from 30.43% for IDR 10000 to 17.54% for IDR 50000. In contrast to previous pattern, the BD and lower bound (LB) provide a different pattern. The proportion of ‘no’ responses to BD and the proportion of ‘yes’ responses to LB ranged from 7.25% for IDR 10000 to 28.07% for IDR 50000. Also, the proportion of ‘no’ responses to BD and LB ranged from 4.35% for IDR 10000 to 40.35% for IDR 50000.

Table 4. Summary of respondent answer for WTP

First Bid (IDR)	Base bid (BD) and upper bid (UB)				Base bid (BD) and lower bid (LB)				Total	
	yes-yes		yes-no		no-yes		no-no			
	N	Per cent	N	Percent	N	Percent	N	Percent	N	Percent
10000	40	57.97	21	30.43	5	7.25	3	4.35	69	100.00
20000	31	46.97	14	21.21	12	18.18	9	13.64	66	100.00
30000	15	24.19	21	33.87	18	29.03	8	12.90	62	100.00
40000	21	35.59	12	20.34	17	28.81	9	15.25	59	100.00
50000	8	14.04	10	17.54	16	28.07	23	40.35	57	100.00

Note. 1 USD was equivalent to 13,000 IDR at the time of the study.

3.4 WTP Estimates

Maximum likelihood estimation using the log-logistic model was used to determine the coefficients. The log-logistic model is estimated using two models. Model 1 includes all variables, whereas model 2 includes only statistically significant variables. The dependent variable is the probability of answering "yes" to the WTP bid for mangrove restoration. In contrast, the explanatory variables consist of bid levels, sociodemographic characteristics and the respondents' perceptions of mangrove functions.

Table 5 shows five variables that impact a respondent's WTP for mangrove restoration. The "bids" variable was statistically significant at 1% and had a negative coefficient. This implies that as bid amount increased, the likelihood of saying "yes" decreased. Of the sociodemographic characteristics recorded, only occupation was statistically significant at 1% and had a negative coefficient. The estimated coefficient for planting seedlings was also negative and significant at the 5% level. Furthermore, the variable of responsibility was positive and significant at 5%. Finally, the "nursery" variable that depicts the mangrove's function as a breeding ground for aquatic organisms was significant at 5% and had a positive coefficient. The mean WTP of the respondents was estimated to be IDR 35,201 (model 1) and IDR 35,413 (model 2). The median value of the WTP was about IDR 32,899 (model 1) and IDR 33,172 (model 2).

Table 5. Maximum likelihood estimation results for WTP

Variables	Model 1 (all variables)			Model 2 (statistically significant only)		
	Coeff		Standard Error	Coeff		Standard Error
Constant	28.09	***	1.76	27.27	***	1.64
Bids	-2.66	***	0.16	-2.63	***	0.16
Gender	0.18		0.27	-		-
Age	-0.18		0.15	-		-
Household	-0.01		0.09	-		-
Resident	0.37		0.27	-		-
Occupation	-0.77	***	0.29	-0.68	**	0.28
Education	-0.11		0.11	-		-
Income	0.24		0.25	-		-
Planting of mangrove seedlings	-0.61	**	0.24	-0.68	***	0.23
Responsibility	0.52	**	0.24	0.47	**	0.23
Nursery	0.49	**	0.23	0.47	**	0.22
The number of samples	313			313		
Log Likelihood	-412.46			-416.46		
Mean	35201			35413		
Median	32899			33172		
[95% Confident Interval of Median]	30098-35961			30310-36305		

Note. ***, **, * = Significant at 1%, 5%, and 10%.

3.5 Costs and Benefits of Mangrove Restoration

We conducted a cost-benefit analysis (CBA) to evaluate the feasibility of future restoration projects. CBA is a tool that can be used by policymakers to quantify the perceived value of all the benefits and costs of a project. CBA is useful for assessing whether a mangrove restoration project will provide net benefits to the local community compared with other development projects that would utilize mangrove resources. CBA is conducted to ascertain efficient allocation of mangrove resources for each policy or program. CBA consider the assessment of all the mangrove benefits and restoration costs that arose from the primary goal of the project. In environmental CBA, individuals' WTP becomes an essential approach to determine non-monetary values as the benefits of environmental investments.

We apply the result of WTP with mangrove restoration project undertaken in the study area to analysis whether the project is viable. In 2014, the collaboration between Planete Urgence, the project financier, and Yayasan Mangrove Lestari, a local non-governmental organization through the Mahakam Delta Integrated Management Program (Madimap) conducted mangrove restoration in Muara Badak village. In this project, a total of 39,575 mangrove seedlings were planted along the river. The estimated initial costs of the restoration project were IDR 68.28 million, which included the cost of the seedlings, bamboo poles, labor, and transportation. Maintenance costs for 4 years were estimated at IDR 9 million per year. After 4 years, the maintenance and protection costs were assumed to be 50% of the initial maintenance costs. Using a standardized 10% decrease for the first 5 and 10 years of the project, the total value cost was determined to be IDR 99.60 million (for the first 5 years) and IDR 110.19 million (for the first 10 years; see Table 6).

To determine the benefits of this mangrove restoration project, we used the unit value transfers method of the benefits transfer approach to estimate the WTP value in Muara Badak sub-district (the policy site) based on the WTP value from the Mahakam delta region (the study site). This method enables the applications of quantitative estimates of non-market ecosystem service values to another site where direct evaluation cannot be carried out. The "policy site" refers to the area to which the estimated values are applied (Johnston, Rolfe, Rosenberger, & Brouwer, 2015). Muara Badak village is located in Muara Badak sub-district in the Mahakam delta region. This village has a demographic makeup that is similar to other villages in the Mahakam delta. Johnston, Rolfe, Rosenberger, and Brouwer (2015) stated that one of the requirements to conduct transfer benefits analysis was that the policy site should not be geographically different from the study site. The formula of benefit transfers is as follows: $WTP_p = WTP_s(Y_p/Y_s)^\beta$, where WTP_p is the mean WTP estimate from the policy site, WTP_s is the mean WTP estimated at the study site (IDR 422,412 per year), Y_p and Y_s are mean the income levels (regional GDP per capita) at the policy and the study sites, respectively, and β is the income elasticity of WTP for environmental good. Of the various environmental goods, Income elasticity of WTP is smaller than 1, and generally in the 0.4-0.7 range.

As mentioned above, the mean WTP value for the Mahakam delta was determined suing respondents who came from three villages: Tani Baru and Muara Pantuan (in the Anggana sub-district), and Muara Badak (in the Muara Badak sub-district). The report of Statistics Indonesia (BPS) (2015) noted that the regional GDPs per capita of Anggana and Muara Badak sub-districts were IDR 100.5 million and 118.1 million, respectively. We estimated the average income level of the study site based on the average GDP per capita from two sub-districts. We determined the estimated GDP per capita of the study site to be IDR 109.3 million. Using the formula above, the mean WTP value at the policy site was determined to be IDR 409,507 per year.

The estimated benefits of mangrove restoration in Muara Badak village was determined as the product of the mean WTP per year, the number of households, and the questionnaire response rate. The mean WTP was valued at IDR 409,507 per household per year; the number of households was 1229; and only 313 respondents were willing to pay for mangrove restoration (thus, the questionnaire response rate was computed as 313/380 = 0.82). Therefore, the benefit of mangrove restoration can be calculated as IDR 414.54 million per year. According to a local biologist, the mangrove ecosystem benefits will start accruing in the fifth year of the project. The estimated values of the benefits of the restoration project were determined to be IDR 257.40 million (5 years) and IDR 1233.15 million (10 years). The cost-benefit ratio for this project is 2.34 (5 years) and 11.19 (10 years).

Table 6. Cost-benefit analysis of a mangrove restoration project after 5 years and 10 years

Description	Life of project	
	5 years	10 years
I. Benefit		
Mean (IDR/year)	409507	409507
Households	1229	1229
Questionnaire response rate	0.82	0.82
Annual benefits beginning from fifth year (IDR Million/Year)	414.54	414.54
(1) Present value of benefit (IDR million)[a]	257.40	1233.15
II. Annual cost		
A. Initial cost (IDR Million)		
Seedlings	39.58	39.58
Bamboo pole	3.96	3.96
Labor for planting	23.75	23.75
Transportation	1.00	1.00
Total initial cost	68.28	68.28
B. Maintenance cost (IDR Million)		
Seedlings and bamboo pole for replanting (year)	5.00	5.00
Labor for monitoring	3.00	3.00
Transportation	1.00	1.00
Maintenance cost (year)	9.00	9.00
Maintenance cost (the first 4 years)	36.00	36.00
Maintenance cost (from in year 5 to in the last project)	4.5	27.00
Total maintenance cost	40.5	63.00
(2) Present value of cost (IDR Million)[b]	99.60	110.19
Discount rate (%)[c]	10	10
B/C ratio ((1)/(2))	2.34	11.19

Note. [a] The present value of benefit was calculated according to the annual benefits starting in the fifth year and multiplied by a 10% discount rate. [b] The present value of cost was calculated by the total cost (i.e. initial costs and maintenance costs) multiplied by a 10% discount rate. [c] The 10% rate refers to the expected interest rate from commercial banks used to determine the value of future cash flows. US$1 was equivalent to IDR 13,000 as of the study period.

4. Discussion

Up till now, few studies have focused on valuing non-marketed resources and applying CVM to the appraisal of ecosystem services for mangrove restoration in the Mahakam delta. Therefore, we sought to apply CVM to investigate whether sociodemographic characteristics and perceived importance of mangrove ecosystem function the value of local communities' WTP for mangrove restoration. The maximum likelihood estimation results confirmed the hypotheses. As explained previously, mangroves in the Mahakam delta are now facing degradation as a result of urban and industrial development as well as shrimp pond expansion. According to previous studies that have demonstrated the ecological services mangroves provide, the economic valuation of mangrove restoration in the Mahakam delta provides useful information for policymakers to develop the strategic approaches for restoring the mangroves in this area.

In this study, we aimed to minimize the limitations of the CVM through various precautions. We conducted a pre-test and revised the hypotheses several times to avoid bias before conducting the main survey. This helped us to figure out the appropriate approach to determine respondents' preferences by providing understandable questions and offering sufficient information about mangroves. We explained current and possible future scenarios for mangroves in the Mahakam delta, including the benefits of mangroves and the influence on participants' livelihoods if the degradation of mangroves continues, using simple and easily understandable terms. Further, we offered bids for the restoration of the mangroves to respondents.

We designed the questionnaire carefully to avoid question bias by testing the questionnaire via a pilot and discussing the questionnaire design with experts and related stakeholders. Accurate and sufficient information about the study sites and mangrove ecosystems services that benefit respondents was provided to avoid the information effect and embedding effect. Respondents were also given detailed information about plans for mangrove restoration in the area.

We used the double-bound model rather than an open-ended WTP question format to reduce strategic bias and the elicitation effect (Burton, Carson, Chilton, & Hutchinson, 2003). Several previous studies have also used this method (Zografakis et al., 2010; Lee & Heo, 2016). CVM is a stated preference method through which respondents' maximum WTP or minimum willingness to accept a bid in exchange for a corresponding increase or decrease in environmental quality is assessed. Diamond and Hausman (1994) expressed that even though CVM has been applied to calculate the value of a broad range of environmental resources, several criticisms have been raised regarding its ability to produce reliable estimates of WTP. However, by following all of the precautions mentioned above, it is expected that the major limitations of CVM were avoided.

In line with studies conducted by Stone, Bhat, Bhatta, and Mathews (2008) and Tuan, My, Anh, and Toan (2014), the current findings also indicated a relationship between a respondent's WTP and the bid levels offered, where a higher bid bid amount decreased WTP for mangrove restoration. Aside from occupation, most of the socioeconomic characteristics of respondents in this study did not significantly influence the WTP of respondents. The results of Tuan, My, Anh, and Toan (2014) showed a similar trend, but only household size influenced the WTP of respondents in their study.

We asked respondents to select their preferred mode of participation if were to participate in a future mangrove restoration program. The possible types of participation for mangrove restoration were planting mangrove seedlings, monitoring plant progress and protecting the mangrove area. Table 5 shows that respondents who selected planting mangrove seedlings tended to be WTP less than respondents who selected other types of participation. This study also tried to examine the relationship between respondents' feeling of responsibility and their acknowledgement that mangroves can function as aquatic nurseries with their willingness to pay for mangrove restoration. We confirmed that respondents who said that they have a responsibility toward the sustainable management of mangrove ecosystems were willing to pay more. Similarly, respondents who recognized that mangroves provide a breeding ground for aquatic organisms were prepared to pay more. These results are important because they indicate that if community responsibility and information regarding mangrove functions are increased, community members will be willing to pay more for restoring mangroves.

The results of the CBA regarding mangrove restoration in this study provide valuable information for policymakers to improve the sustainable use of mangroves and sustainability of local livelihoods in the Mahakam delta. According to the CBA results, the benefits for local communities provided by mangroves clearly outweigh the costs of a mangrove restoration project. Assuming a standard 10% decrease based on bank interest rates and a project life of 5 years, investing in mangrove restoration requires approximately IDR 99.60 million less than the estimated benefits attained from mangrove restoration according to households' WTP (approximately IDR 257.40 million). Thus, the cost-benefit ratio is approximately 2.34. This also suggests that the local community is willing to pay an amount equal to 2.34 of the cost for mangrove restoration and conservation in the Mahakam delta. Furthermore, mangrove restoration will provide benefits for a much longer period. A project life of 10 years, for example, results in a cost-benefit ratio of approximately 11.19. Thus, we recommend that initiating mangrove restoration projects in the study area is a viable plan that should be implemented.

5. Conclusion

Mangroves, which have multiple functions, provide greater tangible and intangible benefits to local communities than other ecosystem types. This leads to the local community highly depending on mangrove for their livelihoods. However, mangroves have been destroyed in the study area owing to a lack of awareness regarding their many functions and useful. We recommend that government agencies or non-governmental organizations should implement mangrove restoration programs in the study area based on our finding that feelings of responsibility influenced WTP for mangrove restoration. The trust of local people toward the mangrove restoration program provides an easiness to reach the goal of the program. An education program could be used to regularly disseminate information about the benefits of mangroves as one of several techniques in future restoration programs to enhance local peoples' awareness of mangrove ecosystem function and responsibility toward their maintenance.

The central and local governments should consider involving the local community in mangrove restoration projects. The participation of local community members from the beginning of the project can enhance participants' feeling of responsibility to conserve mangroves. The reliance of local community as the key players for preserving the mangroves is expected to confirm the success of the project. To strengthen policies regarding sustainable mangrove restoration and management in the Mahakam delta, further research associated with optimizing mangrove utilization to support local community livelihoods is recommended.

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Appendix

Appendix A. Questionnaire on mangrove restoration in Mahakam Delta

As described, rehabilitation and management of mangrove ecosystems will be conducted to restore the function of mangrove that supports productivity, and its role in the life supporting system can be maintained. The mangrove rehabilitation program can offer benefits for local communities as follows:

- Increasing of habitat for the economic juvenile aquatic organisms impacts to sustainable livelihood of local households.
- Vegetation of mangrove vegetation creates new livelihood options for local communities through ecotourism.
- Mangrove vegetation protects housing and infrastructure, including a shrimp pond for aquaculture activities from damage by storms, erosion, and sea level rise.
- Mangrove rehabilitation and management programs provide supplemental income for local communities in the short term through payments for mangrove plantation, monitoring, and protection.

Clearly, the implementation of this program requires cost money and people to contribute by paying their share of the expenses on a continuing basis if they want to enjoy the benefits that the rehabilitation of mangroves offers. *(Example: for bid IDR 10,000 type)*

1) Would you be willing to pay for restoring the mangrove?

a. Yes (next to Q2) b. No

2) Would you be willing to pay at IDR 10,000/month to rehabilitate the mangrove?

a. Yes (next to Q3) b. No (next to Q4)

3) Would you be willing to pay at IDR 20,000/month to rehabilitate the mangrove?

a. Yes b. No

4) Would you be willing to pay at IDR 5,000/month to rehabilitate the mangrove?

a. Yes b. No

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